Chapter 5.0
Effects of the Proposed Action

Section 5.1
Effects of the Proposed Action Common to Multiple Areas

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5 EFFECTS OF THE PROPOSED ACTION

Effects of the Proposed Action are defined as "the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with the action, that will be added to the environmental baseline" (50 CFR 402.02). When project operations directly or immediately injure or kill fish or damage habitat at or near the project site, those are considered direct effects of the project. Indirect effects are defined in 50 CFR 402.02 as "those that are caused by the Proposed Action and are later in time, but still are reasonably certain to occur." They include the effects on listed species of future activities that are induced by the PA and that occur after the action is completed. "Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration" (50 CFR 402.02).

NMFS conducted two related analyses, one to inform its jeopardy determination, and one to inform its critical habitat determination. For the jeopardy analysis, NMFS determined whether the PA is likely to reduce the abundance, productivity, or distribution of a listed ESU. Because there is a paucity of detailed data for some Chinook and steelhead populations, some of this determination is qualitative in nature.

For the critical habitat analysis, NMFS evaluated the effect of the PA on the primary constituent elements (PCEs) of critical habitat and, in particular, on the essential features of that critical habitat by comparing the conditions of the habitat with and without the PA.

5.1 EFFECTS OF THE PROPOSED ACTION COMMON TO MULTIPLE AREAS

NMFS' analysis of the effects of the PA for each occupied tributary and the mainstem Willamette River, the lower Columbia River and the Columbia River plume, is presented in subsections 5.2 through 5.11. This subsection 5.1 describes the effects of specific parts of the Proposed Action that are generally applicable to the tributaries and fish species.

Except as identified below, conditions under the environmental baseline (Chapter 4) are assumed to continue during the life of this consultation.

The Proposed Action includes a number of measures that would have few, if any, direct effects on listed anadromous fish. These measures include, but are not limited to the following:

- WATER committee process and structure
- Willamette System Review Study

The Proposed Action also includes activities that have similar effects throughout the action area. These measures include:

- RME studies
- Revetments

- Hatchery program

NMFS describes effects of these actions in the following subsections.

5.1.1 WATER Committee Process and Structure

Because, the Willamette River is the largest and most densely populated tributary in the Columbia River Basin, effective protection and recovery of ESA listed species in the Willamette Basin's diverse and complex array of streams, habitat, and anthropogenic features will require an ecosystem-wide perspective and the cooperative, interrelated efforts of all concerned parties with resource management authority and responsibility. The structure of the WATER committees and their employment of a collaborative and adaptive planning and review process is designed and intended to serve the Action Agencies and the Services in addressing these needs. Informed decision making will require consideration of the feasibility, effectiveness, and associated risks of actions to be taken, including their integration with or impacts upon actions planned or being taken by others within the Willamette Basin.

While the necessity of a collaborative effort in achieving effective protection and recovery of ESA listed species in the Willamette Basin is apparent, the responsibility for carrying out the measures included in the Action Agencies' Proposed Action remains the sole responsibility of the Action Agencies. Likewise, the authority for assessing the adequacy of individual measures or combinations of measures in avoiding jeopardy to listed species or adverse modification of critical habitat and in effectively achieving protection and recovery goals remains solely the responsibility of the Services.

NMFS does not believe these essential responsibilities are clearly described in the Proposed Action. In order to ensure that decisions are carried out consistent with this Opinion, the Action Agencies must ensure that the Charter for WATER and its technical coordinating committees describes a decision-making process that recognizes the unique role played by NMFS and USFWS in decisions related to measures covered in their respective Biological Opinions.

5.1.2 Willamette System Review Study

The Action Agencies propose to undertake a comprehensive assessment of the Willamette Basin (USACE 2007a) to comprehensively evaluate the feasibility and relative benefits of structural and related operational modifications designed to improve survival and productivity of ESA-listed aquatic species at Willamette dams. The effect of the Willamette Project on the Willamette Basin is widespread, so the research area will also be large. Thus, the areas of investigation would include, but are not limited to:

- Upstream and downstream passage feasibility at USACE facilities
- Monitoring of basin metrics at USACE and non-USACE facilities
- Hatcheries, hatchery traps, and hatchery barriers
- Temperature control systems at dams
- Habitat Restoration
- Water Quality Improvements

NMFS discusses effects of the Willamette System Review Study in each of the subbasin effects sections where Project dams and operations would be evaluated (5.2 Middle Fork Willamette, 5.3 McKenzie, 5.5 South Santiam, and 5.6 North Santiam). In general, the study would help provide information regarding the feasibility and relative benefits of various mitigation measures, but would also have some adverse effects. As described below in 5.1.3, fish would be used in field studies and some individuals would be stressed, injured, and killed from these studies. Additionally, until the studies are completed, none of the major improvements to fish passage, temperature control, and other facilities will be carried out, exposing fish to degraded conditions below the dams and limited access to upstream habitat for an unknown number of years.

5.1.3 RME Studies

RME studies under the Proposed Action would have direct effects on both UWR Chinook and UWR steelhead that are used in field studies. Fish may be trapped, examined, released, confined, re-located, marked or tagged and subjected to related handling operations, subjected to the administration of pharmacological agents, including anesthetics, subjected to capture by electrofishing, propagated, transported between stream basins, killed or injured during test and control conditions, and affected in diverse other ways.

5.1.3.1 Effect on Species Status

Under the Proposed Action, numerous fish protection measures will be carried out that depend on site-specific evaluations to identify feasible alternatives. These measures include restoration actions to address, in part, habitat factors limiting the viability of salmonid populations. These altered habitat conditions will affect the distribution and abundance of Chinook and steelhead.

RM&E actions are a necessary tool for providing data critical to adaptive management. This monitoring information will allow adaptive management decisions to be made to ensure the long-term persistence of listed fish species in the Willamette Basin, as well as the ability to respond to significant changes in environmental conditions. Its implementation will also ensure that managers have information to determine the effectiveness of the Proposed Action.

Under the RME Proposed Action #2.14, Chapter 2, the Action Agencies will monitor and evaluate the effectiveness of various aquatic measures in the Proposed Action, including fish passage, water quality, habitat quality and quantity, and hatchery supplementation programs. The Action Agencies will prepare annual monitoring reports that describe the work conducted each year and the results of each study. Work will be conducted by the Action Agencies, or those hired by the Action Agencies to conduct the work (their contractors).

The various monitoring and evaluation activities for anadromous fish measures would cause many types of take (as defined by ESA §3(19) - The term ‘‘take’’ means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct). The first part of this Section is devoted to a discussion of the general effects known to be caused by the general potential proposed activities—regardless of where they occur or what species are involved.

Research and monitoring programs identified in the RPA will be funded or conducted, or both, by the Action Agencies. These programs are expected to take listed UWR Chinook salmon and steelhead. The activities include, but are not limited to, the following: (1) evaluating fish passage through reservoirs and various outlets at dams; (2) evaluating alternative fish passage facilities, screens, and other bypass systems; (3) evaluating effects of alternative flow scenarios, flow pulses, minimum and maximum flow levels, and of various ramping rates; (4) evaluating salmonid production (i.e., smolt-to-adult survival rates, for example); (5) determining stock composition, population trends, and life history patterns; (6) evaluating habitat restoration projects; (7) evaluating effects of artificial production and supplementation on natural-origin listed fish; (8) evaluating alternative methods for achieving temperature control on fish and fish habitat below Project dams; (9) investigating migration timing and migratory patterns; (10) moving fish above artificial barriers to migration; (11) investigating fish behaviors in streams, reservoirs and off-channel areas; (12) evaluating fish spawning below dams; (13) monitoring and mitigating the effects of USACE dams; (14) evaluating effects of water diversions on fish; (14) conducting total dissolved gas experiments; (15) and investigating effects of alternative reservoir levels on fish passage and survival.

The following subsections describe the types of activities that NMFS expects the Action Agencies will use to carry out the research and monitoring requirements of the Proposed Action. The types of activities are organized into the following categories: observation, capture/handle/release, tagging/marking, biological sampling, and sacrifice. Each is described in terms broad enough to apply to every relevant plan informed by previous experience. The activities would be carried out by trained professionals using established protocols and have widely recognized specific impacts. The Action Agencies are required to incorporate NMFS' uniform, pre-established set of minimization measures, including training, protocol standardization, data management, and reporting for these activities (e.g. electrofishing). These measures will be included in the specific monitoring plans subject to NMFS' approval.

5.1.3.2 Observation

For some studies, fish will be observed in-water (i.e., snorkel surveys). Direct observation is the least disruptive and simplest method for determining presence/absence of the species and estimating their relative abundance. Its effects are also generally the shortest-lived among any of the research activities discussed in this Chapter. Typically, a cautious observer can obtain data without disrupting the normal behavior of a fish. Fry and juveniles frightened by the turbulence and sound created by observers are likely to seek temporary refuge behind rocks, vegetation, and deep water areas. In extreme cases, some individuals may temporarily leave a particular pool or habitat type when observers are in their area. Researchers minimize the amount of disturbance by slowly moving through streams, thus allowing ample time for fish to reach escape cover; though it should be noted that the research may at times involve observing adult fish—which are more sensitive to disturbance. There is little a researcher can do to mitigate the effects associated with observation activities because those effects are so minimal. In general, all they can do is move with care and attempt to avoid disturbing sediments, gravels, and, to the extent possible, the fish themselves.

Monitoring of population status and the effects of programs and actions will include conducting redd surveys to visually inspect and count the nests or redds of spawning salmon and steelhead. Harassment is the primary form of take associated with these observation activities, and few if any injuries or deaths are expected to occur—particularly in cases where the observation is to be conducted solely by researchers on the stream banks or from a raft rather than walking in the water. Fish may temporarily move off of a redd and seek cover nearby until the observer has past. There is little a researcher can do to mitigate the effects associated with observation activities because those effects are so minimal. In general, all researchers can do is move with care and attempt to avoid disturbing sediments, gravels, and, to the extent possible, the fish themselves.

5.1.3.3 Capture/Handle/Release

Capturing and handling fish causes them stress—though they typically recover fairly rapidly from the process and therefore the overall effects of the procedure are generally short-lived. The primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperatures (between the river and the point where fish are held), dissolved oxygen conditions, the amount of time that fish are held out of the water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 18 degrees C or dissolved oxygen is below saturation. Fish that are transferred to holding tanks can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps if the traps are not regularly emptied. Debris buildup at traps can also kill or injure fish if the traps are not monitored and regularly cleared of debris.

The use of capture/handling/release protocols, which are generally standardized throughout the Columbia basin and include maintaining high quality water (appropriate temperature, oxygen levels, anesthetic concentrations) and keeping fish in water to the maximum extent possible, serve to minimize potential adverse impacts on individual fish. Based on experience with the standard protocols that would be used to conduct the research and monitoring, no more than five percent and in most cases, less than two percent of the juvenile salmonids encountered are likely to be killed as an unintentional result of being captured and handled. In any case, researchers will employ the standard protocols and thereby keep adverse effects to a minimum. Finally, any fish unintentionally killed by the research activities in the proposed permit may be retained as reference specimens or used for other research purposes.

5.1.3.4 Smolt, rotary screw (and other out-migration) traps

Smolt, rotary screw (and other out-migration) traps, are generally operated to gain population specific information on natural population abundance and productivity. On average, they achieve a sample efficiency of 4 to 20% of the emigrating population from a river or stream, depending on the river size, although under some conditions traps may achieve a higher efficiency for a relatively short period of time (NMFS 2003d). Based on experience in Columbia River tributaries the mortality of fish captured/handled/released at rotary screw type juvenile fish traps would be expected to be two percent or less on target species.

The trapping, capturing, or collecting and handling of juvenile fish using traps is likely to cause some stress on listed fish. However, fish typically recover rapidly from handling procedures. The primary factors that contribute to stress and mortality from handling are excessive doses of anesthetic, differences in water temperature, dissolved oxygen conditions, the amount of time that fish are held out of water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 64.4 °F (18 °C) or if dissolved oxygen is below saturation. Additionally, stress can occur if there are more than a few degrees difference in water temperature between the stream/river and the holding tank. The potential for unexpected injuries or mortalities to ESA-listed fish will be reduced in a number of ways.

Study protocols and ITS terms and conditions define how the potential for stress will be minimized. The action specifies that the trap would be checked and fish handled in the morning. This would ensure that the water temperature is at its daily minimum when fish are handled. Fish may not be handled if the water temperature exceeds 69.8 °F (21 °C). Sanctuary nets must be used when transferring fish to holding containers to avoid potential injuries. The investigator's hands must be wet before and during fish handling. Appropriate anesthetics must be used to calm fish subjected to collection of biological data. Captured fish must be allowed to fully recover before being released back into the stream and will be released only in slow water areas.

5.1.3.5 Electrofishing

Electrofishing is a process by which an electrical current is passed through water containing fish in order to stun them—thus making them easy to capture. It can cause a suite of effects ranging from simple harassment to actually killing the fish. The amount of unintentional mortality attributed to electrofishing may vary widely depending on the equipment used, the settings on the equipment, and the expertise of the technician. Electrofishing can have severe effects on adult salmonids. Spinal injuries in adult salmonids from forced muscle contraction have been documented. Sharber and Carothers (1988) reported that electrofishing killed 50% of the adult rainbow trout in their study. The long-term effects electrofishing has on both juveniles and adult salmonids are not well understood, but long-term experience with electrofishing indicates that most impacts occur at the time of sampling and are of relatively short duration.

The effects electrofishing may have on the threatened species would be limited to the direct and indirect effects of exposure to an electric field, capture by netting, holding captured fish in aerated tanks, and the effects of handling associated with transferring the fish back to the river (see the previous subsection for more detail on capturing and handling effects). Most of the studies on the effects of electrofishing on fish have been conducted on adult fish greater than 300 mm in length (Dalbey et al. 1996). The relatively few studies that have been conducted on juvenile salmonids indicate that spinal injury rates are substantially lower than they are for large fish. Smaller fish intercept a smaller head-to-tail potential than larger fish (Sharber and Carothers 1988) and may therefore be subject to lower injury rates (Hollender and Carline 1994; Dalbey et al. 1996; Thompson et al. 1997). McMichael et al. (1998) found a 5.1% injury rate for juvenile Middle Columbia River steelhead captured by electrofishing in the Yakima River subbasin. The incidence and severity of electrofishing damage is partly related to the type of equipment used and the waveform produced (Sharber and Carothers 1988; McMichael 1993; Dalbey et al. 1996; Dwyer and White 1997). Continuous direct current (DC) or low-frequency (30 Hz) pulsed DC have been recommended for electrofishing (Snyder 1995; Dalbey et al. 1996) because lower spinal injury rates, particularly in salmonids, occur with these waveforms (McMichael 1993; Sharber et al. 1994; Dalbey et al. 1996). Only a few recent studies have examined the long-term effects of electrofishing on salmonid survival and growth (Dalbey et al. 1996; Ainslie et al. 1998). These studies indicate that although some of the

fish suffer spinal injury, few die as a result. However, severely injured fish grow at slower rates and sometimes they show no growth at all (Dalbey et al. 1996).
NMFS' electrofishing guidelines (2000c) will be followed in all surveys using this procedure. The guidelines require that field crews be trained in observing animals for signs of stress and shown how to adjust electrofishing equipment to minimize that stress. Electrofishing is used only when all other survey methods are not feasible. All areas for stream and special needs surveys are visually searched for fish before electrofishing may begin. Electrofishing is not done in the vicinity of redds or spawning adults. All electrofishing equipment operators are trained by qualified personnel to be familiar with equipment handling, settings, maintenance, and safety. Operators work in pairs to increase both the number of fish that may be seen and the ability to identify individual fish without having to net them. Working in pairs also allows the operators to net fish before they are subjected to higher electrical fields. Only DC units will be used, and the equipment will be regularly maintained to ensure proper operating condition. Voltage, pulse width, and rate will be kept at minimal levels and water conductivity will be tested at the start of every electrofishing session so those minimal levels can be determined. Due to the low settings used, shocked fish normally revive instantaneously. Fish needing to be revived will receive immediate, adequate care.

The preceding discussion focused on the effects of using a backpack unit for electrofishing and the ways those effects will be mitigated. It should be noted, however, that in larger streams and rivers electrofishing units are sometimes mounted on boats. These units often use more current than backpack electrofishing equipment because they need to cover larger (and deeper) areas, and as a result, can have a greater impact on fish. In addition, the environmental conditions in larger, more turbid streams can limit the operators' ability to minimize impacts on fish. For example, in areas of lower visibility it is difficult for operators to detect the presence of adults and thereby take steps to avoid them. Because of its greater potential to harm fish, and because NMFS has not published appropriate guidelines, boat electrofishing has not been given a general authorization and all boat electrofishing projects will be evaluated on a case by case basis.

5.1.3.6 Angling

Fish that are caught and released alive as part of an RM&E project may still die as a result of injuries or stress resulting from the capture method or handling. The likelihood of mortality varies widely, based on a number of factors including the gear type used, the species, the water conditions, and the care with which the fish is released. As detail for the effects analysis below, general catch-and-release effects for steelhead and Chinook salmon are discussed here.

Catch and Release mortality –The available information assessing hook and release mortality of adult steelhead suggests that hook and release mortality is low. Hooton (1987) found catch and release mortality of adult winter steelhead to average 3.4% (127 mortalities of 3,715 steelhead caught) when using barbed and barbless hooks, bait and artificial lures. Among 336 steelhead captured on various combinations of popular terminal gear in the Keogh River, the mortality of the combined sample was 5.1%. Natural bait had slightly higher mortality (5.6%) than did artificial lures (3.8%), and barbed hooks (7.3%) had higher mortality than barbless hooks (2.9%). Hooton (1987) concluded that catch and release of adult steelhead was an effective mechanism for maintaining angling opportunity without negatively impacting stock recruitment. Reingold (1975) showed that adult steelhead hooked, played to exhaustion, and then released returned to their target spawning stream at the same rate as steelhead not hooked and played to exhaustion. Pettit (1977) found that egg viability of hatchery steelhead was not negatively affected by catch-and-release of pre-spawning adult female steelhead. Bruesewitz (1995) found, on average, fewer than 13% of harvested summer and winter steelhead in Washington streams were hooked in critical areas (tongue, esophagus, gills, eye). The highest percentage (17.8%) of critical area hookings occurred when using bait and treble hooks in winter steelhead fisheries.

The referenced studies were conducted when water temperatures were relatively cool, and primarily involve winter-run steelhead. Data on summer-run steelhead and warmer water conditions are less abundant (Cramer et al. 1997). Catch and release mortality of steelhead is likely to be higher if the activity occurs during warm water conditions. In a study conducted on the catch and release mortality of steelhead in a California river, Taylor and Barnhart (1999) reported over 80% of the observed mortalities occurred at stream temperatures greater than 21 degrees C. Catch and release mortality during periods of elevated water temperature are likely to result in post-release mortality rates greater than reported by Hooton (1987) because of warmer water and extended freshwater residence of summer fish which make them more likely to be caught. As a result, NMFS expects steelhead hook and release mortality to be in the lower range discussed above.

Juvenile steelhead occupy many waters that are also occupied by resident trout species and it is not possible to visually separate juvenile steelhead from similarly-sized, stream-resident, rainbow trout. Because juvenile steelhead and stream-resident rainbow trout are the same species, are similar in size, and have the same food habits and habitat preferences, it is reasonable to assume that catch-and-release mortality studies on stream-resident trout are similar for juvenile steelhead. Where angling for trout is permitted, catch-and-release fishing with prohibition of use of natural or synthetic bait will reduce juvenile steelhead mortality more than any other angling regulatory change. Many studies have shown trout mortality to be higher when using bait than when angling with artificial lures and/or flies (Taylor and White 1992; Schill and Scarpella 1995; Mongillo 1984; Wydoski 1977; Schisler and Bergersen 1996). Wydoski (1977) showed the average mortality of trout, when using bait, to be more than four times greater than the mortality associated with using artificial lures and flies. Taylor and White (1992) showed average mortality of trout to be 31.4% when using bait versus 4.9 and 3.8% for lures and flies, respectively. Schisler and Bergersen (1996) reported average mortality of trout caught on passively fished bait to be higher (32%) than mortality from actively fished bait (21%). Mortality of fish caught on artificial flies was only 3.9%. In the compendium of studies reviewed by Mongillo (1984) mortality of trout caught and released using artificial lures and single barbless hooks was often reported at less than 2%.

Most studies have found little difference (or inconclusive results) in the mortality of juvenile steelhead associated with using barbed versus barbless hooks, single versus treble hooks, and different hook sizes (Schill and Scarpella 1995; Taylor and White 1992; Mongillo 1984). However, some investigators believe that the use of barbless hooks reduces handling time and stress on hooked fish and adds to survival after release (Wydoski 1977). In summary, catch-and-release mortality of juvenile steelhead is expected to be less than 10% and approaches 0% when researchers are restricted to use of artificial flies and lures.

Only a few reports are available that provide empirical evidence showing what the catch and release mortality is for Chinook salmon in freshwater. The ODFW has conducted studies of hooking mortality incidental to the recreational fishery for Chinook salmon in the Willamette River. A study of the recreational fishery estimates a per-capture hook-and-release mortality for natural-origin spring Chinook in Willamette River fisheries of 8.6% (Schroeder et al. 2000), which is similar to a mortality of 7.6% reported by Bendock and Alexandersdottir (1993) in the Kenai River, Alaska.

A second study on hooking mortality in the Willamette River, Oregon, involved a carefully controlled experimental fishery, and mortality was estimated at 12.2% (Lindsay et al. 2004). In hooking mortality studies, hooking location and gear type is important in determining the mortality of released fish. Fish hooked in the jaw or tongue suffered lower mortality (2.3 and 17.8% in Lindsay et al. (2004) compared to fish hooked in the gills or esophagus (81.6 and 67.3%). A large portion of the mortality in the Lindsay et al. (2004) study was related to deep hooking by anglers using prawns or sand shrimp for bait on two-hook terminal tackle. Other baits and lures produced higher rates of jaw hooking than shrimp, and therefore produced lower hooking mortality estimates. The Alaska study reported very low incidence of deep hooking by anglers using lures and bait while fishing for salmon.

Based on the available data, the *U.S. v. Oregon* Technical Advisory Committee (TAC 2008) has adopted a 10% rate in order to make conservative estimates of incidental mortality in fisheries (NMFS 2005c). For similar reasons, NMFS currently applies the 10% rate to provide conservative estimates of the hook and release mortality when evaluating the impact of proposed RM&E activities using angling as a monitoring technique.

5.1.3.7 Tagging & Marking

Techniques such as passive integrated transponder tagging, coded wire tagging, fin-clipping, and the use of radio transmitters are common to many scientific research efforts using listed species. All sampling, handling, and tagging procedures have an inherent potential to stress, injure, or even kill the marked fish. This section discusses each of the marking processes and its associated risks.

5.1.3.7.1 Passive Integrated Transponder (PIT) tag

A passive integrated transponder (PIT) tag is an electronic device that relays signals to a radio receiver; it allows salmonids to be identified whenever they pass a location containing such a receiver (e.g., any of several dams) without researchers having to handle the fish again. The tag is inserted into the body cavity of the fish just in front of the pelvic girdle. The tagging procedure requires that the fish be captured and extensively handled; therefore, any researchers engaged in such activities will follow the conditions listed previously in this Opinion (as well as any permit-specific conditions) to ensure that the operations take place in the safest possible manner. In general, the tagging operations will take place where there is cold water of high quality, a carefully controlled environment for administering anesthesia, sanitary conditions, quality control checking, and a carefully regulated holding environment where the fish can be allowed to recover from the operation.

PIT tags have very little effect on growth, mortality, or behavior. The few reported studies of PIT tags have shown no effect on growth or survival (Prentice et al. 1987; Jenkins and Smith 1990; Prentice et al. 1990). For example, in a study between the tailraces of Lower Granite and McNary Dams (225 km), Hockersmith et al. (2000) concluded that the performance of yearling Chinook salmon was not adversely affected by gastrically-or surgically implanted sham radio tags or PIT-tags. Additional studies have shown that growth rates among PIT-tagged Snake River juvenile fall Chinook salmon in 1992 (Rondorf and Miller 1994) were similar to growth rates for salmon that were not tagged (Connor et al. 2001). Prentice and Park (1984) also found that PIT-tagging did not substantially affect survival in juvenile salmonids.

5.1.3.7.2 Coded wire tags (CWTs)

Coded wire tags (CWTs) are made of magnetized, stainless-steel wire. They bear distinctive notches that can be coded for such data as species, brood year, hatchery of origin, and so forth (Nielsen 1992). The tags are intended to remain within the animal indefinitely, consequently making them ideal for long-term, population-level assessments of Pacific Northwest salmon. The tag is injected into the nasal cartilage of a salmon and therefore causes little direct tissue damage (Bergman et al. 1968; Bordner et al. 1990). The conditions under which CWTs may be inserted are similar to those required for applying PIT-tags.

A major advantage to using CWTs is the fact that they have a negligible effect on the biological condition or response of tagged salmon. However, if the tag is placed too deeply in the snout of a fish, it may kill the fish, reduce its growth, or damage olfactory tissue (Fletcher et al. 1987; Peltz and Miller 1990). This latter effect can create problems for species like salmon because they use olfactory clues to guide their spawning migrations (Morrison and Zajac 1987).

In order for researchers to be able to determine later (after the initial tagging) which fish possess CWTs, it is necessary to mark the fish externally—usually by clipping the adipose fin—when the CWT is implanted (see text below for information on fin clipping). One major disadvantage to recovering data from CWTs is that the fish must be killed in order for the tag to be removed. However, this is not a significant problem because researchers generally recover CWTs from salmon that have been taken during the course of commercial and recreational harvest (and are therefore already dead).

5.3.1.7.3 Radio tagging

Radio tagging is another method for tagging fish. There are two main ways to accomplish this and they differ in both their characteristics and consequences. First, a tag can be inserted into a fish's stomach by pushing it past the esophagus with a plunger. Stomach insertion does not cause a wound and does not interfere with swimming. This technique is benign when salmon are in the portion of their spawning migrations during which they do not feed (Nielsen 1992). In addition, for short-term studies, stomach tags allow faster post-tagging recovery and interfere less with normal behavior than do tags attached in other ways.

The second method for implanting radio tags is to place them within the body cavities of (usually juvenile) salmonids. These tags do not interfere with feeding or movement. However, the tagging procedure is difficult, requiring considerable experience and care (Nielsen 1992). Because the tag is placed within the body cavity, it is possible to injure a fish's internal organs. Infections of the sutured incision and the body cavity itself are also possible, especially if the tag and incision are not treated with antibiotics (Chisholm and Hubert 1985; Mellas and Haynes 1985).

Fish with internal radio tags often die at higher rates than fish tagged by other means because radio tagging is a complicated and stressful process. Mortality is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release. It can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal in direct or subtle ways. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982; Matthews and Reavis 1990; Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance.

5.3.1.7.4 Fin clipping

Fin clipping is the process of removing part or all of one or more fins to alter a fish's appearance and thus make it identifiable. When entire fins are removed, it is expected that they will never grow back. Alternatively, a permanent mark can be made when only a part of the fin is removed or the end of a fin or a few fin rays are clipped. Although researchers have used all fins for marking at one time or another, the current preference is to clip the adipose, pelvic, or pectoral fins. Marks can also be made by punching holes or cutting notches in fins, or severing individual fin rays (Kohlhorst 1979; Welch and Mills 1981). Many studies have examined the effects of fin clips on fish growth, survival, and behavior. The results of these studies are somewhat varied; however, it can be said that fin clips do not generally alter fish growth. Studies comparing the growth of clipped and unclipped fish generally have shown no differences between them (Brynildson and Brynildson 1967). Moreover, wounds caused by fin clipping usually heal quickly—especially those caused by partial clips.

Mortality among fin-clipped fish is also variable. Some immediate mortality may occur during the marking process, especially if fish have been handled extensively for other purposes (e.g., stomach sampling). Delayed mortality depends, at least in part, on fish size; small fishes have often been found to be susceptible to it. Coble (1967) suggested that fish shorter than 90 mm are at particular risk. The degree of mortality among individual fishes also depends on which fin is clipped. Studies show that adipose- and pelvic-fin-clipped coho salmon fingerlings have a 100 % recovery rate (Stolte 1973). Recovery rates are generally recognized as being higher for adipose- and pelvic-fin-clipped fish in comparison to those that are clipped on the pectoral, dorsal, and anal fins (Nicola and Cordone 1973). Clipping the adipose and pelvic fins probably kills fewer fish because these fins are not as important as other fins for movement or balance (McNeil and Crossman 1979). Mortality is generally higher when the major median and pectoral fins are removed. Mears and Hatch (1976) showed that clipping more than one fin may increase delayed mortality but other studies have been less conclusive.

Regardless, any time researchers clip or remove fins, it is necessary that the fish be handled. Therefore, the same safe and sanitary conditions required for tagging operations also apply to clipping activities.

5.1.3.8 Stomach Flushing

Stomach flushing is a technique to induce fish to regurgitate the contents of their stomachs without killing the fish. Knowledge of the food and feeding habits of fish are important in the study of aquatic ecosystems. However, in the past, food habit studies required researchers to kill fish for stomach removal and examination. Consequently, several methods have been developed to remove stomach contents without injuring the fish. Most techniques use a rigid or semi-rigid tube to inject water into the stomach to flush out the contents.

Few assessments have been conducted regarding the mortality rates associated with nonlethal methods of examining fish stomach contents (Kamler and Pope 2001). However, Strange and Kennedy (1981) assessed the survival of salmonids subjected to stomach flushing and found no difference between stomach-flushed fish and control fish that were held for three to five days. In addition, when Light et al. (1983) flushed the stomachs of electrofished and anesthetized brook trout, survival was 100% for the entire observation period. In contrast, Meehan and Miller (1978) determined the survival rate of electrofished, anesthetized, and stomach flushed natural-origin and hatchery coho salmon over a 30-day period to be 87% and 84% respectively.

5.1.3.9 Biological Sampling

5.1.3.9.1 Genetic Samples (fin clips)

Genetic sampling uses non-lethal methods to obtain material that is used to assess parentage and develop population structure.

5.1.3.9.2 Sacrifice

In some instances, it is necessary to kill a captured fish in order to gather whatever data a study is designed to produce. In such cases, determining effect is a very straightforward process: the sacrificed fish, if juveniles are forever removed from the listed species' gene pool; if the fish are adults, the effect depends upon whether they are killed before or after they have a chance to spawn. If they are killed after they spawn, there is very little overall effect. Essentially, it amounts to removing the nutrients their bodies would have provided to the spawning grounds. If they are killed before they spawn, not only are they removed, but so are all their potential progeny. Thus, killing pre-spawning adults has the greatest potential to affect the listed species. Due to this, NMFS rarely allows it to happen. And, in almost every instance where it is allowed, the adults are stripped of sperm and eggs so their progeny can be raised in a controlled environment such as a hatchery—thereby greatly decreasing the potential harm posed by sacrificing the adults.

5.1.3.10 Habitat surveys & installation of monitoring devices

The following potential effects to listed species and their habitats associated with the proposed actions for stream channel, floodplain, and upland surveys and installation of stream monitoring devices - erosion and sedimentation, compaction and disturbance of streambed sediments - are negligible and would have little impact on compaction or instream turbidity. The effect of stream channel, floodplain, and upland surveys and installation of stream monitoring devices activity is described in the HIP Biological Opinion (2.2.1.2.1 Stream Channel, Floodplain, and Uplands Surveys and Installation Stream Monitoring Devices such as Streamflow and Temperature Monitors) (NMFS 2008d) as applicable. These actions will incorporate the conservation measures for general construction identified in that Biological Opinion. Similarly, there is the potential for trampling a negligible amount of vegetation during upland and floodplain surveys, but the vegetation would be expected to recover.

Excavated material from cultural resource testing conducted near streams may contribute sediment to streams and increase turbidity. The amount of soil disturbed would be negligible and would have a minimal effect on instream turbidity.

5.1.3.11 Benefits of Monitoring & Evaluation

NMFS will not agree with a monitoring plan if it operates to the disadvantage of an ESA-listed anadromous fish species that is the subject of the plan. In addition, NMFS does not support

monitoring plans unless the proposed activities are likely to result in a net benefit to the listed species, and benefits accrue from the acquisition of scientific information.
For more than a decade, research and monitoring activities conducted with anadromous salmonids in the Pacific Northwest have provided resource managers with a wealth of important and useful information on anadromous fish populations. For example, juvenile fish trapping efforts have enabled the production of population inventories, PIT-tagging efforts have increased the knowledge of anadromous fish migration timing and survival, and fish passage studies have provided an enhanced understanding of fish behavior and survival when moving past dams and through reservoirs. By approving plans, NMFS will enable information to be acquired that will enhance resource manager’s ability to make more effective and responsible decisions to sustain anadromous salmonid populations that are at risk of extinction, to mitigate impacts to endangered and threatened salmon and steelhead, and to implement recovery efforts. The resulting data continue to improve the knowledge of the respective species’ life history, specific biological requirements, genetic make-up, migration timing, responses to anthropogenic impacts, and survival in the river system.

RME studies comprise an essential part of the Proposed Action. In multiple instances, detailed information on geographically-specific environmental conditions (e.g., quantity and distribution of functional spawning and rearing habitat) and the extent to which ongoing Willamette Project operations are continuing to affect those conditions (e.g., flow variation and duration in relation to sediment transport dynamics, channel and habitat complexity, and related juvenile fish behavior and survival) is lacking. In other cases, known problems attributable to Willamette Project dams and operations (e.g., migration barriers and water temperature alteration) cannot be addressed by the Action Agencies until they have narrowed uncertainties about the most prudent and effective remedies. Consequently, the ability of the Action Agencies to carry out meaningful conservation measures within the period covered by this Biological Opinion will often depend upon their ability to complete studies and make timely, informed decisions on how best to achieve protection and restoration objectives associated with each of the listed species.

NMFS will need to make sure that studies the Action Agencies have proposed to assure good decision-making, or to document timely progress toward achieving protection and restoration objectives, are designed and conducted in a manner that is in keeping with the original intent of the RPA measures. NMFS must also assure that the results of these studies are applied effectively and in a timely manner.

5.1.4 Revetments

As described in Chapter 2, Proposed Action, the USACE was authorized to construct and maintain bank protection structures (generally termed revetments) along the mainstem Willamette River and its tributaries. The purpose of these structures is to protect farmland, roads, bridges, and other developments from bank erosion and flooding. The USACE is responsible for maintenance of revetments constructed through 1950, and non-federal sponsors are responsible for those constructed after 1950. Despite the USACE’s ongoing maintenance responsibility at some sites, the USACE is not authorized to remove or modify existing revetments without first obtaining landowner approval and a non-federal sponsor.

The USACE constructed about 100 miles of revetments along the mainstem Willamette River and its tributaries, and has entered into agreements to maintain approximately 42 miles of these structures into the future (USACE 2000). These structures limit natural channel migration and the formation of complex and diverse salmonid habitats, including off-channel areas that are particularly important to juvenile fish during periods of high winter flows. They also impede the establishment and growth of riparian vegetation that might otherwise provide shade (to prevent small, unfavorable temperature increases) and contribute LWD.

The Proposed Action requires the USACE to continue to maintain about 42 miles of revetments. It also includes an evaluation of the effects of these structures and possible identification of opportunities to offset or ameliorate their effects to a degree and on a schedule yet to be defined. However, the Proposed Action includes no firm commitment to remove any of these structures, or to restore habitat as part of the continued existence and maintenance of these revetments. Thus, the effect of the Proposed Action across all of the areas affected within the Willamette Basin would be to continue to diminish habitat suitability for multiple life stages of UWR Chinook and UWR steelhead, and to limit the habitat's capacity to support larger and more productive salmonid populations. These adverse effects are described within each of the Effects Chapters (5.2 through 5.10) for the subbasins and mainstem Willamette where the USACE proposes to continue to maintain revetments.

5.1.5 General Effects of Hatchery Programs on ESA-listed Salmon & Steelhead

The analysis of the effects of the proposed hatchery programs in the Willamette Basin are contained in three components. The first component (section 5.1.5.1) describes the long-term vision for the management of the hatchery spring Chinook, summer steelhead, and resident rainbow trout programs that has been discussed in detail among the co-managers in the Willamette over the last several years (including at Steelhead and Chinook Above Barriers (SCAB) coordination meetings with representatives from ODFW, USACE, NMFS, Forest Service, BLM, and other agencies). The second component (section 5.1.5.2) is a thorough evaluation, based on the latest scientific literature, of the general effects of hatchery programs on ESA-listed salmon and steelhead. The third component [sections 5.2.5 (Middle Fork Willamette), 5.3.5 (McKenzie), 5.4.5 (Calapooia), 5.5.5 (South Santiam), 5.6.5 (North Santiam), 5.7.5 (Molalla), 5.8.5 (Clackamas), 5.9.5 (Coast Fork and Long Tom), and 5.10.5 (mainstem Willamette River)] are specific assessments of the effects of the hatchery programs at the individual population level for the UWR Chinook ESU and winter steelhead DPS.

5.1.5.1 Vision for Hatchery Management in the Willamette Basin

The vision statement described here for the hatchery programs in the Willamette Basin was initiated by NMFS in 2004. At that time, it was unclear how the hatchery programs would be managed over the short- and long-terms, given new information on the status of the natural-origin populations since all returning hatchery fish have been marked in 2002 and the increased effort to outplant adult Chinook above the impassable dams back into their historical habitat. The draft vision statement was presented to the Willamette Steelhead and Chinook Above Barriers (SCAB) -- a multi-agency coordination group with representatives from ODFW, NMFS, USACE, BPA, Forest Service, and BLM. The vision was reviewed and discussed in the SCAB group over a period of time. The vision described in the following sections represents the latest product from the SCAB group.

The following hatchery management vision has also taken into account other important ESA scientific and planning documents, such as WLCTRT documents (Myers et al. 2006; WLCTRT and ODFW 2006; McElhany et al. 2007), Willamette River Draft Recovery Plan (ODFW 2007b), and the Hatchery Scientific Review Group (HSRG) preliminary recommendations on the review of Willamette hatchery programs. It is important to note the Willamette River Recovery Plan and HSRG recommendations are still in draft and have not been finalized. The historical population structure identified in Myers et al. (2006) formed the basis of the populations identified in this hatchery management vision statement. The latest viability criteria (WLCTRT and ODFW 2006) and current viability status evaluations (McElhany et al. 2007) were used to help guide hatchery actions needed in the short-term to help improve the status of the high risk populations, and to help establish the long-term actions necessary to obtain a viable ESU and DPS comprised predominately of natural-origin populations with minimal hatchery influence. The draft Willamette River Recovery Plan identified strategies and actions for management of hatchery programs and reintroducing fish back into their historical habitat above Willamette Project dams. The hatchery vision is consistent with the draft Recovery Plan strategies and actions. The HSRG recently conducted a review of Willamette hatchery programs as part of their Columbia Basin Hatchery Review process. The preliminary HSRG recommendations from the review of Willamette hatchery programs did not identify any issues that were contrary to the hatchery vision statement presented here.

5.1.5.1.1 Spring Chinook Hatchery Programs

Background

The existing hatchery Chinook broodstocks were originally founded from their respective local populations when the Willamette Project dams were built. Fisheries managers and the USACE agreed at that time to use hatchery mitigation to help offset fishery production losses associated with the construction and operation of the Willamette Project. In most cases, hatchery facilities were built at or near the dam, and the hatchery program has continued to operate and release fish annually. From the time that Willamette Project dams were built and blocked migration upstream of the dam, a mix of returning natural-origin and hatchery-origin fish were likely captured at the base of the dam and incorporated into the hatchery broodstocks. As the natural-origin population declined in the following decades after the dams were built, the percentage of natural-origin fish incorporated into the broodstock likely also declined, with hatchery-origin fish making up the majority of the broodstock over the last decade or so. Since the hatchery broodstocks were originally founded from the local population, have likely incorporated natural-origin fish into the broodstock since the program was initiated, and with the existing broodstock being the only genetic resources available (in most populations, with the exception of the McKenzie) that might resemble the historical population, NMFS concluded hatchery Chinook salmon are part of the Willamette Chinook ESU (NMFS 2005c).

The above information is essential to consider with regard to the Proposed Action for the Chinook hatchery programs, the outplanting efforts for Chinook above the Project dams, and the following hatchery effects analyses. Since the existing broodstocks are part of the ESU and represent the only genetic remnants of the historical population, the SCAB group decided to use

Willamette hatchery fish for reintroduction efforts above Project dams. The alternative would be to use only natural-origin returns (which in most cases are too few in number to make an improvement in population viability and would expose the natural-origin fish to high prespawn mortality and expose their progeny to very high downstream mortality rates through the reservoirs and dams). The SCAB group concluded in most cases it would be better to use the abundant hatchery fish until corrective actions could be implemented to improve adult and juvenile survival through the Willamette Project (Beidler and Knapp 2005). Hatchery fish could be used as a surrogate for natural-origin fish in order to gain a better understanding of the limiting factors affecting reintroduction above the dams.

ESU Management Perspective

At present, there are essentially two categories of populations in the Willamette spring Chinook ESU: 1) populations that are still relatively functional with recent returns of natural-origin fish numbering in the 1,000s (moderate to low risk of extinction; McKenzie and Clackamas), and 2) populations that have been significantly impacted with natural-origin returns at very low levels (very high risk of extinction; Middle Fork Willamette, Calapooia, South Santiam, North Santiam, Molalla).

Given this current situation, a range of hatchery management strategies will likely be necessary to accomplish the two primary hatchery management goals for this ESU: 1) minimize hatchery effects immediately in the two populations with relatively healthy runs and quality habitat that is still accessible (i.e. above Leaburg Dam on the McKenzie River and above North Fork Dam on the Clackamas River); and 2) use the hatchery program to help re-establish runs above currently impassable dams into historical habitat in specific populations where appropriate. Figure 5.1-1 shows an ESU perspective of the current management goals that have been identified for spring Chinook populations taking into account current status, key limiting factors and threats, and available genetic resources contained within existing hatchery stocks. Table 5.1-1 describes some of the short- and long-term actions that will be necessary to accomplish this hatchery management scenario.

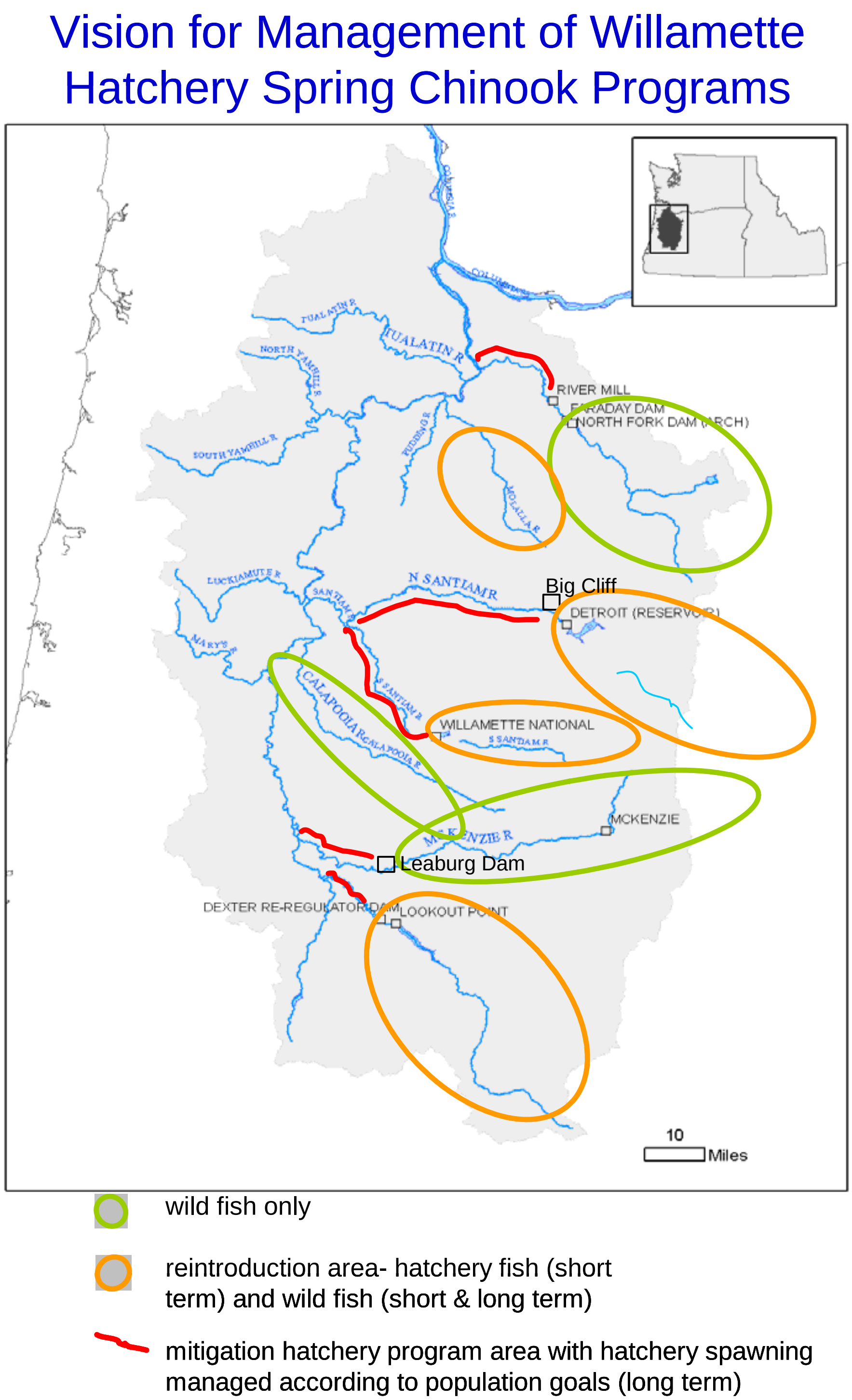

Figure 5.1-1 Conceptual vision for the management of spring Chinook hatchery programs in the Willamette ESU. See Table 5.1-1 for further details on the management actions within each population area.

Table 5.1-1 Brief description of major hatchery management actions needed to help support achievement of a viable, self-sustaining ESU

TRT Population	Current extinction risk (from McElhany et al. 2007)	Hatchery Program: Short term goals	Hatchery Program: Long term goals
Clackamas Chinook	Moderate risk	Maintain <10-20% hatchery Chinook on the spawning grounds above North Fork dam until new sorting trap installed at appropriate dam.	Minimize hatchery influence to population above the dams. Allow <5% of the run above North Fork dam to be hatchery chinook. Headwater area will be wild fish sanctuary area to evaluate status of the run with minimial hatchery effects.
Molalla Chinook	Very high risk	Discontinue S. Santiam releases and develop locally derived stock for supplementation effort for 2-3 generations, or discontinue all hatchery releases and monitor if natural-origin returns increase.	Unknown at this time. Because the potential of this spring Chinook population is more limited than for "core" populations, it may be possible to have a harvest augmentation program in this river without much negative consequence on the recovery potential of the natural-origin run.
N. Santiam Chinook	Very high risk	Implement successful reintroduction program above Detroit dam with hatchery and natural fish returns. Fix problems with high prespawn mortality due to handling, transportation.	Phase out hatchery fish outplants above Detroit Dam once natural-origin returns are sufficient to maintain to sustain the population and promote local adaptation. The area above Detroit dam will be managed for natural-origin fish only once returns are sufficient and downstream passage is sufficiently fixed. The mitigation hatchery program will be confined to the area below Big Cliff dam.
S. Santiam Chinook	Very high risk	Continue to manage the proportion of hatchery fish outplanted with natural-origin fish above Foster Dam. Limit the hatchery proportion to 50% or less of the outplanted fish.	If natural-origin outplants above the dam continue to number greater than 500 fish, consider terminating all hatchery fish outplants so that this area can be used as a reference to evaluate the status of the natural-origin run above the dam and promote local adaptation. Need to be able to differentiate between NORs produced above and below Foster dam though.
Calapooia Chinook	Very high risk	Previous outplanting of adult chinook did not appear to be providing any benefit to the population because of high prespawn mortality rates. Habitat improvements are needed before the population is expected to recover.	Unknown at this time. If habitat improvements occur, a short-term hatchery supplementation may be bolster natural production. Otherwise, no hatchery program will likely exist in the Calapooia over the long term.
McKenzie Chinook	Moderate risk	Implement management actions to reduce the number of hatchery Chinook straying above Leaburg Dam.	Minimize hatchery effects above Leaburg Dam. Allow <5% of the run above Leaburg dam to be hatchery Chinook. Wild fish sanctuary area.
M.F. Willamette Chinook	Very high risk	Implement reintroduction program above Dexter/Lookout dams with hatchery and wild fish returns. Fix problems with high prespawn mortality due to handling, transportation.	Phase out hatchery fish outplants above Dexter/Lookout Point dams once natural-origin fish returns are sufficient to sustain the population and promote natural adaptation. The area above these dams will be managed for wild fish only once returns are sufficient and downstream passage is sufficiently fixed. The mitigation hatchery program will be confined to the area below Dexter dam.

Two important components in evaluating a hatchery program's effects on natural-origin populations are: 1) the proportion of hatchery fish spawning in the natural-origin; and 2) the proportion of natural-origin fish incorporated into the hatchery broodstock. Sampling by ODFW since 2002, the first year when all returning hatchery Chinook had been marked before release, provides estimates of these key proportions (McLaughlin et al. 2008). These data are summarized in tables in sections 5.2.5, 5.3.5, 5.5.5, and 5.6.5, for each of the four Chinook populations in the Middle Fork Willamette, McKenzie, South Santiam, and North Santiam subbasins, respectively. Other aspects of the hatchery program, such as residualism, competition, predation, and disease transfer are also important considerations. However, these aspects are nearly impossible to quantify on a site-specific basis, and effects are generally described qualitatively. Below is a summary of the two most important components of hatchery management in this ESU-managing hatchery fish on the spawning grounds and managing the hatchery broodstocks.

Hatchery Chinook on the Spawning Grounds

The Willamette/Lower Columbia (WLCTRT) and Interior Columbia TRT (ICTRT) have recommended very low levels of naturally spawning hatchery fish (i.e. <5% of the total) to ensure an ESU's natural viability. If hatchery fish comprise a substantial percentage of the natural spawners, the certainty that the population is truly self-sustaining is lowered. In addition, when evaluating recruits per spawner (productivity rates), large numbers of naturally spawning hatchery fish can substantially reduce the calculated productivity rates to <1 because hatchery fish are not naturally produced, indicating a non-viable population. The WLCTRT stated that viability targets/recovery goals must be greater if there are naturally spawning hatchery fish to account for the uncertainty in evaluating an ESU's true viability.

In the areas identified as "wild fish only" in Figure 5.1-1 above, the number of hatchery fish allowed to spawn naturally in the natural-origin fish production areas will be limited to the lowest extent possible in the near term. Over the long-term, there will have to be management solutions that will allow the percentage of naturally spawning hatchery fish to be controlled in order to evaluate the true status and viability of the natural population.

This is an issue for the "hatchery mitigation areas" (the area downstream of Willamette Project dams where some level of hatchery fish will always be present because the hatchery program was implemented to mitigate the effects of the dams) identified in Figure 5.1-1, above, since it may not be possible to strictly control the percentage of hatchery fish spawners below the dams. Additional management actions, such as additional harvest of hatchery fish, better homing to collection facilities, and/or production reductions, will probably be needed depending on the population. To illustrate this issue, take an example from the Middle Fork Willamette and North Santiam Rivers. In the Middle Fork Willamette, the long term hatchery mitigation area is identified in Figure 5.1-1, above, to be below Dexter Dam. This area is downstream of the "extreme range" of Chinook spawning identified by Mattson (1948). Thus, having the area below Dexter as a long-term hatchery mitigation area, which is comprised of mostly hatchery fish spawners, may not help the recovery prospects for this population (assuming reintroduction above the dam is successful). Information to date has shown little to no Chinook production below Dexter Dam even though there has been some spawning. Another example is in the North Santiam, where spawning of hatchery fish over the long term in the identified "hatchery mitigation area" is likely to be a significant issue. The principal spawning area for the historical population as identified by Mattson (1948) was the area one mile above Stayton to the mouth of the Breitenbush River. All of this area has been either blocked by dams and inundated by reservoirs or is directly downstream of the dams and negatively affected by Project operations. Having a high percentage of hatchery fish spawning in this historical principal spawning area may be a problem, especially if efforts to re-establish a portion of the population above the dams are not successful. Hatchery management changes would have to occur over the long term and/or the recovery targets will have to be higher to account for the uncertainty of knowing if the population is truly viable due to naturally spawning hatchery fish (WLCTRT and ODFW 2006). These two examples highlight that depending on the situation, even in the mitigation areas there may still be an adverse effect of allowing hatchery fish to spawn naturally over the long term.

Clackamas River

In the Clackamas River, trap and removal of hatchery fish at North Fork Dam has been somewhat successful over the past few years. PGE estimates less than 10% of the spring

Chinook upstream of North Fork Dam are hatchery fish. However, other information suggests that hatchery fish likely make up 10-30% of the run. PGE plans to upgrade the trapping facility at North Fork Dam as part of the FERC relicensing process so that all hatchery fish can be sorted and removed from the run with acceptable impacts to natural-origin fish. In the area downstream of North Fork Dam, the hatchery program will continue to operate so that mitigation responsibilities are fulfilled. In the recent past, some naturally spawning hatchery fish have been observed below the dam. However, this area was never the primary spring Chinook habitat in the basin. The low number of hatchery spawners should be of little consequence to the conservation and recovery of this population.

McKenzie River

In the McKenzie River, Leaburg Dam is the lower most facility on the river where hatchery fish can be removed. The goal at this dam has been to remove all hatchery fish passing Leaburg Dam so that the area upstream is for natural-origin fish only. However, in recent years, large numbers of hatchery and natural-origin fish have returned and removing large numbers of hatchery fish has not been feasible because of unacceptable impacts to the co-mingled natural-origin fish at the trap. In the next five years, the Action Agencies will need to take additional management actions to reduce the number of hatchery fish crossing Leaburg and/or improve the trapping facility to reduce impacts to natural-origin fish so that the area above Leaburg Dam will be for natural-origin Chinook only. This will reduce genetic risks from naturally spawning hatchery fish and allow evaluation of the true status of this natural-origin population without the masking effects of hatchery fish. Since the hatchery program will be confined to the areas below Leaburg Dam, any natural spawning of fish in this area will likely be predominately hatchery fish based on existing information. Significant numbers of hatchery fish have been observed spawning in this area since the time all returning hatchery fish have been marked. Further management actions to reduce and/or eliminate the number of hatchery spawners may be necessary to reduce hatchery masking effects. Increasing the harvest of hatchery fish in the lower McKenzie, improving fish homing fidelity back to the hatchery, and/or improved water flow attractants to the hatchery have been discussed among the co-managers (ODFW, USACE, BPA, EWEB, NMFS, USFWS) to address the issue of significant numbers of naturally-spawning hatchery fish in the McKenzie River. Reducing or eliminating the current production of McKenzie hatchery Chinook is also an option to be considered, as long as mitigation obligations can still be fulfilled.

Calapooia River

The Calapooia River is also identified as a wild fish only population in this conceptual vision (Figure 5.1-1). In the recent past, some hatchery adults have been outplanted to this river in hopes of providing more spawners. However, monitoring has shown very high prespawning mortality (and possibly poaching). Consequently, very few spawners have been observed. It is unlikely that hatchery fish outplants will provide much benefit to this population in the near term, while habitat restoration may be critical. Termination of hatchery outplants will allow natural recolonization to be monitored as habitat is recovered. Hatchery fish outplanting may be initiated again at a later time, if deemed appropriate.

North Santiam, South Santiam & Middle Fork Willamette Rivers

In the North Santiam, South Santiam, and Middle Fork Willamette where dams have eliminated most if not all of the historical spring Chinook habitat, the hatchery programs will be managed to help reintroduce runs above the dams. The current hatchery programs were initiated when the dams were built. The hatcheries are located at the base of the impassable dam and thus have likely incorporated fish from the historical run into the hatchery broodstocks. The hatchery programs in each of the populations are most likely the best remaining genetic resources of the historical runs above the dams that are still available. There have undoubtedly been some genetic and phenotypic changes with the hatchery stock; however the current hatchery stock is the only remnant of what might have historically existed in these populations.

Natural-origin fish returns in each of these populations have been dismal since 2000, when all returning hatchery fish have been marked and direct estimates of the number of naturally produced fish could finally be obtained. The poor returns of natural fish are attributed to poor production below the dams. It is also important to note the overall returns (predominately hatchery fish) to the Willamette River during these years were some of the largest observed in the last 20-30 years. The approach for using hatchery fish to re-establish runs above the dams in these three populations would be to outplant primarily adult Chinook salmon into the vacant habitats above the dams. Adequate numbers of hatchery fish that are surplus to broodstock needs are typically available every year to provide enough fish to seed habitat above the dams. Outplanting adult hatchery fish would likely have to continue for at least 10 years (two generations) given the problems that have been identified to date with trap and haul, prespawning mortality, and downstream passage. These hatchery fish can also be used for research purposes to monitor the downstream survival of fish through the reservoirs, turbines, and regulating outlets. Given the extremely low returns of natural-origin fish to these populations, it may not be prudent to use the few natural-origin fish returning as the research group to monitor and experiment with fish survival through the dams and reservoirs. Over time, as natural origin returns hopefully start to increase from these reintroduction efforts and return to the base of the dams, these natural origin fish will comprise most of the outplanted fish above the dams with the hatchery component becoming less and less. A successful reintroduction program above the dam would be when only natural-origin fish are outplanted above the dam with no hatchery fish supplementation. Further details on these reintroduction efforts using the hatchery programs are being discussed and formalized by the comanagers.

In order to evaluate the success or failure of this outplanting program, a well developed monitoring and evaluation program will need to be implemented to track hatchery supplementation and hatchery fish performance as it relates to population abundance, productivity, fitness, and survival. Currently, little to no information is available on the status of Chinook above the projects in these rivers. There are many agencies that have a stake in the outcome of this program that should help fund the comprehensive monitoring and evaluation program.

It is important to stress that the success of this hatchery outplanting program depends ultimately on whether additional actions will be taken to improve fish survival through Project dams and reservoirs and maintaining and improving spawning and rearing habitat in the river basins. The hatchery supplementation program alone will not accomplish the goal of a self-sustaining, naturally-produced population of spring Chinook without additional corrective actions in "Habitat" and "Hydro" limiting factors. If the habitat is bad and fish survival through the dams and reservoirs is poor, it would not matter how many hatchery fish are outplanted year after year above the projects.

Molalla River

The status of the spring Chinook run in the Molalla is similar to the Calapooia River. The overall numbers of redds observed in recent years has been low and most of the fish spawning are of hatchery origin. It is unknown at this time whether continued releases of an out of population hatchery stock is benefiting the conservation and recovery of this population, whether a new broodstock should be developed, or if hatchery fish releases should be discontinued altogether. Preliminary discussions have occurred among ODFW, NMFS, and non-governmental organizations to sort out these issues. It is clear that continuing the existing hatchery program will not improve the status of this population without significant habitat improvements in the Molalla Basin.

Management of Chinook Broodstocks

All of the current Chinook hatchery programs are part of the ESU. The HGMPs are proposing to manage Chinook broodstocks as an integrated stock, where natural-origin fish are purposefully incorporated into the broodstock on a regular basis. Since many of the hatchery programs will play an important role in re-establishing runs above the impassable dams back into historical habitat, it is crucial to have an integrated hatchery stock for supplementation purposes (HSRG 2004). Sliding scale broodstock matrices are described in the HGMPs and specify the desired percentage of natural-origin fish to be incorporated into hatchery broodstocks. For the populations where hatchery fish spawning in the wild will be managed to low levels (e.g. McKenzie above Leaburg Dam), natural-origin fish are being incorporated into the broodstock to minimize divergence between the hatchery and natural-origin stocks, and thus further reducing the effects of hatchery fish.

5.1.5.1.2 Summer Steelhead Hatchery Program

In the Willamette Basin, there is a mitigation obligation by the Action Agencies to fund hatchery production of steelhead to mitigate for the effects of the construction and operation of the Willamette Project on winter steelhead (USACE 2007a). In the past, ODFW operated a winter steelhead hatchery program. However, this program was discontinued in the late 1990s. ODFW choose to have the mitigation production be all hatchery summer steelhead.

The purpose of the summer steelhead hatchery program is solely harvest augmentation in recreational fisheries. There is no conservation value of this program for winter steelhead. Long term management of this program is focused on reducing the effects of these summer steelhead on winter steelhead in the North and South Santiam populations. Presently, the primary concern with this hatchery program is the natural spawning of stray summer steelhead in winter steelhead habitat (Schroeder et al. 2006). In the short term, reform actions are necessary to reduce the potential impacts of this program. Additional monitoring and evaluation tasks will be implemented to help identify the extent of natural spawning and if offspring are being produced. This information will help inform future management of this program.

5.1.5.1.3 Resident Rainbow Trout Hatchery Program

At present, the McKenzie River is the only area where hatchery trout are stocked for put-and-take fisheries in free flowing waters. Trout are stocked in nearly all of the reservoirs. The intent is to minimize stocking of trout in salmon and steelhead habitat.

5.1.5.2 General Effects of Hatchery Programs on Salmon & Steelhead

In the Willamette Basin, the Action Agencies are proposing to continue to artificially propagate spring Chinook salmon, summer steelhead, and resident rainbow trout. All of these programs can affect listed salmon and steelhead in the following ways. Below is a discussion of the general factors to be considered when evaluating the effects of hatchery programs on ESA listed salmon and steelhead. The population-specific effects of the hatchery programs are discussed in the appropriate subbasin below.

5.1.5.2.1 Hatchery Operations

Potential risks to listed natural salmonids associated with the operation of hatchery facilities include:

1. Hatchery facility failure (power or water loss leading to catastrophic fish losses).
2. Hatchery water intake impacts (stream de-watering and fish entrainment).
3. Hatchery effluent discharge impacts (deterioration of downstream water quality).

The actual impacts that hatchery facility operations can have on listed fish depend on the likelihood that the hatchery operation will interact with juvenile or adult fish, and whether the program is operated to minimize the risk of adverse impacts on listed fish.

Hatchery Facility Failure

This risk is of particular concern when facilities rear listed species, but must be addressed to ensure meeting program goals and objectives. Factors such as flow reductions, flooding and poor fish culture practices may all cause hatchery facility failure or the catastrophic loss of fish under propagation. The following measures are considered important in reducing the risk of catastrophic loss resulting from propagation facility failures:

- Minimizing the time adult fish are held in traps.
- Minimizing hatchery facility failure through on-site residence by hatchery personnel to allow rapid response to power or facility failures.
- Using low pressure/low water level alarms for water supplies to notify personnel of water emergencies.
- Installing back-up generators to respond to power loss.
- Training all hatchery personnel in standard fish propagation and fish health maintenance methods.

Hatchery Water Intake Impacts

Water withdrawals for those hatcheries within spawning and rearing areas can diminish stream flow, impeding migration and affecting the spawning behavior of listed fish. Water withdrawals may also affect other stream-dwelling organisms that serve as food for juvenile salmonids by reducing habitat, and through displacement and physical injury. Unscreened or inadequately screened hatchery intakes entrain aquatic biota, including fish. Entrainment means that the fish are likely to perish. Older hatchery intakes are often inadequately screened, and may present entrainment hazards. Fish may become impinged on the screens due to larger than current criterion screen openings, or velocities higher than the current criterion. While USACE Willamette Project hatcheries return most of their diverted water back to the stream, there is often significant flow reduction between diversion and water return. The risks associated with water withdrawals can generally be minimized by complying with water right permits and meeting NMFS' screening criteria (NMFS 2000c). These screening criteria for water withdrawal devices set forth conservative standards that help minimize the risk of harming naturally produced salmonids and other aquatic fauna. These risks can also be reduced through the use of well water sources for the operation of all or portion of the facility production.

Hatchery Effluent Discharge Impacts

Effluent discharges can change water temperature, pH, suspended solids, ammonia, organic nitrogen, total phosphorus, and chemical oxygen demand in the receiving stream's mixing zone (Kendra 1991). It is usually not known how a hatchery's effluent affects listed salmonids and other stream-dwelling organisms. The level of impact depends on the amount of discharge and the flow volume of the receiving stream. Any adverse impacts probably occur at the immediate point of discharge, because effluent dilutes rapidly. The Clean Water Act requires hatcheries (i.e. "aquatic animal production facilities") with annual production greater than 20,000 lbs to obtain a National Pollutant Discharge Elimination System (NPDES) permit in order to discharge hatchery effluent to surface waters. These permits are intended to protect aquatic life and public health and ensure that every facility treats its wastewater. The impacts from the releases are analyzed and the permits set site-specific discharge limits and monitoring and reporting requirements. Variations from permitted discharge levels are subject to enforcement actions (EPA 1999). In addition, hatcheries in the Columbia River Basin operate under the policies and guidelines developed by the Integrated Hatchery Operations Team (IHOT 1995) to reduce hatchery impacts on listed fish. Impacts on listed salmon and steelhead are minimized by requiring all hatchery effluents to meet the discharge limits in their respective NPDES permits and by meeting IHOT guidelines.

5.1.5.2.2 Broodstock Collection

Broodstock collection can affect listed salmonids through the method of collection and by the removal of adults from the spawning population.

Collection Method

There are a number of methods for collecting salmonid broodstock including taking spawners as they return to the hatchery and using a weir or a fish ladder-trap combination at a barrier such as a dam. These devices effectively block upstream migration and force returning adult fish to enter a trap-and-holding area. Trapped fish are counted and either retained for use in the hatchery or released to spawn naturally. The physical presence of a weir or trap can affect salmonids by:

- Delaying upstream migration;
- Causing the fish to reject the weir or fishway structure, thus inducing spawning downstream of the trap (displaced spawning);
- Contributing to fallback of fish that have passed above the weir; and
- Injuring or killing fish when they attempt to jump the barrier (Hevlin and Rainey 1993; Spence et al. 1996).
- Affecting the spatial distribution of juvenile salmon and steelhead seeking preferred habitats.

Impacts associated with operating a weir or trap include:

- Physically harming the fish during their capture and retention whether in the fish holding area within a weir or trap, or by the snagging, netting or seining methods used for certain programs;
- Harming fish by holding them for long durations;
- Physically harming fish during handling; and
- Increasing their susceptibility to displacement downstream and predation, during the recovery period.

The proper design and operation of the weirs and traps can reduce many of their potential negative impacts (see Hevlin and Rainey 1993). The installation and operation of weirs and traps are very dependent on water conditions at the trap site. High flows can delay the installation of a weir or make a trap inoperable. A weir or trap is usually operated in one of two modes. Continuously – where up to 100 percent of the run is collected and those fish not needed for broodstock are released upstream to spawn naturally, or periodically – where the weir is operated for a number of days each week to collect broodstock and otherwise left opened to provide fish unimpeded passage for the rest of the week. The mode of operation is established during the development of site-based broodstock collection protocols and can be adjusted based on in-season escapement estimates and environmental factors.

The potential impacts of weir rejection, fallback and injury from the operation of a weir or trap can be minimized by allowing unimpeded passage for a period each week. Trained hatchery personnel can reduce the impacts of weir or trap operation, by removing debris, preventing poaching and ensuring safe and proper facility operation. Delay and handling stress may also be reduced by holding fish for the shortest time possible, less than 24 hours and any fish not needed for broodstock should quickly be allowed to recover from handling and be immediately released upstream to spawn naturally. However, it may be necessary to hold fish longer at the beginning and the end of the trapping season when the adult numbers are low.

Beach seines, hook and line, gillnets and snorkeling are other methods used to collect adult broodstock for artificial production programs. All these methods can adversely affect listed fish through injury, delaying their migration, changing their holding and spawning behavior, and increasing their susceptibility to predation and poaching. Some artificial production programs collect juveniles for their source of broodstock. Programs can collect developing eggs or fry by hydraulically sampling redds or collected emerging juvenile fish by capping redds (Young and Marlowe 1995; Shaklee et al. 1995; WDFW et al. 1995; WDFW 1998). Seines, screw traps and hand nets can also be used to collect juveniles. Each of these methods can adversely affect listed fish through handling or harming the juvenile fish that remain.

Adult Removal

The removal of adults from a naturally-spawning population has the potential to reduce the size of the natural population (sometimes called “mining”), cause selection effects, and remove nutrients from upstream reaches (Spence et al. 1996; NRC 1996; Kapusinski 1997). In cases where listed salmonid populations are not even replacing themselves and a supplementation hatchery program can slow trends toward extinction and buy time until the factors limiting population viability are corrected, risks to the natural population, including numerical reduction and selection effects, are in some cases subordinate to the need to expeditiously implement the artificial production programs that will reduce the likelihood of extinction in the short term of the populations and potentially the ESU (i.e., Redfish Lake sockeye).

5.1.5.2.3 Genetic Introgression

A defining characteristic of anadromous salmonids is their high fidelity to their natal streams. Their ability to home with great accuracy and maintain high fidelity to natal streams has encouraged the development of locally adapted genetic characteristics that allow the fish to use specific habitats. The genetic risks that artificial propagation pose to naturally produced populations can be separated into reductions or changes in the genetic variability (diversity) among and within populations (Hard et al. 1992; Cuenco et al. 1993; NRC 1996; Waples 1996).

Loss of Diversity Among Populations

Genetic differences among salmon populations arise as a natural consequence of their homing tendency. Homing leads to a relatively high degree of demographic isolation among populations. This demographic isolation produces conditions where evolutionary forces such as natural selection and random genetic drift create differences in allele frequencies among populations. Many of these differences are believed to be adaptive – meaning that populations have been shaped by natural selection to have a particularly good fit to their local environment (see Taylor 1991 and McElhany et al. 2000 for reviews).

Hatchery activities can threaten the natural genetic diversity among salmon populations in several different ways. For example, many hatcheries have historically bred and released salmon that were not native to the drainage into which they were released. If these fish stray and breed with native salmon the unique genetic attributes of the local salmon populations can be degraded or lost. Genetic diversity can also be lost by hatchery practices that lead to excessive straying of hatchery fish, or by collecting mixtures of genetically discrete populations for use as hatchery broodstock.

Excessive gene flow into a natural population from naturally spawning hatchery fish can reduce the fitness of individual populations through a process called outbreeding depression. Outbreeding depression arises because natural salmonid populations adapt to the local environment and this adaptation is reflected in the frequency of specific alleles that improve survival in that environment. When excessive gene flow occurs, alleles that may have developed in a different environment are introduced and these new alleles may not benefit the survival of the receiving population leading to outbreeding depression.

Another source of outbreeding depression is the loss of combinations of alleles called coadapted complexes. Gene flow can introduce new alleles that can replace alleles in the coadaptive complexes leading to a reduction in performance (Busack and Currens 1995). Outbreeding depression from gene flow can occur when eggs and fish are transferred among populations and/or when out of basin hatchery populations are released to spawn with the local population.

There is evidence for local adaptation of salmonid populations (see Taylor 1991 and McElhany et al. 2000 for reviews), but the only empirical data on outbreeding depression in fish involves distantly related populations (Busack and Currens 1995). Pacific Northwest hatchery programs historically contributed to the loss of genetic diversity among populations through the routine transfer of eggs and fish from different hatchery populations. Such practices are no longer routine and in fact are being restricted through management policy (see Table 15). The release of hatchery fish into populations different from the introduced fish has also resulted in gene flow above natural levels (genetic introgression), reducing the genetic diversity among populations. Research based primarily on findings in the Kalama River, Washington, for summer-run steelhead has suggested that interbreeding between non-indigenous Skamania hatchery stock steelhead (a highly domesticated, hatchery stock) and native naturally produced fish may have negatively affected the genetic diversity and long term reproductive success of naturally produced steelhead (Leider et al. 1990; Hulett et al. 1996). Non-indigenous hatchery and native naturally produced steelhead crosses may be less effective at producing adult off-spring in the natural environment compared to naturally produced fish (Chilcote et al. 1986, Chilcote1998; Blouin 2004).

Campton (1995) examined the risks of genetic introgression to naturally produced fish and suggested the need to distinguish the biological effects of hatcheries and hatchery fish from the indirect and biologically independent effects of fisheries management actions. In his review of the scientific literature for steelhead, he suggested that many of the genetic effects detected to date appear to be caused by fisheries management practices such as stock transfers and mixed stock fisheries and not by biological factors intrinsic to hatchery fish (Campton 1995). However, loss of among population genetic diversity as a result of these types of hatchery practices has been documented for western trout, where unique populations have been lost through hybridization with introduced rainbow trout (Behnke 1992). Phelps et al. (1994) found evidence for introgression of non-native hatchery steelhead into a number of natural populations within the southwest Washington region. However, in other areas where hatchery production has been extensive, native steelhead genotypes have been shown to persist (Phelps et al. 1994; Narum et al. 2006).

The loss of genetic variability among populations can be minimized by:

- Propagating and releasing only fish from the local indigenous population or spawning aggregate.
- Avoiding or adequately reducing, gene-flow from a hatchery program into a natural population.
- Limiting the transfers of fish between different areas.
- Acclimate hatchery fish in the target watershed to ensure high fidelity to the targeted stream.
- Using returning spawners rather than the transferred donor population as broodstock for restoration programs to foster local adaptation.
- Maintaining natural populations that represent sufficient proportions of the existing total abundance and diversity of an ESU/DPS without hatchery intervention.
- Visually marking all hatchery-produced salmonids to allow for monitoring and evaluation of straying and contribution to natural production (Kapuscinski and Miller 1993; Flagg and Nash 1999).

A NMFS-sponsored workshop in 1995, focused on the biological consequences of hatchery fish straying into natural salmonid populations (Grant 1997). The workshop addressed how much gene flow can occur and still remain compatible with the long-term conservation of local adaptations and genetic diversity among populations. Based on selection effects in other animals, a gene flow rate of greater than 5 percent between local and non-local populations would quickly lead to replacement of neutral and locally-adapted genes (Grant 1997). NMFS notes that gene flow is expected to be much less than 5 percent when the stray rate of non-local fish into a local population is 5 percent because not all fish that stray will spawn successfully. Thus, NMFS supports the standard that hatchery stray rates should be managed such that less than 5 percent of the naturally spawning population consists of hatchery fish from a different area. Furthermore, the number of non-local strays in a particular population should be as low as possible to minimize genetic introgression.

This approach has been applied by the ICTRT and WLCTRT in their development of population viability criteria for the recovery of listed species (ICTRT 2007; WLCTRT and ODFW 2006). The ICTRT (2007) developed a flow-chart approach to assigning risk associated with exogenous spawners in the salmon population (they define exogenous spawners as all hatchery-origin and all natural-origin fish that are present due to unnatural, anthropogenically induced conditions (Figure 5.1-2). The WLCTRT developed similar metrics to describe risk to the diversity of listed populations, including one measuring the potential loss of fitness over time (Figure 3b and 3c in WLCTRT and ODFW 2006) that is based on the Proportion of Natural Influence (PNI). PNI is defined as the relationship between the percent of hatchery-origin fish spawning naturally and the percent of natural-origin fish in the hatchery broodstock (see HSRG 2004). Another metric for diversity looked at the influence of non-local origin fish strays, both within ESU and out-of-ESU, on diversity, but considered these strays only if there was evidence of interbreeding (WLCTRT and ODFW 2006).

As with the ICTRT, the WLCTRT combined these and other metrics together to develop a score for the diversity criteria, used to determine the overall viability of a population. The methods for weighing the different metrics within the criteria and developing a final combined score have not been finalized. It should also be noted that the failure in one of the metrics (e.g. loss of fitness over time) does not prevent the population from meeting the diversity criteria.

As described previously, NMFS has identified two general types of hatchery programs: isolated (or segregated) and integrated. The optimal proportion of hatchery fish spawning naturally depends on the type of program and the status of the natural spawning population. For isolated hatchery programs, the management goal is to minimize the number of naturally spawning hatchery fish and the number should not exceed 5 percent of the naturally spawning population (Mobrand et al. 2005). For supplementation programs, the level of hatchery spawners in the naturally spawning population should be based on the level of gene flow from the natural environment to the hatchery environment, i.e., the PNI goal for the program. The strength of that gene flow should be determined by the status of the natural-origin population and its importance to recovery.

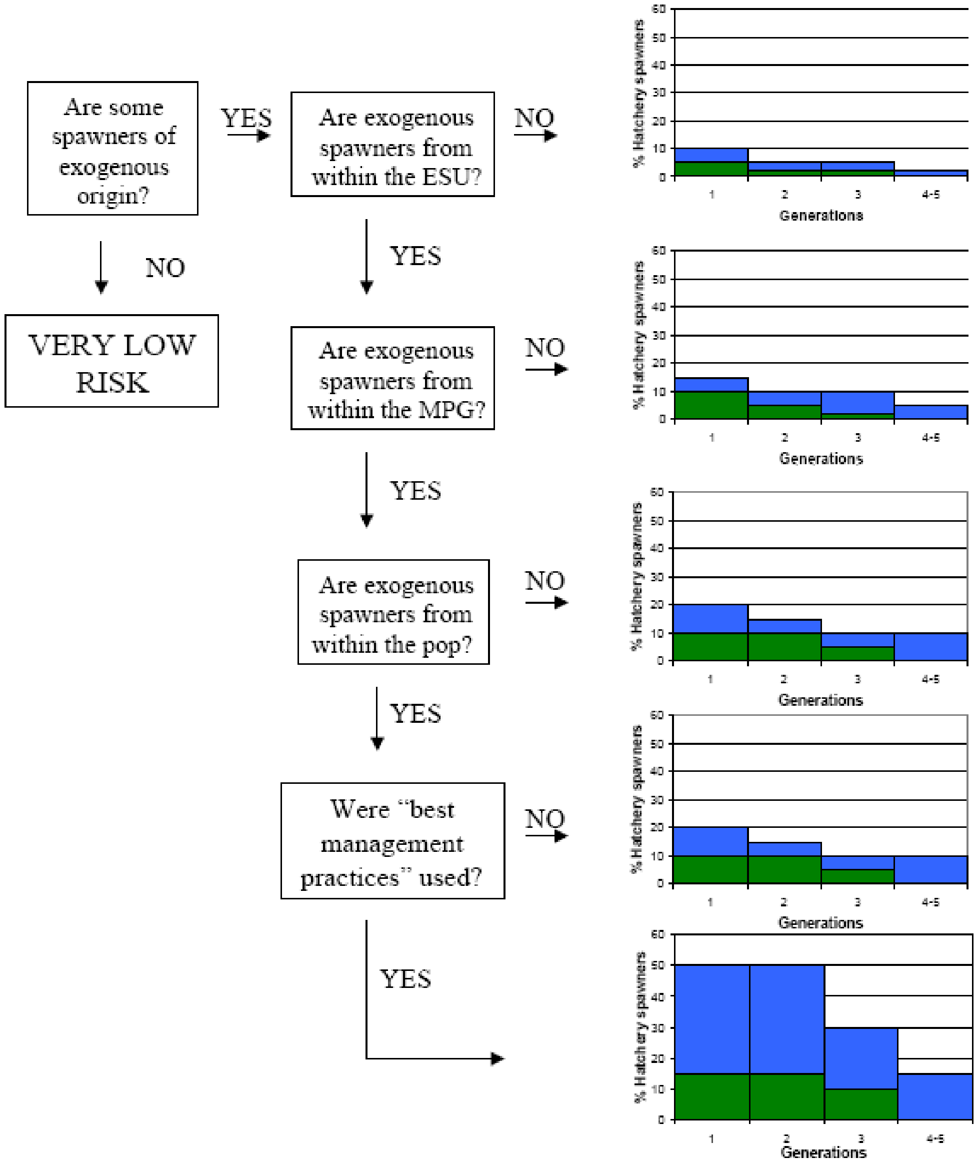

Figure 5.1-2 Graphical representation of risk criteria associated with spawner composition.

Green areas indicate low risk combinations of duration and proportion of spawners, blue areas indicate moderate risk areas and red-striped areas and areas outside the range graphed indicate high risk. Exogenous fish are considered to be all fish of hatchery origin, and non-normative strays of natural origin (ICTRT 2007).

Loss of Diversity Within Populations

Loss of within population genetic diversity due to artificial propagation is caused by:

- genetic drift,
- inbreeding depression, and/or
- domestication selection.

Loss of within population genetic diversity (variability) is defined as the reduction in quantity, variety and combinations of alleles in a population (Busack and Currens 1995). Quantity is defined as the proportion of an allele in the population and variety is the number of different kinds of alleles in the population.

Genetic Drift

Genetic diversity within a population can change from random genetic drift and from inbreeding. Random genetic drift occurs because the progeny of one generation represents a sample of the quantity and variety of alleles in the parent population. Since the next generation is not an exact copy of the parent generation, rare alleles can be lost, especially in small populations where a rare allele is less likely to be represented in the next generation (Busack and Currens 1995).

The process of genetic drift is governed by the *effective population size* rather than the observed number of breeders. The effective size of a population is defined as the size of an idealized population that would produce the same level of inbreeding or genetic drift seen in an observed population of interest (Hartl and Clark 1989). Attributes of such an idealized population typically include discrete generations, equal sex ratios, random mating and specific assumptions about the variance of family size. Real populations almost always violate one or more of these idealized attributes, and the effective size of a population is therefore almost always smaller than the observed census size. Small effective population size in hatchery programs can be caused by:

- Using a small number of adults for hatchery broodstock.
- Using more females than males (or males than females) for the hatchery broodstock.
- Pooling the gametes of many adults during spawning which would allow one male to potentially dominate during fertilization.
- Changing the age structure of the spawning population from what would have occurred naturally.
- Allowing progeny of some matings to have greater survival than allowed others (Gharrett and Shirley 1985; Simon et al. 1986; Busack and Currens 1995; Waples 1991; Campton 1995).

Some hatchery stocks have been found to have less genetic diversity and higher rates of genetic drift than some naturally produced populations, presumably as a result of a small effective number of breeders in the hatcheries (Waples et al. 1993). Potential, negative impacts of artificial propagation on within population diversity may be indicated by changes in morphology (Bugert et al. 1992) or behavior of salmonids (Berejikian 1996). Busack and Currens (1995) observed that it would be difficult to totally control random loss of within population genetic diversity in hatchery populations, but by controlling the broodstock number, sex ratios, and age structure, loss could be minimized. Theoretical work has demonstrated that hatcheries can reduce the effective size of a natural population in cases where a large number of hatchery strays are produced by a relatively small number of hatchery breeders (Ryman et al. 1995). This risk can be minimized by having hatcheries with large effective population sizes and by controlling the rate of straying of hatchery fish into naturally produced populations.

Inbreeding Depression

The breeding of related individuals (inbreeding) can change the genetic diversity within a population. Inbreeding *per se* does not lead directly to changes in the quantity and variety of alleles but can increase both individual and population homozygosity. This homozygosity can change the frequency of phenotypes in the population which are then acted upon by the environment. If the environment is selective towards specific phenotypes then the frequency of alleles in the population can change (Busack and Currens 1995). Increased homozygosity is also often expected to lead to a reduction in fitness called *inbreeding depression.* Inbreeding depression occurs primarily because nearly all individuals harbor large numbers of deleterious alleles whose effects are masked because they also carry a non-deleterious ‘wild type’ allele for the same gene. The increased homozygosity caused by inbreeding leads to a higher frequency of individuals homozygous for deleterious alleles, and thus a reduction in the mean fitness of the population (see Waldman and McKinnon 1993 for a review).

It is important to note that there is little empirical data on inbreeding depression or substantial loss of genetic variability in any natural or hatchery population of Pacific salmon or steelhead, although there are considerable data on the effects of inbreeding in rainbow trout (Myers et al. 1998). Studying inbreeding depression is particularly difficult in anadromous Pacific salmon because of their relatively long generation times, and the logistical complexities of rearing and keeping track of large numbers of families. Monitoring the rate of loss of molecular genetic variation in hatchery and naturally-produced populations is one alternative method for studying the impacts of hatcheries on genetic variability (Waples et al. 1993), but does not provide information on inbreeding depression or other fitness effects associated with changes in genetic variation. Many of these changes are also expected to occur over many generations, so long term monitoring is likely to be necessary to observe all but the most obvious changes.

The impacts of inbreeding between hatchery and natural stocks can be minimized following an isolated hatchery strategy by:

- Releasing fewer or no hatchery fish into the natural population.
- Releasing hatchery fish only at the hatchery or at locations where they are unlikely to interbreed with natural fish when returning as adults.
- Advancing or retarding the time of spawning for hatchery fish, to minimize the overlap in spawning time between hatchery and natural fish.
- Acclimating hatchery fish prior to release to improve homing precision.
- Acclimating and releasing hatchery fish at locations where returning adults can be harvested at high rates (harvest augmentation programs), locations away from natural production areas and sites where returning adults can be sorted and removed from the spawning population.

Domestication Selection

Domestication means changes in quantity, variety and combination of alleles between a hatchery population and its source population that are the result of selection in the hatchery environment (Busack and Currens 1995). Domestication is also defined as the selection for traits that favor survival in a hatchery environment and that reduce survival in natural environments (NMFS 1999d). Domestication can result from rearing fish in an artificial environment that imposes different selection pressures than what they would encounter in the wild. The concern is that domestication effects will decrease the performance of hatchery fish and their descendants in the wild. Busack and Currens (1995) identified three types of domestication selection (1) intentional or artificial selection, (2) biased sampling during some stage of culture, and (3) unintentional or relaxed selection.

(1) Intentional or artificial selection is the attempt to change the population to meet management needs, such as time of return or spawning time. Hatchery fish selected to perform well in a hatchery environment tend not to perform well when released into the wild, due to differences between the hatchery and the naturally produced populations resulting from the artificial propagation. Natural populations can be impacted when hatchery adults spawn with natural-origin fish and the performance of the natural population is reduced (a form of outbreeding depression) (Busack and Currens 1995).

(2) Biased sampling leading to domestication can be caused by errors during any stage of hatchery operation. Broodstock selection is a common source of biased sampling when adults are selected based on particular traits. Hatchery operations can be a source of biased sampling when groups of fish are selected against when feeding, ponding, sorting and during disease treatments because different groups of fish will respond differently to these activities.

(3) Genetic changes due to unintentional or relaxed selection occur because salmon in hatcheries usually have (by design) much higher survival rates than they would have in the wild. Hatchery fish are reared in a sheltered environment that increases their survival relative to similar life stages in the natural environment allowing deleterious genotypes that would have been lost in the natural environment to potentially contribute to the next generation.

Reisenbichler and Rubin (1999) cite five studies indicating that hatchery programs for steelhead and stream-type Chinook salmon (i.e., programs holding fish in the hatchery for one year or longer) genetically change the population and thereby reduce survival for natural rearing. The authors report that substantial genetic change in fitness can result from traditional artificial propagation of salmonids held in captivity for one quarter or more of their life. Bugert et al. (1992) documented morphological and behavioral changes in returning adult hatchery spring Chinook salmon relative to natural adults, including younger age, smaller size, and reduced fecundity. However, since that study, differences in size and age at return have been found to be more related to smolt size at release than domestication selection. Differences in fecundity are still observed, but not fully understood.

Leider et al. (1990) reported diminished survival and natural reproductive success for the progeny of non-native hatchery steelhead when compared to native naturally produced steelhead in the lower Columbia River region. The poorer survival observed for the naturally produced offspring of hatchery fish could have been due to the long term artificial and domestication selection in the hatchery steelhead population, as well as maladaptation of the non-indigenous hatchery stock in the recipient stream (Leider et al. 1990). Ongoing research on winter steelhead in the Hood River basin (Blouin 2004; Araki and Blouin 2005) compared the reproductive success of hatchery and natural-origin adults. The old program, that used out-of-basin broodstock, was determined to be 17 to 54 percent as reproductively successful as the natural-origin adults. The new program used natural-origin winter steelhead adults for broodstock, and their progeny were determined to be 85 to 108 percent as successful as natural-origin adults in producing adult returns to the basin. These results do not support the assumption of domestication selection in first generation of hatchery rearing for steelhead.

Chilcote (1998) reported a strong negative correlation between the proportion of naturally spawning hatchery steelhead and stock productivity, when examining spawner-recruit relationships for 26 Oregon steelhead populations. Based on the best scientific information, the NMFS FCRPS biological opinion assumed a relative reproductive success range of 20 percent to 80 percent for naturally spawning hatchery-origin fish compared to naturally produced fish (NMFS 2000b).

Berejikian (1996) reported that natural-origin steelhead fry survived predation by prickly sculpins (*Cottus asper*) to a statistically significant degree better than size-matched off-spring of locally-derived hatchery steelhead that were reared under similar conditions. Alteration of the innate predator avoidance ability through domestication was suggested by the results of this study. However, Joyce et al. (1998) reported that an Alaskan spring Chinook salmon stock under domestication for four generations did not significantly differ from offspring of naturally produced spawners in their ability to avoid predation. The domesticated and naturally produced Chinook salmon groups tested also showed similar growth and survival rates in freshwater performance trials.

- Domestication effects from artificial propagation and the level of genetic differences between hatchery and natural fish can be minimized by:
- Randomly selecting adults for broodstock from throughout the natural population migration to provide an unbiased sample of the natural population with respect to run timing, size, age, sex ratio, and other traits identified as important for long term fitness.
- Ensuring that returning adults used as broodstock by a hatchery continually incorporate natural-origin fish over the duration of the program to reduce the likelihood for divergence of the hatchery population from the natural population.
- Limiting the duration of a supplementation program to a maximum of three salmon generations (approximately 12 years) to minimize the likelihood of divergence between hatchery broodstocks and target natural stocks and to reduce the risk of domestication of the composite hatchery/natural stock.
- Employing appropriate spawning protocols to avoid problems with inbreeding, genetic drift and selective breeding in the hatchery (Simon et al. 1986; Allendorf and Ryman 1987; Gall 1993). Methods include collection of broodstock proportionally across the breadth of the natural return, randomizing matings with respect to size and phenotypic traits, application of at least 1:1 male to female mating schemes (Kapuscinski and Miller 1993), and avoidance of intentional selection for any life history or morphological trait.
- Using spawning protocols that equalize as much as possible the contributions of all parents to the next breeding generation.
- Using only natural fish for broodstock in the hatchery each year to reduce the level of domestication.

- Setting minimum broodstock collection objectives to allow for the spawning of the number of adults needed to minimize the loss of some alleles and the fixation of others (Kapuscinski and Miller 1993).
- Setting minimum escapements for natural spawners and maximum broodstock collection levels to allow for at least 50 percent of escaping fish to spawn naturally each year, to help maintain the genetic diversity of the donor natural population.
- Using hatchery methods that mimic the natural environment to the extent feasible (e.g. use of substrate during incubation, exposure to ambient river water temperature regimes and structure in the rearing ponds).
- Limiting the duration of rearing in the hatchery by releasing at early life-stages to minimize the level of intervention into the natural salmonid life cycle, minimizing the potential for domestication.

NMFS believes that the measures identified for minimizing the potential adverse genetic impacts of hatchery produced fish on naturally produced fish should be applied to protect listed species. The actual measures selected will depend on a number of factors including but not limited to:

- The objectives of the program (i.e. recovery, reintroduction or harvest augmentation).
- The source of the broodstock, its history and level of domestication.
- The spawning protocols proposed for the hatchery program.
- The status of the natural population targeted by the hatchery program.
- The ability of fish managers to remove or control the number of hatchery adults in the natural spawning population.
- The proposed rearing practices for the hatchery program.
- The total number of hatchery fish released into the subbasin.

More detailed discussions on the measures to implement these strategies can be found in Reisenbichler (1997), Reisenbichler and McIntyre (1986), Nelson and Soule (1987), Hindar et al. (1991), and Waples (1991) among others.

Genetic introgression is the primary concern regarding the proposed artificial propagation programs. Specific impacts and measures to minimize these impacts for all of the proposed programs will be discussed in Section 4.2 of this opinion.

5.1.5.2.4 Disease

Hatchery effluent has the potential to transport fish pathogens out of the hatchery, where natural fish may be exposed to infection. Interactions between hatchery fish and natural fish in the environment may also result in the transmission of pathogens, if either the hatchery or natural fish are harboring fish disease. This latter impact may occur in tributary areas where hatchery fish are released and throughout the migration corridor where hatchery and naturally produced fish may interact. As the pathogens responsible for fish diseases are present in both hatchery and natural populations, there is some uncertainty associated with determining the source of the pathogen (Williams and Amend 1976; Hastein and Lindstad 1991). Hatchery-origin fish may have an increased risk of carrying fish disease pathogens because of relatively high rearing densities that increase stress and can lead to greater manifestation and spread of disease within the hatchery population. Under natural, low density conditions, most pathogens do not lead to a disease outbreak. When fish disease outbreaks do occur, they are often triggered by stressful hatchery rearing conditions, or by a deleterious change in the environment (Saunders 1991). Consequently, it is possible that the release of hatchery fish may lead to the loss of natural fish, if the hatchery fish are carrying a pathogen not carried by the natural fish, if that pathogen is transferred to the natural fish, and if the transfer of the pathogen leads to a disease outbreak.

Recent studies suggest that the incidence of some pathogens in naturally spawning populations may be higher than in hatchery populations (Elliott and Pascho 1994). The incidence of high ELISA titers for *Renibacterium salmoninarum*, the causative agent of Bacterial Kidney Disease (BKD), appears, in general, to be more prevalent to a statistically significant degree among natural-origin smolts of spring/summer Chinook salmon than hatchery smolts (Congleton et al. 1995; Elliot et al. 1997). For example, 95 percent and 68 percent of natural-origin and hatchery smolts, respectively, at Lower Granite Dam in 1995 had detectable levels of *R. salmoninarum* (Congleton et al. 1995). Although pathogens may cause a high rate of post-release mortality among hatchery fish, there is little evidence that hatchery-origin fish routinely infect naturally produced salmon and steelhead in the Pacific Northwest (Enhancement Planning Team 1986; Steward and Bjornn 1990).

Many of the disease concerns related to hatchery fish are based on old management styles that emphasized the release of large numbers of fish regardless of their health status. Since that time, the desire to reduce disease has instigated better husbandry, including critical decreases in fish numbers to reduce crowding and stress that affects the resistance of salmonids to disease (Salonius and Iwama 1993; Schreck et al. 1993). Along with decreased densities and improved animal husbandry, advances in fish health care and adherence to federal and interagency fish health policies have considerably decreased the possibility of disease transmission from hatchery fish to natural-origin fish.

State and federal fisheries agencies have established Fish Pathology labs and personnel who monitor and manage fish health in state, federal and tribal hatcheries. The success of hatchery programs as reflected in the production of quality smolts that will survive and reproduce depend on good fish health management. Fisheries managers, to meet hatchery fish quality goals and to address concerns of potential disease transmission from hatchery salmonids to naturally produced fish, have established a number of fish health policies in the Pacific Northwest Region. These policies established guidelines to ensure that fish health is monitored, sanitation practices are applied, and that hatchery fish are reared and released in healthy condition (PNFHPC 1989; IHOT 1995; WDFW 1996; WDFW and WWTIT 1998; USFWS 1995; USFWS 2004). Standard fish health monitoring under these policies include monthly and pre-release checks of propagated salmonid populations by a fish health specialist, with intensified efforts to monitor presence of specific pathogens that are known to occur in the populations. Specific reactive and proactive strategies for disease control and prevention are also included in the fish health policies. Fish mortality at the hatchery due to unknown cause(s) will trigger sampling for histopathological study. Incidence of viral pathogens in a salmonid broodstock is determined by sampling fish at spawning. Populations of particular concern may be sampled at the 100 percent level and may require segregation of eggs/progeny in early incubation or rearing. In some programs, progeny of high titer adults are culled to minimize disease incidence within the hatchery populations. Compliance with NPDES permit provisions at hatcheries also acts to minimize the likelihood for disease epizootics and water quality impacts that may lead to increased naturally produced fish susceptibility to disease outbreaks. Full compliance with the regional fish health policies minimizes the risk for fish disease transfer.

5.1.5.2.5 Competition/Density-Dependent Effects

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Adverse impacts of competition may result from direct interactions, whereby a hatchery-origin fish interferes with the accessibility to limited resources by naturally produced fish, or through indirect means, as in when utilization of a limited resource by hatchery fish reduces the amount available for naturally produced fish (SIWG 1984). Specific hazards associated with adverse competitive impacts of hatchery salmonids on listed naturally produced salmonids may include food resource competition, competition for spawning sites, and redd superimposition. In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (SIWG 1984) categorized species combinations as to whether there is a high, low, or unknown risk that competition by hatchery fish will have a negative impact on productivity of naturally produced salmonids in freshwater areas (Table 5.1-2).

Table 5.1-2 Risk of hatchery salmonid species competition on naturally produced salmonid species in freshwater areas (SIWG 1984).

Hatchery Species	Naturally produced Species					
	Steelhead	Pink Salmon	Chum Salmon	Sockeye Salmon	Coho Salmon	Chinook Salmon
Steelhead	H	L	L	L	H	H
Pink Salmon	L	L	L	L	L	L
Chum Salmon	L	L	L	L	L	L
Sockeye Salmon	L	L	L	L	L	L
Coho Salmon	H	L	L	L	H	H
Chinook Salmon	H	L	L	L	H	H

Note: "H" = High risk; "L" = Low risk

Adult fish

It is apparent that salmonids have evolved a variety of strategies to partition available resources between species that are indigenous to a particular watershed. The addition of homing or straying adult hatchery-origin fish can perturb these mechanisms and impact the productivity of naturally produced stocks. For adult salmonids, impacts from hatchery/naturally produced fish competition in freshwater are assumed to be greatest in the spawning areas where competition for redd sites and redd superimposition may be concerns (USFWS 1994). Adult salmonids originating from hatcheries can also compete with naturally produced fish of the same species for mates, leading to an increased potential for outbreeding depression. Hatchery-origin adult salmonids may home to, or stray into, natural production areas during naturally produced fish spawning or egg incubation periods, posing an elevated competitive and behavioral modification risk. Returning or straying hatchery fish may compete for spawning gravel, displace naturally produced spawners from preferred, advantageous spawning areas, or adversely affect listed salmonid survival through redd superimposition. Superimposition of redds by similar-timed or later spawners, disturbs or removes previously deposited eggs from the gravel, and has been identified as an important source of natural salmon mortality in some areas (Bakkala 1970).

Recent studies suggest that hatchery-origin fish may be less effective in competing for spawning sites than naturally produced fish of the same species, possibly indicating the effects of domestication selection in the hatchery environment (Fleming and Gross 1993; Berejikian et al. 1997). These studies were based on comparisons of natural-origin salmonid adults and captive-brood origin hatchery fish. Hatchery-origin salmonid adults returning to spawn after a period of rearing in the wild may exhibit different competitive effectiveness levels.

The risk of straying by hatchery-produced species may be minimized through acclimation of the fish to their stream of origin, or desired stream of return. Acclimation of hatchery steelhead prior to release, however, does not reduce staying when compared to hatchery steelhead that are directly released into the target stream (Kenaston et al. 2001). Homing fidelity may be improved through the use of locally adapted stocks, and by rearing of the fish for an extended duration (e.g., eyed egg to smolt) in the “home” stream prior to release or transfer to a marine area net-pen site for further rearing.

The risk of redd superimposition can be minimized through high removal rates of the hatchery-origin fish, and by propagation and release of only indigenous species and stocks. Indigenous-origin hatchery adults that are not removed upon return may be assumed to still carry traits that foster temporal and spatial resource partitioning with natural-origin-spawning fish populations (see SIWG 1984). The risk of redd disturbance may therefore be minimal with escapement of indigenous-origin hatchery fish, if the home stream has the physical characteristics (e.g., stream flow, usable channel width) that will allow such partitioning at the time of spawning.

Juvenile Fish

For salmonids rearing in freshwater, food and space are the resources in demand, and thus are the focus of inter- and intra-specific competition (SIWG 1984). Newly released hatchery smolts may compete with naturally produced fish for food and space in areas where they interact during downstream migration. Naturally produced fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, of equal or greater size, and (if hatchery fish are released as non-migrants) the hatchery fish have taken up residency before naturally produced fry emerge from redds. Release of large numbers of hatchery pre-smolts in a small area is believed to have greater potential for competitive impacts because of the extended period of interaction between hatchery fish and natural fish. In particular, hatchery programs directed at fry and non-migrant fingerling releases will produce fish that compete for food and space with naturally produced salmonids for longer durations, if the hatchery fish are planted within, or disperse into, areas where naturally produced fish are present. A negative change in growth and condition of naturally produced fish through a change in their diet or feeding habits could occur following the release of hatchery salmonids. Any competitive impacts likely diminish as hatchery-produced fish disperse, but resource competition may continue to occur at some unknown, but lower level as natural-origin juvenile salmon and any commingled hatchery juveniles emigrate seaward.

Hatchery-origin smolts and sub-adults can also compete with naturally produced fish in estuarine and marine areas, leading to negative impacts on naturally produced fish in areas where preferred food is limiting. Steward and Bjornn (1990) concluded that hatchery fish kept in the hatchery for extended periods before release as smolts (e.g., yearling salmon) may have different food and habitat preferences than naturally produced fish, and that hatchery fish will be unlikely to out-compete naturally produced fish. Interactions with juvenile hatchery-origin salmonids may lead to behavioral changes in listed natural salmonids that are detrimental to productivity and survival.

Hatchery fish might alter naturally produced salmon behavioral patterns and habitat use, making them more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter naturally produced salmonid migratory responses or movement patterns, leading to a decrease in foraging success (Steward and Bjornn 1990; Hillman and Mullan 1989). In a review of the potential adverse impacts of hatchery releases on naturally produced salmonids, Steward and Bjornn (1990) indicated that it was indeterminate from the literature whether naturally produced parr face statistically significant risk of displacement by introduced hatchery fish, as a wide range of outcomes from hatchery-naturally produced fish interactions has been reported. The potential for negative impacts on the behavior, and hence survival, of naturally produced fish as a result of hatchery fish releases depends on the degree of spatial and temporal overlap in occurrence of hatchery and naturally produced fish. The relative size of affected naturally produced fish when compared to hatchery fish, as well as the abundance of hatchery fish encountered, also will determine the degree to which naturally produced fish are displaced (Steward and Bjornn 1990). Actual impacts on naturally produced fish would thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

En masse hatchery salmon smolt releases may cause displacement of rearing naturally produced juvenile salmonids from occupied stream areas, leading to abandonment of advantageous feeding stations, or premature out-migration (Pearsons et al. 1994). Pearsons et al. (1994) reported displacement of juvenile naturally produced rainbow trout from discrete sections of streams by hatchery steelhead released into an upper Yakima River tributary, but no large scale displacements of trout were detected. Small scale displacements and agonistic interactions that were observed between hatchery steelhead and naturally produced trout resulted from the larger size of hatchery steelhead, which behaviorally dominated most contests. They noted that these behavioral interactions between hatchery-reared steelhead did not appear to have impacted the trout populations examined to a statistically significant degree, however, and that the population abundance of naturally produced salmonids did not appear to have been negatively affected by releases of hatchery steelhead.

Competition between hatchery and naturally produced salmonids in freshwater may only be at high risk for coho, Chinook salmon, steelhead, and sockeye, since pink and chum salmon do not rear for extended periods in freshwater (SIWG 1984). Studies indicate that hatchery coho salmon have the potential to adversely impact certain naturally produced salmonid species through competition. Information suggests that juvenile coho salmon are behaviorally dominant in agonistic encounters with juveniles of other stream-rearing salmonid species, including Chinook salmon, steelhead, and cutthroat trout (*O. clarki*), and with natural-origin coho salmon (Stein et al. 1972; Allee 1974; Swain and Riddell 1990; Taylor 1991). Dominant salmonids tend to capture the most energetically profitable stream positions (Fausch 1984; Metcalfe et al. 1986), providing them with a potential survival advantage over subordinate fish. However, where interspecific populations have evolved sympatrically, Chinook salmon and steelhead have evolved slight differences in habitat use patterns that minimize their interactions with coho salmon (Nilsson 1967; Lister and Genoe 1970; Taylor 1991). Along with the habitat differences exhibited by coho salmon and steelhead, they also show differences in foraging behavior. Peterson (1966) and Johnston (1967) reported that juvenile coho salmon are surface oriented and feed primarily on drifting and flying insects, while steelhead are bottom oriented and feed largely on benthic insects.

There is a hypothesis that large numbers of hatchery-produced smolts released into the Columbia River (including the Willamette) have adverse effects on naturally produced smolts in the migration corridor and ocean. High numbers of hatchery fish released throughout the Columbia Basin would have effects on listed Willamette fish when interacting in the lower Columbia, estuary, and ocean. This hypothesis assumes that there is a limitation on the capacity of the migration corridor and ocean and that there are adverse interactions between hatchery-produced and naturally produced smolts.

Interactions between hatchery juveniles and naturally produced fish in the migration corridor have been reduced by decreases in the number of hatchery fish released by Columbia River basin hatchery programs and by the mortality of hatchery fish after release. A production ceiling for all artificial propagation programs in the Columbia River basin was described in the Proposed Recovery Plan (NMFS 1995a) and in the 1999 artificial propagation Biological Opinion (NMFS 1999e). This production ceiling was approximately 197.4 million anadromous fish. Although releases occur throughout the year, approximately 80 percent occur from April through June. A significant portion of these releases do not survive to the Snake and Columbia River migration corridors. For example, the historical passage index of hatchery fish released into the Snake River Basin surviving to Lower Granite Dam shows a ratio of 0.23 for spring/summer Chinook salmon and 0.60 for steelhead; for hatchery releases in the Columbia River above McNary Dam the ratio is 0.185 for spring/summer Chinook salmon, 0.477 for sub-yearling Chinook salmon, 0.093 for steelhead, and 0.215 for coho salmon (FPC 1992). While the actual number of hatchery fish entering the Columbia River migration corridor is unknown, it is substantially less than the numbers released.

The speed of travel of upriver smolts also serves to reduce interaction and competition in the mainstem of the Columbia and the estuary. Bell (1991) gives rates of 13 miles/day (21 km/day) low flows and 23 miles/day (38 km/d) in moderate flows, as a general average for downstream migrants. Dawley et al. (1986) found rates of 1 to over 59 km/day in the estuary, depending on size, species and distance traveled, with the faster rates correlated with larger smolts from further upriver. In the free-flowing reaches of the Snake, Clearwater and Salmon, currents in excess of 10 km/hr are common during the spring freshet. Smolts could move in excess of 100 km/d just by holding in the thalweg, but the literature would indicate 40 to 50 km/day is a more likely average in moderate to high flows.

As occurs in rearing areas, habitat partitioning in the migration corridor among the species has evolved to reduce interspecific competition. Bell (1991) and Dawley et al. (1986) comment on differential habitat selection with steelhead choosing the thalweg and nearer to the surface, subyearling Chinook salmon being more likely to follow the shorelines and yearling Chinook salmon seeking greater depths.

Historically the bulk of the Columbia River adult returns were spring and summer Chinook salmon, coho salmon, sockeye salmon, and steelhead. Chapman (1986) calculated only 1.25 million adult fall Chinook salmon historically returned to the Columbia River in his high estimate, so over 80 percent of the smolts would have been spring migrating yearlings. Therefore, 160 to 320 million spring migrating yearling smolts (based on historical returns of approximately 10 million salmon and steelhead) would have passed through the estuary and entered the ocean in May and June each year, compared to less than 40 million under current conditions. In the past, when hatchery production in the basin reached nearly 200 million fish, over half of the production was fall Chinook salmon that produce sub-yearling, summer-migrating smolts, thus limiting potential to exceed the capacity of the migration corridor.

Habitat partitioning and speed of travel should function to reduce predation, competition and interspecies interactions. The reduced number of smolts in the corridor should also decrease the potential for detrimental interactions. However, the behavior of fish in the hydropower reservoirs and bottlenecks in collection and transportation systems may increase opportunities for interaction. Smolts may be disoriented by slack water and may be concentrated as the fish traveling 50 km/d in free-flowing rivers catch up to the fish traveling 10 km/d in the reservoirs. Smolts have been observed to concentrate in front of dams before they enter the collection system. In the collection and transportation system any habitat partitioning is eliminated, densities are increased and both inter- and intra-specific interactions are forced.

Considerable speculation, but little scientific information, is available concerning the overall impacts on listed salmon and steelhead from the combined number of hatchery fish in the Columbia River migration corridor. In a review of the literature, Steward and Bjornn (1990) indicated that some biologists consider density-dependent mortality during freshwater migration to be negligible; however, they also cited a steelhead study that indicated there may have been a density-dependent effect (Steward and Bjornn 1990). Hatchery and natural populations have similar ecological requirements and can potentially be competitors where critical resources are in short supply (Lower Granite Migration Study Steering Committee (LGMSC 1993).

The limited information available concerning impacts from changes in the historical carrying capacity to listed salmon is insufficient to determine definitive effects. It is for this reason that NMFS has called for a limitation of hatchery releases in the Columbia Basin. The effects of hatchery production on listed salmon and steelhead in the ocean would be speculative, since hatchery fish intermingle at the point of ocean entry with natural-origin and hatchery anadromous salmonids from many other regions. Witty et al. (1995) assessing the effects of Columbia River hatchery salmonid production on natural-origin fish stated:

> "We have surmised the ocean fish rearing conditions are dynamic. Years of limited food supply affect size of fish, and reduced size makes juveniles more subject to predation. Mass enhancement of fish populations through fish culture could cause density-dependant affects during years of low ocean productivity. However, we know of no studies which demonstrate, or even suggest, the magnitude of changes in numbers of smolts emigrating from the Columbia River Basin which might be associated with some level of change in survival rate of juveniles in the ocean. We can only assume that an increase in smolts might decrease ocean survival rate and a decrease might improve ocean survival rate."

However, the assumptions made by Witty et al. (1995) would apply only if the ocean were near carrying capacity. The current production from the Columbia River is lower than the number carried by the migration corridor and ocean in the fairly recent past.

The species of primary concern in the Columbia Basin are Chinook salmon, sockeye salmon and steelhead. There is no evidence in the literature to support the speculation that there is some compensatory mortality of Chinook salmon and steelhead in the ocean environment. There is evidence of density-dependent compensatory ocean survival in the cases of massive pink and chum salmon hatchery programs in Alaska, Russia and Japan (Pearcy 1992). There are currently two small chum salmon hatchery programs in the Lower Columbia River, the WDFW's Grays River program (including Chinook salmon River releases) and the Duncan Creek program below Bonneville Dam. These produce chum salmon at a level that is only a fraction of a percent of the numbers seen in Alaska, Russia and Japan. Pink salmon are functionally extinct in the Columbia River.

SIWG (1984) acknowledged that the risk of adverse competitive interactions in marine waters is difficult to assess, because of a lack of data collected at times when hatchery fish and naturally produced fish likely interact, and because competition depends on a variety of specific circumstances associated with hatchery-naturally produced fish interaction, including location, fish size, and food availability. In marine waters, the main limiting resource for naturally produced fish that could be affected through competition posed by hatchery-origin fish is food. The early marine life stage, when naturally produced fish have recently entered the estuary and populations are concentrated in a relatively small area, may create short term instances where food is in short supply, and growth and survival declines as a result (SIWG 1984). This period is viewed as of special concern regarding food resource competition posed by hatchery-origin chum salmon and pink salmon to naturally produced chum salmon and pink salmon populations (Cooney et al. 1978; Simenstad et al. 1980; Bax 1983). The degree to which food is limiting after the early marine portion of a naturally produced fish's life depends upon the density of prey species. This does not discount limitations posed on naturally produced fish in more seaward areas as a result of competition by hatchery-origin fish, as data are available that suggests that marine survival rates for salmon are density dependent, and thus possibly a reflection of the amount of food available (SIWG 1984).

The risk of adverse competitive interactions can be minimized by:

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile naturally produced fish in freshwater (Steward and Bjornn 1990).
- Operating hatcheries such that hatchery fish are reared to sufficient size that smoltification occurs within nearly the entire population (Bugert et al. 1992).
- Rearing juvenile hatchery fish on parent river water, or acclimating them for several weeks to parent river water, will contribute to the smoltification process and reduced retention time in the streams.
- Releasing hatchery smolts after the major seaward emigration period for naturally produced salmonid populations to minimize the risk of interaction that may led to competition.
- Releasing hatchery smolts in lower river areas, below upstream areas used for stream-rearing young-of-the-year naturally produced salmonid fry.

5.1.5.2.6 Predation

Risks to naturally produced salmonids attributable to direct predation (direct consumption) or indirect predation (increases in predation by other predator species due to enhanced attraction) can result from hatchery salmonid releases in freshwater and estuarine areas. Hatchery-origin fish may prey upon juvenile naturally produced salmonids at several stages of their life history. Newly released hatchery smolts have the potential to prey on naturally produced fry and fingerlings that are encountered in freshwater during downstream migration, or if the hatchery fish residualize prior to migrating. Hatchery-origin smolts, sub-adults, and adults may also prey on naturally produced fish of susceptible sizes and life stages (smolt through sub-adult) in estuarine and marine areas where they commingle. Hatchery salmonids planted as non-migrant fry or fingerlings, and progeny of naturally spawning hatchery fish also have the potential to prey upon natural-origin salmonids in freshwater and marine areas where they co-occur. In general, naturally produced salmonid populations will be most vulnerable to predation when naturally produced populations are depressed and predator abundance is high, in small streams, where migration distances are long, and when environmental conditions favor high visibility. SIWG (1984) categorized species combinations as to whether there is a high, low, or unknown risk that direct predation by hatchery fish will have a negative impact on productivity of naturally produced salmonids (Table 5.2-3).

SIWG (1984) rated most risks associated with predation as unknown, because, although there is a high potential that hatchery and naturally produced species interact, due to a high probability of spatial and temporal overlap, there was relatively little literature documentation of predation interactions in either freshwater or marine areas. Predation may be greatest when large numbers of hatchery smolts encounter newly emerged fry or fingerlings, or when hatchery fish are large relative to naturally produced fish (SIWG 1984). Some reports suggest that hatchery fish can prey on fish that are ½ their length (HSRG 2004; Pearsons and Fritts 1999), but other studies have concluded that salmonid predators prefer smaller fish and are generally thought to prey on fish 1/3 or less their length (Horner 1978; Hillman and Mullan 1989; Beauchamp 1990; Cannamela 1992; CBFWA 1996). Hatchery fish may also be less efficient predators as compared to their natural-origin co-specifics reducing the potential for predation impacts (Sosiak et al. 1979; Bachman 1984; Olla et al. 1998).

Table 5.2-3 Risk of hatchery salmonid species predation on naturally produced salmonid species in freshwater areas (SIWG 1984).

Hatchery Species	Naturally produced Species					
	Steelhead	Pink Salmon	Chum Salmon	Sockeye Salmon	Coho Salmon	Chinook Salmon
Steelhead	U	H	H	H	U	U
Pink Salmon	L	L	L	L	L	L
Chum salmon	L	L	L	L	L	L
Sockeye Salmon	L	L	L	L	L	L
Coho Salmon	U	H	H	H	U	U
Chinook Salmon	U	H	H	H	U	U

Note: "H" = High risk; "L" = Low risk; and "U" = Unknown risk of a significant impact occurring.

Due to their location, size, and time of emergence, newly emerged salmonid fry are likely to be the most vulnerable to predation by hatchery released fish. Their vulnerability is believed to be greatest as they emerge and decreases somewhat as they move into shallow, shoreline areas (USFWS 1994). Emigration out of hatchery release areas and foraging inefficiency of newly released hatchery smolts may minimize the degree of predation on salmonid fry (USFWS 1994).

Although considered as of "unknown" risk by SIWG (1984), data from hatchery salmonid migration studies on the Lewis River, Washington, Hawkins and Tipping (1998) provide evidence of hatchery coho salmon yearling predation on salmonid fry in freshwater. The WDFW Lewis River study indicated low levels of hatchery steelhead smolt predation on salmonids. In a total sample of 153 out-migrating hatchery-origin steelhead smolts captured through seining in the Lewis River between April and June 24, 12 fish (7.8 percent) were observed to have consumed juvenile salmonids (Hawkins and Tipping 1998). The juvenile salmonids contained in the steelhead stomachs appeared to be Chinook salmon fry. Sampling through this study indicated that no emergent natural-origin steelhead or trout fry (30-33 mm fl) were present during the first two months of sampling. Hawkins (1998) documented hatchery spring Chinook salmon yearling predation on naturally produced fall Chinook salmon juveniles in the Lewis River. A small number (11) of spring Chinook salmon smolts were sampled and remains of 10 salmonids were found (includes multiple observations of remains from some smolts). Predation on smaller Chinook salmon was found to be much higher in naturally produced smolts (coho salmon and cutthroat predominately) than their hatchery counterparts. Steward and Bjornn (1990) referenced a report from California that estimated, through indirect calculations, rather than actual field sampling methods, the potential for substantial predation impacts by hatchery yearling Chinook salmon on naturally produced Chinook salmon and steelhead fry. They also reference a study in British Columbia that reported no evidence of predation by hatchery Chinook salmon smolts on emigrating naturally produced Chinook salmon fry in the Nicola River. In addition, young coho salmon in some British Columbia streams averaged two to four chum salmon fry per stomach sampled (Bakkala 1970).

Predation by hatchery fish on natural-origin smolts or sub-adults is less likely to occur than predation on fry. Coho salmon and Chinook salmon, after entering the marine environment, generally prey upon fish one-half their length or less and consume, on average, fish prey that is less than one-fifth of their length (Brodeur 1991). During early marine life, predation on naturally produced Chinook salmon, coho, and steelhead will likely be highest in situations where large, yearling-sized hatchery fish encounter sub-yearling fish or fry (SIWG 1984). Juanes (1994), in a survey of studies examining prey size selection of piscivorus fishes, showed a consistent pattern of selection for small-sized prey. Hargreaves and LeBrasseur (1986) reported that coho salmon smolts ranging in size from 100-120 mm fl selected for smaller chum salmon fry (sizes selected 43-52 mm fl) from an available chum salmon fry population including larger fish (available size range 43-63 mm fl). Ruggerone (1989, 1992) also found that coho salmon smolts (size range 70-150 mm fl) selected for the smallest sockeye fry (28-34 mm fl) within an available prey population that included larger fish (28-44 mm fl). However, extensive stomach content analyses of coho salmon smolts collected through several studies in marine waters of Puget Sound, Washington, do not substantiate any indication of significant predation upon juvenile salmonids (Simenstad and Kinney 1978). Similarly, Hood Canal, Nisqually Reach, and north Puget Sound data show little or no evidence of predation on juvenile salmonids by juvenile and immature Chinook salmon (Simenstad and Kinney 1978). In a recent literature review of Chinook salmon food habits and feeding ecology in Pacific Northwest marine waters, Buckley (1999) concluded that cannibalism and intra-generic predation by Chinook salmon are rare events. Likely reasons for apparent low predation rates on salmon juveniles, including Chinook salmon, by larger Chinook salmon and other marine predators suggested by Cardwell and Fresh (1979) include:

- The rapid growth in fry, resulting in the increased ability to elude predators and becoming accessible to a smaller proportion of predators due to size alone.
- The rapid dispersal of fry, making them present in lower densities relative to other fish and invertebrate prey.
- The learning or selection for some predator avoidance.

Large concentrations of migrating hatchery fish may attract predators (birds, fish, and seals) and consequently contribute indirectly to predation of emigrating naturally produced fish (Steward and Bjornn 1990). The presence of large numbers of hatchery fish may also alter naturally produced salmonid behavioral patterns, potentially influencing their vulnerability and susceptibility to predation (Hillman and Mullan 1989; USFWS 1994). Hatchery fish released into naturally produced fish production areas, or into migration areas during naturally produced fish emigration periods, may therefore pose an elevated, indirect predation risk to commingled listed fish. Alternatively, a mass of hatchery fish migrating through an area may overwhelm established predator populations, providing a beneficial, protective effect to co-occurring listed naturally produced fish.

Hatchery impacts from predation can be minimized by:

- Releasing actively migrating smolts through volitional release practices.
- Insuring that a high proportion of the population has smolted prior to release using minimum coefficient of variation population size limits. Smolts tend to migrate seaward rapidly when fully smolted, limiting the duration of interaction between hatchery fish and naturally produced fish present within, and downstream of, release areas.
- Delaying hatchery fish releases until the major seaward emigration period for naturally produced salmonid populations has been completed can minimize the risk of interaction that may led to predation.
- Releasing hatchery smolts in lower river areas, below upstream areas used for stream-rearing young-of-the-year naturally produced salmon fry, reducing the likelihood for interaction between the hatchery and naturally produced fish.
- Operating hatchery programs and releases to minimize the potential for residualism (see discussion below).

5.1.5.2.7 Residualism

Artificially propagated smolts are released into rivers and streams with the anticipation that they will migrate to the ocean. In many cases, some portion of the hatchery-produced juveniles will "residualize," or become residents of the receiving water for an extended period of a year or more. The general effects of hatchery-produced fish on natural fish, as described by Steward and Bjornn (1990) may be exacerbated if a substantial portion of the hatchery-produced juvenile salmonids residualize.

As discussed in sections 4.1.5 and 4.1.6, above, particular concern has been identified when hatchery steelhead, released into spawning and nursery areas, fail to migrate (residualize), and potentially prey upon or compete with listed salmon and steelhead juveniles. Steelhead residualism has been found to vary greatly, but is thought to typically average between 5 percent and 10 percent of the number of fish released (USFWS 1994). Releasing hatchery steelhead smolts that are prepared to migrate and timing the release to occur during high flow conditions may minimize impacts on listed fish from hatchery steelhead programs.

Coho salmon, in most situations, do not have the same potential to residualize as steelhead, but approximately 6 percent of the coho salmon planted as parr residualized in the receiving stream in the Clearwater River drainage for a year after release (Johnson and Sprague 1996). Coho salmon parr stocked in 1995, were observed two years after release in snorkel surveys and screw traps (BIA 1998) and about 2,000 age two coho salmon smolts were counted at Snake River mainstem dams (BIA 1998). So far there does not appear to be any residualism of coho salmon smolts released into the Yakima and Methow Rivers.

Ocean-type Chinook salmon, like the fall Chinook salmon of the Snake River and mid-Columbia generally begin migration towards salt water soon after emergence, however some may spend up to one year before undertaking the smolt migration (Healey 1991). In the Snake River, Connor et al. (1992) report a small percentage of hatchery-produced fall Chinook salmon smolts spend more than a year as residents in the Snake River before smolting. Although most stream-type Chinook salmon juveniles become smolts in the spring one year after emergence, some may spend a second year in fresh water, particularly slower- growing individuals. This effect may be related to cooler water temperatures in more northern or higher elevation waters (Healey 1991).

The variability in life history exhibited by naturally produced anadromous salmonids probably has some adaptive and survival advantages. By allowing slow-growing fish extra time in freshwater this strategy may ensure smolts that are large enough to improve migration survival. That not all spawners are the same age allows transfer of genetic material between brood years of a population and protects against loss of an entire spawning year to a single natural catastrophe. Adaptability to cooler water or less productive water by extending freshwater residency may allow anadromous fish to occupy a greater variety of habitats. The current conventional wisdom on hatchery management would support the standardization of life history and the rearing protocols which produce smolts on a single, uniform, schedule, but this practice may be intentionally selecting away from the genetic heritage of the fish. For supplementation hatchery programs, and as artificial propagation practices include more natural rearing environments, hatchery managers may have to accommodate variable life histories in their production protocols.

In the case of artificial propagation programs for unlisted steelhead, particularly the programs that rear composite, domesticated and out-of-basin stocks, hatchery managers should continue to develop rearing and release protocols that reduce residualism and improve the smolting response, including acclimation, volitional release and growth schedules that produce healthy smolts that are of the proper size and stage of development at the appropriate time to initiate the smolt migration.

Steelhead residuals normally remain near their release point (Whitesel et al. 1993; Jonasson et al. 1994; 1995 and 1996; Cannamela 1992). Partridge (1985) noted that most residual steelhead were within about 8 km of the upper Salmon River release site. Schuck et al. (1998) reported steelhead residuals were found about 20 km below and 10 km above release sites in the Tucannon River, Washington. Steelhead residual densities were highest within 8 km of release sites and decreased quickly above and below these sites in the Grande Ronde and Imnaha Rivers in Oregon (Whitesel et al. 1993).

The number of residual steelhead appears to decline steadily throughout the summer in most Snake River basin release areas. This may be due to harvest, other mortality, and outmigration. Viola and Schuck (1991) noted that residual populations in the Tucannon River of Washington declined at a rate of about 50 percent per month from June to October (declining from 4.3 to 0.8 percent of the total released). Whitesel et al. (1993) found residual steelhead up to twelve months after release, however, densities declined rapidly over time.

Acclimation ponds and volitional release strategies are currently the subject of active research in the Columbia River Basin. It is unclear at this time whether or not acclimating and volitionally releasing steelhead smolts can substantially reduce the proportion of residualized steelhead in all cases. WDFW appears to be able to substantially reduce the number of residualized steelhead by using a combination of acclimation, volitional release strategies, and active pond management whereby remaining steelhead are not released when sampling indicates the majority of remaining fish in a pond are males. This action is taken because preliminary WDFW research indicates that the majority of residualized steelhead are males. The ODFW monitoring has not confirmed WDFW results (USFWS 1994). The ODFW saw no reduction in steelhead residualism rates in 1993 from acclimated fish in comparison to direct stream releases; however, they did not employ active pond management strategies (USFWS 1994). Lindsay et al. (2001) found no difference in the number of residualized hatchery steelhead observed at the release site between acclimated and direct stream release groups. Lindsay et al. (2001) observed that residualism was related more to the size of the fish than to whether they were acclimated.

In the 1995-98 Biological Opinion for Hatchery Operations in the Columbia River Basin (NMFS 1995b), NMFS recommended that hatchery steelhead smolts be released at sizes between 170 and 220 mm total length (TL), approximately 163-212 mm fork length (FL), based primarily on the work of two IDFG researchers, Cannamela (1992, 1993) and Partridge (1985). The maximum size recommendation was based on reports of higher residualism among steelhead over 240 mm TL and higher predation rates by residual steelhead over 250 mm TL. Analysis by IDFG suggests that the 220 mm maximum size is less than the ideal size to release smolts (Rhine et al. 1997). In several tests, Rhine reports that residualized steelhead are significantly smaller than smolts. Of those steelhead smolts carrying PIT tags, 52.1 percent of fish released at 163-211 mm, 66 percent of steelhead 212-250 mm TL, and 83.3 percent of steelhead greater than 250 mm TL were detected at downstream dams. Bigelow (1997) reported similar results in PIT tagged steelhead smolts released from Dworshak Hatchery. Over 70 percent of steelhead less than 180 mm TL were not detected while approximately 85 percent of smolts over 180 mm TL were detected at the downstream sites.

This information suggests that release of juvenile steelhead less than 180 mm TL will contribute to residualism and the ideal release size may be larger than 220 mm TL. However, concern for both residualism and predation by very large smolts (over 250 mm TL) is still valid. Jonasson et al. (1996) reported predation on naturally produced juvenile steelhead by residual hatchery steelhead as small as 189 mm TL, but in general the larger residual fish tended more toward predation. Overall, Jonasson et al. (1996) reports a low level of piscivory by residuals less than 230-250 mm TL.

Based on this information the recommended steelhead smolt size range should be 180 mm to 250 mm TL. Further, if predation increases as size of fish released from hatcheries increases, then hatchery managers should avoid release of larger smolts in waters that support rearing fry of listed species. Hatchery managers should continue to evaluate the impacts of size at release on predation and residualism along with other measures to increase smolting success.

Smolts that residualize for some period of time not only pose a potential threat to naturally produced salmonids, they have a lower probability of returning as adults and fulfilling the intended purpose of recovery, fishery enhancement, or mitigation. Healthy hatchery-produced smolts that migrate to the ocean soon after release have a good chance to return as adults, while those that select an extended stream residence often do not survive (Steward and Bjornn 1990). If a high percentage of hatchery-produced smolts successfully return as adults, less production is required to meet recovery, mitigation or treaty trust responsibilities.

Residualism is primarily a concern for releases of hatchery steelhead and not spring Chinook salmon, fall Chinook salmon, and coho salmon. However, a small portion of coho salmon when released as parr have been observed to have residualized (Dunnigan 1999).

5.1.5.2.8 Fisheries

Fisheries managed for, or directed at, the harvest of hatchery-origin fish have been identified as one of the primary factors leading to the decline of many naturally produced salmonid stocks (Flagg et al. 1995; Myers et al. 1998). Depending on the characteristics of a fishery regime, the commercial and recreational pursuit of hatchery fish can lead to the harvest of naturally produced fish in excess of levels compatible with their survival and recovery (NRC 1996). Listed salmon and steelhead may be intercepted in mixed stock fisheries targeting predominately returning hatchery fish or healthy natural stocks (Mundy 1997). Fisheries can be managed for the aggregate return of hatchery and naturally produced fish, which can lead to higher than expected harvest of naturally produced stocks.

In recent years harvest management has undergone substantial reforms and many of the past problems have been addressed. Principles of weak stock management are now the prevailing paradigm. Listed salmon and steelhead are no longer the target of fisheries. Mixed stock fisheries are managed based on the needs of natural-origin stocks. In many areas fisheries have been closed to protect natural-origin populations (e.g., before 2005 upper Salmon River spring Chinook salmon fisheries were closed to non-treaty recreational fishing for more than 20 years). Managers also account, where possible, for total harvest mortality across all fisheries. The focus is now correctly on conservation and secondarily on providing harvest opportunity where possible directed at harvestable hatchery and natural-origin stocks. For an in depth review of harvest management actions affecting Columbia River salmon and steelhead see chapter 3 of the LCFRB's recovery plan (LCFRB 2004). These management changes have resulted in harvest no longer being considered one of the top five limiting factors for almost all of the listed species (see Table 14).

Rutter (1997) observed that the effects on listed stocks from harvesting hatchery-produced fish can be reduced by certain management actions:

- Externally marking hatchery fish so that they can be differentiated from unmarked, natural fish.
- Conducting fisheries that can selectively harvest only hatchery-produced fish with naturally produced fish being released.
- Managing fisheries for the cumulative harvest rate from all fisheries to ensure impacts are not higher than expected (Mundy 1997).
- Ensuring that harvest rates are not increased because of a large return of hatchery fish, fisheries can be managed based on the abundance and status of naturally produced fish.

- Releasing hatchery fish from terminal areas so that returning adults can be harvested with little or no interception of naturally produced fish. Fisheries can occur near acclimation sites or in other areas where released hatchery fish have a tendency to concentrate, which reduces the catch of naturally produced fish.
- Reducing or eliminating the number of fish released from hatcheries if fisheries targeting hatchery fish cannot be managed compatible with the survival and recovery of listed fish.

Catchable Trout Fisheries

Many hatchery programs produce rainbow trout (and other trout species) for recreational fisheries to meet mitigation obligations for lost recreational harvest opportunities. These programs have had an adverse effect on anadromous steelhead juveniles because fisheries targeting the trout typically intercept, catch, handle, and sometimes kill juvenile salmon and steelhead.

5.1.5.2.9 Masking

Returning adult hatchery fish can stray into natural spawning areas confounding the ability to determine the annual abundance of naturally produced fish. This can lead to an over-estimation of the actual abundance and productivity of the natural population, and to an inability to assess the health and production potential of the critical habitat for that population. This latter factor exists because the hatchery fish are not subject to the same spawning and early life history productivity limits experienced by the natural population in the natural freshwater environment. The abundance and productivity of the naturally produced fish and the health of the habitat that sustains them, is therefore "masked" by the continued infusion of hatchery-produced fish.

Masking of natural fish status by naturally spawning hatchery fish produced for harvest augmentation purposes was one basis for the recommended listing of the Puget Sound Chinook salmon ESU as "threatened" under the ESA (Myers et al. 1998). Annual spawning ground censuses of fall Chinook salmon populations had historically aggregated naturally spawning hatchery and naturally produced fish. When an identifying mark was applied to a proportion of the hatchery fish, efforts were made to subtract out hatchery fish from escapement estimates through expanded mark recovery estimates. In many instances, however, the release of unmarked hatchery fall Chinook salmon groups, predominately of a single stock, led to the situation where salmon spawning escapement abundances were artificially sustained, and the actual annual abundances of the indigenous naturally produced fall Chinook salmon populations in some watersheds were over-estimated or unknown.

Attempts to identify and remedy anthropogenic factors adversely affecting fish habitat may be impeded through masking of natural fish status. For example, instability and degradation of spawning gravel areas through flooding during critical spawning or egg incubation periods may not be recognized as a limiting factor to natural production if annual spawning ground censuses are subsidized by returning adults from annual hatchery releases. If the vast majority of the adult fish observed were of direct hatchery origin, the poor natural productivity status of the spawning areas will not be evident without additional, expansive monitoring efforts.

Resolution of the masking issue can be achieved by:

- Providing an effective means to easily differentiate hatchery fish from natural-origin fish on the spawning grounds. One avenue available is a readily visible external mark applied to hatchery fish prior to release combined with an effective spawning ground census program designed to derive separate estimates of hatchery and natural fish. Mass marking of hatchery fish using an internal mark (e.g., otolith banding) may also be used to differentiate hatchery from natural-origin fish on the spawning grounds, if a statistically valid adult sampling design to collect and analyze mark recovery data is also implemented.
- Plant or release fish only in areas where "masking" is not an issue but still mark enough fish to monitor straying.
- Removing hatchery fish through selective fisheries or at weirs and dams.
- Imprinting hatchery fish to return to lower river or tributary areas not used by natural fish in a watershed.
- Reducing or limiting hatchery fish release numbers leading to decreased adult hatchery fish returns may also reduce masking effects.

5.1.5.2.10 Nutrient Cycling

The flow of energy and biomass from productive marine environments to relatively unproductive terrestrial environments supports high productivity in the ecotone where the two ecosystems meet (Polis and Hurd 1996). Anadromous salmon are a major vector for transporting marine nutrients across ecosystem boundaries (i.e. from marine to freshwater and terrestrial ecosystems). Because of the long migrations of some stocks of Pacific salmon, the link between marine and terrestrial production may be extended hundreds of miles inland. Nutrients and biomass extracted from the milt, eggs, and decomposing carcasses, of spawning salmon stimulate growth and restore the nutrients of aquatic ecosystems. Nutrients originating from salmon carcasses are also important to riparian plant growth. Direct consumption of carcasses and secondary consumption of plants and small animals that are supported by carcasses is an important source of nutrition for terrestrial wildlife (Cederholm et al. 1999).

Current escapements of naturally produced and naturally spawning hatchery-produced anadromous salmonids in the Columbia Basin are estimated at about 7 percent of the historical biomass (Cederholm et al. 1999). Throughout the Pacific Northwest, the delivery of organic nitrogen and phosphorus to the spawning and rearing streams for anadromous salmonids has been estimated at 5 to 7 percent of the historical amount (Gresh et al. 2000). Cederholm et al. (1999) calculate the historical spawning escapement at 45,150 mt (metric ton) of biomass annually added to the aquatic ecosystems of the Columbia compared to 3,400 mt annually with current spawning escapements.

Artificial propagation programs in the basin add substantial amounts of fish biomass to the freshwater ecosystem. The annual hatchery production cap of nearly 200 million smolts, at 25 g/smolt average weight, adds about 5,000 mt of biomass to the Columbia Basin. Returning adults from artificial propagation programs have totaled 800,000 to 1,000,000 in recent years (ODFW and WDFW 1998). At the average weight of 6.75 kg used by Cederholm et al. (1999), 5,400 to 6,750 mt of fish biomass is potentially returned to the Columbia River annually due to artificial propagation programs. Of course, most of the hatchery smolt production is expected to leave freshwater and migrate to the marine ecosystem, but undoubtedly some is retained in freshwater and terrestrial ecosystems as post-release mortalities and consumption by predators such as bull trout, ospreys and otters. Much of the adult return from hatchery production may be removed from the ecosystem by selective fisheries or taken at hatchery weirs and traps.

However, the potential to utilize the marine-derived nutrients that are imported to freshwater ecosystems in the carcasses of hatchery returns may be of value for stimulating ecosystem recovery. Experiments have shown that carcasses of hatchery-produced salmon can be an important source of nutrients for juvenile salmon rearing in streams (Bilby et al. 1998). Hatchery carcasses may also replace some of the nutrient deficit in riparian plant and terrestrial wildlife communities where naturally produced spawners are lacking. The contribution of artificial propagation programs has the potential to exceed the contribution of naturally produced fish in replenishing the nutrient capital of aquatic ecosystems in the short term, but should not be regarded as a long term solution to replacing the nutrient subsidy provided by naturally produced salmon.

5.1.5.2.11 Monitoring & Evaluation

Monitoring and Evaluation programs are necessary to determine the performance of artificial propagation programs. The Artificial Production Review (NPPC 1999) listed four criteria for evaluating both augmentation and mitigation programs:

1. Has the hatchery achieved its objectives?
2. Has the hatchery incurred costs to natural production?
3. Are there genetic impacts associated with the hatchery production?
4. Is the benefit greater than the cost?

Historically, hatchery performance was determined solely on the hatchery's ability to release fish (NPPC 1999), this was further expanded to include hatchery contribution to fisheries (Wallis 1964; Wahle and Vreeland 1978; Vreeland 1989). Past program-wide reviews of artificial propagation programs in the Northwest have indicated that monitoring and evaluation has not been adequate to determine if the hatchery objectives are being met (ISG 1996; NRC 1996; NFHRP 1994). The lack of adequate monitoring and evaluation has resulted in the loss of information that could have been used to adaptively manage the hatchery programs (NRC 1996).

Under the ESA, monitoring and evaluation programs for artificial production are not only necessary for adaptive management purposes but are required to ensure that artificial propagation activities do not limit the recovery of listed populations. Monitoring and evaluation of artificial propagation activities are necessary to determine if management actions are adequate to reduce or minimize the impacts from the general effects discussed previously, and to determine if the hatchery is meeting its performance goals. Monitoring and evaluation activities will occur within the hatchery facilities as well as in the natural production areas. Monitoring and evaluation within the hatchery can include measurements to evaluate hatchery production (i.e., survival, nutrition, size at age, condition, disease prevention, genetic makeup, total released, percent smolted, etc.).

Monitoring and evaluation to determine impacts on listed fish from artificial propagation programs can itself have potential adverse impacts on listed fish in the hatchery though injuries incurred during sampling and marking. Sampling within the hatchery can include direct mortalities (e.g., genetic analysis, disease pathology, smolt condition) and indirect take (e.g. sorting, marking, transfers). Marking of hatchery fish prior to release is required for all programs to monitor and evaluate hatchery effects (positive and negative). Marking is necessary to evaluate a number of objectives including selecting broodstock, determining hatchery stray rates and hatchery contributions to fisheries, and for the implementation of selective fisheries that target hatchery fish.

For hatchery supplementation programs, the goal is to promote the viability of natural-origin populations as the factors limiting viability are reduced by using hatchery fish to increase the number of natural spawners. Monitoring and evaluation for this goal requires the sampling of naturally produced adults and juveniles in natural production areas. In the Columbia River Basin, many of these naturally produced populations are listed under the ESA.

Monitoring and evaluating fish and fish assemblages in the natural environment is necessary to determine any positive or negative effects the artificial production program is having on the natural population. Genetic and life-history data may need to be collected from the natural population to determine if the hatchery population has diverged from the natural population and if the natural population has been altered by the incorporation of hatchery fish into the spawning population. Sampling methods can include the use of weirs, electro-fishing, rotary screw traps, seines, hand nets, spawning ground surveys, snorkeling, radio tagging, and carcass recovery. Each sampling method can be used to collect a variety of information. Sample methods, like tagging methods, can adversely impact listed fish, both those targeted for data collection and those taken incidentally to the data collection.

NMFS has developed some general guidelines to reduce impacts when collecting listed adult and juvenile salmonids (NMFS 2000c) which have been incorporated as terms and conditions into section 10 and section 7 permits for research and enhancement activities (NMFS 2000c). Though necessary to monitor and evaluate impacts on listed populations from artificial propagation programs, monitoring and evaluation programs should be designed and coordinated with other plans to maximize the data collection while minimizing take of listed fish.

5.1.6 Water Marketing

Under baseline conditions, there are a total of 205 long-term water service contracts for the diversion of water released from storage at Project dams in the Willamette basin (Table 2-12). This water is used exclusively for irrigation, with use primarily occurring during the summer (July and August).

There are 62 pending applications that, if approved, would divert an additional 30,200 acre-feet of stored water. Upon execution of these contracts, the Reclamation water contract program will include 267 active long-term contracts for annual irrigation with up to 80,431 acre-feet of stored water; approximately 5% of the active conservation storage space available in project reservoirs.[1]

[1] The 205 contracts presently in force cover approximately 3% of the available conservation storage space.

Under the Proposed Action, Reclamation would cap its water marketing program at 95,000 acre-feet for the term of this Opinion. Taking both existing contracts and pending contract applications into account, 14,569 acre-feet would remain available to meet future irrigation demands under the duration of the Opinion. In the event that future irrigation demand exceeded the 95,000 acre-feet, Reclamation and the USACE would reevaluate the availability of water from conservation storage for the water marketing program and would consult with the Services prior to marketing additional water.

Because USACE intends to serve these contracts with water released from storage to meet maintain tributary and mainstem minimum flows, water diverted under these water service contracts is likely to reduce the fish habitat value of the affected streams from the point of diversion downstream. That is, under the Proposed Action more water would be removed from the Willamette River and its tributaries during the irrigation season without any additional water being released from USACE's reservoirs.

Such flow reductions may reduce the habitat area, or habitat quality, available to salmon and steelhead during the late summer. Such flow reductions could exacerbate local fish passage problems but are most likely to affect juvenile Chinook and steelhead that rear in the affected stream reaches. Reducing streamflow would also reduce the mass of water subject to atmospheric heating, causing water temperatures to increase, which could adversely affect rearing juveniles and holding adults. Water development and fish use vary among the tributary basins and these effects are considered for each occupied tributary in the sections below.

5.1.7 Climate Change Considerations

As described in Section 4.1, ongoing climate change has the potential to adversely affect habitat conditions for salmonids throughout the Columbia basin, including the Willamette basin. The following sections describe how the Proposed Action would respond to the ISAB's recommendations to proactively address these effects.

5.1.7.1 ISAB Recommendations

In addition to describing the potential effects of climate change in the Columbia basin (Section 4.1 of this document), the ISAB provides a series of recommendations to proactively address these anticipated effects (ISAB 2007). This section presents ISAB's recommendations and identifies those elements of the Proposed Action that would respond to them.

Planning Actions

1. Assessing potential climate change impacts in each subbasin and developing a strategy to address these concerns should be a requirement in subbasin plan updates. Providing technical assistance to planners in addressing climate change may help ensure that this issue is addressed thoroughly and consistently in the subbasin plans.
2. Tools and climate change projections that will aid planners in assessing subbasin impacts of climate change are becoming more available. Of particular interest for the Columbia Basin is an online climate change streamflow scenario tool that is designed to evaluate vulnerability to climate change for watersheds in the Columbia Basin

(www.cses.washington.edu/cig/fpt/ccstreamflowtool/sft.shtml). Models like this one can be used by planners to identify sensitivities to climate change and develop restoration activities to address these issues.

3. Locations that are likely to be sensitive to climate change and have high ecological value would be appropriate places to establish reserves through purchase of land or conservation easements. Landscape-scale considerations will be critical in choice of reserve sites, as habitat fragmentation and changes of habitat will influence the ability of such reserves to support particular biota in the future. These types of efforts are already supported by the Fish and Wildlife Program, but actions have not yet been targeted to address climate change concerns.

Tributary Habitat

1. Minimize temperature increases in tributaries by implementing measures to retain shade along stream channels and augment summer flow
    - Protect or restore riparian buffers, particularly in headwater tributaries that function as thermal refugia
    - Remove barriers to fish passage into thermal refugia
2. Manage water withdrawals to maintain as high a summer flow as possible to help alleviate both elevated temperatures and low stream flows during summer and autumn
    - Buy or lease water rights
    - Increase efficiency of diversions
3. Protect and restore wetlands, floodplains, or other landscape features that store water to provide some mitigation for declining summer flow
    - Identify cool-water refugia (watersheds with extensive groundwater reservoirs)
    - Protect these groundwater systems and restore them where possible
    - May include tributaries functioning as cool-water refugia along the mainstem Columbia where migrating adults congregate
    - Maintain hydrological connectivity from headwaters to sea

Mainstem and Estuary Habitat

1. Remove dikes to open backwater, slough, and other off-channel habitat to increase flow through these areas and encourage increased hyporheic flow to cool temperatures and create thermal refugia

Mainstem Hydropower

1. Augment flow from cool/cold water storage reservoirs to reduce water temperatures or create cool water refugia in mainstem reservoirs and the estuary
    - May require increasing storage reservoirs, but must be cautious with this strategy
    - Seasonal flow strategy

2. Use of removable spillway weirs (RSW) to move fish quickly through warm forebays and past predators in the forebays.
   - Target to juvenile fall Chinook salmon
3. Reduce water temperatures in adult fish ladders
   - Use water drawn from lower cool strata of forebay
   - Cover ladders to provide shade
4. Transportation
   - Develop temperature criteria for initiating full transportation of juvenile fall Chinook salmon
   - Explore the possibility of transporting adults through the lower Snake River when temperatures reach near-lethal limits in later summer
   - Control transportation or in-river migration of juveniles so that ocean entry coincides with favorable environmental conditions
5. Reduce predation by introduced piscivorous species (e.g., smallmouth bass, walleye, and channel fish) in mainstem reservoirs and the estuary

Harvest

1. Harvest managers need to adopt near-and long-term assessments that consider changing climate in setting annual quotas and harvest limits
   - Reduce harvest during favorable climate conditions to allow stocks that are consistently below sustainable levels during poor phase ocean conditions to recover their numbers and recolonize areas of freshwater habitat
   - Use stock identification to target hatchery stocks or robust natural-origin stocks, especially when ocean conditions are not favorable
   - Control juvenile migration to ensure that ocean entry coincides with favorable ocean conditions[2]

5.1.7.2 Measures in the Proposed Action Responding to the ISAB Recommendations

The Proposed Action includes measures designed to restore a more natural thermal regime to waters downstream from the dams to benefit salmonid habitat. During the period of the Opinion the Action Agencies will continue to implement and study the long term effects of the current water temperature control system at Cougar Dam. In the Proposed Action, the Action Agencies propose continued operation of the Cougar Water Temperature Control Facility and to conduct a

[2] If the ocean condition becomes less productive, density dependence will be intensified, resulting in increased competition among species and stocks in the ocean. This may result in lower growth and survival rates for wild salmon in the ocean. Reduction in hatchery release during poor ocean conditions may enhance survival of wild stocks, but more research is necessary (ISAB 2007).

program of RM&E to evaluate its biological effectiveness. However, they do not propose to implement temperature control operations or to build facilities in other subbasins.

The Proposed Action includes minimum and maximum flow objectives for reaches below the Project dams. The Action Agencies propose to use water stored in Project reservoirs to meet these objectives in a manner that addresses changes in seasonal streamflow patterns related to climate change. The Action Agencies will conduct studies to ensure that these requirements are adequate and will operate to meet revised objectives, if needed.

The Action Agencies will implement habitat improvement projects including those that will enhance habitat conditions on the mainstem Willamette, by improving stream shading, providing floodplain and hydraulic connectivity to the Delta Ponds near Eugene, and using large wood taken from Project reservoirs to create deep, cool water pools in downstream reaches. These actions address the ISAB's recommendations by increasing habitat connectivity and the availability of thermal refugia.

Section 5.2 Middle Fork Willamette Effects

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5.2 Middle Fork Willamette River Subbasin: Effects of the Willamette Project Proposed Action on UWR Chinook Salmon & Critical Habitat

Summary of the Effects of the Proposed Action

- The Proposed Action (continued operation of the dams, maintenance of revetments, and hatchery operations) would allow existing adverse conditions for Middle Fork Willamette Chinook salmon to persist:
  - Fish would continue to have limited upstream and downstream passage at Project dams, preventing safe access to historical habitat and limiting spatial distribution (VSP parameter) and access to spawning and rearing habitat (PCEs of critical habitat).
  - Habitat downstream of Project dams would continue to be degraded by lack of sediment and large wood transport, altered flow regimes, and altered water quality below the dams, resulting in continued decline in abundance and productivity.
- As a result, the Middle Fork Willamette River Chinook salmon population already at very low levels, would continue to decline. Critical habitat would be further degraded.

Chinook Population & Critical Habitat

Historically, the Middle Fork Willamette Chinook salmon population may have been the largest of all populations in the UWR Chinook salmon ESU. McElhany et al. (2007) have suggested that the Middle Fork subbasin once likely produced tens of thousands of adult spring Chinook. However, recent returns of naturally spawning Chinook salmon have been in the low hundreds within the Middle Fork subbasin (including returns to Dexter trap and Fall Creek trap) and the population is at very high risk of extinction. An array of anthropogenic causes have likely contributed to this decline, but the primary cause of the decline for this population is elimination of nearly all of the historical spawning habitat by the construction of impassable dams low in the basin, and altered water temperature regimes downstream of the dams (Hills Creek, Dexter/Lookout) that cause poor egg survival (McElhany et al. 2007; ODFW 2007b). See the baseline chapter for more information.

In general, the Proposed Action includes the following broad on-the-ground actions:

- Project dams - current configuration, continued operation, and maintenance of Fall Creek, Dexter, Lookout Point, and Hills Creek dams in the Middle Fork Willamette watershed.
- Flow management - targets for volume and seasonal timing of water released downstream from Fall Creek and Lookout/Dexter dams.

- Ramping rates - targets would be intended to limit down-ramp rates below Fall Creek and Lookout/Dexter Dams to no greater than 0.1 ft/hr at night and to no greater than 0.2 ft/hr during the daytime.
- Hatchery program - continued production of hatchery Chinook for fishery augmentation and conservation purposes.
- Outplanting program - trap and haul of Chinook from below Fall Creek and Dexter dams to release locations above the dams.
- Dexter and Fall Creek adult fish collection facilities - rebuild both facilities in the future, date uncertain and based on funding.

The Action Agencies' assessment of the effects of the Proposed Action in the Middle Fork Willamette describes minimal to no reduction in the effects of their actions from the current baseline conditions (see Table 5.2-5 at the end of this section and Table 6-4 and Table 6-12 of the Supplemental BA, USACE 2007a). As described in the following subsections, NMFS agrees with the effects assessment of the Action Agencies in the Middle Fork Willamette watershed, meaning that the ESUs will continue to be at high risk of extinction.

5.2.1 Habitat Access & Fish Passage

Under the Proposed Action, Dexter, Lookout Point, Hills Creek, and Fall Creek dams would continue to block access to and from nearly all Chinook salmon spawning habitat in the Middle Fork Willamette watershed. The Action Agencies propose, as an interim measure, to continue experimentally transporting some adult UWR Chinook above Fall Creek, Dexter, Lookout Point, and Hills Creek dams (USACE 2007a, p. 3-47) providing a modicum of upstream passage, as noted in the baseline conditions. Downstream passage of juvenile salmon through these reservoirs and dams would continue to occur under the current configuration of the project, but would be ineffective. As noted in the baseline chapter (see section 4.2.3.1), no downstream passage routes are equipped with screen or bypass facilities to safely pass juvenile fish downstream. Though the Action Agencies propose to conduct studies to evaluate passage mortality over the term of the Opinion, no actions are proposed at this time to help improve downstream passage of juvenile salmon beyond the baseline conditions of current project configurations and operations.

While the Proposed Action would continue the interim, experimental outplanting program using truck transport, data so far indicate that, due to mortality of adults and juveniles from a number of causes, it is not effective in providing upstream and downstream fish passage and access to limited spawning habitat in the Middle Fork Willamette subbasin. As described in Section 4.2.3.1, UWR Chinook salmon access to habitat blocked by the dams in the Middle Fork Willamette is of critical importance because the remaining spawning habitat below the dams does not support adequate reproduction because of high mortality of incubating eggs (see section 5.2.3.1 for a full explanation). The habitat upstream of the dams is relatively high quality habitat for Chinook salmon and able to support successful reproduction, growth, and rearing of adult and juvenile fish (see section 5.2.3 below).

The practice of holding fish in the river below dams (rather than either trapping or passing them immediately) means that adult fish holding below dams have increased likelihood of trying to swim up into turbines, where they may experience severe injuries. Particularly when turbines are started and stopped, velocities in turbine tailraces are reduced to levels that are within the swimming abilities of UWR Chinook.

The key proposed actions related to habitat access in the Middle Fork Willamette watershed that will affect UWR Chinook salmon are the following:

- Continue to collect adult salmon at the base of Fall Creek and Dexter Dams using existing facilities, truck and haul the fish above the reservoirs, and release the fish in appropriate habitat to spawn.
- Continue to pass juvenile salmon downstream through the reservoirs and dams under current configurations. Flow operations would be as described in section 3.3 of the Supplemental BA.
- Conduct the "Willamette System Review Study" that will evaluate Dexter and Fall Creek adult collection facilities and downstream passage alternatives at Fall Creek, Dexter/Lookout, and Hills Creek dams and reservoirs. The actual order in which the Middle Fork Willamette would be studied among the other watersheds would be determined in Phases I and II of the study. However, the North Santiam was proposed to be first priority (USACE 2007a, page 3-143).

The following is an assessment of the effects of adult upstream passage via the outplanting program, resulting juvenile production, and downstream juvenile fish passage through the reservoirs and dams.

5.2.1.1 Upstream Passage/Potential Utilization of Blocked Habitat

Outplanting adult spring Chinook salmon above Fall Creek and Dexter dams, the lowermost impassable barriers in the watershed, began in the early 1990's (Beidler and Knapp 2005). The outplanting program was initially focused on benefitting bull trout by providing a food base (Chinook fry) and nutrients (Chinook carcasses) to habitat upstream of the dams since anadromous fish migration to the upper watershed was eliminated by the dams. The USACE found that some of the outplanted fish survived and reproduced. Therefore, in recent years (2002 to date), the outplanting program transitioned into a more formal program with the goal of increasing the spawning and natural production of UWR Chinook salmon above the impassable dams.

All adult Chinook arriving at the Fall Creek Trap are transported above the dam, with projected rates of injury of 1% and mortality of 1% at the fishway and an additional 1% mortality during transport (Willis 2008). Due to the outdated trap-and-haul facilities and operations (see below), levels of stress and delayed mortality are likely to be high and to contribute to the high levels of prespawning mortality in some years (also see below).

Some Chinook trapped at Dexter are transported above the dams (McLaughlin et al. 2008). Projected rates of injury and mortality at the Dexter Trap are 1% each, with another 2% mortality during transport (Willis 2008). Some of these fish are released at sites within the Middle Fork subbasin, including upstream of Hills Creek Reservoir. Levels of stress and delayed mortality are likely to be high (see above).

The success of the outplanting program in providing more natural production in the Middle Fork Willamette population above the dams has been limited, based upon available information. Outplanting, as presently carried out, does not provide effective upstream fish passage. However, until better measures are in place, this program is the only mechanism by which Chinook salmon can access historical habitat above the dams. The USACE monitored the survival of outplanted adult Chinook above Dexter/Lookout Point dams in 2004 through 2006 (Taylor et al. 2007). Taylor et al. (2007) revealed some important information that should be considered in future assessments of the outplanting program for increasing the viability of the Middle Fork Willamette Chinook population. First, the survival of outplanted adults varied substantially among the three years studied although the trapping facilities, trucking protocols, personnel, and overall returns to Dexter Dam were similar: prespawning mortality of outplanted adults was extremely high in 2004 and 2005 (>85%), but was very low in 2006 (<10%; (Figure 5.2-1), a circumstance that was common to spring Chinook populations throughout the Willamette Basin during the latter year (McLaughlin et al. 2008).

High prespawning mortality also occurs in adult fish residing below Dexter Dam. These fish have not been trapped, handled, or transported, but have been exposed to poor conditions (delay and crowding) while holding before spawning. Similar results have been observed in the South Santiam (Section 5.5.1.1) and the North Santiam (Section 5.6.1.1) with adult fish both outplanted above and residing below the Project dams (McLaughlin et al. 2008). In contrast, significantly lower prespawning mortality rates have been observed in the Clackamas and McKenzie rivers (Schroeder et al. 2006; McLaughlin et al. 2008) where adult Chinook are not delayed (or forced to reside) below Project dams for extended periods of time. In summary, stress and the delayed effects of injuries during trapping and handling are likely to contribute to high prespawning mortality of UWR Chinook outplanted above the Middle Fork projects. However, the relationship is not clear because other environmental conditions such as delay and crowding appear to cause prespawning mortality below the dams.

In 2004 and 2005 (the years when prespawning mortality was very high), adult Chinook were collected early in the return (late May-early June) and then outplanted above the dams because it was thought that leaving fish to reside in warm water below the dam before being outplanted was contributing to the high mortality rates. However, this approach did not seem to improve the survival of outplanted fish (Figure 5.2-1). The total number of spring Chinook collected at Dexter Dam was similar in two years of study when prespawning mortality differed (i.e., 5,600 fish in 2005 [high prespawning mortality] and 5,900 in 2006 [low prespawning mortality]). In addition, total returns to Willamette Falls were similar in 2005 and 2006 (36,600 and 37,000 fish, respectively; ODFW 2008c).

In contrast, adult Chinook outplanted later in the summer (e.g., August versus May/June) exhibited somewhat higher survival (Figure 5.2-1). Based on these data, it appears outplanting the fish closer to spawning time may contribute to spawning success above the dams. However, as a result of this approach, many of the fish held below Dexter Dam in warm water until August died. That is, only those that survived the holding period were transported and released above the dam, and survival to spawning of this group was relatively high.

Conclusion

The results to date on the success of outplanting adult salmon above the Middle Fork Willamette dams have been mixed. Overall NMFS expects that prespawning mortality would be with high the outplanting program under the Proposed Action. Improvements to the collection schedules, collection facilities, transporting protocols, and release locations will undoubtedly benefit the post-release survival of outplanted fish. However, until the causes of the high prespawning mortality rates in Chinook residing below these dams are known and addressed, NMFS anticipates that the Proposed Action will result in minor improvements to the success of the adult outplanting program.

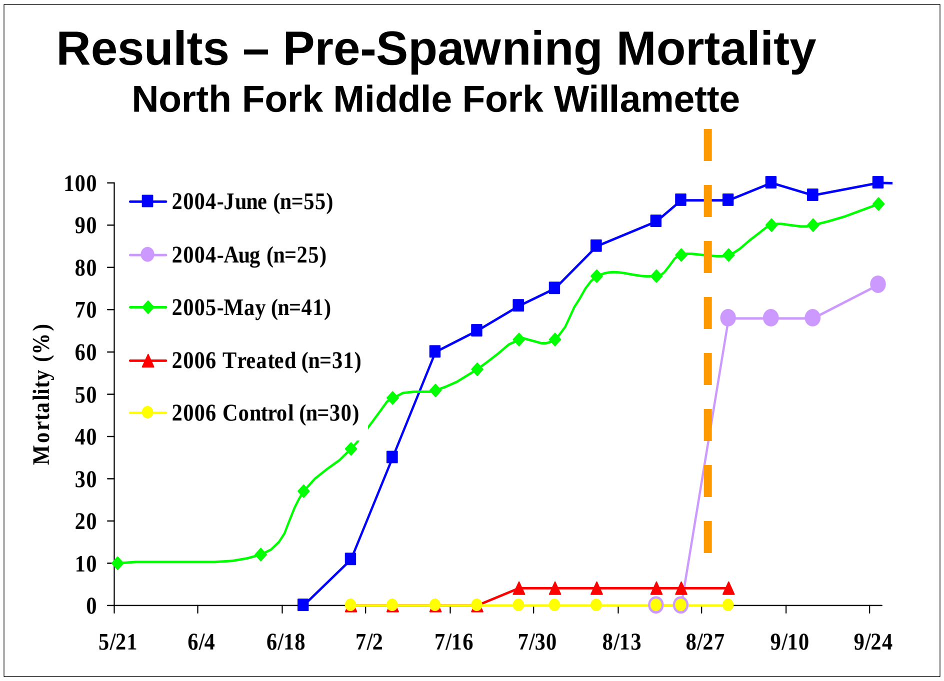

Figure 5.2-1 Prespawning mortality rates of radio-tagged spring Chinook released above Dexter Dam into the North Fork Middle Fork Willamette River, 2004-2006. Figure taken from Taylor et al. (2007).

Based on Taylor's et al. (2007) monitoring, prespawning mortality is not solely caused by the adult trap and transport program in the Middle Fork Willamette subbasin. However, the present facilities and operations are likely to contribute to poor adult survival. Physical handling during trapping, transport, and release stresses Chinook salmon, resulting in increased susceptibility to disease, possible delay in spawning, and in some cases, indirectly mortality. Risk is associated with even modern fish trapping, sorting, and transport operations, but the fish trapping and transport facilities on the Middle Fork (Dexter and Fall Creek facilities) are outdated and great risks.

The existing adult trapping facility at Dexter Dam was originally built to collect broodstock for the hatchery program (fish that will have their eggs taken in a hatchery setting) rather than to safely handle fish for outplanting purposes (fish must that survive until they can spawn on their own in the wild). The Fall Creek trap is somewhat better, although the facility does not meet current fish handling criteria and guidelines. Direct mortality of Chinook observed during the trap and haul activities is typically <1% of the fish handled (Willis 2008). Direct mortality losses have been higher on occasion, but these cases are usually attributable to an unforeseen circumstance, equipment malfunctions, or human error. The numbers of fish handled at the Fall Creek trap varies; 2,805 was the highest number during 2002-2007.

The Proposed Action requires only intermittent trap operation at Dexter Dam (USACE 2000, p. 2-55), which increases the likelihood that congregated fish immediately downstream of the turbines will experience turbine tailrace injuries.

The Fall Creek trap will also only be operated intermittently. There are no turbines at Fall Creek currently, though a private investor in the process of proposing to add hydropower generation facilities.

5.2.1.2 Juvenile Production

In 2006, when the prespawning mortality of adults was very low, juvenile production in the Middle Fork Willamette above Dexter and Lookout Point was substantial, with over 100,000 age-0 fry estimated to have emigrated downstream of the trap throughout the spring and summer of 2007 (Taylor 2008a). During January 2008, thousands of age-1 smolts have also emigrated by the trap location. Thus, when adult prespawning survival is good, the habitat can produce and support at least two age classes of juvenile Chinook salmon. Therefore, the habitat upstream of the dams is capable of producing and rearing spring Chinook salmon. Historically these areas were the primary places in the Middle Fork Willamette where Chinook salmon spawned and reared. In addition, these higher elevation habitats in the Cascades are in relatively good shape. The majority of this habitat is managed by the Federal government and applies some of the best aquatic and terrestrial management under the Northwest Forest Plan standards and guidelines.

5.2.1.3 Dam & Reservoir Survival

None of the four dams in the Middle Fork Willamette River subbasin (Dexter, Lookout Point, Hills Creek, and Fall Creek) is equipped with fish screens and bypass facilities to safely pass juvenile fish around turbines. As described in Section 4.2.3.1.2, Fall Creek Dam was equipped with “fish horns” intended to pass juvenile fish downstream, but these are not used for their intended purpose due to low collection efficiency and high fish mortalities in the bypass system. Juvenile UWR Chinook salmon that are produced above the dams must migrate downstream through the reservoirs and pass over or through the dams on their seaward migration. Data on the survival rates of juvenile Chinook through the reservoirs and dams in the Middle Fork Willamette are limited.

Hills Creek Dam

- Beidler and Knapp (2005) summarize a study conducted at Hills Creek dam by Larson (2000). In the fall of 1999, Larson estimated mortality rates for juvenile Chinook passing through the turbines and regulating outlets of 59% and 32%, respectively. Willis (2008) assumes a direct mortality rate from Hills Creek forebay to tailrace of 60%. Rates of injury and potential delayed mortality have not been documented.
- Survival/mortality through Hills Creek Reservoir has not been documented.

Dexter/Lookout Point

- Willis (2008) assumes 21% juvenile Chinook mortality between the Lookout Point forebay and Dexter Dam. Rates of injury and potential delayed mortality have not been documented.
- Survival/mortality through Lookout Point Reservoir has not been documented.

Fall Creek Dam

- Studies conducted in 1991 noted 41% mortality through the regulating outlet (Downey 1992). Rates of injury and potential delayed mortality have not been documented.
- Downey (1992) also reported 68.3% mortality through the "fish horns" associated with the "downstream migrant system" from the Fall Creek forebay to the Fall Creek Dam downstream migrant facility. Rates of injury and potential delayed mortality have not been documented.
- Survival/mortality through Fall Creek Reservoir has not been documented.

The Action Agencies propose to conduct studies to evaluate reservoir and dam passage mortality as described below.

Table 5.2-1. Numbers of outplanted spring Chinook and redds in the North Fork Middle Fork Willamette River. Table taken from Taylor et al. 2007.

OUTPLANT & REDD COUNTS		
North Fork Middle Fork Willamette		
Chinook Outplanted	Redd Counts (Est.)	Fish/Redd
578		
798		
1,650	35	46
3,765	166	22
1,695	18	91
2,864	84	34
798	42	19
827	363	2.3

Adult UWR Chinook salmon are outplanted upstream of the dams and reservoirs and thus have not been found in the reservoirs and do not pass the dams downstream. Their tendency is to continue upstream migrations to cool, headwater habitats for oversummering. Spring Chinook are semelparous and die after spawning. Thus, there is no concern about adults migrating downstream through the reservoirs and dams back to the ocean (e.g. unlike steelhead, which are repeat spawners).

The Proposed Action describes the Willamette System Review Study, a process that will be undertaken for the Willamette Project (all 13 Project dams in the Willamette Basin) to prioritize fish passage needs and improvements. However, the Action Agencies state that they cannot make a firm commitment to construct or carry out any fish passage facilities or operations indicated by the study because of uncertainty with obtaining authorization and funding (USACE 2007a). Other than studies, no specific actions are identified in the study proposal for the Middle Fork Willamette. NMFS therefore assumes that juvenile UWR Chinook salmon will continue to experience mortality rates like observed in the past-- 41% (turbines) and 19 to 68% (regulating outlets) per project for juvenile fish passing downstream through the dams in the Middle Fork Willamette River subbasin.

There is insufficient information with which to make any estimates of juvenile UWR Chinook mortality through the reservoirs.

Conclusion

The Proposed Action would continue to prevent safe access for UWR Chinook salmon to their historical habitat above the dams, and would continue to kill and injure large numbers of individual juvenile fish migrating downstream past the dams.

5.2.2 Water Quantity/Hydrograph

The Action Agencies propose to continue flow management as done since 2000. This includes attempting to meet specified seasonal minimum and maximum flows, seasonal drafting and refilling, and ramping rates for changing discharge.

5.2.2.1 Seasonal Flows

The Corps has estimated the frequency with which it anticipates not meeting the minimum and maximum flows under its proposed operations (Table 5.2-2).

Table 5.2-2 Estimated frequency that proposed minimum and maximum tributary flows would not be met downstream from projects in the Middle Fork Willamette River. Source: Donner 2008.

Dam	Period	Primary Use	Minimum Flow (cfs)[1]	Chance of Not Meeting Flow	Maximum Flow (cfs)[2]	Chance Of Not Meeting Flow	
Hills Creek	Sep 1 – Jan 31	Chinook migration & rearing	400	<1%			
	Feb 1 – Aug 31	Chinook rearing	400	<1%			
Fall Creek	Sep 1 – Oct 15	Chinook spawning	200	5%	400 Through Sep 30, when possible	25%	Sep
	Oct 16 – Jan 31	Chinook incubation	50 [3]	<1%			
	Feb 1 – Mar 31	Chinook rearing	50	<1%			

Dam	Period	Primary Use	Minimum Flow (cfs)[1]	Chance of Not Meeting Flow	Maximum Flow (cfs)[2]	Chance Of Not Meeting Flow	
	Apr 1 – May 31	Chinook rearing	80	<1%			
	Jun 1 – Jun 30	Chinook rearing / adult migration	80	<1%			
	Jul 1 – Aug 31	Chinook rearing	80	5%			
Dexter	Sep 1 – Oct 15	Chinook spawning	1,200	<1%	3,500 Through Sep 30, when possible	10% 45%	Sep Oct
	Oct 16 – Jan 31	Chinook incubation	1,200 [3]	<1%			
	Feb 1 – June 30	Chinook rearing	1,200	<1%			
	Jul 1 – Aug 31	Chinook rearing	1,200	<1%			

Exceedence of maximum flow objective over a 66-year record from 1936-2001 (probability figures are approximate).

1 Minimum flow will equal inflow or Congressionally authorized minimum flows, whichever is higher, when the reservoir is at a minimum conservation pool elevation. This avoids drafting the reservoir below minimum conservation pool and, where applicable, into the power pool.

2 Maximum flows are intended to minimize the potential for spawning to occur at stream elevations that might subsequently be dewatered at the specified minimum flow during incubation.

3 When feasible, incubation flows should be no less than ½ the maximum 72-hour average discharge observed during the preceding spawning season. Efforts will be made to avoid prolonged releases in excess of the recommended maximum spawning season discharge to avoid spawning in areas that would require high incubation flows that would be difficult to achieve and maintain throughout the incubation period.

These proposed minimum flow objectives are consistent with recommendations developed by NMFS' staff and ODFW managers familiar with fish habitat conditions in the Middle Fork basin. In general, the more often these objectives are met, the better the conditions for salmon and steelhead survival. Nevertheless, when these flows are not met (projected at 1% of the time) adults Chinook will encounter less spawning and holding habitat and juveniles will be subjected to desiccation of eggs, barriers to shallow water rearing areas and entrapment during fluctuations at low flows (Willis 2008). When these adverse effects occur, the effect will extend over the reach from Fall Creek Dam to the creek's confluence with the Middle Fork Willamette (about 7 miles), from Dexter Dam to the confluence of the Middle Fork with the Coast Fork Willamette (about 17 miles), and from Hills Creek Dam to the upstream end of the Lookout Point Reservoir (about 9 miles) (Willis 2008.) These flows closely correlate with fish management agencies' recommendations and the best currently available information. NMFS considers these proposed operations, which would miss the minimum flow objectives <5% (and often <1%) of the time to be highly protective.

Maximum flows are intended to minimize the potential for spawning to occur at stream elevations that might subsequently be dewatered at the specified minimum flow during incubation. It may not be possible to stay below these maxima, especially in the fall when drafting reservoirs in preparation for the flood damage reduction management period. Project operations will be managed to minimize the frequency and duration of necessary periods of exceedence.

The Action Agencies also propose to conduct instream flow compliance and effectiveness monitoring and may also conduct limited experimental operations to determine if the proposed water management operations meet the needs of anadromous fish. As these data become available, NMFS anticipates that water management programs would be modified as necessary to meet anadromous fish needs. Because it is unclear whether such investigations would result in any changes in project operations, we cannot assume any benefit to anadromous fish at this time.

5.2.2.2 Frequency of Channel-forming & Over-bank Flows

By continuing to reduce the frequency of channel-forming and over-bank flows downstream of Fall Creek and Dexter dams, project operations would continue to limit channel complexity and thereby limit rearing habitat for juvenile Chinook salmon in Fall Creek and the Middle Fork Willamette River downstream. Peak flow reduction may also reduce the recruitment and suitability of channel substrates for spawning salmon. Although these habitat-altering processes would continue under the proposed action, water quality issues (primarily water temperatures) are considered to be the most likely causes of poor reproductive success in the Middle Fork Willamette River and its tributaries. If these water quality issues are favorably resolved, habitat alteration issues associated with peak flow reduction might limit reproductive success.

Given the low level of current use of the Middle Fork Willamette River by spawning and rearing spring Chinook and the limitation on success posed by high water temperatures, the effect of peak flow reduction in the Middle Fork watershed likely has only a small effect on the ESU at present. Once the temperature concerns are successfully resolved, the habitat-limiting effects of peak flow reduction could then limit the abundance, productivity, and juvenile outmigrant production of the population. The USACE does not propose any actions to investigate or reduce these effects. These effects are expected to continue and may worsen over the life of the proposed action.

Reduction of peak flows in ongoing flood control operations could continue to benefit spring Chinook salmon by reducing the likelihood that high flows would scour and disrupt salmon eggs incubating within redds (compared to the unregulated condition). However, the rate at which flows are reduced during flood control operations is also a factor (see below).

5.2.2.3 Flow Fluctuations

The Action Agencies propose to operate Project dams in an effort to meet an 0.1 ft. per hour downramping rate restriction during nighttime hours and an 0.2 ft. per hour rate restriction during daylight hours, when possible. These rates are derived from available literature on protective ramping rates compiled by Hunter (1992). Based on the best available information, NMFS assumes that meeting this commitment would be sufficient to minimize the adverse effects of rapid discharge fluctuations on stranding and entrapment of juvenile salmonids downstream of Project dams as long as existing equipment at the dams allows the USACE to operate within the proposed restrictions. However, the Action Agencies have indicated that the USACE will be unable to meet these ramp rate restrictions during periods when flow releases approach proposed minimums (USACE 2007a). This suggests that the proposed protections of juveniles against rapid flow changes may be inadequate to prevent losses. Results of studies that the Action Agencies have proposed for evaluating the effectiveness of their efforts to control ramp rates below Project dams will address this issue and may indicate a need for improved ramp rate controls.

5.2.2.4 Water Contracting

The USACE's Middle Fork projects are lightly used for water supply purposes. Reclamation has contracted a total of 253 acre-feet of water from the USACE reservoirs for irrigation within the Middle Fork subbasin. This use would increase dramatically under the proposed action as the Reclamation intends to issue contracts to an additional 813 acre-feet of water stored in USACE's Middle Fork basin projects and has proposed to issue contracts for delivery of up to an additional 10,000 acre-feet of water throughout the Willamette basin.[1]

The USACE intends to continue serving these contracts with water released from storage to maintain project and mainstem minimum flows. That is, under the proposed action more water would be removed from the Middle Fork Willamette River during the irrigation season without any additional water being released from USACE's reservoirs. In general, Reclamation water service contracts are supplemental to natural flow water rights held by individual water users and are only exercised when natural flows are insufficient to serve all users and meet instream water rights held by ODWR. Assuming that such conditions would occur for only about 60 days each summer, the total level of future Reclamation-supported water use could reduce flows in some sections of the Middle Fork Willamette River by about 7.7 cfs. Summer low flows at the USGS's Jasper, Oregon gage have seldom fallen below 400 cfs with a minimum for the period of record of 366 cfs. Thus the total amount of project-supported flow reduction would be about 2 percent of the lowest flows observed in the river. Also, the effects of water withdrawals on juvenile rearing habitat in the Middle Fork Willamette River are mitigated during July and August in most years when it becomes necessary to release water stored at the Hills Creek, Lookout Point, Dexter, and Fall Creek reservoirs to maintain the Albany and Salem minimum flows. The annual fall drawdown reduces the impact of September water withdrawals. By October, irrigation water use is substantially reduced and the streamflows tend to be increasing as the western Oregon rainy season begins. The proposed level of water service to be provided by Reclamation under the proposed action is not expected to appreciably impact anadromous salmonids in the Middle Fork Willamette River watershed.

5.2.2.5 Flow-related Research, Monitoring & Evaluation (RM&E)

The Action Agencies would develop and implement a comprehensive research, monitoring and evaluation program to determine compliance with, and effectiveness of, their flow management action. The RM&E program would be designed to better discern and evaluate the relationships between flow management operations and the resulting dynamics of ecosystem function and environmental conditions downstream of Willamette Project dams, and related effects on ESA-

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[1] No specific location for these future contracts has been specified. If these contracts follow the areal distribution of current Reclamation contracts, less than one-half percent (40 acre-feet) would be issued to serve areas in the Middle Fork subbasin.

listed fish species. The recommendations for a Flow Management RM&E program would be integrated into the comprehensive program overseen by the RM&E Committee and following the principles and strategic questions developed by the committee.

5.2.3 Water Quality

Water temperature and dissolved gas supersaturation are important water quality characteristics that are affected by operation of the dams in the Middle Fork Willamette and which influence natural production of UWR Chinook salmon in habitat downstream of the dams. The Proposed Action would continue operation of the Projects as has occurred since 2000. The details of these actions are described in the Supplemental BA (USACE 2007a). The water quality is degraded because temperatures are warmer when they should be colder, and vice versa, as well as having high TDG and toxics levels. A summary of the effects of the Proposed Action on all of the water quality attributes is described in Table 5.2-5.

5.2.3.1 Water Temperature

Spring Chinook are ectothermic, meaning that their body temperature is regulated by the surrounding water; thus water temperature significantly affects survival, development, growth, migrations, and diurnal movement of salmon in both the fresh- and salt-water (Quinn 2005). In the Willamette River Basin, water temperatures below the dams have an important effect on adult migrations upstream, prespawning mortality, egg survival and development, and juvenile growth. Lower temperatures than normal below dams contribute to pre-spawner straying and mortality for adult Chinook; for juveniles, elevated temperatures cause reduced egg viability and increase susceptibility to disease. These effects extend from Dexter Dam to the confluence of the Willamette and McKenzie rivers, approximately 17 miles; from Fall Creek Dam to the confluence of the Middle Fork, approximately 7 miles; and from Hills Creek Dam to upper end of the Lookout Point Reservoir, approximately, 9 miles (Willis 2008).

Under the proposed action, the temperature of water released from Fall Creek, Hills Creek, and Lookout Point/Dexter dams would continue to be altered as compared to pre-dam conditions. Water is colder in the summer and warmer in the fall (e.g., Figure 5-2.2). NMFS anticipates that few fish would survive to spawn in the reach below the dams and the available information suggests egg survival would continue to be very low due to high temperatures during the incubation period in the fall. Taylor and Garletts (2007) reported in a study of egg survival above and below Dexter/Lookout Point dams that 100% of the eggs incubating below Dexter Dam died before emergence. The eggs began to show signs of fungus growth as soon as 10 days after fertilization. Only one sac-fry developed enough to hatch, but was deformed and died. In contrast, 81% of the eggs incubating in natural water temperatures in Salmon Creek (an unregulated stream above the dams) survived to the swim-up fry stage.

For those few eggs that may survive below Dexter Dam, accelerated development allows the alevins to emerge from the gravel earlier than would occur naturally. Emergence during winter flow conditions has been shown to reduce juvenile fish survival because alevins are exposed to scouring flows associated with winter freshets. Using a different method of analysis, Taylor and Garletts (2007) compared hatch and emergence timing of juvenile spring Chinook from below and above Dexter Dam based on cumulative temperature units (Figure 5-2.2). He estimated an emergence date for eggs incubating below Dexter Dam to be November 18th, compared to February 1st for eggs incubating in natural water temperatures upstream—a difference of approximately 2.5 months (Figure 5.2-3).

The Action Agencies propose to continue operating the dams under current configurations and flow regimes. No water temperature control structures or operational changes that could decrease the temperature problems associated with the dams are proposed for the Middle Fork Willamette.

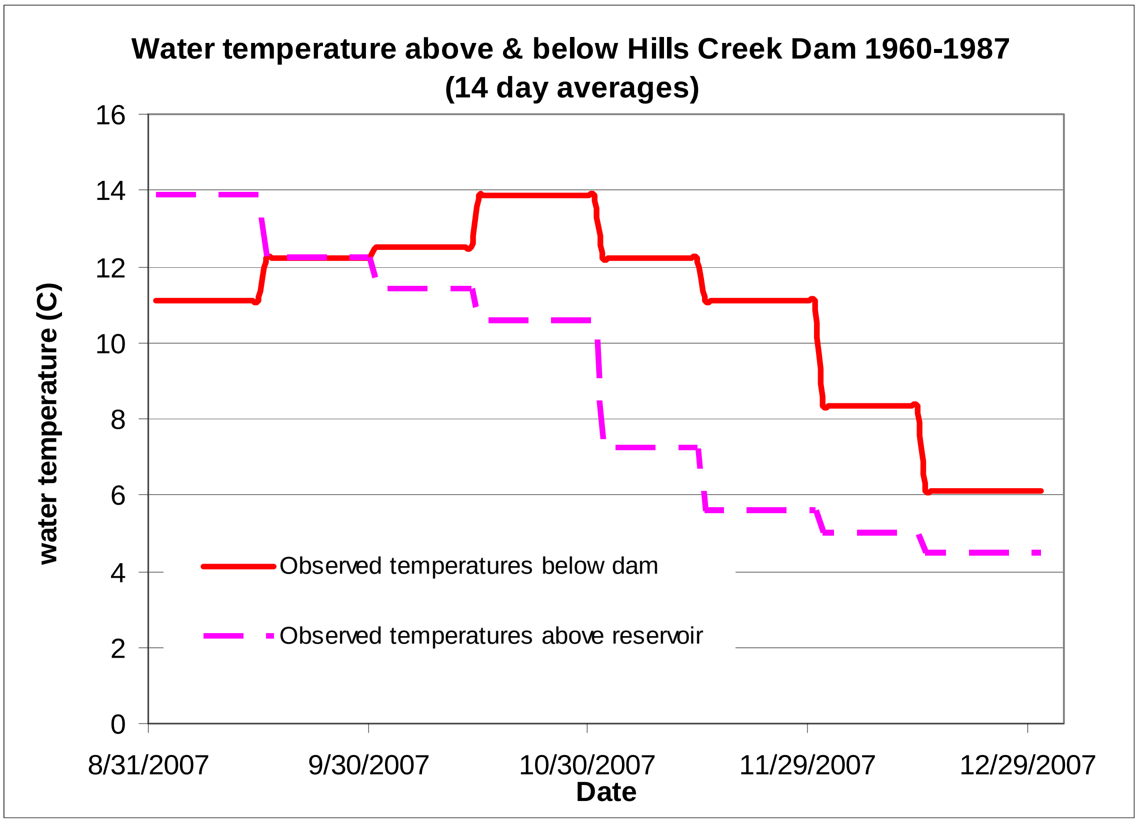

Figure 5.2-2 Comparison of observed water temperatures above Hills Creek reservoir (natural temperatures) and below Hills Creek dam (altered temperatures) in the Middle Fork Willamette during Chinook spawning and egg incubation. Data are 14 day averages from 1960-1987.

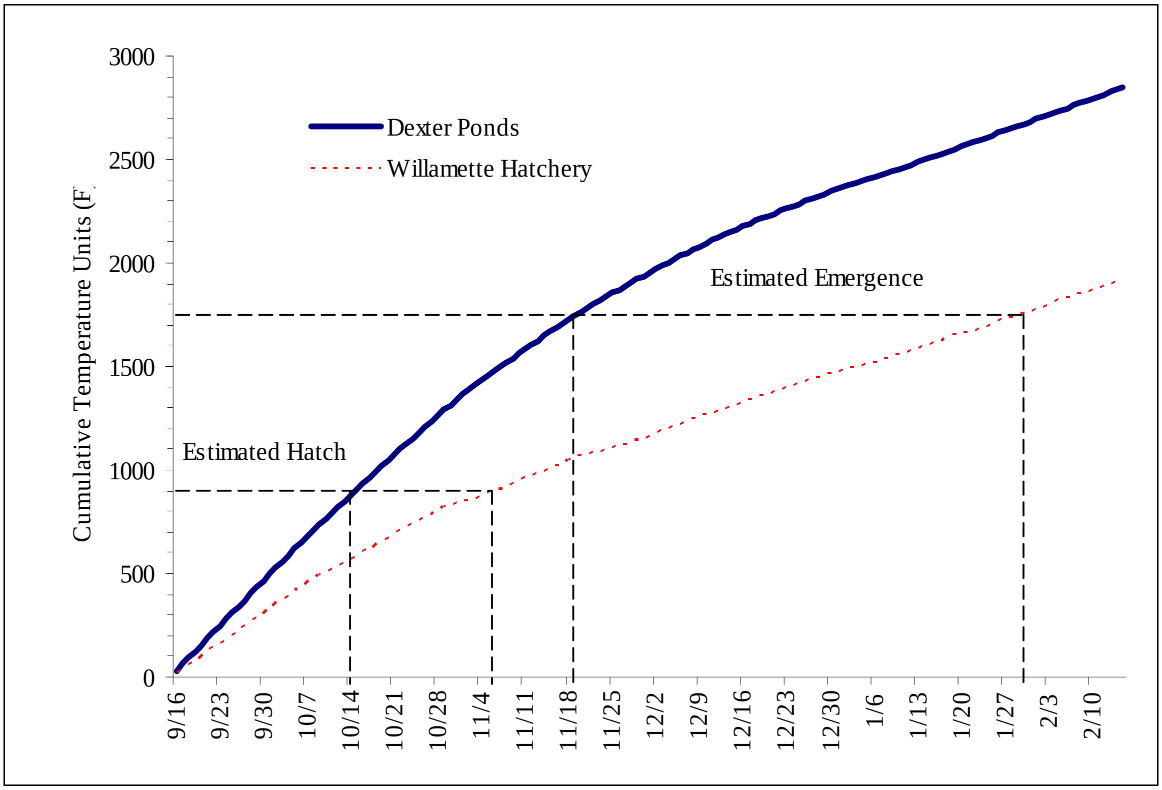

Figure 5.2-3 Comparison of estimated hatch and emergence timing of spring Chinook incubating in natural water temperatures above Dexter Dam (Willamette Hatchery) and altered water temperatures below Dexter Dam (Dexter Ponds). Figure taken from Taylor et al. (2007).

5.2.3.2 Total Dissolved Gas (TDG)

Dissolved gas concentrations exceeding 105% of saturation (i.e., supersaturated), which can be detrimental to spring Chinook eggs and alevins, have been observed downstream from Dexter Dam (Monk et al. 1975). Because most of spawning occurs near the dam, it is likely that eggs would be exposed to elevated dissolved gas levels. The extent of TDG-related juvenile mortality has not been documented, but it is reasonable to assume that some occurs when spill operations and flow management drive TDG above 105% at the redd level during the fall and winter periods. TDG effects are assumed to extend one mile below Dexter and Fall Creek dams. (Willis 2008).

Hills Creek Dam
Spill over 1,500 cfs can generate more than 110% TDG at the surface (100% at the gravel assuming an average depth of about 1 m) below Hills Creek Dam. In most years, spill stays below this level. The winter of 1996 was an exception: 25 days in January, 10 days in February, 11 days in November, and 15 days in December (Willis 2008).

Dexter Dam
Spill over 1,000 cfs through 1 spillway bay at Dexter Dam generates more than 115% TDG at the surface (about 105% at the gravel) below Dexter Dam. In most years, spill stays below this level (exceeded about 30% of the time during January 1996) (Willis 2008).
Fall Creek Dam

Spill over 1,500 cfs generates more than 110% TDG at the surface (about 100% at the gravel) below Fall Creek Dam. In most years, spill stays below this level. The winter of 1996 was an exception: 21 days in January, 5 days in February, 13 days in November, and 10 days in December (Willis 2008).

5.2.4 Physical Habitat Quality

The key proposed actions related to physical habitat quality in the Middle Fork Willamette subbasin that will affect UWR Chinook salmon are the following:

- Continue to operate Dexter, Lookout Point, Hills Creek, and Fall Creek dams, blocking sediment and large wood transport from upstream reaches and tributaries into the lower Middle Fork Willamette River and Fall Creek.
- Continue to reduce peak flows as part of flood control operations at the four dams, preventing creation of new gravel bars, side channels, and alcoves that provide rearing habitat for anadromous salmonids
- Continue the existence and maintenance of 1.47 miles of revetments along the lower Middle Fork Willamette River, preventing channel migration and reducing channel complexity.
- Study effects of Project dams and revetments on downstream habitat and consider projects to restore habitat, including gravel augmentation, if authorized and funding becomes available.
- Continue the Willamette Floodplain Restoration Study, including focus on mechanisms to provide channel-forming flows from Project dams in the Middle Fork Willamette subbasin and possibly testing peak flow releases.

5.2.4.1 Substrate, Sediment Transport, Large Wood, & Channel Complexity in the Middle Fork Willamette Subbasin

Under the environmental baseline, substrate, sediment transport, large wood, and channel complexity are degraded and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon (section 4.2.6). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.2-5 and described below. These effects occur year-round and extend from:

- Dexter Dam to the confluence with the Coast Fork Willamette River, about 17 miles.
- Fall Creek Dam to the confluence with the Middle Fork Willamette River, about 7 miles.
- Hills Creek Dam to the upstream end of the Lookout Point Reservoir, about 9 miles (Willis 2008).

Under the Proposed Action, operation of Dexter, Lookout Point, Hills Creek and Fall Creek dams for flood control would continue to store sediment and large wood in the reservoirs, prevent recruitment of large wood and sediment from streambanks, allow stabilization of formerly active bar surfaces, and prevent flows capable of creating new bars, side channels, and alcoves. These habitat features are used by UWR Chinook salmon for rearing and spawning, and when substrate is coarsened and side channels deprived of new sediment, macroinvertebrate productivity decreases, reducing food availability for rearing fish, and redd construction and egg survival is likewise reduced (See Appendix E for summary of fish and habitat relationships). As described in section 4.2.3.4, operation of the USACE dams in the Middle Fork Willamette has trapped gravel and large wood from 90% of the Middle Fork Willamette subbasin and has reduced the magnitude of peak flows. As a result of both the altered hydrologic regime and the dams acting as barriers to sediment transport, fish rearing and spawning habitat below the dams would continue to be degraded by substrate coarsening and the inability to create new gravel bars, islands, and side channels.

The Proposed Action additionally includes continued existence and maintenance of 1.47 miles of revetments in the lower Middle Fork Willamette River. The revetments would continue to prevent the recruitment of gravel from the floodplain and would limit lateral migration of the channel. The reduction in peak flows would exacerbate these problems by reducing the frequency of flows with sufficient magnitude to re-shape the channel and form new habitat.

The continued degradation of habitat downstream of Dexter and Fall Creek dams would likely further reduce the carrying capacity of this habitat for rearing juvenile fish and spawning adults, thus reducing the number of individual UWR Chinook salmon that can be produced in this presently degraded habitat. Because adults do not have access to historical spawning grounds upstream of Dexter Dam, a reduction in spawning habitat in the reaches below Dexter could further limit spawning or contribute to overuse of redds (i.e., a second female could disrupt the eggs of one that’s already spawned). A lack of complex rearing and refugia habitat in both the mainstem Middle Fork Willamette and its tributaries could also limit juvenile production in the subbasin, particularly since the temperature regime in this river is high enough to cause the early emergence of fry in winter months, when fry need refuge from high waters (see Section 5.2.3 Water Quality, above). Aside from unspecified habitat restoration actions that may result from the Willamette Floodplain Restoration Study and other proposed studies related to gravel augmentation and other habitat features, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the Middle Fork Willamette subbasin.

5.2.4.2 Riparian Vegetation & Floodplain Connectivity in the Middle Fork Willamette Subbasin

Under the environmental baseline, riparian vegetation and floodplain connectivity are degraded and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon (section 4.2.6). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.2-5 and described below.

Under the Proposed Action, operation of the Willamette Project and continued existence and maintenance of 1.47 miles of revetments in the lower Middle Fork Willamette River would continue to degrade riparian vegetation and floodplain connectivity by preventing recruitment of large wood and sediment that creating new bars and islands on which riparian vegetation can establish and by preventing peak flows that maintain stream connectivity to the floodplain. Although the Proposed Action includes study of potential habitat restoration and gravel augmentation in reaches below the dams, there is no certainty that any restoration work would be done during the term of this Opinion. Given the adverse water temperature conditions in the lower Middle Fork Willamette River associated with Project operations (as described in Section 5.2.3 Water Quality), and the lack of fish passage to historical upstream habitat (as described in

Section 5.2.1 Habitat Access/Fish Passage), further degradation of physical habitat characteristics would reduce what little habitat remains available to the UWR Chinook salmon population in the Middle Fork Willamette subbasin.

The extent and function of the Middle Fork Willamette subbasin's riparian vegetation and floodplains have been and would continue to be impaired by operation of the Willamette Project under the proposed action. Hills Creek Reservoir inundated approximately 200 acres of riparian hardwoods, while Lookout Point and Dexter reservoirs inundated another 2,025 acres of riparian forest along the Middle Fork Willamette River. Fall Creek Reservoir inundated approximately 6.8 miles of riparian vegetation along Fall Creek. USACE revetments replaced approximately 4 miles of riparian vegetation along the Middle Fork Willamette River, such that 50% of the banks below river mile 19 are hardened (USACE 1989b). 1.47 miles of these revetments would be maintained by the USACE under the proposed action.

The flood control afforded by the Willamette Project in the Middle Fork Willamette subbasin has probably increased development within the floodplain and indirectly facilitated clearing of riparian vegetation for agricultural, residential, and urban development, and this effect would continue under the proposed action. However, additional development in the floodplain is at the discretion of private parties, so these effects are discussed in Chapter 6 (Cumulative Effects).

As described above in sections 5.2.4.1, operation of Hills Creek, Lookout Point, Dexter, and Fall Creek dams would continue to trap gravel and large wood and reduce the magnitude of peak flows in the Middle Fork Willamette subbasin. Both of these operations deprive downstream reaches of material and transport mechanisms needed to create new gravel bars and floodplains on which new riparian vegetation can establish. Additionally, USACE revetments would continue to prevent river migration and contribution of sediment from 1.47 miles of streambank in the lower Middle Fork Willamette, further depriving the river of sediment and the ability to construct new surfaces on which riparian vegetation can establish.

Conclusion

The proposed operation of the Willamette Project would continue to reduce the extent, quality, and inundation frequency of riparian and floodplain forests in the Middle Fork Willamette subbasin downstream of Dexter and Fall Creek dams. This limits recruitment of large wood into the aquatic system, which is needed to deposit spawning gravel, create resting pools for migrating adults, and provide cover for rearing juveniles or outmigrating smolts. Reduced inundation of forested floodplains limits nutrient and organic matter exchange during flood events, and reduces the availability of high-water refugia for juveniles, which could limit over-wintering survival of rearing juveniles. Aside from unspecified habitat restoration actions that may result from the Willamette Floodplain Restoration Study, the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain connectivity in the Middle Fork Willamette subbasin. Given the lack of upstream and downstream passage to historical habitat above Project dams, and the limited habitat below the dams for spawning, rearing, and holding, continued degradation of this habitat under the Proposed Action would put the Middle Fork Willamette population of UWR Chinook salmon at even higher risk of extinction than its current status.

5.2.5 Hatcheries

As described in Chapter 2, the Proposed Action is to continue to artificially propagate hatchery spring Chinook salmon (ODFW stock # 22) and summer steelhead (ODFW stock # 24) and release these fish into the Middle Fork Willamette River at Dexter Dam. Further details about these programs are described in the Middle Fork Willamette spring Chinook HGMP (ODFW 2003) and Willamette Basin summer steelhead HGMP (ODFW 2004a).

Below is an analysis of the specific effects of these actions on listed spring Chinook in the Middle Fork Willamette.

5.2.5.1 Hatchery Operations

There are two hatchery facilities located within the Middle Fork watershed. The broodstock collection facility is located at the base of Dexter Dam. The Willamette Hatchery, used to incubate and rear hatchery fish, is located upstream of Dexter and Lookout Point Reservoirs on Salmon Creek, a small tributary to the Middle Fork Willamette. As described above in the "General effects of hatchery programs on ESA-listed salmon and steelhead" section, there are two primary concerns with the effects of hatchery facilities on listed spring Chinook in the Middle Fork- 1) risk of facility failure leading to fish mortality in the hatchery (particularly progeny of wild fish), and 2) improperly screened water intakes at the hatchery facility that lead to the mortality or injury of naturally rearing listed fish. Other potential adverse of effects of the facilities or related activities are addressed below.

The occurrence of catastrophic loss (or unforeseen mortality events) of spring Chinook at the Willamette Hatchery has been very low over the last several decades because facility failures have resulted in few mortalities in the past and there is a very low percentage of wild fish offspring being reared at this hatchery (Table 5.2-3). Therefore, NMFS considers this risk to continue to be very low.

The water intake for the water supply at Willamette Hatchery is located on Salmon Creek. Due to the significant problems associated with the adult outplanting program to date to re-establish natural production above Dexter/Lookout Dams, the presence of juvenile Chinook in the area of Willamette hatchery is likely to be minimal. Most of the observed juvenile production of Chinook has been downstream of the hatchery in the North Fork of the Middle Fork Willamette. The extent of designated critical habitat in Salmon Creek is limited to the lowermost reach of the creek. A significant barrier to fish occurs just upstream of the hatchery intake—limiting the habitat available to juvenile and adult Chinook. Even though the water intake at the hatchery does not meet NMFS criteria for listed juvenile fish, the risk of juvenile fish being taken into the hatchery's water supply is very low due to the lack of juvenile Chinook in Salmon Creek at this time.

Table 5.2-3 Composition of spring Chinook salmon without fin clips that were spawned at Willamette Hatchery, based on the presence or absence of thermal marks in otoliths, 2002–2006. . (from McLaughlin et al. (2008).

	Unclipped[a]		Fin-clipped	Percent wild	
Year	**Wild**	**Hatchery**	**hatchery**	**in broodstock**	**of run**
2002	5	53	1,602	0.3	---
2003	5	59	1,465	0.3	---
2004	16	28	1,807	0.9	---
2005	19	24	1,497	1.2	---
2006	45	55	1,608	2.6	---

[a] *Includes fish with partial or questionable fin-clips.*

5.2.5.2 Broodstock Collection

Dexter Dam

The Dexter broodstock collection facility is located at the base of Dexter Dam. When the trap is opened at the dam, spring Chinook enter volitionally. The fish collected are either used for broodstock or are trucked upstream of the dam and released to spawn in historically occupied habitat. During the period 2000-2006, between 5,541 and 11,375 Chinook were collected each year at the Dexter trap. Willis (2008) estimates <1% injury and 1% mortality during handling, and an additional 2% mortality during the subsequent truck transport operations (Willis 2008). Even though the direct levels of injury and mortality of spring Chinook during the collection process are low, significant handling stress does occur. The facility was designed only for hatchery broodstock collection; significant crowding of fish occurs and fish are transferred out-of-water between the holding pond and the trucks. These conditions are thought to contribute to the chronically high levels of post-release, prespawning mortality of adult spring Chinook (Section 5.2.2.1). However, high levels of prespawning mortality occur throughout the subbasin and the other contributing factors are unknown.

The Action Agencies have proposed to rebuild the collection facility at Dexter Dam to allow build trapping, handling, sorting, and loading of hatchery and wild spring Chinook salmon. The schedule for completing the new trap is not specified in the Supplemental BA, thus NMFS cannot rely on this actions to occur or on the accrual of benefits to the Middle Fork Willamette Chinook population.

Fall Creek Dam

During the period 2000-2007, between 339 and 2,805 Chinook were collected each year at the Fall Creek trap. Willis (2008) estimates <1% injury and <1% mortality during handling, and an additional 1% mortality during the subsequent truck transport operations (Willis 2008). Even though the direct levels of injury and mortality of spring Chinook during the collection process are low, significant handling stress does occur.

The Action Agencies have not proposed to rebuild the collection facility at Fall Creek Dam.

5.2.5.3 Genetic Introgression

Significant genetic introgression from hatchery fish into the natural population in the Middle Fork Willamette River has occurred since this mitigation program was initiated in the 1950's. Ever since all returning hatchery fish have been mass marked (adipose finclipped) so that they could be distinguished from naturally-produced fish in 2002, nearly all of the returns have been hatchery fish (see section 4.2.2.1 and Figure 4.2-3). In addition, nearly of the fish spawning naturally below Dexter Dam have been hatchery fish (Table 5.2-4). The percentage of natural-origin fish recovered in carcass surveys on the spawning grounds has ranged from 4% to 18% from 2002-2005. Hatchery origin fish have dominated the spawning grounds and the percentage of natural-origin fish incorporated into the hatchery broodstock has been very low (see Table 5.2-3, above). Thus the PNI values for this population have been very low since 2002, indicating hatchery fish are dominating genetic processes in this population (Figure 5.2-4).

Table 5.2-4 Composition of spring Chinook salmon in the Middle Fork Willamette subbasin based on carcasses recovered. Source: McLaughlin et al. (2008).

	Fin-	Unclipped[a]		Percent
River (section), run year	**clipped**	**Hatchery**	**Wild**	**wild[b]**
Middle Fk Willamette (Dexter–Jasper[c])				
2002	228	91 (85)	16	5
2003	62	48 (92)	4	4
2004	120	32 (59)	22	13
2005	37	10 (50)	10	18

[a] The proportion of hatchery and wild fish was determined by presence or absence of thermal marks in otoliths. Number in parentheses is percentage of unclipped fish that had a thermal mark (unclipped hatchery fish).
[b] Percentage not weighted for redd distribution.
[c] Including Fall Creek. Data on clipped fish in spawning population were incomplete for 2006.

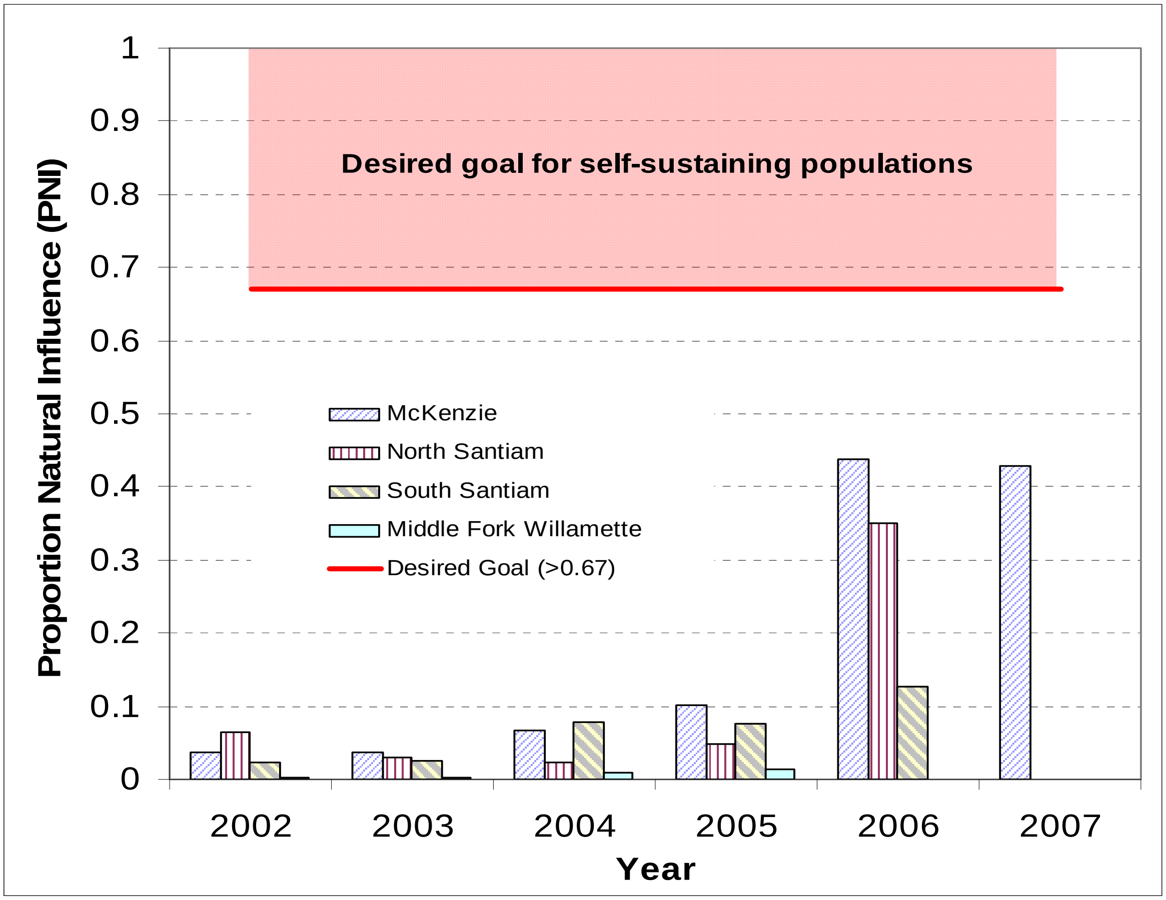

Figure 5.2-4 Proportionate natural fish influence (PNI) in four Chinook salmon populations within the Willamette Basin. PNI is an index of the influence of hatchery or natural fish within a population. PNI values greater than 0.67 indicate relatively low hatchery influence within a population (the desired goal for a naturally, self-sustaining population that does not rely on the continual support from artificial propagation).

The influence of hatchery fish should not be reduced until significant improvements are made to address the causes for the lack of natural production in this population. The reason why hatchery fish are influencing this population to a substantial degree is because there are so few natural-origin fish returning (<100 in recent years). The root causes for the lack of wild fish production must be addressed before any improvements in the hatchery situation can be made. The current spring Chinook hatchery program could be eliminated entirely and natural production in this population would not improve substantially due to the lack of historically habitat currently available and the temperature problems for incubating eggs downstream of Dexter Dam in the fall (see the discussion of these effects above). The current hatchery program is a consequence of the choices that were made in the 1950's to mitigate for fishery losses associated with the construction and operation of Fall Creek, Dexter, Lookout Point, and Hills Creek dams in the Middle Fork spring Chinook population.

5.2.5.4 Disease

Hatchery fish can be agents for the spread of disease to wild fish residing in the natural environment. Due to the high rearing densities of fish in the hatchery, hatchery fish can have elevated levels of certain pathogens, disease, and/or bacteria. After they are released, these fish may expose and/or transfer the disease to wild fish. Below is an assessment of these risks to the juvenile and adult life stages.

Juveniles
In the Middle Fork Willamette subbasin, the risk of hatchery fish spreading disease to wild juvenile Chinook salmon is low. The hatchery fish are released as smolts from Dexter Dam, located low in the watershed, thus interaction with wild juveniles is minimized. In addition, natural production is so poor in this population, not many wild fish are present in the area where hatchery fish are released.

The effects of hatchery fish interacting with other Chinook and steelhead populations downstream are addressed in the section "Mainstem Willamette River."

Adults
The potential also exists for returning hatchery fish to spread diseases to wild adult fish commingled in the area below Dexter Dam. Since this dam is located low in the watershed, spring Chinook have a tendency to congregate at the base of the dam. Thus, thousands of fish are residing together which increases the risk of spreading any kind of disease. Available information suggests the adults that die before spawning have a variety of pathogen and bacterial infections (Schroeder et al. 2006). However, it is unknown whether hatchery fish elevate the disease outbreaks in wild fish.

5.2.5.5 Competition/Density Dependence

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Information on the potential competitive interactions between hatchery and wild fish is very limited in the Willamette Basin. Below is an assessment of the likely implications on the juvenile and adult life stages.

Juveniles
Given the poor natural production within the Middle Fork Willamette population, particularly downstream of Dexter Dam, where juvenile hatchery fish are present, it is unlikely competition between hatchery and wild Chinook is occurring at an adverse level of effect.

Adults
Given the problem of crowding of adult Chinook at the base of Dexter Dam, there is the potential for competitive interactions for space. There is a limited amount of habitat in the holding pool at the base of the dam. It is unknown whether adult fish are displaced into suboptimal holding habitat downstream due to the high number of fish at the base of the dam. Given the primary limiting factors for this population (habitat access, temperature problems), competition is not likely one of the primary or secondary limiting factors.

5.2.5.6 Predation

Hatchery fish released into the population areas throughout the Willamette Basin can predate upon co-occurring wild fish. In general, salmonids can prey upon fish approximately 2/3 of their size. Thus there is significant potential for hatchery summer and spring Chinook to prey upon wild steelhead and Chinook. Even though information is lacking on the extent of this issue, predation by hatchery fish undoubtedly occurs. Schroeder et al. (2006) examined predation by hatchery summer steelhead and rainbow trout on Chinook fry in the McKenzie River. Predation did occur on Chinook fry by a few individual fish. However, due to the fast digestion rates of Chinook fry in the stomachs of summer steelhead and rainbow trout (e.g. one to seven hours), it was difficult to estimate the amount of predation in their sampling design. Given the primary and secondary limiting factors identified for Willamette populations, predation by hatchery fish is not likely a limiting factor and the risk to listed fish is low.

5.2.5.7 Residualism

All hatchery programs in the Willamette Basin release hatchery fish as smolts. The intent is to release the hatchery fish at a size and time so that they will actively migrate to the ocean; thus minimizing the potential interaction between hatchery and wild fish. However, a percentage of the smolts do not emigrate and residualize in the river. These residual fish may migrate to the ocean at a later time or may stay in freshwater the rest of their life.

In general, hatchery steelhead have more of a tendency to residualize than hatchery spring Chinook. In the Willamette Basin, the primary concern is with residual summer steelhead. The percentage of the smolt release of summer steelhead that do residualize is unknown. However, residual summer steelhead have been observed in all areas where hatchery fish are released. Several new actions are included in the Proposed Action that will help reduce the adverse effects of residual summer steelhead on wild winter steelhead and spring Chinook. The most beneficial is the proposal to not release any summer steelhead smolts that do not volitionally emigrate from the hatchery facility. These “non-migrants” will be collected and released into standing water bodies for trout fisheries. Previously, all of these non-migrant fish were forced out into the river. In addition, ODFW is proposing a new angling regulation that will allow the harvest of any fin-clipped, residual summer steelhead in all recreational fisheries. These regulation changes will decrease the number of residual hatchery fish left in the river and thus reduce adverse effects of residual fish on wild steelhead and spring Chinook.

5.2.5.8 Fisheries

As discussed in the “General effects of hatchery programs on ESA-listed salmon and steelhead” section above, the production of hatchery fish can lead to commercial and recreational fisheries that cause the overharvest of natural-origin fish. An abundance of hatchery fish can promote expanding fisheries, which may be detrimental to commingled natural-origin fish. In the Willamette, all hatchery fish have been mass marked since the 1990s. This mass marking has facilitated implementation of selective fisheries—where only hatchery fish can be harvested. Thus freshwater fishery impacts on winter steelhead and spring Chinook have been reduced substantially compared to historical harvest rates. Freshwater fishery impacts are now in the range of 1-5% for winter steelhead and 8-12% for spring Chinook populations in the Willamette Basin.

The production of Willamette hatchery fish are of no consequence to the management of ocean fisheries. In general, steelhead (of either natural or hatchery origin) are rarely caught in ocean fisheries. Hatchery spring Chinook are caught in ocean fisheries, particularly in Alaska and West Coast Vancouver Island fisheries (see Figure 4.2-13) in the Fisheries section of the Environmental Baseline chapter). However, these hatchery fish are not a driver for fisheries management. Protection of other stocks of concern in Canada and the United States currently constrain ocean fishery quotas and regulations. In addition, harvest of Willamette spring Chinook in ocean fisheries is governed by the Pacific Salmon Treaty between the US and Canada and impacts have been typically been in the range of 10-15%.

5.2.5.9 Masking

The production of unmarked hatchery fish can have an impact on wild fish if these hatchery fish stray and intermingle with wild populations. Not knowing whether naturally spawning fish are of hatchery- or natural-origin confounds the ability to monitor the true status of the wild population. This effect has been termed “masking” by hatchery fish.

In the Willamette Basin, this concern has been eliminated because all hatchery spring Chinook, summer steelhead, and rainbow trout are all adipose fin-clipped. In addition, all hatchery spring Chinook are otolith marked in the hatchery which provides an additional safeguard to detect hatchery fish that may have been missed during fin-clipping (currently <5% of all the smolt releases; McLaughlin et al. 2008). The Action Agencies are also proposing to coded wire tag (CWT) all hatchery spring Chinook salmon, which will also allow individual fish to be identified upon their return to freshwater.

5.2.5.10 Nutrient Cycling

Hatchery fish can provide essential marine-derived nutrients to the freshwater environment if they spawn naturally or are outplanted as carcasses (see “General effects of hatchery programs on ESA-listed salmon and steelhead” section above). Hatchery spring Chinook salmon and summer steelhead are known to spawn naturally throughout the Willamette Basin, thus providing benefits in terms of marine nutrients to the local environment. Thousands of hatchery-origin Chinook are also outplanted alive above the dams in an effort to restore natural production in historical habitats. This provides benefits to aquatic and terrestrial food chains.

5.2.5.11 Monitoring & Evaluation

Monitoring and evaluation of Willamette hatchery programs under the ESA began in response to NMFS’ (2000) *Biological Opinion on the impacts from the collection, rearing, and release of listed and non-listed salmonids associated with artificial propagation programs in the Upper Willamette spring Chinook and winter steelhead ESUs.* The ODFW implemented specific monitoring and evaluation activities to collect information on the effects of hatchery programs in the Willamette (NMFS 2000a).

Monitoring and evaluation of hatchery programs in the Willamette Basin will continue to occur in order to assess whether the programs are meeting their intended goals and to evaluate the impacts on wild populations. The specific HGMPs for each program describe the monitoring and evaluation that will occur in the future.

5.2.6 Summary of Effects on the Middle Fork Willamette Chinook Salmon Population

Below is a summary of the effects of the Proposed Action on the four Viable Salmonid Population (VSP) parameters (abundance, productivity, spatial structure, and diversity) for the Middle Fork Willamette Chinook salmon population. These VSP parameters are described in detail in Section 3. All four of the VSP parameters for the Middle Fork Willamette spring Chinook population are at very risk levels (ODFW 2007b).

Abundance
The current abundance of naturally-produced Chinook salmon in the Middle Fork Willamette population is very low. The current status of this population is at very high risk of extinction (see Chapter 3, Rangewide Status). The latest available information indicates naturally-produced fish returns to the base of Dexter and Fall Creek dams (the lowermost dams) and spawning below these dams was likely in the range of 200-300 wild fish from 2005-2007 (Schroeder et al. 2006; McLaughlin et al. 2008; Taylor 2008b). Most of the wild Chinook production appears to be coming from above Fall Creek Dam, and virtually no wild Chinook production occurs above or below Dexter Dam. The abundance of hatchery-origin Chinook returning to the Middle Fork Willamette is comparatively very high and stable (NMFS 2004b).

The Willamette/Lower Columbia Technical Recovery Team has identified the Middle Fork Willamette as a “large” and “core” population for the ESU. In order for this population to be considered viable (less than 5% risk of extinction), the geometric mean abundance over the long term should exceed 700 to 1,400 naturally-produced, wild spring Chinook (WLCTRT and ODFW 2006). The draft Recovery Plan for UWR Chinook salmon (ODFW 2007b) states the Middle Fork Willamette population would be at low risk if it had an average abundance of 2,000-2,600 natural fish. Thus, significant survival improvements are necessary to improve the populations’ current status of very high risk.

Taking into account existing conditions and analysis of effects described above, the Proposed Action would continue to restrict natural production of UWR Chinook salmon in the Middle Fork Willamette watershed. The elimination of nearly all of the historical spawning and rearing habitat in the watershed due to the construction of Fall Creek, Dexter, Lookout Point, and Hills Creek dams has been the primary factor leading to the current low abundance of this population. In addition, the high prespawn mortality rates observed with Chinook (predominately of hatchery-origin) throughout the summer residing below Fall Creek and Dexter Dams and outplanted above the dams has greatly limited spawning success and, the number of offspring produced for the next generation.

Given the relatively high return of hatchery fish every year to the base of the dams, efforts to reintroduce Chinook back into their historical habitat have been occurring using hatchery fish. The results of these outplanting efforts have been variable and unpredictable. In most years, high prespawn mortality rates limit the number of hatchery fish that spawn. However, in certain years, as observed in 2006 when adult mortality rates were significantly lower throughout all of the Chinook populations in the Willamette, hatchery fish have spawned and produced significant numbers of juvenile offspring. However, it is not known what proportion of these juvenile Chinook survive the emigration through the large reservoirs and high-head dams that have no juvenile fish passage facilities. Information to date suggests survival through the dams varies depending upon migration timing and operations, but likely ranges from 20-60% (see above section “Reservoir and Dam Survival.”

Given the poor returns of wild Chinook to this population and the continuing adverse effects of the Proposed Action on the species and PCEs of critical habitat in the watershed, NMFS expects population abundance to continue to decline under the Proposed Action.

Productivity

A viable salmon population has a productivity rate (or recruits per spawner) that is equal to or greater than one (McElhany et al. 2000). In other words, a population that is not replacing itself is not viable over the long term. Productivity of the Middle Fork Willamette population has been declining over the long- (>50 years) and short-terms (<6 years). Given the long-term decline of wild Chinook in this population from tens of thousands of fish before 1950 to the current two to three hundred fish, significant improvements in productivity are needed in order for this population to increase in abundance. Survival increases are needed in adult survival, egg incubation, and juvenile downstream passage in order for the productivity rate to be greater than one over several generations. However, NMFS does not expect productivity of this population to improve under the Proposed Action as a result of 1) continued limited and degraded spawning habitat below Dexter and Fall Creek dams; 2) low survival of eggs from redds in this habitat caused by adverse water temperatures released from Project dams; and 3) lack of access to upstream habitat capable of producing more fish.

Spatial Structure

The spatial structure of the Middle Fork Willamette UWR Chinook salmon population has been severely constrained due to the lack of or very inadequate passage at the four Project dams in the watershed. Over 95% of the historical spawning habitat is currently not naturally accessible to Chinook. Access to the upstream habitat is dependent upon the fish being captured, transported, and released above the dams and reservoirs. Juvenile Chinook movement within the watershed is constrained by the large reservoirs and dams. The dams do not inhibit downstream movement of juveniles, although mortality is high, but upstream movement by juveniles throughout the watershed cannot occur. The use of hatchery fish for outplanting above the dams has provided some spatial structure benefits to the population by allowing fish to access historical habitats. The success of this program has been mixed; depending upon adult survival. The Proposed Action identifies possible improvements to existing traps at Dexter and Fall Creek dams that, if funded and carried out, would improve upstream passage to this habitat. Additionally, the Proposed Action includes studies conducted as part of the Willamette System Review Study that could result in downstream fish passage facilities at one or more of the dams. However, no certainty is provided that the studies will be funded or improvements will be made at the dams during the term of this Opinion. Consequently, until adequate upstream and downstream passage facilities are provided at some (or all) of the projects, the spatial structure of this population will continue to be severely impacted by the Proposed Action.

Diversity

Since the Middle Fork Willamette UWR Chinook salmon population is at very high risk of extinction and the abundance and productivity of this population is depressed, its natural life history diversity is simplified. Due to the high mortality rates of adults and juvenile migrating downstream through the reservoirs and dams, there are strong selective pressures that allow only a small segment of the population to survive in these altered conditions. Consequently, there is likely to be only certain life history types that survive and reproduce, thus confining the natural life history diversity needed for a healthy population to survive over the long term under varying environmental conditions.

In addition, the continual and widespread spawning of hatchery fish in all areas continues to pose risks to the long term survival and diversity of a potentially reestablished natural population. Once the primary limiting factors of habitat access and fish passage through the reservoirs and dams are corrected, the hatchery program will have to be managed to limit the effects of hatchery fish on the recovering wild population. The Proposed Action will not manage the effects of the hatchery on diversity until more wild fish return to the population and can be incorporated as broodstock.

Conclusion for Middle Fork Spring Chinook

Significant improvements to the status of the Middle Fork spring Chinook population are necessary in order to improve the viability of the ESU as a whole. Historically, this population may have been the most abundant in the ESU, but now is at “very high” risk of extinction. The likelihood of improving the status of this population, considering the Environmental Baseline, Proposed Action, and Cumulative Effects, is low. Re-establishing natural production in historical habitats above Project dams is of critical importance.

5.2.7 Effects of the Proposed Action on Designated Critical Habitat

- The Middle Fork Willamette River and a number of its tributaries have been designated as Critical Habitat for UWR Chinook salmon. Table 5.2-5 identifies the anticipated effects of the Proposed Action on the PCEs of this habitat. The effects are attributable to a lack of functional fish passage at USACE dams, the effects these dams and their reservoirs have on water quality and physical habitat conditions in the lower reaches of the Middle Fork and Fall Creek, and USACE maintenance of 2.86 miles of revetments. The following PCEs will be adversely affected by the Proposed Action:
- Freshwater spawning sites above the USACE dams, with flow regimes, water quality conditions, and substrates well suited to the species’ successful spawning, incubation, and larval development, will continue to be at best marginally accessible to naturally produced UWR Chinook. Spawning habitat below Dexter and Fall Creek dams is accessible to these fish, but this habitat is degraded as a result of ongoing Project operation. Flow releases from Dexter, Lookout Point, and Hills Creek dams continue to create adverse temperature conditions that result in delayed spawning, embryo mortality, and accelerated incubation in the habitat below Dexter. This habitat is also affected by sudden Project shutdowns that can cause extreme ramping of outflows, which reduces the quality of spawning habitat by dewatering redds, reducing egg-to-fry survival. The habitat is further degraded by the Project’s interruption of sediment transport, such that new gravels needed for spawning are not replacing those that move downstream during high flows. Additionally, the continued

existence and maintenance of revetments downstream of Dexter Dam prevent channel formation processes that might otherwise allow for new gravels and spawning habitat to be created.

- The quantity and quality of freshwater rearing sites for juvenile UWR Chinook will remain limited and degraded in the fully accessible portion of the Middle Fork subbasin, below Dexter and Fall Creek dams, and may continue to decline. Diminished peak flows, lack of sediment and LWD delivery from areas above Project dams, and revetments, contribute to losses of off-channel rearing habitat and impair processes that would otherwise create complex habitats along main channel areas. Sudden reductions in outflows below Project Dams may, when flows are relatively low, continue to pose risks of juvenile stranding and loss.
- Historically important migratory corridors will continue to be obstructed by Dexter, Lookout Point, and Hills Creek dams and reservoirs. Under current conditions these obstructions preclude reestablishment of a productive naturally spawning UWR Chinook population in the subbasin. Although trap and haul facilities will continue to operate under the Proposed Action, these facilities are outdated and, without modification, do not ensure unobstructed migration corridors. Functional downstream passage conditions for juveniles have yet to be established at any of the USACE dams.

In aggregate, these effects will continue to diminish habitat availability and suitability within the Middle Fork subbasin for juvenile and adult lifestages of UWR Chinook. These adverse effects to the functioning of designated critical habitat within the subbasin will limit the habitat's capacity to serve its conservation role supporting a large, productive, and diverse population.

Table 5.2-5 Effects of the Proposed Action on UWR Chinook salmon population (VSP column) and critical habitat (PCE column) in the Middle Fork Willamette River subbasin. Modified from USACE 2007a, Table 6-4

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater migration corridors	Habitat Access	Physical Barriers	Population abundance and productivity, and spatial distribution, have the potential to substantially increase as a result of successfully re-establishing a self-sustaining, naturally produced population of spring Chinook salmon in habitat located upstream of Dexter, Lookout Point, Fall Creek, and Hills Creek dams, but under the Proposed Action, the likelihood of this occurring is low.	Upstream passage will continue to be inadequate unless the Action Agencies firmly commit to rebuild Dexter and Fall Creek traps; downstream passage will continue to kill and injure juvenile fish unless the Action Agencies complete studies and commit to improve survival at the dams to levels comparable to that at other dams in the NW. Fish will continue to lack access to historical habitat.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in Peak/Base Flow	Improved ramping rates and flow conditions below Dexter Dam would reduce risks to ESA-listed fish species. If water temperature conditions are also improved, the improved ramping and flow conditions could result in improved ecosystem health and function, expanded rearing habitat, higher egg-to-smolt survival, improved migration conditions, and improved overall productivity. As a result, local population abundance also may increase. Biological monitoring would document changes in local habitat conditions and in local population productivity resulting from a combination of Action Agency actions.	Flow-related components of habitat quality for UWR Chinook will be improved in the near-term within areas downriver of the USACE dams in the subbasin. Longer term effects of diminished flood events on channel processes that help create or maintain channel complexity will continue.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Continue to limit juvenile production from lower Middle Fork Willamette below Dexter, Hills Creek below Hills Cr dam, and Fall Cr below Fall Cr. Dam.	With no firm commitment on when and if temperature control will be carried out, NMFS expects continued temperature effects, significantly reducing juvenile production from lower Middle Fork Willamette below Dexter, Hills Creek below Hills Cr dam, and Fall Cr below Fall Cr. Dam.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ turbidity	No effect.	No change in effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination /Nutrients	Flow management at USACE dams within the subbasin will continue to elevate summer flows and dilute pollutants, providing a benefit to ESA-listed salmonids downstream of the dams. The consequences of this particular benefit are likely minor relative to the substantially negative effect that unnaturally warm temperatures below Dexter and Fall Creek dams during fall have on the spawning success and emergence timing of UWR Chinook (see above).	No change in effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	No effect.	No change in effect.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	No change in effect. Occasional spills may elevate TDG to levels sufficient to harm UWR Chinook embryos, alevins, and juveniles in the Middle Fork Willamette River below Dexter Dam	No change in effect
Freshwater spawning sites	Habitat Elements	Substrate	Continued lack of new gravels to existing spawning habitat below dams reduces abundance and productivity of UWR Chinook salmon by limiting and degrading available habitat.	Operation of Project dams will continue to block sediment transport to downstream reaches, further increasing substrate coarsening, and thereby degrading limited spawning habitat. .
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris (LWD)	Continued lack of large wood reduces abundance and productivity of UWR Chinook salmon in the Middle Fork Willamette because holding and rearing habitat below the dams continues to be degraded and is not being replaced.	Operation of Project dams will continue to block transport of large wood from reservoirs to downstream habitat; revetments will continue to prevent floodplain connectivity, reducing large wood recruitment from streambanks, resulting in less structure available to create complex channel habitat, gravel bars and large pools...

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Continued degradation of pool habitat will reduce rearing and adult holding habitat, resulting in lowered productivity and abundance	Continued low frequency of pools and poor pool quality below Dexter and Fall Creek dams. Operation of Project dams and continued existence and maintenance of revetments will continue to prevent peak flows, block sediments and large wood, preventing channel movement that would allow for new pools to form.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-Channel Habitat	Continued lack of off-channel habitat will reduce rearing habitat, resulting in lowered productivity and abundance.	Continued reduced off-channel habitat below Dexter and Fall Creek dams. Project operation will continue to reduce peak flows, limiting overbank flows, and channel forming processes. Although studies may consider special operations to provide peak flows, the Action Agencies provide no certainty that this operation will occur during the term of the Opinion, nor that the operation will connect the main channel to off-channel habitat.
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/Depth Ratio	Continued degraded channel conditions habitat will reduce rearing habitat, resulting in lowered productivity and abundance.	Project operation will continue to reduce peak flows and block large wood and sediment transport, limiting channel forming processes. Although studies may consider special operations to provide peak flows, the Action Agencies provide no certainty that this operation will occur during the term of this Opinion.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Streambank condition	Degraded streambanks will inhibit channel forming processes that create complex habitat essential for juvenile rearing, adult spawning and holding, resulting in lowered productivity and abundance.	Project operation and revetment existence and maintenance will continue to prevent streambanks from supporting natural floodplain function in the Middle Fork Willamette below Dexter Dam. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve streambank conditions, the Action Agencies provide no certainty that these changes will be funded or carried out during the term of this Opinion.
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain Connectivity	Continued lack of floodplain connectivity reduces availability of off-channel habitat, limiting available rearing habitat, including reduced macroinvertebrate production as a food supply, resulting in lowered productivity and abundance.	Project operation and continued existence and maintenance of revetments will continue to prevent overbank flow and side channel connectivity in reaches below Dexter and Fall Creek dams. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve off-channel habitat, restoring normative ecosystem functions, the Action Agencies provide no certainty that these changes will be funded or carried out during the term of this Opinion.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	Continued degradation of riparian habitat will reduce large wood available for channel complexity, thereby reducing already limited rearing, holding, and spawning habitat, resulting in lowered abundance and productivity.	Project operation and continued existence and maintenance of revetments will continue to prevent formation of new gravel bars on which riparian vegetation could grow below Dexter and Fall Creek dams. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially restore riparian vegetation, the Action Agencies provide no certainty that these changes will be funded or carried out during the term of this Opinion.

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Chapter 5.3
McKenzie River Subbasin Effects

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5.3 McKenzie River Subbasin: Effects of the Willamette Project Proposed Action on UWR Chinook Salmon & Critical Habitat

Summary of the Effects of the Proposed Action

- The effects of the Proposed Action on the McKenzie population of Chinook salmon would be continued degradation of habitat downstream of Cougar Dam and restricted access to historical habitat, reducing abundance and productivity of this population and adversely modifying critical habitat. The Proposed Action would continue to:
  - Restrict fish access to historical spawning and rearing habitat;
  - Degrade physical habitat downstream from the dam complex;
  - Decrease fitness and productivity of the population due to excessive hatchery stray rates.
- Continued operation of the temperature control tower at Cougar Dam would restore normative water temperatures to downstream fish habitat in the South Fork McKenzie and McKenzie rivers, increasing productivity of those UWR Chinook salmon spawning below the dam.

In the McKenzie River subbasin, the only listed anadromous fish species is UWR Chinook salmon. The McKenzie population is a stronghold population for the ESU and still sustains the highest production of natural-origin spring Chinook salmon in the Willamette Basin. The current abundance however is greatly reduced compared to historical levels and the population is at a "moderate" risk of extinction (McElhany et al. 2007). The primary causes for the decline of this population include loss of access to historical spawning and rearing habitat, altered physical and biological conditions downstream of the dams (hydrograph, temperature, flow, recruitment of gravel and woody debris), interbreeding between hatchery and natural-origin Chinook, and unscreened water diversions (Leaburg-Walterville canals). For a full description of the status of the ESU and Environmental Baseline, see Chapters 3 and 4 above.

Taking into account the environmental baseline and current status of the McKenzie population, described briefly in the preceding paragraph and in detail within section 4.3, below is an assessment of the effects of the Proposed Action in the McKenzie River subbasin.

The Proposed Action includes the following broad on-the-ground actions:

- Current configuration, continued operation, and maintenance of Cougar Dam on the South Fork McKenzie River and Blue River Dam on Blue River, both in the McKenzie River watershed.
- Flow Management- volume and seasonal timing of water released from Cougar and Blue River dams.

- Ramping Rates- efforts by the USACE to limit downramping rates below Cougar and Blue River dams to no greater than 0.1 ft. per hour during nighttime hours and 0.2 ft. per hour rate during daylight hours.
- Hatchery Program- continued production of hatchery Chinook at McKenzie Hatchery for fishery augmentation and conservation purposes.
- Outplanting Program- trap and haul of UWR Chinook from below Cougar Dam to release locations above impassible barriers in the McKenzie, as well as locations below barriers on the McKenzie, to hatcheries for spawning, and other unnamed locations (USACE 2007a, Table 3-16)
- Cougar adult fish collection facilities- operate and maintain a new fish trap at the base of Cougar Dam.[1]

In this section, NMFS considers the effects of the Proposed Action on the McKenzie Chinook salmon population. In general, NMFS expects that the Proposed Action would cause continued degradation of habitat downstream of Cougar Dam and restricted access to historical habitat, reducing abundance and productivity of this population. NMFS expects the Proposed Action will result in some improvements in hatchery management, although straying of hatchery fish will continue to be a problem, resulting in further decline in genetic diversity from baseline conditions. NMFS concludes that the Proposed Action will continue to harm individual fish such that the McKenzie Chinook salmon population will continue to decline and critical habitat will continue to be adversely modified as a result of the Proposed Action.

5.3.1 Habitat Access & Fish Passage

Cougar Dam blocked 56 km (Myers et al. 2006, p 55) of spawning habitat historically available to the McKenzie population of UWR Chinook. Blue River Dam blocked 2.7 miles (USACE 2007a). The Action Agencies propose, as an interim measure, to continue to experimentally[2] transport some UWR Chinook above Cougar Dam (USACE 2007a) providing a modicum of upstream passage. Downstream passage of juvenile salmon through the reservoir and dam would continue to occur under the current configuration of the project, but would be problematic in the current downstream configuration. Juvenile salmon would pass through either the turbines or regulating outlet at Cougar Dam, depending on how much water is released and whether turbines are in service. Neither downstream passage route is equipped with a screen or other bypass structures that would allow it to safely pass juvenile fish.

The Action Agencies propose to conduct several studies to evaluate passage mortality over the term of the Opinion. However, no definitive actions are proposed at this time to help improve downstream passage of juvenile salmon beyond baseline conditions of project configurations and operations. Therefore, with respect to habitat access, there would be no improvement over baseline conditions certain.

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[1] Construction of the proposed Cougar Adult Fish Facility was consulted upon separately; however, facility operation is part of this consultation.

[2] USACE 2007a, p. 3-43,48. The Action Agencies state that their Proposed Action is not to be construed as a commitment to permanently restore access to now-blocked historical habitat, but that they will do this to a degree to evaluate *". . . the natural production potential of historic habitat."*

The key proposed actions related to habitat access in the McKenzie River watershed that need to be evaluated for the effects on UWR Chinook salmon are the following:

- Continue to use a portion of the broodstock collected at McKenzie Hatchery for the outplanting program, and truck and haul these fish above Cougar reservoir, and release them in appropriate habitat to spawn.
- In 2010, begin to collect adult fish at the proposed Cougar adult fish collection facility (construction addressed in a separate biological opinion (NMFS 2007a) and use a portion of these fish for the outplanting program.
- Continue to pass juvenile salmon downstream through the Cougar reservoir and dam under current configurations. Flow operations would be as described in the Supplemental BA.
- Conduct the "Willamette System Review Study" that will evaluate downstream passage alternatives at Cougar Dam and reservoir. The actual order in which the McKenzie River would be studied among the other watersheds would be determined in Phases I and II of the study. However, the North Santiam was proposed to be first priority (USACE 2007a).

UWR Chinook salmon access to historical habitat blocked by the dams (particularly in the South Fork McKenzie above Cougar Dam) in the McKenzie River is of critical importance in order to reduce spatial structure risks of the population, increase the habitat area available for reproduction to mitigate for habitat effects downstream of the Projects, and utilize the high quality habitat upstream of the impassable dams.

The following is an assessment of the adult outplanting program, resulting juvenile production, and downstream juvenile fish survival through the reservoirs and dams.

5.3.1.1 Upstream Passage/Potential Utilization of Blocked Habitat

Outplanting of adult Chinook salmon above Cougar dam, the lowermost impassable barrier in the watershed, began in the early 1990s (Beidler and Knapp 2005). Of those hatchery Chinook salmon that were transported and released above Cougar Dam, some successfully spawned in the habitat above Cougar Reservoir, and produced juvenile fish, some of which emigrated downstream through Cougar Reservoir and Dam. The outplanting of Chinook above Cougar Dam has been more successful than other outplanting efforts in the basin (Beidler and Knapp 2005; ODFW 2007a). The mortality of adults released above Cougar Dam has been low. The combination of relatively good collection facilities (McKenzie hatchery), good quality adult fish that have not held for an extended period below an impassable dam, short travel time to point of release, and high quality habitat above Cougar Dam in the South Fork McKenzie have all likely contributed to the greater success of the outplanting program here in the McKenzie compared to other areas (Beidler and Knapp 2005). As discussed further below in section 5.3.1.2, a relatively high number of smolts (14,000 fish; Taylor 2000) have been observed below Cougar Dam considering less than 1,000 outplanted fish would have produced these juvenile offspring (Beidler and Knapp 2005).

Construction of a new fish trap at the base of Cougar Dam was described in Baseline section 4.3.3.1.3. NMFS completed a biological opinion on this project (NMFS 2007a), and construction is expected in 2009. Operation of the new Cougar trap would be part of this

Proposed Action. It would allow UWR Chinook salmon, and other fish species, that ascend to the base of Cougar dam to be captured for later truck transport to various dispositions. Willis estimates that about 1300 UWR Chinook will be handled annually by this trap, with 1% mortality and another 1% injured in trapping operations, another 1% mortality in transport operations (Willis 2008). Some trapped fish would be transferred and released above the dam where abundant quality habitat remains. Some fish would likely be taken to hatcheries for artificial spawning, while other, hatchery-origin fish might be returned downstream to allow anglers further opportunities to catch them. Fish could also be returned to the base of Cougar Dam, although the Action Agencies propose this only if other options are precluded. The facility would have several ponds in which to hold and segregate fish to facilitate their later transfer. While fish subjected to handling and trucking always have some risk of being injured or killed, fish at this modern facility would be handled as gently as current technology allows. This fish trap would include a short fish ladder to assist in raising the fish to a level where trapping operations could be conveniently conducted. The ladder could hypothetically be extended in future years to allow fish a means to volitionally pass over Cougar Dam. However, extending the ladder is unlikely due to the 452' height of the dam and the wide range of forebay water surface elevations that would need to be accommodated by a ladder.)

The practice of holding fish in the river below dams (rather than either trapping or passing them immediately) means that adult fish holding below dams have increased likelihood of trying to swim up into turbines, where they may experience severe injuries. Such injuries have been noted at Cougar Dam (Wade 2007). Particularly when turbines are started and stopped, velocities in turbine tailraces are reduced to levels that are within the swimming abilities of UWR Chinook, and they may seek to move upstream through the turbines if no alternatives are presented.

Once constructed, the new Cougar trap, designed as closely to NMFS hydraulic design criteria as possible, would be less stressful to fish than the other existing traps at the base of Project dams. However, even the safest trap facilities and transport operations put stress on fish due to handling, sampling, and delay in passage. NMFS does not consider trap and haul as a preferred method of upstream passage at a dam (NMFS 2008e) and would expect that under the Proposed Action, a small proportion of individual UWR Chinook salmon adults would experience physiological stress during these operations, resulting in increased rates of prespawning mortality compared to fish that are not subjected to trap and haul.

The Chinook outplanting program above Cougar Dam on the South Fork McKenzie has been more successful than in other areas. Even though prespawning mortality of outplanted Chinook is suspected to still be high, spawning of fish in the fall has been consistently observed. The improved collection, handling, and transporting protocols identified in the supplemental BA will likely improve adult survival once fully implemented in the future (ODFW 2007a). There is also concern with the continued outplanting of only hatchery-origin Chinook above Cougar Dam and the risks to the genetic integrity of the McKenzie population as a whole (as described in section 5.3.5.3).

5.3.1.2 Juvenile Production

Between 1998 and 2000 Taylor experimentally introduced adult UWR Chinook above Cougar Dam, which resulted in their subsequent spawning, and juvenile production. Productivity of upstream habitat was not specifically investigated, however, prior to the construction of the dam the area was noted as highly productive and little had changed. The screw traps placed by Taylor below the dam caught 14,000 juvenile UWR Chinook during this period, indicating indirectly that the habitat remains suitable (Taylor 2000.)

5.3.1.3 Reservoir & Dam Survival

Downstream fish passage through Cougar reservoir and dam is causing adverse effects on fry and smolt life stages of UWR Chinook salmon. Juvenile fish must migrate downstream through the reservoirs and pass over or through the dams on their seaward migration. Data on the survival rate of juvenile Chinook through the reservoirs and dams in the McKenzie River is limited. Studies conducted by Taylor between 1998 and 2000 showed that between 81.9% and 92.9% of fish trapped immediately below the Cougar Dam turbines survived, while 67.7% of fish passing through the Regulating Outlet (a non-turbine route) survived (Taylor 2000, p. 4).

5.3.1.4 Willamette System Review Study

The Proposed Action describes a process that will be undertaken for the Willamette Project (all 13 Project dams in the Willamette Basin) to prioritize fish passage needs and improvements. There are five phases to the study that will occur within the next 15 years. Since no specific actions have been identified in the study proposal for the McKenzie River, it is currently unknown what the potential benefits may be to this population in the future from eventual actions that may be carried out as a result of this comprehensive study. NMFS expects that there will be significant benefits to UWR Chinook salmon and UWR steelhead at various tributaries in the Willamette Basin eventually, if the Action Agencies complete the studies and carry out recommended fish passage, water quality, and habitat improvement projects.

Conclusion

The effect of the Proposed Action on habitat access and fish passage in the McKenzie subbasin would be to continue to provide good upstream passage conditions for adult spring Chinook at Cougar Dam on the South Fork McKenzie River, based on operation of the soon-to-be-constructed Cougar trap at the base of the dam. This will continue to provide good spatial distribution for UWR Chinook salmon by ensuring adult fish access to what was once a heavily used spawning area. Downstream passage conditions for the offspring of adults passed above Cougar Dam would remain poor at the dam unless new and effective downstream passage facilities are constructed and operated as an outcome of the Willamette System Review Study. It is uncertain whether or when effective downstream passage conditions would be provided at the dam.

5.3 2 Water Quantity/Hydrograph

Under the environmental baseline, the Action Agencies are attempting to provide streamflow conditions below USACE dams that will support properly functioning habitat for UWR Chinook salmon. These attempts appear successful except that active flood control operations may dewater incubating eggs downstream from Cougar Dam, flood control impairs processes that might otherwise create complex salmonid habitat, and equipment at the dam may be insufficient to keep downramp rates low enough to assure that juvenile fish will not be entrapped or stranded when flows are low (see Section 4.3.3.2). Other water developments, notably EWEB's Leaburg and Walterville developments also have small adverse flow-related effects on UWR Chinook. Increasing population and water demands in the Eugene, Oregon area indicate that flow-related anadromous fish habitat will likely continue to decline in the environmental baseline for the duration of this Opinion.

The Action Agencies propose to continue flow management as conducted since 2000. This includes attempting to meet specified seasonal minimum and maximum flows, seasonal drafting and refilling, and ramping rates for changing discharge. Thus the hydrologic effects of the Proposed Action would be the same as those described under the environmental baseline for the McKenzie River (Section 4.3.3.2).

5.3.2.1 Seasonal Flows

The Action Agencies propose to continue flow management as conducted since 2000. This includes attempting to meet specified seasonal minimum and maximum flows, seasonal drafting and refilling, and ramping rates for changing discharge.

The USACE has estimated the frequency with which it anticipates not meeting the minimum and maximum flows under its proposed operations (Table 5.3-1). Failure to meet these flows will affect the South Fork of the McKenzie River to its confluence with the mainstem McKenzie River, about 4 miles, by limiting adult spawning and holding habitat; for juveniles, eggs may be desiccated, barriers to juvenile rearing habitat presented, and opportunities for stranding and entrapment during flow fluctuations enhanced.

Table 5.3-1 Estimated frequency that proposed minimum and maximum tributary flows would not be met downstream from projects in the McKenzie River. Source: Donner 2008.

Dam	Period	Primary Use	Minimum Flow (cfs) [1]	Chance of Not Meeting Flow	Maximum Flow (cfs) [2]	Chance of Not Meeting Flow	
Blue River	Sep 1 - Oct 15	Chinook spawning	50	<1%			
	Oct 16 - Jan 31	Chinook incubation[3]	50	<1%			
	Feb 1 - Aug 31	Chinook rearing	50	<1%			

Dam	Period	Primary Use	Minimum Flow (cfs) [1]	Chance of Not Meeting Flow	Maximum Flow (cfs) [2]	Chance of Not Meeting Flow	
Cougar	Sep 1 - Oct 15	Chinook spawning	300	<1%	580 Through Sep 30, when possible	40	Sep
	Oct 16 - Jan 31	Chinook incubation[3]	300	<1%			
	Feb 1 - May 31	Chinook rearing	300	<1%			
	Jun 1 - Jun 30	Chinook rearing / adult migration	400	<1%			
	Jul 1 - Jul 31	Chinook rearing	300	<1%			
	Aug 1 - Aug 31	Chinook rearing	300	<1%			

Exceedence of maximum flow objective over a 66-year record from 1936-2001 (probability figures are approximate).

1 Minimum flow will equal inflow or Congressionally authorized minimum flows, whichever is higher, when the reservoir is at a minimum conservation pool elevation. This avoids drafting the reservoir below minimum conservation pool and, where applicable, into the power pool.

2 Maximum flows are intended to minimize the potential for spawning to occur at stream elevations that might subsequently be dewatered at the specified minimum flow during incubation. It may not be possible to stay below these maxima, especially in the fall when drafting reservoirs in preparation for the flood damage reduction management period. Project operations will be managed to minimize the frequency and duration of necessary periods of exceedence.

3 When feasible, incubation flows should be no less than ½ the maximum 72-hour average discharge observed during the preceding spawning season. Efforts will be made to avoid prolonged releases in excess of the recommended maximum spawning season discharge to avoid spawning in areas that would require high incubation flows that would be difficult to achieve and maintain throughout the incubation period.

These proposed flow objectives are consistent with recommendations developed by NMFS' staff and ODFW managers familiar with fish habitat conditions in the McKenzie subbasin. In general, the lower the frequency that these objectives are not met, the better the conditions for salmon and steelhead survival. Because these flows closely correlate with fish management agency recommendations, the best currently available information, we consider these proposed operations to be highly protective and an improvement over baseline conditions prior to 2000.

The Action Agencies also propose to conduct instream flow compliance and effectiveness monitoring and may also conduct limited experimental operations to determine if the proposed water management operations meet the needs of anadromous fish. As these data become available, NMFS anticipates that water management programs would be modified as necessary to meet anadromous fish needs. Because it is unclear whether such investigations would result in any changes in project operations, we cannot assume any benefit to anadromous fish at this time.

5.3.2.2 Frequency of Channel-forming & Over-bank Flows

By continuing to reduce the frequency of channel-forming and over-bank flows downstream from Cougar and Blue River dams, project operation would continue to limit channel complexity and thereby limit rearing habitat for juvenile UWR Chinook salmon. Peak flow reduction also reduces the recruitment and suitability of channel substrates for spawning salmon and greatly reduces recruitment of large woody debris to areas downstream of the Projects. These effects are expected to continue over the life of the Proposed Action.

On the other hand, reducing peak flows during flood events likely provides some benefits to UWR Chinook salmon by reducing the likelihood that high flows would scour redds and disrupt incubating eggs (compared to the unregulated condition), particularly in the South Fork McKenzie downstream from Cougar Dam.

5.3.2.3 Ramping Rates

The Action Agencies propose to operate the projects to meet a 0.1 ft. per hour downramping rate during nighttime hours and a 0.2 ft. per hour rate during daylight hours whenever existing equipment at their dams will allow, and to investigate the effectiveness of these measures. These rates are derived from available literature on protective ramping rates compiled by Hunter (1992).

The USACE (2007a) has suggested that existing equipment at their dams will be unable to keep downramp rates below the targeted levels when flows approach agreed-upon seasonal minimums. Until further information becomes available, NMFS considers the Action Agency efforts to constrain downramping rates to be sufficient to minimize the adverse effects of rapid discharge fluctuations on stranding and entrapment at moderate to moderately low flows but potentially ineffective at doing so when discharges from the USACE dams approach the minimums. Measures are needed to identify and carry out mechanical, operational, or structural changes that would enable the finer adjustments to meet ramping rates at low flows when they are most needed for fish protection.

5.5.2.4 Water Use

Reclamation has contracted a total of 1,640 acre-feet of water stored in Cougar and Blue River reservoirs to irrigators along the McKenzie River (USACE 2007a). As part of the Proposed Action, Reclamation intends to issue contracts to an additional 100 acre-feet of water stored in USACE's McKenzie River basin projects and has proposed issuing contracts for delivery of up to an additional 10,000 acre-feet of water throughout the Willamette basin.[3]

USACE intends to continue serving these contracts with water released from storage to maintain project and mainstem minimum flows. That is, under the Proposed Action more water would be removed from the McKenzie River during the irrigation season without any additional water being released from USACE's reservoirs. In general, Reclamation water contracts are supplemental to natural flow water rights held by individual water users and are only exercised when natural flows are insufficient to serve all users and meet instream water rights held by OWRD.

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[3] No specific location for these future contracts has been specified. If these contracts follow the areal distribution of current Reclamation contracts, about 2% or 190 acre-feet would be issued to serve areas in the South Santiam subbasin.

Assuming that such conditions would occur for only about 60 days each summer, the total level of proposed future Reclamation-supported water use could reduce flows in some sections of the McKenzie River by 15 cfs, an increase of 1 cfs over current use. Because the average flow during July and August at the USGS gaging station near Vida, Oregon (USGS Station Number 14162500) is 2580, this level of project-based water use is unlikely to substantially affect listed species. These effects are expected to continue and worsen over the life of the Proposed Action.

5.5.2.5 Flow-related Research, Monitoring & Evaluation (RM&E)

The Action Agencies would develop and implement a comprehensive research, monitoring and evaluation program to determine compliance with, and effectiveness of, their flow management actions. The RM&E program would be designed to better discern and evaluate the relationships between flow management operations and the resulting dynamics of ecosystem function and environmental conditions downstream of Willamette Project dams, and related effects on ESA-listed fish species. The recommendations for a Flow Management RM&E program would be integrated into the comprehensive program overseen by the RM&E Committee and following the principles and strategic questions developed by the committee.

5.3.3 Water Quality

Water temperature and TDG are two important water quality attributes that are affected by operation of the USACE dams in the McKenzie subbasin and that influence natural production of UWR Chinook salmon in habitat downstream of the dams. The Proposed Action would continue operation of Cougar Dam with the temperature control facility in place. The effect of this action would be to continue to provide a more normative thermal regime in the lower South Fork and in the mainstem McKenzie River below the South Fork. This regime is better suited to adult spring Chinook that migrate up the McKenzie and South Fork McKenzie rivers to spawn in these areas and is expected to continue to assure proper embryo development rates and fry emergence timing, resulting in continued survival and productivity of the McKenzie Chinook salmon population. A summary of the effects of the Proposed Action on all water quality attributes is described in Table 5.3-4.

5.3.3.1 Water Temperature

The Action Agencies propose to operate the recently completed Cougar Dam Water Temperature Control (WTC) facility to better meet downstream water temperature requirements of ESA-listed species and to undertake an extended research, monitoring and evaluation (RM&E) program associated with Cougar Dam. Evaluation of the physical and biological effects downstream from the Cougar Dam facility is critical to the decision-process associated with the potential for structural modification of other dams in the system, but will have no effect on salmon in the McKenzie.

Available water temperature monitoring data (see Figure 4.3-6) clearly shows that Cougar Dam, with the new WTC operating, no longer disrupts the natural temperature regime of the South Fork McKenzie River. Results from 2007 suggest water temperatures below Cougar Dam have improved for Chinook spawning and egg incubation compared to water temperatures before the Cougar WTC facility was constructed (Figure 5.3-1). Water temperatures in 2007 below Cougar

Dam were similar (or below) temperature targets established to benefit Chinook salmon production downstream of Cougar Dam (NMFS and USFWS 2000). The cooler fall temperatures, when eggs are developing in the redds, allow juvenile Chinook to emerge in late winter or early spring, increasing their chances of survival compared to the early emergence that occurred prior to completion of the WTC facility. Figure 5.3-2 shows calculations of estimated hatch and emergence timing of juvenile Chinook above (representing normative temperatures) and below Cougar Dam and reservoir (prior to completion of the WTC facility) based on water temperature units.

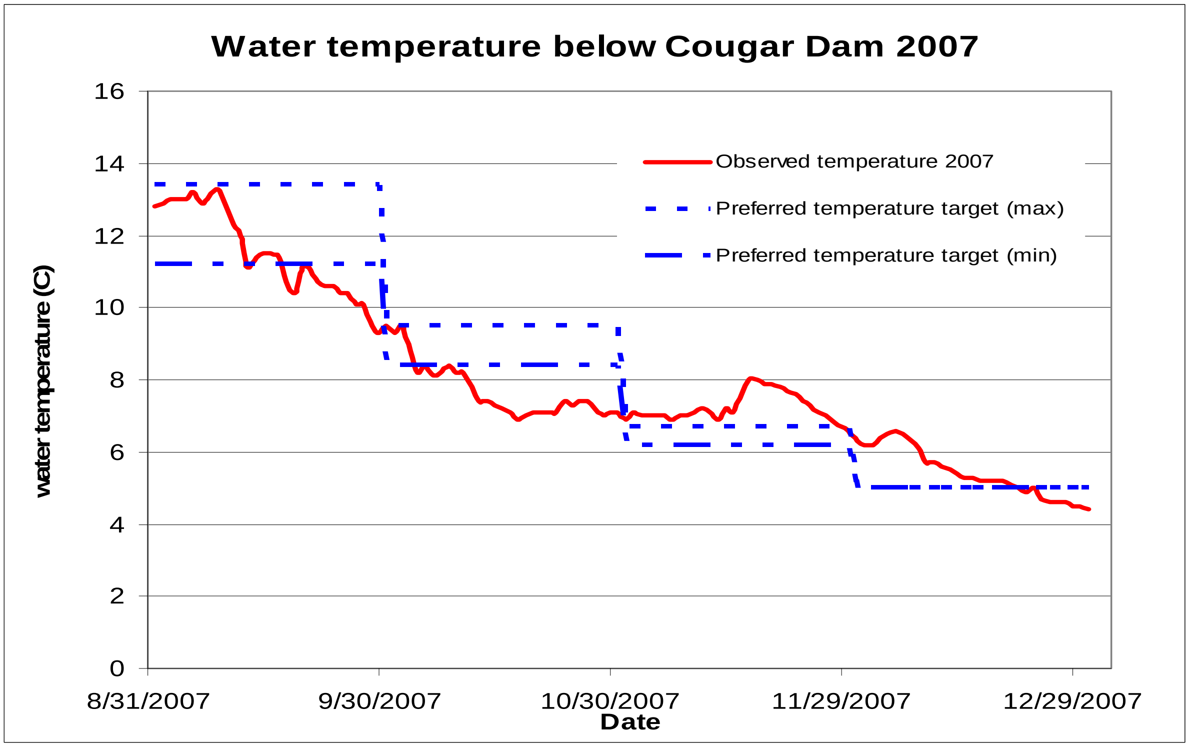

Figure 5.3-1 Comparison of observed and target water temperatures released from Cougar Dam during Chinook spawning and egg incubation in 2007.

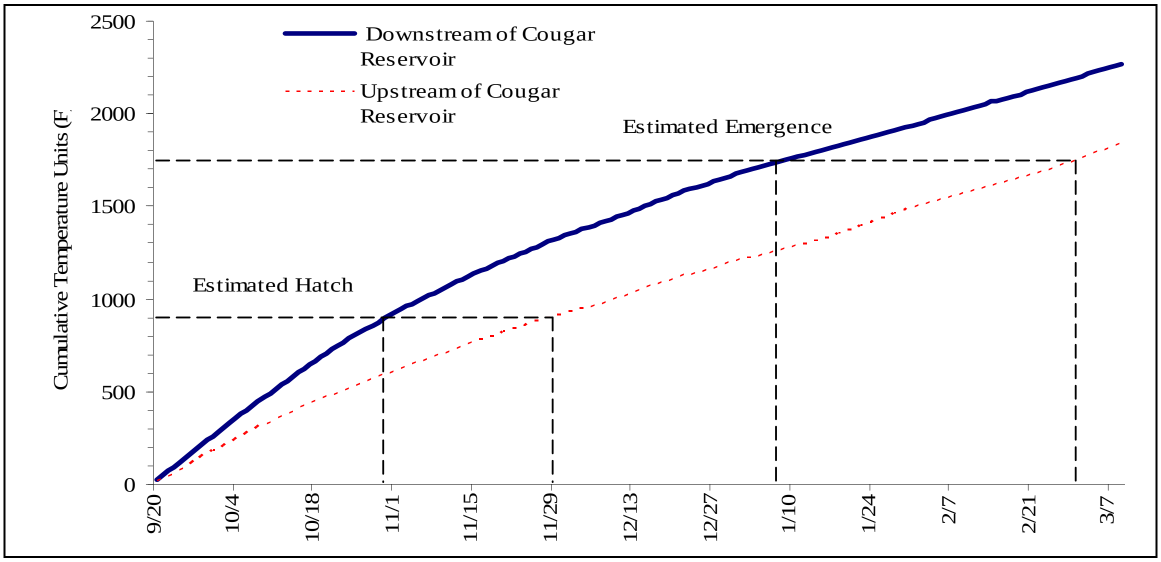

Figure 5.3-2 Estimated hatch and emergence timing of juvenile Chinook above and below Cougar Dam and reservoir, fall 2004 through late-winter 2005, before the WTC was completed. Figure taken from Taylor and Garletts (2007).

The McKenzie Chinook salmon population will likely benefit from this more normative temperature regime below Cougar Dam in terms of more natural upstream adult migration (USACE 2000) and appropriate water temperatures for spawning and egg incubation that leads to increased juvenile production with a more natural emergence timing (ODFW 1985, 1987, 2000). Available data from the Rogue River Basin has demonstrated that spring Chinook production downstream of Lost Creek Dam has benefited significantly from the WTC facility on this dam and the corresponding more normative temperature regime in late summer, fall, and early winter that improved egg survival, emergence timing, and the abundance of juvenile Chinook (ODFW 2000a). NMFS expects similar results will accrue to the natural production area affected downstream of Cougar Dam.

During development of its McKenzie River water temperature control plan, the USACE (1995) recommended the construction of temperature control facilities at both its Cougar and Blue River dams to benefit UWR Chinook salmon reproductive success. The estimated benefit was based on the combined effects of both temperature control projects on McKenzie River water temperatures and temperature-related fish production effects. Both temperature control projects were approved by Congress.

Final design and construction of the new Cougar Dam temperature control intake structure was more expensive than anticipated and the completed project proved to be more effective than had been estimated. Therefore, the likely benefits of the Blue River control structure would be smaller than anticipated.

With the agreement of the fishery agencies (NMFS, USFWS, ODFW), USACE shifted project funds from the Blue River temperature control structure to constructing a new fish trap in the South Fork McKenzie River, downstream from Cougar Dam. The fishery agencies agreed that an adult fish collection facility downstream from Cougar Dam would provide greater benefit to fish management and fish populations than would be provided by completing the Blue River water temperature control project at this time. Consequently, available funds were shifted to final design and construction of a trap and haul facility downstream from Cougar Dam. Construction of a temperature control structure at Blue River Dam was deferred. The Cougar fish trap is scheduled for completion during 2010. The Blue River temperature control structure remains authorized and the Corps could pursue project completion in the future, if warranted.

5.3.3.2 TDG

Supersaturation of dissolved oxygen in the water released below Cougar Dam has also been observed and can be detrimental to spring Chinook eggs and alevins downstream from the dam. In April 2006, USACE tested TDG under increasing spill from the Cougar Dam regulating outlet and turbine discharge ranging from 0 to 530 cfs (Britton 2006). When regulating outlet discharge reached 2000 cfs, TDG exceeded 120% in the South Fork McKenzie just below the confluence of the regulating outlet channel and the tailrace. Because TDG is compensated at greater depths,[4] TDG was estimated at 100% at depths ranging from 0.8 to 2.2 meters. Flows exceeding 2,000 cfs are projected to occur at the following frequency: Oct 0%, Nov 3%, Dec 14%, Jan 20%, Feb 7%, Mar 6%, Apr 0%, May 2%, June 1%, Jul – Sep 0%. NMFS has no information on TDG at Blue River Dam, but would expect spill operations there to cause TDG exceedences there, as well.

No other changes in the water quality conditions and their effects on anadromous fish described for the Environmental Baseline (Chapter 4) are expected in the McKenzie basin.

5.3.4 Physical Habitat Quality

The key proposed actions related to physical habitat quality in the McKenzie River subbasin that will affect UWR Chinook salmon are the following:

- Continue to operate Cougar Dam, blocking sediment and large wood transport from upstream reaches and tributaries into the South Fork McKenzie River below the dam and much of the mainstem McKenzie River.
- Continue to operate Blue River Dam, blocking sediment and large wood transport from upstream reaches and tributaries into the Blue River below the dam and the lower x miles of the mainstem McKenzie River.
- Continue to reduce peak flows as part of flood control operations at the two Project dams, preventing creation of new gravel bars, side channels, and alcoves that provide rearing habitat for anadromous salmonids.
- Continue the existence and maintenance of 4.17 miles of revetments along the lower McKenzie River, preventing channel migration and reducing channel complexity.

[4] For example, Weitkamp, D.E., and Katz, M. A Review of Dissolved Gas Supersaturation Literature. Transaction of the American Fisheries Society 9:659-702, 1980. This paper notes that depth compensates for supersaturation at an approximate rate of 10%/meter of depth.

- Study effects of Project dams and revetments on downstream habitat and consider projects to restore habitat, including gravel augmentation, if authorized and funding becomes available.

5.3.4.1 Substrate, Sediment Transport, Large Wood & Channel Complexity in the McKenzie River Subbasin

Under the environmental baseline, substrate, sediment transport, large wood, and channel complexity are degraded and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon (section 4.3.3.4). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.3-4 and described below. Adverse substrate effects on the South Fork McKenzie River extend from Cougar Dam to the confluence with the McKenzie River, about 4.5 miles (Willis 2008), and on Blue River from Blue River Dam to its confluence with the McKenzie River.

Under the Proposed Action, operation of Cougar and Blue River dams for flood control would continue to store sediment and large wood in the reservoirs, prevent recruitment of large wood and sediment from streambanks, allow stabilization of formerly active bar surfaces, and prevent flows capable of creating new bars, side channels, and alcoves. As a result, already impaired habitat would continue to degrade, limiting the abundance, productivity, and juvenile outmigrant production of the McKenzie subbasin population of UWR Chinook salmon. These effects would be most apparent in the South Fork McKenzie from Cougar Dam at RM 4.4 to its mouth, and in Blue River, from Blue River Dam at RM 1.8 to its mouth. Aside from unspecified habitat restoration actions that may result from gravel, large wood, and habitat restoration studies, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the McKenzie subbasin.

As described in sections 4.3.3.4, operation of Cougar and Blue River dams has trapped gravel and large wood from 23% of the subbasin and has reduced the magnitude of peak flows. As a result of both the altered hydrologic regime and the dams acting as barriers to sediment transport, fish rearing and spawning habitat below the dams would continue to be degraded by substrate coarsening and the inability to create new gravel bars, islands, and side channels.

Continued existence and maintenance of the USACE revetments would prevent river migration and contribution of sediment from 4.17 miles of streambank in the lower McKenzie, further depriving the river of sediment and the ability to create new gravel bars or side channels. Reduction in peak flows will exacerbate these problems by reducing the frequency of flows with sufficient magnitude to re-shape the channel and form new habitat.

The continued degradation of habitat in the South Fork McKenzie downstream of Cougar Dam and in Blue River downstream of Blue River Dam will likely reduce the carrying capacity of this habitat for rearing juvenile fish and spawning adults, thus reducing the number of individual UWR Chinook salmon that can be produced in this presently degraded habitat. Additionally, these dams would also decrease sediment input into the mainstem McKenzie River, but the adverse effects on UWR Chinook would be less dramatic because sediment inputs from other tributaries are expected to continue. Because adults do not have access to historical spawning grounds upstream of Cougar Dam, a reduction in spawning habitat in the reach below Cougar could further limit spawning and contribute to overuse of redds (i.e., a second female could disrupt the eggs of one that's already spawned). Aside from unspecified habitat restoration actions that may result from proposed habitat studies, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the McKenzie subbasin. Therefore, the effects of the proposed action on substrate, sediment transport, large wood, and channel complexity will continue to be negative for Chinook salmon.

5.3.4.2 Riparian Vegetation & Floodplain Connectivity in the McKenzie River Subbasin

Under the environmental baseline, riparian vegetation and floodplain connectivity are degraded and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon (section 4.3.3.4). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.3-4 (end of this section 5.3) and described below.

Under the Proposed Action, operation of Cougar and Blue River dams and continued existence and maintenance of 4.17 miles of revetments in the lower McKenzie River will continue to degrade riparian vegetation and floodplain connectivity by preventing recruitment of large wood and sediment that create new bars and islands on which riparian vegetation can establish and by preventing peak flows that maintain stream connectivity to the floodplain. Although the Proposed Action includes study of potential habitat restoration and gravel augmentation in reaches below the dams, there is no certainty that any restoration work will be done during the term of this Opinion. As noted above in Section 5.3.3, NMFS expects that operation of the water temperature control facility at Cougar Dam will improve conditions for spawning and incubation in the South Fork McKenzie River below the dam. Nonetheless, this limited spawning habitat would continue to degrade under the Proposed Action without habitat restoration efforts aimed at restoring floodplain connectivity and establishing riparian vegetation.

The extent and function of riparian vegetation and floodplains in the McKenzie subbasin will continue to be impaired by Cougar and Blue River dam operations under the Proposed Action. Cougar Reservoir inundated approximately 200 acres of riparian hardwoods in the South Fork McKenzie drainage, while Blue River inundated 975 acres of stream channel, riparian forest, and upland forest in the Blue River drainage. The USACE replaced 11 miles of riparian vegetation with revetments in the lower McKenzie River, and would maintain 4.17 miles of revetments under the Proposed Action.

Flood control operations in the McKenzie River subbasin have probably increased development within the floodplain and indirectly facilitated clearing of riparian vegetation for agricultural, residential, and urban development, and this effect would continue under the Proposed Action. However, additional development in the floodplain is at the discretion of private parties, so these effects are discussed in Chapter 6 (Cumulative Effects).

As described above in section 5.3.4.1, operation of Cougar and Blue River dams would continue to trap gravel and large wood and reduce the magnitude of peak flows in the McKenzie River subbasin. Both of these factors deprive downstream reaches of material and transport mechanisms needed to create new gravel bars and floodplains on which new riparian vegetation can establish. Additionally, USACE revetments will continue to prevent river migration and contribution of sediment from 4.17 miles of streambank along the lower McKenzie, further depriving the river of sediment and the ability to construct new surfaces on which riparian vegetation can establish. The reduced width of riparian forests could prevent shading of the McKenzie River, which could allow summer water temperatures to increase.

In summary, the proposed operation of the Willamette Project will continue to reduce the extent, quality, and inundation frequency of riparian and floodplain forests in the McKenzie River subbasin downstream of Cougar and Blue River dams. This limits recruitment of large wood into the aquatic system, which is needed to deposit spawning gravel, create resting pools for migrating adults, and provide cover for rearing juveniles or outmigrating smolts. Reduced inundation of forested floodplains reduces nutrient and organic matter exchange during flood events, and reduces the availability of high-water refugia for juveniles, which could limit over-wintering survival of rearing juveniles. Aside from unspecified habitat restoration actions that may result from the Willamette Floodplain Restoration Study or other habitat restoration studies described in the Sup BA, Section 3.5.2, Offsite Habitat Restoration Actions (USACE 2007a), the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain connectivity in the McKenzie River subbasin. Given the uncertainty in upstream and downstream passage to historical habitat above Cougar Dam (see Section 5.3.1), continued degradation of limited spawning and rearing habitat under the Proposed Action will put the McKenzie subbasin population of UWR Chinook salmon at even higher risk of extinction than its current status.

5.3.5 Hatcheries

As described in Chapter 2, the Proposed Action is to continue to artificially propagate hatchery spring Chinook salmon (ODFW stock # 23) and summer steelhead (ODFW stock # 24) and release these fish into the McKenzie River at McKenzie and Leaburg Hatcheries. Details about these programs are described in the McKenzie spring Chinook HGMP (ODFW 2007a) and Willamette Basin summer steelhead HGMP (ODFW 2004a).

Below is an analysis of the specific effects of these actions on listed spring Chinook in the McKenzie River.

5.3.5.1 Hatchery Operations

There are three hatchery-related facilities located within the McKenzie River watershed: 1) McKenzie Hatchery, 2) Leaburg Hatchery, and 3) fish trap at Leaburg Dam. McKenzie Hatchery collects, spawns, incubates, and rears spring Chinook salmon for the McKenzie River hatchery program. Broodstock are collected at this hatchery and also at a trap in the fish ladder at Leaburg Dam when necessary. The Leaburg Hatchery rears and releases resident rainbow trout and summer steelhead into the McKenzie River.

As described above in the "General effects of hatchery programs on ESA-listed salmon and steelhead" section 5.1 above, there are two primary concerns with the effects of hatchery facilities on listed spring Chinook in the McKenzie River- 1) risk of facility failure leading to fish mortality in the hatchery (particularly progeny of wild fish), and 2) improperly screened water intakes at the hatchery facility that lead to the mortality or injury of naturally rearing listed fish. Other potential adverse of effects of the facilities or related activities are addressed below under their appropriate section (i.e. effects of disease-laden water discharges from a hatchery on listed fish downstream).

The occurrence of catastrophic loss (or unforeseen mortality events) of spring Chinook, summer steelhead, and rainbow trout at McKenzie and Leaburg Hatcheries has been very low over the last several decades and are of no consequence to the conservation and recovery of spring Chinook. All of the normal safeguard equipment and procedures are being implemented at this hatchery. Because there have been few significant mortality accidents at this hatchery in the past, and since the fraction of wild spring Chinook used as hatchery broodstock is low (Table 5.3-2), the risk of facility failure is deemed to be a low risk to wild spring Chinook in the McKenzie population at this time.

The water intake for the McKenzie Hatchery water supply is located on Leaburg Canal (a diversion that starts at Leaburg Dam). This canal was recently screened using NMFS' criteria by the Eugene Water and Electric Board (EWEB). Since the hatchery's water supply is downstream of this screen, there should not be a problem with juvenile Chinook entering or getting impinged on the hatchery intake. Leaburg Hatchery's water intake is located upstream of Leaburg Dam on the McKenzie River. This water intake does not meet NMFS' criteria for listed juvenile salmon. The potential problems associated with this intake should be evaluated and addressed, particularly since EWEB's diversions are now screened adequately.

Table 5.3-2 Composition of spring Chinook salmon without fin clips that were spawned at McKenzie Hatchery, based on the presence or absence of thermal marks in otoliths, 2002–2006. Run of wild fish is estimated from dam count and does not include run of wild fish downstream of Leaburg Dam. Source: McLaughlin et al. (2008)

	Unclipped[a]		Fin-clipped	Percent wild—	
River, year	**Wild**	**Hatchery**	**hatchery**	**in broodstock**	**of run**
McKenzie					
2002	13	101	933	1.2	0.4
2003	14	42	953	1.4	0.3
2004	24	105	880	2.4	0.5
2005[b]	20	40	1,022	1.8	0.8
2006	100	46	845	10.1	4.6

[a] Includes fish with partial or questionable fin-clips.
[b] Otoliths were analyzed for 53 fish (of which 18 were wild).

5.3.5.2 Broodstock Collection

The only broodstock collections that occur in the McKenzie River are for spring Chinook salmon. Summer steelhead broodstock are collected at Foster Dam on the South Santiam and rainbow trout broodstock are raised at Leaburg Hatchery.

Spring Chinook broodstock are collected from volitional returns to McKenzie Hatchery and also at the fish trap at Leaburg Dam. The impacts to the wild population from broodstock collection are minimal. Ever since all returning hatchery fish have been fin-clipped, which allows wild fish to be distinguished from hatchery fish, few wild fish have been observed returning to the McKenzie Hatchery facility. In recent years, 2%-6% of the Chinook entering the hatchery were unclipped (McLaughlin et al. 2008). This equates to a range of 60 to 180 unclipped fish (of which some proportion are undoubtedly hatchery fish that did not get fin-clipped). Since the hatchery stock is an “integrated” stock, where wild fish are purposefully incorporated into the broodstock, all of these unclipped fish have been incorporated into the broodstock. In 2006 and 2007, in an effort to incorporate more wild fish into the broodstock, collections have also occurred at the fish trap on the ladder at Leaburg Dam. The trap is operated and checked daily for a few days during the peak of the wild run in June. Once the desired number of wild fish are collected for broodstock (according to the HGMP broodstock sliding scale), then trapping is discontinued and upstream migration occurs as normal.

5.3.5.3 Genetic Introgression

Genetic introgression of hatchery fish into the wild population in the McKenzie River is of significant concern and is the most critical hatchery issue in this consultation. The McKenzie population is one of two stronghold populations for the entire ESU. The WLCTRT identified this population as a “core” and “genetic legacy” population (Myers et al. 2006). A substantial amount of habitat is still functioning properly in the McKenzie River Basin, as evidenced by the thousands of wild fish that return on an annual basis. This situation is drastically different than in other populations-- like the Middle Fork Willamette or North Santiam-- where few wild fish are being produced and the only source of fish for recovery efforts are found in the abundant hatchery stock. Using hatchery fish in these populations is the only option because there are very low numbers of wild fish.

Before all hatchery fish returns were adipose fin-clipped in 2002, it was presumed that hatchery fish straying above Leaburg Dam was minimal (NMFS 2000a). However, in recent years when all hatchery Chinook returns have been marked, a substantial proportion of the Chinook that migrated upstream of Leaburg Dam were of hatchery-origin. Hatchery fish have comprised up to 36% of the spawners upstream of Leaburg Dam in the core spawning areas for this population as shown in Table 5.3-3 (McLaughlin et al. 2008). In 2005-2006, hatchery fish spawning decreased to 13-16%.

Table 5.3-3 Composition of spring Chinook salmon in the McKenzie subbasin above Leaburg Dam, based on carcasses recovered. Weighted for distribution of redds among survey areas within a watershed. Source: McLaughlin et al. (2008)

Run year	Fin-clipped	Unclipped[a] Hatchery	Unclipped[a] Wild	Percent wild[b]
2001	62	53 (17)	263	70 (69)
2002	140	78 (15)	454	68 (62)
2003	131	60 (15)	333	64 (62)
2004	134	26 (8)	316	66 (60)
2005	32	15 (6)	251	84 (84)
2006	32	4 (2)	247	87 (83)

[a] The proportion of hatchery and wild fish was determined by presence or absence of thermal marks in otoliths. Number in parentheses is percentage of unclipped fish that had a thermal mark (unclipped hatchery fish).
[b] Percentage not weighted for redd distribution is in parentheses.

There are substantial risks with having hatchery fish interbreeding with the wild population, as described in the “General effects of hatchery programs on ESA-listed salmon and steelhead” section above (see section 5.1.5.2.3). The genetic risks are well documented in the literature. Naturally spawning hatchery fish can also confound the evaluation of the health of the wild population because non-natural, hatchery fish are continually spawning in the wild (McElhany et al. 2000). Both of these risks are concerns in the McKenzie population.

Over the last few years, efforts were conducted to remove hatchery Chinook from the ladder at Leaburg Dam in order to reduce hatchery fish spawning in the wild. However, the ladders on Leaburg Dam are not adequate for sorting out hatchery fish without having significant impacts to commingled wild fish. Due to these wild fish concerns, the efforts to remove hatchery fish were discontinued. In order to address the hatchery fish straying issue in the McKenzie River, possible solutions include reducing hatchery production so that fewer hatchery fish return to the McKenzie and thus reduce the number of hatchery fish straying above Leaburg Dam. Another option would be to sort out hatchery fish at Leaburg Dam with an improved facility to automatically sort out hatchery fish with a coded wire tag. Similar automatic sorting facilities are used in other areas such as the Warm Springs Hatchery on the Deschutes River.

There is also concern with using hatchery-origin fish for outplanting efforts above Cougar Dam on the South Fork McKenzie. This risk was described in NMFS and USFWS (2000). Under the Proposed Action, ODFW would continue to outplant substantial numbers of hatchery-origin fish above Cougar Dam. The risk is that progeny of these hatchery fish will be unmarked and indistinguishable upon return from other natural-origin fish. These F1 (first generation naturally spawning) hatchery fish would likely interbreed in the wild population, and thus put more hatchery genes into the wild population. Once the trap is built at Cougar Dam, an alternative to continuing to place hatchery fish from McKenzie Hatchery above Cougar Dam would be to collect Chinook that volitionally return to the South Fork McKenzie and outplant only those fish. It may be important to only outplant natural-origin returns, even though the return may be low (e.g. <100 fish) in order to promote local adaptation within the South Fork subbasin.

5.3.5.4 Disease

Hatchery fish can be agents for the spread of disease to wild fish residing in the natural environment. Due to the high rearing densities of fish in the hatchery, hatchery fish can have elevated levels of certain pathogens, disease, and/or bacteria. After they are released, these fish may expose and/or transfer the disease to wild fish. Below is an assessment of these risks to the juvenile and adult life stages.

Juveniles
In the McKenzie subbasin, the risk of hatchery fish spreading disease to wild juvenile Chinook salmon is unknown. Hatchery fish are released as smolts from McKenzie Hatchery, located in the lower river. Significant juvenile fish rearing occurs in the lower river and in the mainstem Willamette River. The effects of hatchery fish interacting with other Chinook and steelhead populations downstream are addressed in Section 5.10, Mainstem Willamette River.

Adults
The potential also exists for returning hatchery fish to spread diseases to wild adult fish commingled in the McKenzie River. The risk of hatchery fish spreading diseases in the McKenzie is likely to be lower than in other areas where wild and hatchery fish are all congregated below an impassable dam.

5.3.5.5 Competition/Density-Dependence

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Information on the potential competitive interactions between hatchery and wild fish is very limited in the Willamette Basin. Below is an assessment of the likely implications on the juvenile and adult life stages.

Juveniles
Since all hatchery fish are released as smolts and are expected to migrate quickly to the ocean, it is unlikely significant competitive interactions will occur over a period of time.

Adults
No competitive interactions are likely in the adult life stage in the McKenzie River.

5.3.5.6 Predation

Hatchery fish released into the population areas throughout the Willamette Basin can predate upon co-occurring wild fish. In general, salmonids can prey upon fish approximately 2/3 of their size. Thus there is significant potential for hatchery summer and spring Chinook to prey upon wild steelhead and Chinook. Even though information is lacking on the extent of this issue, predation by hatchery fish undoubtedly occurs. Schroeder et al. (2006) examined predation by hatchery summer steelhead and rainbow trout on Chinook fry in the McKenzie River. Predation did occur on Chinook fry by a few individual fish. However, due to the fast digestion rates of Chinook fry in the stomachs of summer steelhead and rainbow trout (e.g. one to seven hours), it was difficult to estimate the amount of predation in their sampling design. Given the primary and secondary limiting factors identified for Willamette populations, predation by hatchery fish is not likely a limiting factor and the risk to listed fish is low.

5.3.5.7 Residualism

All hatchery programs in the Willamette Basin release hatchery fish as smolts. The intent is to release the hatchery fish at a size and time so that they will actively migrate to the ocean; thus minimizing the potential interaction between hatchery and wild fish. However, a percentage of the smolts do not emigrate and residualize in the river. These residual fish may migrate to the ocean at a later time or may stay in freshwater the rest of their life.

In general, hatchery steelhead are more likely to residualize than hatchery spring Chinook. In the Willamette Basin, the primary concern is with residual summer steelhead. The percentage of the smolt release of summer steelhead that do residualize is unknown. However, residual summer steelhead have been observed in all areas where hatchery fish are released. Several new actions are included in the Proposed Action that will help reduce the adverse effects of residual summer steelhead on wild winter steelhead and spring Chinook. The most beneficial is the proposal to not release any summer steelhead smolts that do not volitionally emigrate from the hatchery facility. These “non-migrants” will be collected and released into standing water bodies for trout fisheries. Previously, all of these non-migrant fish were forced out into the river. In addition, ODFW is proposing a new angling regulation that will allow the harvest of any fin-clipped, residual summer steelhead in all recreational fisheries. These regulation changes will decrease the number of residual hatchery fish left in the river and thus reduce adverse effects of residual fish on wild steelhead and spring Chinook.

5.3.5.8 Fisheries

As discussed in the general effects of hatchery program section above, the production of hatchery fish can lead to commercial and recreational fisheries that cause the overharvest of natural-origin fish. An abundance of hatchery fish can promote expanding fisheries, which may be detrimental to commingled natural-origin fish. In the Willamette, all hatchery fish have been mass marked since the 1990’s. This mass marking has facilitated implementation of selective fisheries—where only hatchery fish can be harvested. Thus freshwater fishery impacts on winter steelhead and spring Chinook have been reduced substantially compared to historical harvest rates. Freshwater fishery impacts are now in the range of 1-5% for winter steelhead and 8-12% for spring Chinook populations in the Willamette Basin.

The production of Willamette hatchery fish are of no consequence to the management of ocean fisheries. In general, it is unusual to catch steelhead of either natural or hatchery origin in ocean fisheries. Hatchery spring Chinook are caught in ocean fisheries, particularly in Alaska and West Coast Vancouver Island fisheries (see Figure 4.2-13). However, these hatchery fish are not a driver for fisheries management. Protection of other stocks of concern in Canada and the United States currently constrain ocean fishery quotas and regulations. In addition, harvest of Willamette spring Chinook in ocean fisheries is governed by the Pacific Salmon Treaty between the US and Canada and impacts have been typically been in the range of 10-15%.

5.3.5.9 Masking

The production of unmarked hatchery fish can have an impact on wild fish if these hatchery fish stray and intermingle with wild populations. Not knowing whether naturally spawning fish are of hatchery- or natural-origin confounds the ability to monitor the true status of the wild population. This effect has been termed “masking” by hatchery fish.

In the Willamette Basin, this concern has been eliminated because all hatchery spring Chinook, summer steelhead, and rainbow trout are all adipose fin-clipped. In addition, all hatchery spring Chinook are otolith marked in the hatchery which provides an additional safeguard to detect hatchery fish that may have been missed during fin-clipping (currently <5% of all the smolt releases; McLaughlin et al. 2008). The Action Agencies are also proposing to coded wire tag (CWT) all hatchery spring Chinook salmon, which will also allow individual fish to be identified upon their return to freshwater.

5.3.5.10 Nutrient Cycling

Hatchery fish can provide essential marine-derived nutrients to the freshwater environment if they spawn naturally or are outplanted as carcasses (see “General effects of hatchery programs on ESA-listed salmon and steelhead” section above). Hatchery spring Chinook salmon and summer steelhead are known to spawn naturally throughout the Willamette Basin, thus providing benefits in terms of marine nutrients to the local environment. Thousands of hatchery Chinook are also outplanted above the dams in an effort to restore natural production in historical habitat. This provides benefits to aquatic and terrestrial food chains.

5.3.5.11 Monitoring & Evaluation

Monitoring and evaluation of Willamette hatchery programs under the ESA began in response to NMFS’ (2000a) *Biological Opinion on the impacts from the collection, rearing, and release of listing and non-listed salmonids associated with artificial propagation programs in the Upper Willamette spring Chinook and winter steelhead ESUs.* The ODFW implemented specific monitoring and evaluation activities to collect information on the effects of hatchery programs in the Willamette. This information can be found in Schroeder et al. (2006).

Monitoring and evaluation of hatchery programs in the Willamette Basin will continue to occur in order to assess whether the programs are meeting their intended goals and to evaluate the impacts on wild populations. The specific HGMPs for each program describe the monitoring and evaluation that will occur in the future.

5.3.6 Summary of Effects on the McKenzie Chinook Salmon Population

Table 5.3-4 summarizes anticipated effects of the revised proposed action on VSP parameters for UWR Chinook salmon in the McKenzie River subbasin. In summary, considering the current status of this population, environmental baseline conditions, and the Proposed Action, NMFS is concerned with the viability of this “stronghold” population because its numbers are decreasing and will continue to decrease under the Proposed Action. Loss of historical spawning habitat, impacts to habitat downstream of the Projects, and significant hatchery fish introgression are still impacting this population. The Proposed Action continues to represent substantial impacts to the abundance, productivity, spatial structure, and diversity of the McKenzie Chinook population. These parameters are further described below.

5.3.6.1 Abundance

The impacts of the Proposed Action has and will continue to affect the survival of spring Chinook at both the juvenile and adult life stages in the McKenzie River and thereby affect the abundance of this population. Juvenile Chinook are impacted directly by mortality associated with downstream migration at the Projects and affected indirectly by the degraded habitat conditions downstream of the Projects that reduce habitat quantity and quality and thereby reduce their survival. Adult Chinook are impacted directly by collection of fish for broodstock, mortality associated with outplanting efforts above the dams, and direct mortality as they migrate to the base of the dams. In addition, there is an indirect impact of the Proposed Action from the changes that have occurred to adult migration, holding, and spawning habitats.

5.3.6.2 Productivity

As described above, the problem associated with hatchery Chinook straying and spawning above Leaburg Dam represents substantial risk to the productivity of the McKenzie population over the long term. The best available science shows hatchery influences on wild populations need to be low for a population to be viable. There are risks associated with fitness loss, decreased production, and concerns with knowing whether the McKenzie population is truly viable in the absence of the hatchery fish subsidy that need to be corrected.

5.3.6.3 Spatial Structure

The Proposed Action would continue to prevent Chinook salmon from safely accessing historical habitats above Cougar and Blue River dams. Of particular concern is the loss of habitat above Cougar Dam because historically this area accounted for the most spring Chinook production lost. Restoring production above Cougar Dam, with appropriate survival of adult and juveniles, will increase the spatial distribution of the population and increase the capacity of the population to respond to fluctuating environmental conditions.

5.3.6.4 Diversity

Many aspects of the McKenzie population have been and will continue to be impacted by the Proposed Action. Since the impacts have been substantial, there have undoubtedly been changes in the diversity of the McKenzie population. Population traits are now not as diverse as the historical population, which is of concern with fluctuating environmental conditions and the ability of salmon to respond and survive. The habitat changes that have occurred by the Proposed Action downstream of the Projects have affected the population in an unquantifiable manner. The influence of hatchery fish on the wild population also represents risk to the diversity of the natural-origin population.

5.3.7 Effects of the Proposed Action on Designated Critical Habitat

The South Fork McKenzie River above and below Cougar Dam, the Blue River below Blue River Dam, and the mainstem McKenzie River have been designated as critical habitat for UWR Chinook salmon. The PCEs identified in this portion of critical habitat include sites for spawning, rearing, and migration. Table 5.3-2 assesses the anticipated effects of the revised proposed action on PCEs and VSP parameters for UWR Chinook salmon in the McKenzie River subbasin. These effects are attributable to a lack of functional fish passage at Cougar and (to a much lesser extent) Blue River dams, the effects these dams and their reservoirs have on water quality and physical habitat conditions in the lower reaches of the McKenzie, South Fork McKenzie, and Blue rivers, and USACE maintenance of 4.17 miles of revetments along the lower McKenzie River. The following PCEs will be adversely affected by the Proposed Action:

- Except for the outplanting program, freshwater spawning sites above Cougar Dam, with flow regimes, water quality conditions, and substrates well suited to the species' successful spawning, incubation, and larval development, will remain inaccessible to naturally produced UWR Chinook. Spawning habitat in the lower-most South Fork McKenzie (below Cougar) and in the mainstem McKenzie below the South Fork is accessible to these fish, but will continue to be diminished by the Project's interruption of sediment transport, such that new gravels needed for spawning may not fully replace those that move downstream during high flows. Additionally, the continued existence and maintenance of revetments along the lower McKenzie prevent channel formation processes that might otherwise allow for new gravels and spawning habitat to be created in adjacent areas.
- The quantity and quality of freshwater rearing sites for juvenile UWR Chinook will remain limited and degraded in the fully accessible portions of the South Fork and mainstem McKenzie, and may continue to decline. Diminished peak flows, lack of sediment and LWD delivery from areas above Project dams, and revetments, contribute to losses of off-channel rearing habitat and impair processes that might otherwise create complex habitats along main channel areas. Sudden reductions in outflows below Cougar Dam when flows are relatively low will continue to pose risks of juvenile stranding and loss in the lower South Fork.
- The historically important migratory corridor along the lower South Fork McKenzie will continue to be obstructed by Cougar Dam and Reservoir. Under the Proposed Action these obstructions are likely to continue to preclude reestablishment of a productive naturally spawning component of the McKenzie's UWR Chinook population in the once highly productive upper South Fork watershed. Adult UWR Chinook will be passed over Cougar Dam as part of the outplanting program and for research purposes, but downstream migrating juveniles will face hazards and delay in Cougar Reservoir as well as at Cougar Dam.

In aggregate, these effects will continue to diminish habitat availability and suitability within the McKenzie subbasin for juvenile and adult lifestages of UWR Chinook. These adverse effects to the functioning of designated critical habitat within the subbasin will limit the habitat's capacity to serve its conservation role supporting a large, productive, and diverse population.

Table 5.3-4 Effects of the Proposed Action on UWR Chinook salmon population (VSP column) and Critical Habitat (PCE column) in the McKenzie River Subbasin. (Modified from USACE 2007a, Table 6-3).

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater migration corridors	Habitat Access	Physical Barriers	Population abundance, productivity, and spatial distribution will continue to be impaired under the Proposed Action, which does not commit to providing long-term access to preferred habitat above Cougar Dam; Blue River Dam has similar, but much smaller adverse effects (before inundation, there was a natural fish barrier on Blue River, limiting historical use of upstream habitat.)	Except for research purposes, adult UWR Chinook will be prevented from accessing habitat above Cougar Dam,. Downstream migrating juveniles will face hazards and delay in the Cougar Pool, as well as transiting through Cougar Dam itself.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in Peak/Base Flow	Improved ramping rates and flow conditions below Cougar Dam could result in improved ecosystem health and function, expanded rearing habitat, higher egg-to-smolt survival, improved migration conditions, and improved overall productivity. As a result, local population abundance may also increase. Biological monitoring will document changes in local habitat conditions and in local population productivity resulting from a combination of Action Agency actions.	Flow-related components of habitat quality for UWR Chinook will be improved in the near-term within areas downriver of the USACE dams in the subbasin. Longer term effects of diminished flood events on channel processes that help create or maintain channel complexity will continue.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Population abundance and productivity will increase. Habitat quality of the natural production areas in the South Fork and mainstem McKenzie rivers from below Cougar Dam to above Leaburg Dam will improve. Both spawning activity and egg-to-fingerling survival are expected to increase, especially in the South Fork, resulting in improved spatial distribution. Biological monitoring will document realized changes.	Shifts toward a more normal thermal regime in the lower South Fork McKenzie and in the mainstem McKenzie below the South Fork will continue to restore desirable conditions to migration, holding, spawning, incubation, and rearing habitat.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	No change in effect.	No change in effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination /Nutrients	Productivity above the Cougar Dam may increase to an unknown extent as a result of increased levels of marine derived nutrients. At this time, the Action Agencies make a conservative assumption of no effect from our activities.	No effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	No effect.	No effect.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	No change in effect. High TDG immediately below USACE dams during spill events will continue to have the potential to unfavorably affect early lifestages of UWR Chinook.	No change in effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination /Nutrients	Productivity above the Cougar Dam may increase to an unknown extent as a result of increased levels of marine derived nutrients. At this time, the Action Agencies make a conservative assumption of no effect from our activities.	No effect.
Freshwater spawning sites	Habitat elements	Substrate	Continued lack of new gravels to existing spawning habitat below Cougar Dam reduces abundance and productivity of UWR Chinook salmon by limiting and degrading available habitat.	Operation of Project dams will continue to block sediment transport to downstream reaches, further increasing substrate coarsening, and thereby degrading limited spawning habitat. Study of gravel augmentation will not guarantee that sediment will be placed below Cougar Dam at adequate levels to restore fully functioning habitat.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris (LWD)	Continued lack of large wood reduces abundance and productivity of UWR Chinook salmon in the McKenzie Subbasin because holding and rearing habitat below the dams continues to be degraded and is not being replaced.	Operation of Project dams will continue to block transport of large wood from reservoirs to downstream habitat, revetments will continue to prevent floodplain connectivity, reducing large wood recruitment from streambanks, resulting in less structure available to create complex channel habitat, gravel bars and large pools. Study of stockpiling LWD will not guarantee new LWD will be placed in reaches below the dams.
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Continued degradation of pool habitat will reduce rearing and adult holding habitat, resulting in lowered productivity and abundance	Continued low frequency of pools and poor pool quality below Cougar and Blue River dams. Operation of Project dams and continued existence and maintenance of revetments will continue to prevent peak flows, block sediments and large wood, preventing channel movement that would allow for new pools to form.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-channel Habitat	Continued lack of off-channel habitat will reduce rearing habitat, resulting in lowered productivity and abundance.	Continued reduced off-channel habitat in the South Fork McKenzie River below Cougar Dam and in the mainstem and lower McKenzie River. Project operation will continue to reduce peak flows, limiting overbank flows and channel forming processes. Although studies may consider special operations to provide peak flows, the Action Agencies provide no certainty that this operation will occur during the term of this Opinion, nor that the operation will open up off-channel habitat.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/Depth Ratio	Continued degraded channel conditions habitat will reduce rearing habitat, resulting in lowered productivity and abundance.	Project operation will continue to reduce peak flows and block large wood and sediment transport, limiting pool formation. Although studies may consider stockpiling LWD for later placement to create habitat complexity and funding habitat restoration projects, the Action Agencies provide no certainty that these measures will occur during the term of this Opinion.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Streambank Condition	Degraded streambanks will inhibit channel forming processes that create complex habitat essential for juvenile rearing, adult spawning and holding, resulting in lowered productivity and abundance.	Project operation and revetments will continue to prevent streambanks from supporting natural floodplain function in the mainstem McKenzie River and the South Fork McKenzie River below Cougar Dam. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve streambank conditions, the Action Agencies provide no certainty that these changes will be funded or carried out during the term of this Opinion.
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain Connectivity	Continued lack of floodplain connectivity reduces availability of off-channel habitat, limiting available rearing habitat, including reduced macroinvertebrate production as a food supply, resulting in lowered productivity and abundance.	Project operation and revetments will continue to prevent overbank flow and side channel connectivity in the mainstem McKenzie River and the South Fork McKenzie River below Cougar Dam. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve off-channel habitat, restoring normative ecosystem functions, the Action Agencies provide no certainty that these changes will be funded or carried out during the term of this Opinion.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	Continued degradation of riparian habitat will reduce large wood available for channel complexity, thereby reducing already limited rearing, holding, and spawning habitat, resulting in lowered abundance and productivity.	Project operation and revetments will continue to prevent formation of new gravel bars on which riparian vegetation could grow below Cougar and Blue River dams and in the mainstem McKenzie River. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially restore riparian vegetation, the Action Agencies provide no certainty that these changes will be funded or carried out during the term of this Opinion.

Section 5.4
Calapooia Subbasin Effects

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5.4 Calapooia Subbasin: Effects of the Willamette Project Proposed Action on UWR Chinook Salmon & UWR Steelhead Critical Habitat

Summary of the Effects of the Proposed Action

- The effects of the Proposed Action on Calapooia populations of UWR Chinook salmon and UWR steelhead would be relatively small compared to baseline conditions, but would contribute to continued degradation of habitat along the mainstem Calapooia, causing minor reduction in abundance and productivity of these populations and adversely modifying critical habitat. The Proposed Action would continue to degrade physical habitat elements in the lower Calapooia River

Introduction

For the Calapooia populations of UWR Chinook salmon and UWR steelhead, the Proposed Action includes the following on-the-ground actions:

- Revetments - Continue the existence and maintenance of 0.17 miles of revetments along the Calapooia River
- Studies - Additionally, the Proposed Action includes a study of the effects of revetments on downstream habitat and possible habitat restoration projects in the Willamette basin projects to restore habitat, if authorized and funding becomes available.

In this section, NMFS considers the effects of the Proposed Action on the Calapooia UWR Chinook salmon and UWR steelhead populations. In general, NMFS expects that the Proposed Action would cause minor increments of continued degradation of habitat due to ongoing existence and maintenance of revetments, resulting in small reductions in abundance and productivity of these populations. NMFS expects the Proposed Action would have no effect on genetic diversity of these populations because there are no hatchery management actions that would affect these populations. NMFS concludes that the Proposed Action would continue to harm a few individual fish such that the Calapooia UWR Chinook salmon and UWR steelhead populations would continue to decline and critical habitat would continue to be adversely modified as a result of the Proposed Action (see Table 5.4-1).

5.4.1 Habitat Access & Fish Passage

The Proposed Action would have minimal effect on habitat access and fish passage, except to the extent that continued existence and maintenance of revetments precludes fish access to side channels and complex habitat. (See section 5.4.4 below).

5.4.2 Water Quantity/Hydrograph

The Proposed Action would have not affect water quantity or the baseline hydrograph in the Calapooia subbasin.

5.4.3 Water Quality

The Proposed Action would have a very small effect on the baseline water quality conditions as a result of continued existence and maintenance of 0.17 miles of revetments in the lower Calapooia River. By reducing riparian vegetation and stream processes that enable formation of complex habitats and deep pools, existence and maintenance of revetments would result in small increases in summer water temperatures, particularly in the lower part of the Calapooia watershed.

5.4.4 Physical Habitat Quality

The key proposed actions related to physical habitat quality in the Calapooia River subbasin that would affect UWR Chinook salmon and UWR steelhead include the following:

- Continue the existence and maintenance of 0.17 miles of revetments along the Calapooia River, preventing channel migration and reducing channel complexity.
- Study effects of Project revetments on downstream habitat and consider projects to restore habitat, if authorized and funding becomes available.

5.4.4.1 Substrate, Sediment Transport, Large Wood, & Channel Complexity in the Calapooia River Subbasin

Under the environmental baseline, substrate, sediment transport, large wood, and channel complexity are degraded and do not support adequate rearing and holding habitat for UWR Chinook salmon and UWR steelhead (section 4.4.6). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.4-1 and described below.

Under the Proposed Action, the Action Agencies would continue the existence and maintenance of about 0.17 miles of revetments in the lower Calapooia River. Although this length comprises a small percentage of the total revetments and length of this stream, this action would continue to have very small adverse effects by restricting channel migration and preventing recruitment of large wood and sediment from streambanks, both of which inhibit natural processes that create and maintain channel complexity. As described in the Calapooia Baseline section 4.4.6, the middle and lower reaches of the Calapooia River are more heavily impacted by land use practices, including channelization and revetments, that have caused coarsening and siltation of substrate, low levels of large wood, and reduced channel complexity. The Proposed Action would cause minor reductions in juvenile rearing and adult holding habitat, further limiting abundance and productivity of the Calapooia populations of UWR Chinook salmon and UWR steelhead.

The Action Agencies propose to conduct a general study of USACE revetments in the Willamette basin, including consideration of habitat restoration projects, but the Action Agencies do not propose specific measures that would restore large wood, sediment transport, and channel complexity in the Calapooia subbasin.

In summary, although the revetments maintained by the Action Agencies in the Calapooia subbasin are a small percentage of total river length, they contribute to continued degradation of habitat and would likely cause minimal reduction in the carrying capacity of this habitat for rearing juvenile fish and holding adults, thus reducing the number of individual UWR Chinook salmon and UWR steelhead that can be produced in this presently degraded habitat. Aside from unspecified habitat restoration actions that may result from proposed habitat and revetment mitigation measures, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the Calapooia subbasin.

5.4.4.2 Riparian Vegetation & Floodplain Connectivity in the Calapooia River

Under the environmental baseline, riparian vegetation and floodplain connectivity are degraded and do not support adequate rearing and holding habitat for UWR Chinook salmon and UWR steelhead (section 4.4.6). NMFS expects that conditions would not improve, and could degrade further under the Proposed Action, as shown in Table 5.4-1 and described below.

Under the Proposed Action, the Action Agencies would continue the existence and maintenance of about 0.17 miles of revetments in the lower Calapooia River. Although this length of revetments comprises a small percentage of the total revetments and length of this stream, this action would continue to restrict overbank flows, river migration, and contribution of sediment and large wood from streambanks. Infrequent inundation of forested floodplains reduces nutrient and organic matter exchange during flood events and reduces the availability of high-water refugia for juveniles, which could limit over-wintering survival of rearing juveniles. Additionally, the Proposed Action would continue to prevent establishment of riparian vegetation in the lower Calapooia subbasin by interfering with the processes needed for new floodplain forests to establish. The reduced extent of riparian vegetation and lack of floodplain connectivity hinders recruitment of large wood into the aquatic system and reduces off-channel refugia, both habitat features needed to create resting pools for migrating adults and provide cover for rearing juveniles. The Proposed Action, although limited in extent in the Calapooia subbasin, would continue to degrade this already impaired habitat, reducing juvenile rearing and adult holding habitat, with minor effects on abundance and productivity of the Calapooia populations of UWR Chinook salmon and UWR steelhead. Although the Proposed Action includes study of revetments in the Willamette basin and potential habitat restoration, there is no certainty that any restoration work would be done in the Calapooia River subbasin during the term of this Opinion.

Conclusion

The proposed continued existence and maintenance of revetments in the Calapooia River would be a small factor in the continued degradation of riparian and floodplain forests and floodplain connectivity. Aside from unspecified habitat restoration actions that may result from revetment and habitat restoration studies described in the Sup BA, Section 3.5.2, Offsite Habitat

Restoration Actions (USACE 2007a), the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain connectivity in the Calapooia River subbasin. Continued degradation of juvenile rearing and adult holding habitat under the Proposed Action would cause a small reduction in the abundance and productivity of Calapooia subbasin populations of UWR Chinook salmon and UWR steelhead.

5.4.5 Hatcheries

There are no proposed actions related to hatchery programs in the Calapooia subbasin. As described in Section 4.4.4, hatchery fish are no longer released in the Calapooia at any life stage.

5.4.6 Summary of Effects on UWR Chinook Salmon & UWR Steelhead Populations in the Calapooia River Subbasin

Table 5.4-1 summarizes anticipated effects of the Proposed Action on the status of the Calapooia populations of Chinook salmon and steelhead relative to the four VPS parameters.

5.4.6.1 Abundance

The Proposed Action would have no measurable effect within the Calapooia subbasin.

5.4.6.2 Productivity

The Proposed Action would have no measurable effect within the Calapooia subbasin.

5.4.6.3 Spatial Structure

The Proposed Action would have no measurable effect within the Calapooia subbasin.

5.4.6.4 Diversity

The Proposed Action would have no measurable effect within the Calapooia subbasin.

5.4.7 Effects of the Proposed Action on Designated Critical Habitat

The mainstem Calapooia River and many of its tributaries have been designated as Critical Habitat for UWR Chinook salmon and steelhead. Table 5.4-1 identifies the anticipated effects of the Proposed Action on the PCEs of this habitat. All of the effects are attributable to the Action Agencies' continued existence and maintenance of 0.17 miles of revetments along the mainstem Calapooia.

The USACE revetments limit natural channel migration and the formation of complex and diverse salmonid habitats, including off-channel areas that are particularly important to juvenile fish during periods of high winter flows. They also impede the establishment and growth of riparian vegetation that might otherwise provide shade (to prevent unfavorable temperature increases) and contribute LWD. Across all of the areas affected within the Calapooia subbasin and elsewhere, the Action Agencies' continued existence and maintenance of these structures will continue to assure diminished habitat suitability for multiple lifestages of UWR Chinook and UWR steelhead, and to limit the habitat's capacity to support large and productive populations of these fish.

Table 5.4-1 Effects of the Proposed Action on UWR Chinook salmon and UWR steelhead populations (VSP column) and critical habitat (PCE column) in the Calapooia River subbasin

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater migration corridors	Habitat Access	Physical Barriers	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in Peak/Base Flow	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Minor effect of elevated water temperatures could decrease survival and/or growth of juvenile UWR Chinook salmon and steelhead and increase prespawning mortality of adult Chinook and steelhead.	Minor effect of revetments, by reducing riparian vegetation and stream processes that enable formation of complex habitats and deep pools, that contribute to elevated summer water temperatures, particularly in the lower part of the Calapooia watershed.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination /Nutrients	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	No effect	No effect

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	No effect	No effect
Freshwater spawning sites	Habitat Elements	Substrate	Very small effect of Proposed Action on substrate in the Calapooia that prevents formation of new gravels, but lower Calapooia not historically used for spawning, and thus effect is mainly to reduce invertebrate productivity on which rearing fish feed. Minimal reduction in abundance and productivity of Calapooia populations of UWR Chinook salmon and UWR steelhead due to small length of revetment in Calapooia.	Continued existence and maintenance of 0.17 miles of revetments would prevent channel migration, limiting production of new gravel bars and substrate.
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris	Very small effect of Proposed Action on continued lack of large wood; would cause small reduction in abundance and productivity of UWR Chinook salmon in the Calapooia subbasin because adult holding and juvenile rearing habitat would continue to degrade and would not be replaced.	Continued existence and maintenance of 0.17 miles of revetments would continue to prevent floodplain connectivity, reducing large wood recruitment from streambanks, resulting in less structure available to create complex channel habitat, gravel bars and large pools. Habitat restoration studies would not guarantee new LWD would be placed in the Calapooia River.
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Very small effect of Proposed Action on continued degradation of pool habitat; would cause small reduction in rearing and adult holding habitat, resulting in small reduction in productivity and abundance of Calapooia populations of UWR Chinook salmon and steelhead.	Continued low frequency of pools in lower Calapooia River. Continued existence and maintenance of 0.17 miles of revetments would continue to prevent peak flows and block sediments and large wood, preventing channel movement that would allow for new pools to form.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-Channel Habitat	Very small effect of Proposed Action on continued lack of off-channel habitat, which would cause small reduction in juvenile refugia and rearing habitat, resulting in small reduction in productivity and abundance of Calapooia populations of UWR Chinook salmon and steelhead.	Continued existence and maintenance of 0.17 mi. of revetments would contribute to continued reduced off-channel habitat in the lower Calapooia River. Although studies may consider habitat restoration projects that could provide access to off-channel habitat, the Action Agencies provide no certainty that such projects would be funded and carried out in the Calapooia subbasin.
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/Depth Ratio	Very small effect of Proposed Action on continued degradation of width/depth ratio; would cause small reduction in rearing habitat, resulting in small reduction in productivity and abundance of Calapooia populations of UWR Chinook salmon and steelhead.	Continued existence and maintenance of 0.17 mi. of revetments would continue to facilitate channel cutting and deepening, reducing width/depth ratio and limiting formation of complex habitats. Although studies may consider habitat restoration projects, the Action Agencies provide no certainty that these measures would occur during the term of this Opinion.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Streambank condition	Very small effect of Proposed Action on streambank condition, by inhibiting channel forming processes that create complex habitat essential for juvenile rearing and adult holding; would result in small reduction in productivity and abundance of Calapooia populations of UWR Chinook salmon and steelhead	Continued existence and maintenance of 0.17 miles of revetments would continue to prevent streambanks from supporting natural floodplain function in the lower Calapooia River. Although studies may consider habitat restoration projects to improve streambank conditions, the Action Agencies provide no certainty that these changes would be funded or carried out in the Calapooia River during the term of this Opinion.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Floodplain connectivity	Very small effect of Proposed Action on continued lack of floodplain connectivity reduces availability of off-channel habitat, which would cause small reduction in available refugia and juvenile rearing habitat, resulting in small reduction in productivity and abundance of Calapooia populations of UWR Chinook salmon and steelhead.	Continued existence and maintenance of 0.17 mi. of revetments would continue to prevent overbank flow and side channel connectivity in the lower Calapooia River. Although studies may consider habitat restoration projects that could provide access to off-channel habitat, the Action Agencies provide no certainty that such projects would be funded and carried out in the Calapooia subbasin.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed conditions	Riparian reserves	Very small effect of Proposed Action on continued degradation of riparian forests, which would cause small reduction in large wood recruitment, further limiting juvenile rearing and adult holding habitat, resulting in small reduction in productivity and abundance of Calapooia populations of UWR Chinook salmon and steelhead.	Continued existence and maintenance of 0.17 mi. of revetments would continue to constrain the channel and prevent overbank flow, limiting extent and quality of riparian forests in the lower Calapooia River. Although studies may consider habitat restoration projects that could potentially restore riparian vegetation, the Action Agencies provide no certainty that such projects would be funded and carried out in the Calapooia subbasin.

Section 5.5
South Santiam Subbasin Effects

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5.5 South Santiam Subbasin: Effects of the Willamette Project Proposed Action on UWR Chinook Salmon & UWR Steelhead & Critical Habitat

Summary of the Effects of the Proposed Action

- The effects of the Proposed Action on South Santiam populations of UWR Chinook salmon and UWR steelhead would be to continue to reduce abundance, productivity, spatial distribution, and diversity of these populations and to adversely modify critical habitat. The primary effects would include:
  - Continued prevention of fish access to historic habitat above Project dams
  - Continued degradation of water quality and physical habitat elements downstream from Project dams
  - Continued loss of floodplain connectivity and off-channel habitat due to continued existence and maintenance of 1.82 miles of revetments
  - Continued risks and potential benefits associated with the South Santiam Hatchery Chinook and steelhead programs
  - Continued loss of streamflow through the Reclamation irrigation water contract program.

In the South Santiam subbasin, the population of winter steelhead is currently at “moderate” risk of extinction and the spring Chinook are currently at “very high” risk. The abundance of steelhead and Chinook is much reduced compared to historical levels. The primary causes of the decline for these populations include loss of access to historical spawning and rearing habitat above Foster and Green Peter Dams, altered physical and biological conditions downstream of the dams (hydrograph, temperature, flow, recruitment of gravel and woody debris), interbreeding between hatchery and natural-origin Chinook and steelhead, and degraded habitat conditions associated with land management in the tributaries downstream of Foster Dam (ODFW 2007b). For a full description of the status of the ESU and Environmental Baseline, see Chapters 3 and 4 above.

In general, the Proposed Action includes the following actions:

- Current configuration, continued operation, and maintenance of Foster and Green Peter dams in the South Santiam watershed.
- Flow Management- volume and seasonal timing of water released downstream from Foster and Green Peter dams.
- Ramping Rates- targets would be intended to limit down-ramp rates below Foster and Green Peter dams to no greater than 0.1 ft/hr at night and to no greater than 0.2 ft/hr during the daytime.

- Revetments – continued existence and maintenance of 1.82 miles of revetments
- Hatchery Program- continued production of hatchery Chinook for fishery augmentation and conservation purposes; and continued production of summer steelhead for fishery augmentation
- Outplanting Program- trap and haul of UWR Chinook and UWR steelhead from below Foster dam to release locations above and below Foster dam.
- Continued operation of the Foster dam adult fish collection facilities, including possibly rebuilding the facility in the future, date uncertain, contingent on securing funding.

In this section, NMFS considers the effects of the Proposed Action on UWR Chinook salmon and UWR steelhead populations in the South Santiam subbasin. In general, NMFS expects that the Proposed Action would cause continued degradation of habitat downstream of the dams and continued lack of access to historical habitat, reducing abundance and productivity of these populations. NMFS expects the Proposed Action would result in some improvements in hatchery management, preventing further decline in genetic diversity from baseline conditions. NMFS concludes that the Proposed Action would continue to harm individual fish such that the North Santiam UWR Chinook salmon and UWR steelhead populations would continue to decline and critical habitat would be adversely modified as a result of the Proposed Action (see Table 5.5-3 at the end of this section 5.5).

5.5.1 Habitat Access & Fish Passage

Under the Proposed Action, Foster and Green Peter dams would continue to block UWR Chinook salmon and UWR steelhead from volitional access to historical spawning habitat above Foster Dam in the South Santiam watershed. An existing, but outmoded, fish trap would continue to be operated at the base of Foster Dam, providing a modicum of upstream passage for UWR steelhead, and for UWR Chinook salmon as part of an experimental program. Downstream passage of juvenile salmon and steelhead through Foster reservoir and dam would continue to occur to some degree under the current configuration of the project, but would remain problematic. Though the Action Agencies propose to conduct studies to evaluate passage conditions over the term of the Opinion, no definitive actions are proposed to improve upstream and downstream fish passage beyond the baseline conditions of current project configurations and operations.

The key Proposed Actions related to habitat access in the South Santiam watershed that need to be evaluated for the effects on UWR Chinook salmon and UWR steelhead access and fish passage are the following:

- Continue to operate Foster and Green Peter dams, thereby continuing to block adult UWR Chinook salmon and UWR steelhead from accessing historical habitat above the dams.
- Continue to operate (and possibly rebuild) a fish trap at the base of Foster Dam:

  - Continue to collect UWR Chinook salmon, taking some fish to the South Santiam Hatchery and releasing a portion of adult hatchery-origin returning fish into habitat above Foster reservoir.

  - Continue to collect UWR steelhead, and truck all of them to release location above Foster Reservoir.

- Continue to pass juvenile salmon downstream (progeny of those adults transported above Foster Dam) through Foster Reservoir and Dam under current configuration and flow operations.

- Conduct the Willamette System Review Study, described earlier, that will evaluate, among other things, upstream and downstream passage at Big Cliff and Detroit dams, and may result in experimental fish introductions in various locations, including UWR steelhead into or above Detroit Reservoir.

- Continue and increase the Action Agency water contract program for irrigation diversions, increasing the potential for fish entrainment at water diversions

The following is an assessment of the effects of conducting adult upstream passage via the existing trucked transport program, resulting juvenile production, and downstream juvenile fish passage through the reservoirs and dams.

5.5.1.1 Upstream Passage/Potential Utilization of Blocked Habitat

Under the baseline, Foster and Green Peter dams block access to spawning and rearing habitat in the upper South Santiam subbasin, an area that historically produced steelhead and an estimated 85% of the spring Chinook in the South Santiam River (Mattson 1948). Beidler and Knapp (2005) reported that the subbasin above Foster produced a run of about 1400 adult Chinook salmon prior to dam construction. Buchanan et al. (1993) noted that this same area produced about 2600 steelhead prior to dam construction, with about 60 to 70% coming from the Middle Santiam River above the current site of Green Peter Reservoir.

As noted in the description of baseline conditions given in Section 4.5.3.1, both Green Peter and Foster dams originally incorporated upstream and downstream fish passage provisions, though results were disappointing. Buchanan et al. (1993) found that only 46% of adult UWR steelhead natal to upstream of Green Peter Reservoir successfully migrated through Foster Dam to the trap at the base of Green Peter Dam, possibly due to trap attraction problems. Additionally, juvenile downstream migrants were lost in Green Peter Reservoir, presumably due to high levels of predation. Based on these results, the USACE and ODFW terminated all efforts to place UWR Chinook and UWR steelhead above that dam in 1988 (USACE 2000). Adult Chinook passage above Foster was also discontinued due to problems with fallback, but was resumed after 1996 via truck transport.

The Action Agencies propose, as an interim measure (until permanent passage measures are operational), to experimentally[1] trap and transport some hatchery UWR Chinook salmon (and all

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[1] USACE 2007a. The Action Agencies state that their Proposed Action is not to be construed as a commitment to permanently restore access to now-blocked historical habitat, but that they will do this to a degree to evaluate *". . . the natural production potential of historic habitat.*"

winter steelhead)[2] above Foster Dam (USACE 2007a). As noted in Section 4.5.3.1, winter steelhead have been continuously placed above Foster Dam since construction, although these fish experience fallback rates of up to 4% (USACE 2007a). No fish would be released above Green Peter Dam, due to the observed high rate of loss in Green Peter reservoir.

The Action Agencies proposed to trap fish at the base of Foster Dam and to handle them as described in Table 5.5-1.

Table 5.5-1 Proposed Disposition of Fish Collected at the Foster Fish Facility (Excerpt from USACE 2007a, Table 3-13).

Species	Destination	Target # of Adult Fish *		Maximum % of Wild Run
		Clipped	Unclipped	
Spring Chinook	Broodstock	600	300	30*
	South Santiam above Foster Dam (Riverbend and Gordon Road release sites)	As needed to meet unclipped goal	800 (in excess of broodstock collection goal of 4,000 females)	10
	Recycled into South Santiam below Foster Dam		None	0
	Crabtree, Thomas, and Wiley creeks	Any excess (approx. 100 to Crabtree; 150 to Thomas)	None	0
Winter Steelhead	South Santiam above Foster Dam	0	All	100
	Remove from system	All	0	0
Summer Steelhead	Broodstock	1,700	0	N/A
	Recycling below Foster	Any excess to brood	0	N/A
	Remove from system	Excess to brood and recycling	All	N/A

*These numbers reflect management targets, and are not intended to provide annual on-the-ground direction to personnel operating the fish facilities.

5.5.1.2 Juvenile Production

Beidler and Knapp (2005) report that overall production of Chinook salmon from fish outplanted above Foster Reservoir is relatively low, as compared to the North Santiam above Detroit Reservoir. Based on snorkel surveys above Foster reservoir from 1999 through 2004, ODFW found that juvenile production varies from year to year, and does not correlate with number of adults released in the previous year. Beidler and Knapp recommend smolt trapping below the dams and at the head of Foster reservoir to determine juvenile production from the outplanting program and to assess fish mortality through the dams and reservoirs. They were unable to

[2] All winter steelhead in the subbasin are of natural origin.

explain the variable and low productivity from this habitat, but indicated that high prespawning mortality of hatchery outplants might be the cause of low juvenile production. Given that habitat above these dams historically produced 85% of the South Santiam Chinook salmon run, and that this habitat generally remains in good condition, NMFS would expect that juvenile production would not be a limiting factor if measures were taken to reduce adult fish prespawning mortality rates.

5.5.1.3 Dam & Reservoir Survival

Foster and Green Peter dams were originally equipped with facilities intended for upstream and downstream fish passage, but they never worked well and are considered outmoded by current standards (Beidler and Knapp 2005). Direct mortality of downstream migrating Chinook is 83% past Green Peter Dam and 8-10% past Foster Dam and is assumed to be the same for juvenile steelhead (Willis 2008). Passage routes available to downstream migrating fish at Foster are 1) through unscreened turbines, 2) through other outlets, and 3) over the spillways, during infrequent periods when water is spilled. The Action Agencies propose to continue the spring spill operation at Foster Dam (92 to 238 cfs spill, depending on reservoir elevation and inflow), from April 15 to May 15, to facilitate downstream passage of juvenile and kelt steelhead and juvenile Chinook salmon. This operation is based on a study by Buchanan et al. (1993) that concluded that steelhead smolts could be passed safely at Foster Dam if reservoir elevations were reduced and 300 cfs was released as surface spill. The Proposed Action does not include other measures, beyond studies, to improve reservoir and dam survival at Foster Dam.

Existing egress routes at Green Peter are 1) though unscreened turbines, 2) through other outlets, 3) over the spillways, during infrequent periods when water is spilled, and 4) through existing fish horns that are known to be problematic. As noted above in section 5.5.1.1, fish passage at Green Peter Dam was terminated in 1988, after studies indicated problems with both upstream passage of adult fish and downstream passage of juvenile fish through the reservoir and dam. In 1968 soon after dam construction, over 50,000 UWR steelhead smolts were noted at the Green Peter downstream fish bypass evaluator, but this number declined to 1400 smolts in 1987 and 1988 (Buchanan et al. 1993), likely due to the reservoir creating habitat conducive to predators, including pike minnows and bass. The Proposed Action does not include any measures to consider passage at Green Peter Dam.

The Proposed Action describes a process that will be undertaken for the Willamette Project to prioritize fish passage needs and improvements. However, the Action Agencies state that they cannot make a firm commitment to construct any fish passage facilities or carry out operations indicated by the study because of uncertainty with obtaining authorization and funding. Other than studies, no specific actions are identified that would improve downstream fish passage through Project dams and reservoirs in the South Santiam subbasin.

Conclusion
The effects of the Proposed Action would not improve access for UWR Chinook salmon and UWR steelhead to their historical habitat above Foster and Green Peter dams, and would not increase survival of juveniles traveling downstream through the reservoirs and past the dams.

5.5.2 Water Quality/Hydrology

5.5.2.1 Seasonal Flows

The Action Agencies propose to continue flow management as conducted since 2000. This includes attempting to meet specified seasonal minimum and maximum flows, seasonal drafting and refilling, and ramping rates for changing discharge. Thus the hydrologic effects of the Proposed Action are the same as those described under the environmental baseline for the South Santiam River (Section 4.5).

The USACE has estimated the frequency with which it anticipates not meeting the minimum and maximum flows under its proposed operations (Table 5.5-2). When these flows are not met adverse effects – reduced access to spawning habitat and reduced adult holding habitat – occur downstream 37.7 miles to the confluence with the N. Santiam River. Also, the effectiveness of spawning habitat can be reduced if flows are reduced post-spawning, exposing redds and desiccating eggs.

Table 5.5-2 Estimated frequency that proposed minimum and maximum tributary flows would not be met downstream from projects in the South Santiam River. Source: Donner 2008. Minimum and Maximum Tributary Flow Objectives below Willamette Dams.

Dam	Period	Primary Use	Minimum Flow (cfs)[1]	Chance of Not Meeting Flow	Maximum Flow (cfs)[2]	Chance Of Not Meeting Max Flow and Period of Miss	
Foster	Sep 1 - Oct 15	Chinook Spawning	1,500	25%	3,000 through Sep 30, When Possible	0% 2%	Sep Oct 1-15
	Oct 16 - Jan 31	Chinook incubation	1,100 [1]	20%			
	Feb 1 - Mar 15	Steelhead and Chinook rearing	800	5%			
	Mar 16 - May 15	Steelhead spawning	1,500	20%	3000	30%	Mar 16 - May 15
	May 16 - Jun 30	Steelhead incubation	1,100 [1]	5%			
	Jul 1 - Aug 31	Chinook and steelhead rearing	800	1%			

Exceedence of maximum flow objective over a 66-year record from 1936-2001 (probability figures are approximate).

1 Minimum flow will equal inflow or Congressionally authorized minimum flows, whichever is higher, when the reservoir is at a minimum conservation pool elevation. This avoids drafting the reservoir below minimum conservation pool and, where applicable, into the power pool.

2 Maximum flows are intended to minimize the potential for spawning to occur at stream elevations that might subsequently be dewatered at the specified minimum flow during incubation. It may not be possible to stay below these maxima, especially in the fall when drafting reservoirs in preparation for the flood damage reduction management period. Project operations will be managed to minimize the frequency and duration of necessary periods of exceedence.

The USACE's reservoir drafting priority schedule (Table 2-6 in Chapter 2, Proposed Action) creates sub-optimal water resource management from the perspective of maintaining desirable tributary flows as high flows and high reservoir drafting rates in other tributaries are required to offset low draft rates from priority reservoirs, principally Detroit reservoir. Tributaries downstream from such low priority reservoirs then tend to have higher flows than needed to support anadromous fish needs during the summer flow augmentation season and may then have insufficient stored water to meet fall flow objectives This effect is not fully defined but is likely most severe during below average water years when drafting demands are highest.

Green Peter and Foster project operations would continue to reduce the flows in the lower South Santiam River during late winter and spring (compared to historical levels) while the reservoirs are being refilled. During this period, juveniles of both species are rearing, smoltifying, and migrating through the Willamette River system to the Pacific Ocean. UWR Chinook fry are emerging from the gravels and winter steelhead are spawning in the South Santiam River downstream from Foster Dam. This flow reduction effect of the Proposed Action may have its largest biological effect on emigrating juvenile spring Chinook and winter steelhead. Reductions in spring flows may also interfere with recruitment of age-0 rainbow trout (*O. mykiss*) (Mitro et al. 2003). Winter flow reductions associated with active flood control operations may dewater Chinook salmon redds, reducing egg survival. These effects are expected to continue over the life of the Proposed Action.

These proposed operations do not provide properly functioning habitat for UWR Chinook salmon and UWR steelhead. Of particular concern is the relatively low probability of meeting the UWR Chinook spawning and rearing objectives in late summer and fall and the difficulty of meeting the maximum flow objectives for steelhead spawning.

5.5.2.2 Foster Dam Spring Spill

The Action Agencies would continue spring spill operation at Foster Dam. Under this operation, approximately 92 to 238 cfs (0.5 to 1.5 feet of water depth), depending upon reservoir elevation and inflow, would be spilled daily from 0600 through 2100 hours from April 15 through May 15 each year to facilitate passage of juvenile and kelt winter steelhead and juvenile spring Chinook salmon that may be passing from the reservoir near its surface.

5.5.2.3 Frequency of Channel-Forming & Over-Bank Flows

By continuing to reduce the frequency of channel-forming and over-bank flows downstream from Foster Dam, project operations would continue to limit channel complexity and thereby limit rearing habitat for juvenile Chinook salmon and steelhead (Section 4.5.3.2). Peak flow reduction may also reduce the recruitment and suitability of channel substrates for spawning salmon and steelhead. The USACE does not propose any actions to investigate or reduce these effects. These effects are expected to continue and may worsen over the life of the Proposed Action.

Reduction of peak flows in ongoing flood control operations could continue to benefit spring Chinook salmon by reducing the likelihood that high flows would scour and disrupt incubating redds (compared to the unregulated condition). However, the rate at which flows are reduced during flood control operations is also a factor (see below).

5.5.2.4 Flow Fluctuations

The Action Agencies propose to operate Foster and Green Peter dams in an effort to meet an 0.1 ft. per hour downramping rate restriction during nighttime hours and an 0.2 ft. per hour rate restriction during daylight hours, when possible. These rates are derived from available literature on protective ramping rates compiled by Hunter (1992). Based on the best available information, NMFS assumes that meeting this commitment would be sufficient to minimize the adverse effects of rapid discharge fluctuations on stranding and entrapment of juvenile salmonids downstream of the dams as long as existing equipment at the dams allows the USACE to operate within the proposed restrictions. However, the Action Agencies have indicated that the USACE will be unable to meet these ramp rate restrictions during periods when flow releases approach proposed minimums (USACE 2007a). Therefore the proposed protections of juveniles against rapid flow changes may be inadequate to prevent losses. Results of studies that the Action Agencies have proposed for evaluating the effectiveness of their efforts to control ramp rates below Project dams will address this issue and may indicate a need for improved ramp rate controls.

5.5.2.5 Water Contracting

Reclamation has contracted a total of 1,096 acre-feet of water stored in Green Peter and Foster reservoirs to irrigators along the South Santiam River (USACE 2007a), which constitutes a small fraction of the surface water withdrawals issued by OWRD. Another 1,485 acre-feet are contracted to users downstream from the confluence of the North and South Santiam rivers served by USACE reservoirs in both drainages. As part of the Proposed Action, Reclamation intends to issue a contract to an additional 350 acre-feet of water stored in USACE's Santiam River basin projects (primarily Green Peter and Detroit) and has proposed to issue contracts for delivery of up to an additional 10,000 acre-feet of water throughout the Willamette basin.[3]

USACE intends to continue serving these contracts with water released from storage to maintain project and mainstem minimum flows. That is, under the Proposed Action more water would be removed from the Santiam River during the irrigation season without any additional water being released from USACE's reservoirs. In general, Reclamation water contracts are supplemental to natural flow water rights held by individual water users and are only exercised when natural flows are insufficient to serve all users and meet instream water rights held by OWRD.

Assuming that such conditions would occur for only about 60 days each summer, the total level of proposed future Reclamation-supported water use could reduce flows in some sections of the South Santiam River by 11 cfs and in the Santiam River mainstem by about 25 cfs, an increase of 5 cfs over current use. Because the minimum flow downstream from Foster Dam would be 400 cfs during the late summer, this level of project-based water use is unlikely to substantially

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[3] No specific location for these future contracts has been specified. If these contracts follow the areal distribution of current Reclamation contracts, about 2% or 190 acre-feet would be issued to serve areas in the South Santiam subbasin.

affect listed species during most years. During very low water years, flow reductions associated with existing and new water use could limit juvenile UWR Chinook and winter steelhead rearing habitat during the late summer and thus reduce survival. During the late summer, the USACE operates the Willamette Project to augment Willamette River flows as needed to maintain Albany and Salem minimum flows. To the extent that water stored in Green Peter reservoir is used to meet those targets, low flow conditions in the South Santiam River, including those caused by the Proposed Action, would be mitigated. These effects are expected to continue and worsen over the life of the Proposed Action.

5.5.2.6 Flow-related Research, Monitoring and Evaluation (RM&E)

The Action Agencies would develop and implement a comprehensive research, monitoring and evaluation program to determine compliance with, and effectiveness of, their flow management actions. The RM&E program would be designed to better discern and evaluate the relationships between flow management operations and the resulting dynamics of ecosystem function and environmental conditions downstream of Willamette Project dams, and related effects on ESA-listed fish species. The recommendations for a Flow Management RM&E program would be integrated into the comprehensive program overseen by the RM&E Committee and following the principles and strategic questions developed by the committee.

5.5.3 Water Quality

Under the environmental baseline, certain aspects of water quality do not provide properly functioning habitat for UWR Chinook and UWR steelhead. These aspects include unnaturally warm water in the South Santiam River downstream of Foster Dam during the spawning and early incubation period for spring Chinook as well as high total dissolved gas concentrations in the river below the dam during spill events. Under the Proposed Action these conditions would not improve, and could further degrade.

5.5.3.1 Water Temperature

Water temperature conditions downstream from Foster Dam currently limit the abundance, productivity, and life history diversity (i.e., spawning, incubation, and emergence timing) of UWR Chinook salmon and UWR steelhead in the South Santiam below Foster Dam and in the mainstem Santiam River (see Section 4.5.3.3.). As will be elaborated upon later in this section, lower temperatures than normal below Foster Dam cause pre-spawner straying and mortality; elevated temperatures cause reduced egg viability and increased susceptibility to disease. These adverse effects extend the confluence with the North Santiam River, to 37.7 miles (Willis 2008).

Beginning in the late 1960s, state and federal fisheries managers began to express concerns that changes in the thermal regimes downstream from the large Willamette Project dams in the McKenzie and Santiam watersheds were adversely affecting salmon and steelhead. Following Congressional authorization in 1981, the USACE produced the first in a series of reports responding to these concerns (USACE 1982); and in 1984, the USACE initiated the Willamette System Temperature Control Study. That study produced two primary products: a Santiam sub-basin report (USACE 1988); and a McKenzie sub-basin report (USACE 1987). The Santiam sub-basin report determined that modifying the intake tower at Green Peter Dam and constructing a multilevel release system that drew water from different elevations in the reservoir could restore the natural seasonal water temperature hydrograph to the South Santiam River downstream from Foster Dam.

The majority of the current spawning of Chinook salmon is confined to the area just downstream of Foster Dam (Schroeder et al. 2006). One of the key limiting factors identified for Chinook salmon is the adverse effects associated with altered water temperatures released from Foster Dam, particularly during spawning and egg incubation (see Environmental Baseline Chapter for more details). High mortality of eggs and alevins has been observed in other populations where higher than normal (pre-Project) water temperatures have likely exceeded the temperature limits of Chinook eggs and alevins (see Middle Fork, North Santiam, and McKenzie results in the effects section). The preferred water temperature for spawning and egg incubation is reported in the literature to be in the range 5.0-14.4 C for Chinook in general (Bell 1986; Meehan and Bjornn1991). Significant mortality occurs when eggs are exposed to temperatures outside of this range (Murray and McPhail 1988). Water temperatures downstream of the Projects typically exceed these thresholds for at least a period of time during egg incubation and likely results in high egg mortality in Chinook below Foster Dam (Figure 5.5-1).

There is also concern that even if the eggs survive the warmer than normal temperature regime, the higher temperatures lead to increased development and growth and Chinook emerge from the gravel earlier than normal which also has been shown to decrease juvenile survival (Beacham and Murray 1990; USACE 2000). Data on emergence timing in the North Santiam, McKenzie, and Middle Fork populations below Project dams indicates that Chinoook emergence below dams can occur 8-10 weeks earlier than emergence in a normal temperature regime (see Effects Sections for this discussion). Similar earlier emergence timing is likely to occur with Chinook juveniles below Foster Dam in the South Santiam River due to the elevated temperature regime (Figure 5.5-1). The effect of this earlier emergence timing on Chinook is to cause them to emerge in the winter instead of in the spring. Winter conditions are considerably less suitable and production of food organisms is less, adversely influencing survival of the young fish. Significant mortality is likely (USACE 2000, p. 6-35.) In addition, higher flows in the winter also lead to poorer survival (USACE 2000, p. 6-46).

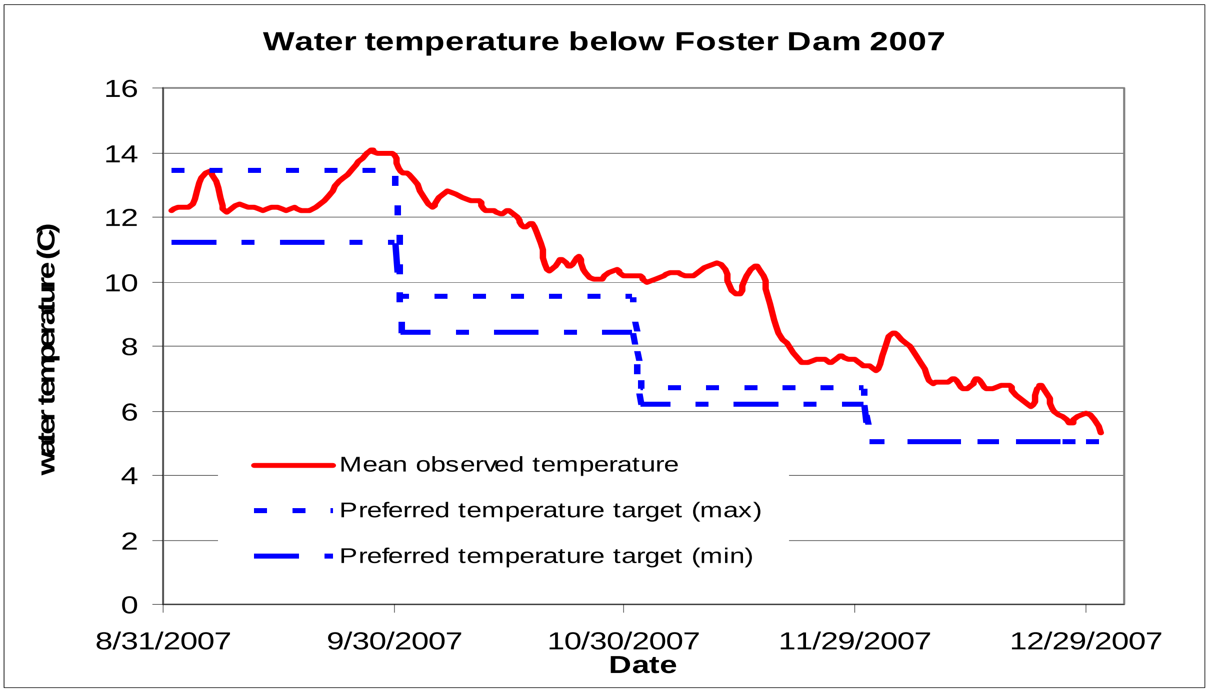

Figure 5.5-1 Comparison of observed and preferred temperature target range (using McKenzie River temperature targets: NMFS, FWS, ODFW 1984.) during spring Chinook spawning and egg incubation.

The Action Agencies have not proposed to modify the intake tower at Foster Dam. However, they propose to further evaluate temperature control at dams without such facilities under the proposed Willamette System Review Study. The goal of this study, which will be completed in three phases, "would be to recommend for implementation those measures shown to be technically feasible, biologically justified, and cost-effective" (USACE 2007a). Completion of these studies would likely require at least 4 years with final design and implementation likely to take another 4 years.

Thus, under the Proposed Action, correction of adverse water temperature conditions in the South Santiam would not be guaranteed. These conditions would continue to adversely affect UWR Chinook and UWR steelhead by causing juveniles to emerge in less favorable conditions, namely during earlier higher flow periods with scarcer forage.

5.5.3.2 TDG

The Proposed Action would maintain the current dam configurations in which spill operations create TDG concentrations high enough to kill UWR Chinook salmon and UWR steelhead yolk sac larvae for a one mile (Willis 2008) downstream from Foster Dam, potentially limiting the abundance, productivity, and juvenile outmigrant production of these South Santiam subbasin populations. The Action Agencies have not proposed to investigate total dissolved gas concentrations below Foster Dam, where Monk et al. (1975) observed TDG concentrations greater than 120% saturation during spills. The proposed operations would continue to minimize the frequency of spill operations but cannot entirely prevent them. Spill occurs primarily during high flow events during winter months, affecting UWR Chinook salmon in redds, but spill also occurs infrequently in other months when emergency events cause powerhouse shutdowns. The Proposed Action does not include any measures to develop emergency bypass valves or protocols using existing facilities to moderate sudden increases in TDG or to quickly address potential effects on UWR Chinook salmon and UWR steelhead downstream from Foster Dam.

Spill over 1,400 cfs at Foster generates more than 115% TDG below foster dam. The expected frequency of this occurrence varies as follows: Oct 0%, Nov 29%, Dec 54%, Jan 65%, Feb 25%, Mar 28%, Apr 13 %, May 4%, June 5% Jul-Sep 0% (Willis 2008). NMFS has no information on TDG below Green Peter Dam, but would expect enhanced TDG during spill there, as well.

5.5.3.3 Summary

Under the environmental baseline, operations at Foster and Green Peter dams have adversely affected the water temperatures in habitat in the lower Middle and South Santiam rivers used by all life stages of UWR Chinook salmon and by juvenile UWR steelhead. A Willamette System Review Study will study these effects. However, because the USACE has not proposed to install a water temperature control system, or to seek appropriations and authorization from Congress, implementation is highly uncertain. Another water quality issue that is directly related to project operations, total dissolved gas, would not be addressed under the Proposed Action and could degrade habitat even further.

5.5.4 Physical Habitat Quality

The key Proposed Actions related to physical habitat quality in the South Santiam River subbasin that will affect UWR Chinook salmon and UWR steelhead are listed below.

- Continue to operate Foster and Green Peter dams, blocking sediment and large wood transport from upstream reaches and tributaries into the South Santiam River below Foster Dam.
- Continue to reduce peak flows as part of flood control operations at the two Project dams, preventing creation of new gravel bars, side channels, and alcoves that provide rearing habitat for anadromous salmonids
- Continue the existence and maintenance of 1.82 miles of revetments along the South Santiam River, preventing channel migration and reducing channel complexity.
- Study the potential for gravel augmentation and large wood restoration projects in the South Santiam subbasin to improve salmonid habitat.
- Study effects of Project dams and revetments on downstream habitat and consider projects to restore habitat, including gravel augmentation, if authorized and funding becomes available.

5.5.4.1 Substrate, Sediment Transport, Large Wood, & Channel Complexity

Under the environmental baseline, substrate, sediment transport, large wood, and channel complexity are degraded, and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon and UWR steelhead (Section 4.5.3.4). This effect occurs continually and extends to the confluence of the N. Santiam River, 37.7 miles downstream from Foster Dam, as well as the short reach between Green Peter Dam and the upper extent of the Foster Reservoir pool. NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.5-5 and described below.

Under the Proposed Action, operation of Foster and Green Peter dams for flood control would continue to store sediment and large wood in the reservoirs, prevent recruitment of large wood and sediment from streambanks, allow stabilization of formerly active bar surfaces, and prevent flows capable of creating new bars, side channels, and alcoves. As a result, already impaired habitat would continue to degrade, limiting the abundance, productivity, and juvenile outmigrant production of the South Santiam subbasin populations of UWR Chinook salmon and UWR steelhead. Aside from unspecified habitat restoration actions that may result from gravel, large wood, and habitat restoration studies, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the South Santiam subbasin.

Operation of Green Peter and Foster dams has trapped gravel and large wood from 50% of the subbasin and has reduced the magnitude of peak flows, as described above in Section 4.5.3.4. Both of these operations deprive downstream reaches of bed material and transport mechanisms needed to create new gravel bars, islands, and side channels, which are necessary components of rearing and spawning habitat for both UWR Chinook salmon and UWR steelhead. The only large tributaries that enter the South Santiam downstream of Foster Dam are Crabtree and Thomas creeks, but they join the South Santiam River near its confluence with the North Santiam and do not replenish the most depleted reach just downstream of Foster Dam. Small tributaries to this reach, such as Wiley Creek, cannot contribute sufficient sediment and large wood to compensate for the loss in upstream supply.

The continued existence and maintenance of 1.82 miles of revetments by the USACE would prevent river migration and contribution of sediment from this length of streambank along the lower South Santiam River, further depriving the lower river of sediment and the ability to create new gravel bars or side channels. Reduction in peak flows would exacerbate these problems by reducing the frequency of flows with sufficient magnitude to re-shape the channel and form new habitat.

In summary, the continued degradation of habitat in the South Santiam subbasin downstream of Foster and Green Peter dams would likely further reduce the carrying capacity of this habitat for rearing juvenile fish and spawning adults, thus reducing the number of individual UWR Chinook salmon and UWR steelhead that can be produced in this presently degraded habitat. It is likely that areas of spawning gravel in the lower river would continue to be replaced with coarse bed material unsuitable for spawning, and that rearing habitat in the form of alcoves and side channels would continue to be reduced as well. Because these populations do not have safe passage and access to historical habitat upstream of the two dams, a reduction in spawning habitat in the reach below Foster could further limit spawning and contribute to overuse of redds (i.e., a second female could disrupt the eggs of one that's already spawned). Additionally, a lack of complex rearing and refugia habitat lower South Santiam River could limit juvenile outmigrant production in the subbasin. Aside from unspecified habitat restoration actions that may result from proposed habitat, revetment, and gravel studies, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the South Santiam subbasin.

5.5.4.2 Riparian Vegetation & Floodplain Connectivity

Under the environmental baseline, riparian vegetation and floodplain connectivity are degraded and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon and UWR steelhead (section 4.5.3.4). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.5-5 and described below.

Under the Proposed Action, operation of Foster and Green Peter dams and continued existence and maintenance of 1.82 miles of revetments in the lower South Santiam River would continue to degrade riparian vegetation and floodplain connectivity by preventing recruitment of large wood and sediment that create new bars and islands on which riparian vegetation can establish and by preventing peak flows that maintain stream connectivity to the floodplain. Although the Proposed Action includes study of potential habitat restoration and gravel augmentation in reaches below the dams, there is no certainty that any restoration work would be done during the term of this Opinion. Given the adverse water temperature conditions in the South Santiam River below Foster Dam associated with Project operations (as described in Section 5.5.3 Water Quality), and the lack of fish passage to historical upstream habitat (as described in Section 5.5.1 Habitat Access/Fish Passage), further degradation of riparian vegetation and floodplain connectivity would result in a net reduction in the already limited habitat available to UWR Chinook salmon and UWR steelhead in the South Santiam subbasin.

The extent and composition of riparian vegetation in the South Santiam subbasin would continue to be impaired by Foster and Green Peter dam operations under the Proposed Action by interfering with the processes needed for new floodplain forests to establish. Green Peter and Foster dams would continue to trap sediment and large wood and reduce the magnitude of peak flows in the South Santiam River, as described above in section 5.5.4.1. Additionally, the continued existence and maintenance of 1.82 miles of revetments in the lower South Santiam River would further prevent river migration and contribution of sediment and large wood from streambanks of the Santiam River. These operations would continue to deprive downstream reaches of sediment, channel-forming flows, and large wood needed to create gravel bars, islands, and floodplains on which new riparian vegetation can establish. The reduced width and continuity of riparian forests could prevent the shading of the South Santiam River, rendering the river susceptible to increased water temperatures.

In summary, the proposed operation of Foster and Green Peter dams and continued existence and maintenance of revetments along the mainstem Santiam River will continue to reduce the extent, quality, and inundation frequency of riparian and floodplain forests in the South Santiam subbasin downstream of Foster and Green Peter dams. The reduced extent of riparian vegetation (combined with reduced peak flows and limited channel migration) hinders recruitment of large wood into the aquatic system, which is needed to deposit spawning gravel, create resting pools for migrating adults, and provide cover for rearing juveniles or outmigrating smolts. Infrequent inundation of forested floodplains due to flood control operations would reduce nutrient and organic matter exchange during flood events, and reduce the availability of complex high-water refugia for juveniles, which could limit survival of rearing juveniles. Aside from unspecified habitat restoration actions that may result from the Willamette Floodplain Restoration Study or other habitat restoration studies described in the Sup BA, Section 3.5.2, Offsite Habitat Restoration Actions (USACE 2007a), the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain connectivity in the South Santiam subbasin. Given the uncertainty in upstream and downstream passage to historical habitat above Foster and Green Peter dams (see Section 5.5.1), continued degradation of limited spawning and rearing habitat under the Proposed Action will reduce the abundance and productivity of South Santiam subbasin populations of UWR Chinook salmon and UWR steelhead.

5.5.5 Hatcheries

As described in Chapter 2, the Proposed Action is to continue to artificially propagate hatchery spring Chinook salmon (ODFW stock 024) and summer steelhead (ODFW stock 024), and release these fish into the South Santiam River at Foster Dam. Details about these programs are described in the South Santiam spring Chinook HGMP (ODFW 2008b) and Willamette Basin summer steelhead HGMP (ODFW 2004a).

Below is an analysis of the specific effects of these actions on listed spring Chinook and winter steelhead in the South Santiam River.

5.5.5.1 Hatchery Operations

There is one hatchery in the South Santiam watershed, South Santiam Hatchery, located at the base of Foster Dam on the South Santiam River. South Santiam Hatchery collects, spawns, incubates, and raises spring Chinook salmon and summer steelhead for the South Santiam Chinook program and the entire Willamette Basin summer steelhead program. Broodstock are collected at the fish ladder on Foster Dam and, to some extent, as volitional returns to the hatchery across the river.

There are two primary concerns with the effects of hatchery facilities on listed spring Chinook and winter steelhead in the South Santiam River- 1) risk of facility failure leading to fish mortality in the hatchery (particularly progeny of natural-origin fish), and 2) improperly screened water intakes at the hatchery facility that lead to the mortality or injury of naturally rearing listed fish, as described in section 5.1, the “General effects of hatchery programs on ESA-listed salmon”. Other potential adverse of effects of the facilities or related activities are addressed below.

The occurrence of catastrophic loss (or unforeseen mortality events) of spring Chinook and summer steelhead at South Santiam Hatchery has been very low over the last several decades and of no consequence to the conservation and recovery of spring Chinook or winter steelhead. All of the normal safeguard equipment and procedures are being implemented at this hatchery. Since there have been few significant mortality accidents at this hatchery in the past, the risk of facility failure is deemed to be a low risk to natural-origin spring Chinook and winter steelhead in the South Santiam populations.

The water intake for the South Santiam Hatchery water supply is in Foster Reservoir. There are two pipes located on Foster Dam that draw water to the hatchery year round. This water intake does not meet NMFS' criteria for listed juvenile salmon and steelhead. However, given the poor survival of outplanted spring Chinook above Foster Dam, there is a low risk that spring Chinook would be impacted by the water intake of the hatchery at Foster Dam. In contrast, winter steelhead are passed upstream of Foster Dam and juvenile production does occur. It is unknown how emigrating winter steelhead may be impacted by the intake on the dam. Generally, steelhead migrate near the surface of the reservoir and pass over the spillway at Foster Dam. Further evaluation should occur to ascertain the degree of risk the water intake affords to juvenile winter steelhead, especially when juvenile passage through the spillway and turbines of Foster Dam are taken into account.

5.5.5.2 Broodstock Collection

Broodstock collections for the South Santiam spring Chinook program (ODFW 2008b) and Willamette Basin summer steelhead program (ODFW 2004a) both occur at Foster Dam/South Santiam Hatchery. The Supplemental BA and HGMPs specify the specific collection schedules. Approximately 5,500 Chinook are handled annually. Of these, 1% are injured, and less than 1% are killed at the trap. During subsequent trucking operations approximately 1500 fish are transferred to the hatchery or release sites upstream and downstream of Foster Dam, with a mortality of 1% (Willis 2008).

For UWR steelhead, approximately 600 fish are handled; 2% of these are injured and 1% die during trapping operations. Another 1% fail to survive subsequent trucking operations. (Willis 2008)

The effects of hatchery broodstock collection at the Foster Dam trap on UWR Chinook salmon and UWR steelhead from these hatchery programs are likely to be substantial. The trapping situation at Foster Dam is different than any other situation in the Willamette Basin. Listed winter steelhead have been trapped and hauled at Foster Dam for the last few decades in an effort to conserve the winter steelhead run above Foster Dam (impassable barrier). The late run timing of winter steelhead overlaps with the first arrivals of spring Chinook and summer steelhead in April and May. Consequently, it is common to handle winter steelhead that will be outplanted above Foster reservoir, hatchery and natural-origin Chinook, and hatchery summer steelhead at the same time. Early arriving hatchery Chinook and summer steelhead are typically taken back downriver and released in the lower South Santiam so that they are available for harvest in recreational fisheries. All of these collections occur at a trapping facility that was not built for proper handling of natural-origin fish (e.g., crowding in small areas, no water-to-water transfer of fish) nor the high numbers of fish that typically return.

There are few alternatives available for further reducing the effects of this trapping on natural-origin winter steelhead and spring Chinook; besides rebuilding the existing facility. The Foster Dam trap has to be operated from April through May in order to collect wild winter steelhead for transport above the dam. Spring Chinook and summer steelhead that are present will also enter the trap because the fish are actively migrating upstream. Even if the Chinook and summer steelhead hatchery programs were eliminated (which is not an option due to mitigation responsibilities), the problem would still exist but to a lesser degree because hatchery fish would not overwhelm the trap.

5.5.5.3 Genetic Introgression

Spring Chinook

Significant genetic introgression from hatchery fish into the natural population in the South Santiam has occurred since Foster and Green Peter Dams were constructed and this mitigation hatchery program was initiated. Ever since all returning hatchery fish have been mass marked (adipose fin-clipped) so that they could be distinguished from naturally-produced fish in 2002, most of the return has been fish of hatchery-origin (see Figure 4.5-2). In addition, the majority of the fish spawning naturally below Foster Dam have been hatchery fish (Table 5.5-3). The percentage of natural-origin fish recovered in carcass surveys on the spawning grounds has ranged from 9% to 21% from 2002-2006. Hatchery origin fish have dominated the spawning grounds and the percentage of natural-origin fish incorporated into the hatchery broodstock has been very low (see Table 5.5-4). Thus the PNI values for this population have been very low since 2002—indicating hatchery fish are dominating genetic processes in this population (see Figure 5.2-3).

Table 5.5-3 Composition of spring Chinook salmon in the South Santiam River from Foster to Waterloo, based on carcasses recovered. Weighted for distribution of redds among survey areas. Source: McLaughlin et al. (2008).

	Fin-	Unclipped[a]		Percent
Run year	**clipped**	**Hatchery**	**Wild**	**wild[b]**
2002	1,604	37 (14)	224	12 (12)
2003	970	31 (17)	151	13 (13)
2004	838	30 (26)	85	9 (9)
2005	467	12 (9)	128	21 (20)
2006	243	9 (15)	50	17 (16)

[a] The proportion of hatchery and wild fish was determined by presence or absence of thermal marks in otoliths. Number in parentheses is percentage of unclipped fish that had a thermal mark (unclipped hatchery fish).
[b] Percentage not weighted for redd distribution is in parentheses.

Table 5.5-4. Composition of spring Chinook salmon without fin clips that were spawned at South Santiam Hatchery, based on the presence or absence of thermal marks in otoliths, 2002–2006. Source: McLaughlin et al. (2008).

	Unclipped[a]		Fin-clipped	Percent wild—	
Year	**Wild**	**Hatchery**	**hatchery**	**in broodstock**	**of run**
2002	26	19	1,174	2.1	---
2003	25	23	1,048	2.3	---
2004	78	16	905	7.8	---
2005[b]	71	19	999	6.5	---
2006[c]	137	46	957	12.0	---

[a] Includes fish with partial or questionable fin-clips.
[b] Otoliths were analyzed for 63 fish (50 wild).
[c] Otoliths were collected on 152 unclipped fish, of which 114 were wild and 38 were of hatchery origin.

The effect of managing gene flow between the hatchery program and the natural-origin population in the South Santiam River is difficult to discern with the available data. If there were high numbers of natural-origin fish, it would be important to protect and conserve these genetic resources (e.g. like managing hatchery strays in the McKenzie River). However, if there are key limiting factors that prohibit natural production in the natural-origin by hatchery or natural-origin fish (e.g. Middle Fork Willamette), it would first be necessary to correct these key limiting factors and then possibly use the hatchery program for supplementation purposes (Nickum et al. 2004). Prior to the mass marking of hatchery fish, it was believed the natural-origin population was extinct in the South Santiam (Nicholas 1995). However, in recent years a modest number of unmarked Chinook have been collected at the Foster trap and observed in spawning surveys downstream (McLaughlin et al. 2008). However, the trend in natural-origin Chinook returns from 2002 to 2007 has clearly been declining (based upon the number of unmarked fish collected at Foster trap) from a high of 1,457 in 2004 to the most recent low of 131 in 2007 (Schroeder et al. 2006; McLaughlin et al. 2008). Since most of the spawning below Foster Dam has been of fish from hatchery-origin (see Table 5.5-3), it is likely a large proportion of the unmarked adult Chinook returning in recent years are progeny of hatchery spawners.

The modest return of unmarked Chinook back to Foster Dam in certain years from 2002-2007 suggests conditions can be favorable for natural production of spring Chinook in the South Santiam River. It may be that juvenile Chinook production is occurring in the South Santiam River on a regular basis, but when ocean conditions are favorable, survival is greater and more natural-origin Chinook return to the South Santiam (2004 was a good return year with more favorable ocean conditions than experienced by the 2007 adult return).

As more data becomes available on the status of natural production in the South Santiam population of spring Chinook salmon, the management of hatchery Chinook on the spawning grounds below Foster Dam may need to be modified. Actions to reduce the proportion of hatchery fish spawners in the natural-origin may need to be taken in the future in order to reduce genetic risks to acceptable levels. The long-term vision for hatchery management in the South Santiam is to increase natural-origin Chinook production to a level where hatchery mitigation can be reduced and hatchery fish on the spawning grounds above and below Foster Dam are managed for the long-term sustainability of natural-origin fish (see "General effects of hatchery programs on ESA-listed salmon and steelhead" section above for further explanation).

Winter Steelhead
There are no hatchery winter steelhead programs in the South Santiam River. However, hatchery summer steelhead spawn naturally in the same areas as winter steelhead (Schroeder et al. 2006). Since there is some overlap in the spawn timing of summer- and winter-run fish from February through March, the potential exists for summer steelhead to interbreed with winter steelhead in the South Santiam River. However, the likelihood of this occurrence is low. Most of the summer steelhead spawning occurs in January and February (Schroeder et al. 2006). The peak of the listed winter steelhead run over Willamette Falls (downstream of the South Santiam) occurs from late February through March (Myers et al. 2006). Actual spawn timing of these winter steelhead would be weeks later in the tributaries of the South Santiam River.

The primary concerns with the hatchery summer steelhead program are predation and competition, which are addressed below.

5.5.5.4 Disease

Hatchery fish can be agents for the spread of disease to natural-origin fish residing in the natural environment. Due to the high rearing densities of fish in the hatchery, hatchery fish can have elevated levels of certain pathogens, disease, and/or bacteria. After they are released, these fish may expose and/or transfer the disease to natural-origin fish. Below is an assessment of these risks to the juvenile and adult life stages.

Juveniles
In the South Santiam subbasin, the risk of hatchery fish spreading disease to natural-origin juvenile Chinook salmon and winter steelhead is unknown. Hatchery fish are released as smolts from South Santiam Hatchery. Significant juvenile fish rearing occurs in the lower river and in the mainstem Santiam River. The effects of hatchery fish interacting with other Chinook and steelhead populations downstream are addressed in the section "Mainstem Willamette River".

Adults
The potential also exists for returning hatchery fish to spread diseases to natural-origin adult fish commingled in the South Santiam River. The risk of hatchery fish spreading diseases in the South Santiam may be substantial since Chinook congregate at the base of Foster Dam throughout the summer until spawning time in September and October. There is no effect of hatchery adults on winter steelhead due to the differences in run timing.

5.5.5.5 Competition/Density-Dependence

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Information on the potential competitive interactions between hatchery and natural-origin fish is very limited in the Willamette Basin. Below is an assessment of the likely implications on the juvenile and adult life stages.

Juveniles
Since all hatchery fish are released as smolts and are expected to migrate quickly to the ocean, it is unlikely significant competitive interactions will occur over a period of time.

As described in the "genetic introgression" above, hatchery summer steelhead spawn naturally in winter steelhead habitat. Summer steelhead spawning has been widespread; with the number of spawners positively correlated with run strength (Schroeder et al. 2006). It is likely that progeny from these summer steelhead would negatively affect listed juvenile winter steelhead rearing in their natal habitat. It is unknown whether there is in fact a competitive interaction due to limited resources. However, any interaction between non-native summer steelhead and listed winter steelhead would be undesirable. Juvenile summer steelhead would have a competitive advantage because these fish would hatch earlier and be of larger size than winter steelhead. Monitoring and evaluation is scheduled to occur to evaluate the proportion of juvenile steelhead that are the progeny of summer steelhead.

Adults
Given the problem of crowding of adult Chinook at the base of Foster Dam, there is the potential for competitive interactions for space. There is a limited amount of habitat in the holding pool at the base of the dam. It is unknown whether adult fish are displaced into suboptimal holding habitat downstream due to the high number of fish at the base of the dam. Given the primary limiting factors for this population (habitat access, temperature problems), competition is not likely one of the primary or secondary limiting factors.

5.5.5.6 Predation

Hatchery fish released into the population areas throughout the Willamette Basin can predate upon co-occurring natural-origin fish. In general, salmonids can prey upon fish approximately 2/3 of their size. Thus there is significant potential for hatchery summer and spring Chinook to prey upon natural-origin steelhead and Chinook. Even though information is lacking on the extent of this issue, predation by hatchery fish undoubtedly occurs. Schroeder et al. (2006) examined predation by hatchery summer steelhead and rainbow trout on Chinook fry in the McKenzie River. Predation did occur on Chinook fry by a few individual fish. However, due to the fast digestion rates of Chinook fry in the stomachs of summer steelhead and rainbow trout (e.g. one to seven hours), it was difficult to estimate the amount of predation in their sampling design. Given the primary and secondary limiting factors identified for Willamette populations, predation by hatchery fish is not likely a limiting factor and the risk to listed fish is low.

Juvenile summer steelhead (that are the progeny of naturally spawning summer steelhead in winter steelhead habitat) could also predate upon listed age-0 and age-1 juvenile winter steelhead. The extent of this potential problem is unknown at this time. However, monitoring and evaluation is scheduled to occur to evaluate the proportion of juvenile steelhead that are the progeny of summer steelhead.

5.5.5.7 Residualism

All hatchery programs in the Willamette Basin release hatchery fish as smolts. The intent is to release the hatchery fish at a size and time so that they will actively migrate to the ocean; thus minimizing the potential interaction between hatchery and natural-origin fish. However, a percentage of the smolts do not emigrate and residualize in the river. These residual fish may migrate to the ocean at a later time or may stay in freshwater the rest of their life.

In general, hatchery steelhead are more likely to residualize than hatchery spring Chinook. In the Willamette Basin, the primary concern is with residual summer steelhead. The percentage of the smolt release of summer steelhead that do residualize is unknown. However, residual summer steelhead have been observed in all areas where hatchery fish are released. Several new actions are included in the Proposed Action that will help reduce the adverse effects of residual summer steelhead on natural-origin winter steelhead and spring Chinook. The most beneficial is the proposal to not release any summer steelhead smolts that do not volitionally emigrate from the hatchery facility. These "non-migrants" will be collected and released into standing water bodies for trout fisheries. Previously, all of these non-migrant fish were forced out into the river. In addition, ODFW is proposing a new angling regulation that will allow the harvest of any finclipped, residual summer steelhead in all recreational fisheries. These regulation changes will decrease the number of residual hatchery fish left in the river and thus reduce adverse effects of residual fish on natural-origin steelhead and spring Chinook.

5.5.5.8 Fisheries

As discussed in the "General effects of hatchery programs on ESA-listed salmon and steelhead" section above, the production of hatchery fish can lead to commercial and recreational fisheries that cause the overharvest of natural-origin fish. An abundance of hatchery fish can promote expanding fisheries, which may be detrimental to commingled natural-origin fish. In the Willamette, all hatchery fish have been mass marked since the 1990's. This mass marking has facilitated implementation of selective fisheries—where only hatchery fish can be harvested. Thus freshwater fishery impacts on winter steelhead and spring Chinook have been reduced substantially compared to historical harvest rates. Freshwater fishery impacts are now in the range of 1-5% for winter steelhead and 8-12% for spring Chinook populations in the Willamette Basin.

The production of Willamette hatchery fish are of no consequence to the management of ocean fisheries. In general, it is unusual to catch steelhead of either natural or hatchery origin in ocean fisheries. Hatchery spring Chinook are caught in ocean fisheries, particularly in Alaska and West Coast Vancouver Island fisheries (see Figure 4.2-13). However, these hatchery fish are not a driver for fisheries management. Protection of other stocks of concern in Canada and the United States currently constrain ocean fishery quotas and regulations. In addition, harvest of Willamette spring Chinook in ocean fisheries is governed by the Pacific Salmon Treaty between the US and Canada and impacts have been typically been in the range of 10-15%.

5.5.5.9 Masking

The production of unmarked hatchery fish can have an impact on natural-origin fish if these hatchery fish stray and intermingle with natural-origin populations. Not knowing whether naturally spawning fish are of hatchery- or natural-origin confounds the ability to monitor the true status of the natural-origin population. This effect has been termed “masking” by hatchery fish.

In the Willamette Basin, this concern has been eliminated because all hatchery spring Chinook, summer steelhead, and rainbow trout are adipose finclipped. In addition, all hatchery spring Chinook are otolith marked in the hatchery which provides an additional safeguard to detect hatchery fish that may have been missed during finclipping (currently <5% of all the smolt releases, McLaughlin et al. 2008). The Action Agencies are also proposing to coded wire tag (CWT) all hatchery spring Chinook salmon, which will also allow individual fish to be identified upon their return to freshwater.

5.5.5.10 Nutrient Cycling

Hatchery fish can provide essential marine-derived nutrients to the freshwater environment if they spawn naturally or are outplanted as carcasses (see “General effects of hatchery programs on ESA-listed salmon and steelhead” section above). Hatchery spring Chinook salmon and summer steelhead are known to spawn naturally throughout the Willamette Basin, thus providing benefits in terms of marine nutrients to the local environment. Thousands of hatchery Chinook are also outplanted above the dams in an effort to restore natural production in historical habitats. This provides benefits to aquatic and terrestrial food chains.

5.5.5.11 Monitoring & Evaluation

Monitoring and evaluation of Willamette hatchery programs under the ESA began in response to NMFS (2000a) *Biological Opinion on the impacts from the collection, rearing, and release of listing and non-listed salmonids associated with artificial propagation programs in the Upper Willamette spring Chinook and winter steelhead ESUs.* The ODFW implemented specific monitoring and evaluation activities to collect information on the effects of hatchery programs in the Willamette. This information is found in Schroeder et al. (2006) and McLaughlin et al. (2008).

Monitoring and evaluation of hatchery programs in the Willamette Basin will continue to occur in order to assess whether the programs are meeting their intended goals and to evaluate the impacts on natural-origin populations. The specific HGMPs for each program describe the monitoring and evaluation that will occur in the future.

5.5.6 Summary of Effects on the South Santiam Populations of Chinook Salmon & Steelhead

Table 5.4-5 summarizes anticipated effects of the Proposed Action on the VSP parameters for South Santiam populations of Chinook salmon and steelhead.

5.5.6.1 Abundance

There have been substantial impacts of the Proposed Action on UWR Chinook salmon and UWR steelhead in the South Santiam subbasins. The Proposed Action is essentially status quo management of the Projects and thus the abundance of these species is likely to continue decreasing. This is of concern particularly for Chinook since their abundance is low and their trend is clearly declining.

5.5.6.2 Productivity

Productivity of UWR Chinook salmon and steelhead in the South Santiam has been declining over the long- and short- terms. The recent decline in Chinook abundance is of particular concern because productivity has not been increasing. The current hatchery programs represent risks to the listed populations. However, the recent returns of natural-origin Chinook are likely the offspring of hatchery spawners. Thus, production is so poor in this population that hatchery supplementation has to be relied upon until other limiting factors are corrected. Even though this is a high risk scenario, alternatives are limited due to the poor status of natural-origin Chinook. Without substantial improvements to the habitat conditions below Foster Dam and adequate passage of fish above Foster Dam into historical habitats, NMFS expects the productivity and capacity of these populations to reproduce naturally will not improve but will remain at a very low level. There is also concern with the productivity of the steelhead population, particularly for the remnant run that is trapped and hauled above Foster Dam. The productivity of this segment of the population is also declining. The Proposed Action lacks certainty that any improvements would be carried out during the term of this Opinion.

5.5.6.3 Spatial Structure

The Proposed Action continues to limit UWR Chinook salmon and UWR steelhead access to historical habitats above Foster and Green Peter dams. Access is dependent upon trap and haul at Foster Dam. Success of the outplanting program has been mixed. Steelhead outplanting has been successful. Chinook efforts have been poor with high prespawning mortality rates in outplanted fish. Restoring production above Foster Dam, with appropriate survival of adult and juveniles, is needed to increase the spatial distribution of the population and increase the capacity of the population to respond to fluctuating environmental conditions. However, the Proposed Action would not provide safe upstream and downstream passage.

5.5.6.4 Diversity

Many aspects of the South Santiam Chinook and steelhead populations have been and will continue to be impacted by the Proposed Action. Since the impacts have been substantial, there has undoubtedly been changes in the diversity of the Chinook and steelhead in the South Santiam. Population traits are now not as diverse as they were in historical populations, and this decreases the ability of salmon and steelhead to respond and survive in response to fluctuating environmental conditions. The Proposed Action would be expected to continue to degrade habitat downstream of Project dams, resulting in more uniform channel characteristics that would select for less diverse life history patterns in the remaining natural-origin Chinook salmon and steelhead. The influence of hatchery fish on the natural-origin population also represents risk to the diversity of the natural-origin population.

5.5.7 Effects of the Proposed Action on Designated Critical Habitat

The mainstem South Santiam and a number of its tributaries have been designated as critical habitat for UWR Chinook salmon and UWR steelhead. The PCEs identified in this portion of critical habitat include sites for spawning, rearing, and migration. Table 5.5-5 identifies the anticipated effects of the Proposed Action on the PCEs of this habitat. The effects are attributable to a lack of functional fish passage at USACE dams, the effects these dams and their reservoirs have on water quality and physical habitat conditions in the lower South Santiam River, and continued existence and maintenance of 1.82 miles of revetments along the lower river. The following PCEs will be adversely affected by the Proposed Action:

- Freshwater spawning sites above Foster Dam with flow regimes, water quality conditions, and substrates well suited to the successful spawning, incubation, and larval development of UWR Chinook and UWR steelhead will be marginally accessible to these fish and such sites above Green Peter Dam will remain inaccessible. Spawning habitat will remain accessible to these fish below Foster, but much of this habitat is degraded as a result of ongoing Project operation. Flow releases from Green Peter and Foster dams during late summer and fall will continue to create suboptimal temperature conditions for UWR Chinook that spawn, incubate, and emerge as fry in the habitat below Foster. This habitat is further degraded by the Project's interruption of sediment transport, such that new gravels needed for spawning are not replacing those that move downstream during high flows. Additionally, continued existence and maintenance of revetments downstream of Foster Dam prevent channel formation processes that might otherwise allow for new gravels and spawning habitat to be created.
- The quantity and quality of freshwater rearing sites for juvenile UWR Chinook will remain limited and degraded in the fully accessible portion of the mainstem South Santiam River, below Foster, and may continue to decline. Diminished peak flows, lack of sediment and LWD delivery from areas above Project dams, and revetments, contribute to losses of off-channel rearing habitat and impair processes that might otherwise create complex habitats along main channel areas. Sudden reductions in outflows below Project dams will, when flows are relatively low, continue to pose risks of juvenile stranding and loss.
- Historically important migratory corridors will continue to be obstructed by Foster and Green Peter dams and reservoirs. Under current conditions these obstructions diminish the abundance and productivity of an above-dam component of naturally produced UWR steelhead and preclude reestablishment of a productive naturally spawning UWR Chinook population in the upper South Santiam subbasin.

In aggregate, these effects will continue to diminish habitat availability and suitability within the South Santiam subbasin for juvenile and adult lifestages of UWR Chinook and UWR steelhead. These adverse effects to the functioning of designated critical habitat within the subbasin will limit the habitat's capacity to serve its conservation role supporting large, productive, and diverse populations of these fish.

Table 5.5-5 Effects of the Proposed Action on Chinook Salmon and Steelhead Populations (VSP column) and Critical Habitat (PCE column) in the South Santiam subbasin. Modified USACE 2007a, Table 6-2.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater migration corridors	Habitat Access	Physical Barriers	Proposed Action would continue to limit access to historical habitat for UWR Chinook salmon and UWR steelhead above Foster Dam, and prevent access above Green Peter Dam.	Proposed Action would continue to limit access to historical habitat for UWR Chinook salmon and UWR steelhead above Foster Dam, and prevent access above Green Peter Dam.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in Peak/Base Flow	Improved ramping rates and flow conditions below Foster Dam will reduce risks to ESA-listed fish species. The improved ramping and flow conditions could result in improved ecosystem health and function, expanded rearing habitat, higher egg-to-smolt survival, improved migration conditions, and improved overall productivity. As a result, local population abundance also may increase. Biological monitoring will document changes in local habitat conditions and in local population productivity resulting from a combination of Action Agency actions.	Flow-related components of habitat quality for UWR Chinook and UWR steelhead will be improved in the near-term within areas downriver of the USACE dams in the subbasin. Longer term effects of diminished flood events on channel-forming processes that help create or maintain channel complexity will continue.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Initially, no change in effect from existing suboptimal conditions for spawning, incubation, and emergence of UWR Chinook. If and when WTC capability is developed and implemented, population abundance and productivity would increase. Habitat quality in the natural production area below Foster would improve. Spawning activity and egg-to-fingerling survival is expected to increase for UWR Chinook, resulting in the potential for improved abundance and productivity. Biological monitoring would document realized changes.	Unfavorable thermal conditions below Foster Dam during fall will continue into the future unless the Action Agencies develop WTC capability.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	No effect.	No effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical contamination /Nutrients	Productivity above the Green Peter/Foster project may increase to an unknown extent as a result of increased levels of marine derived nutrients. At this time, the Action Agencies make a conservative assumption of no improvement in effect from our activities.	No effect.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	Continued augmentation of summer flows will continue to help overcome historical water quality problems in the river below Lebanon.	Continuing minor positive effect on the quality of rearing/migration habitat provided in the lower-most South Santiam River.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	Spill operations would continue to create TDG concentrations high enough to kill UWR Chinook salmon and UWR steelhead yolk sac larvae for a short distance downstream from Foster Dam, potentially limiting the abundance, productivity, and juvenile outmigrant production of these South Santiam subbasin populations.	Continued unfavorable effect during spill events on spawning/early rearing habitat immediately below Foster Dam.
Freshwater spawning sites	Habitat Elements	Substrate	Continued lack of new gravels to existing spawning habitat below Foster Dam would reduce abundance and productivity of UWR Chinook salmon and UWR steelhead by limiting and degrading available habitat.	Operation of Foster and Green Peter dams would continue to block sediment transport to downstream reaches, further increasing substrate coarsening, and thereby degrading limited spawning habitat. Study of gravel augmentation would not guarantee that sediment would be placed below Foster Dam at adequate levels to restore fully functioning habitat.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris (LWD)	Continued lack of large wood reduces abundance and productivity of UWR Chinook salmon in the South Santiam Subbasin because holding and rearing habitat below the dams would continue to degrade and would not be replaced.	Operation of Project dams would continue to block transport of large wood from reservoirs to downstream habitat, revetments would continue to prevent floodplain connectivity, reducing large wood recruitment from streambanks, resulting in less structure available to create complex channel habitat, gravel bars and large pools. Study of stockpiling LWD would not guarantee new LWD will be placed in reaches below the dams.
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Continued degradation of pool habitat would reduce rearing and adult holding habitat, resulting in lowered productivity and abundance	Continued low frequency of pools and poor pool quality below Foster Dam. Operation of Project dams and continued existence and maintenance of revetments would continue to prevent peak flows and block sediments and large wood, preventing channel movement that would allow for new pools to form.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-channel habitat	Continued lack of off-channel habitat would reduce rearing habitat, resulting in lowered productivity and abundance.	Continued reduced off-channel habitat in the South Santiam River below Foster Dam. Project operation would continue to reduce peak flows, limiting overbank flows and channel forming processes. Although studies may consider special operations to provide peak flows, the Action Agencies provide no certainty that this operation would occur during the term of this Opinion, nor that the operation would open up off-channel habitat.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/Depth Ratio	Continued degraded channel conditions would reduce rearing habitat, resulting in lowered productivity and abundance.	Project operation would continue to reduce peak flows and block large wood and sediment transport, limiting pool formation. Although studies may consider stockpiling LWD for later placement to create habitat complexity and funding habitat restoration projects, the Action Agencies provide no certainty that these measures would occur during the term of this Opinion.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Streambank Condition	Degraded streambanks would inhibit channel forming processes that create complex habitat essential for juvenile rearing, adult spawning and holding, resulting in lowered productivity and abundance.	Project operation and revetments would continue to prevent streambanks from supporting natural floodplain function in the lower South Santiam River below Foster Dam. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve streambank conditions, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain Connectivity	Continued lack of floodplain connectivity reduces availability of off-channel habitat, limiting available rearing habitat, including reduced macroinvertebrate production as a food supply, resulting in lowered productivity and abundance.	Project operation and revetments would continue to prevent overbank flow and side channel connectivity in the South Santiam River below Foster Dam. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve off-channel habitat, restoring normative ecosystem functions, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	Continued degradation of riparian habitat would reduce large wood available for channel complexity, thereby reducing already limited rearing, holding, and spawning habitat, resulting in lowered abundance and productivity.	Project operation and revetments would continue to prevent formation of new gravel bars on which riparian vegetation could grow in the South Santiam River below Foster Dam. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially restore riparian vegetation, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.

Section 5.6
North Santiam Subbasin Effects

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5.6 North Santiam Subbasin: Effects of the Willamette Project Proposed Action on UWR Chinook Salmon & UWR Steelhead & Critical Habitat

Summary of the Effects of the Proposed Action

- The effects of the Proposed Action on North Santiam populations of UWR Chinook salmon and UWR steelhead would be substantially the same as NMFS determined in its baseline analysis, that Chinook and steelhead ESUs would continue to decline and critical habitat would continue to be adversely modified. The Proposed Action would continue to:
  - prevent fish access to historical spawning and rearing habitat
  - degrade water quality and physical habitat elements downstream from the dam complex
  - reduce streamflow through the Reclamation irrigation water contract program
  - create risks and potential benefits associated with the North Santiam Hatchery Chinook and steelhead programs

Introduction

The North Santiam River subbasin supports a population of UWR steelhead and also one of UWR Chinook salmon. The population of winter steelhead is currently at “moderate” risk of extinction. Spring Chinook are currently at “very high” risk of extinction. The abundance of steelhead and Chinook is currently much reduced compared to historic levels. The primary causes of the decline for these populations include loss of access to historical spawning and rearing habitat above Big Cliff and Detroit Dams, altered physical and biological conditions downstream of the dams (hydrograph, temperature, flow, recruitment of gravel and woody debris), interbreeding between hatchery and natural-origin Chinook and steelhead, and degraded habitat conditions associated with land management in the tributaries downstream of Big Cliff Dam (ODFW 2007b). For a full description of the status of the ESU and environmental baseline, see Chapters 3 and 4.

The Proposed Action includes the following broad actions:

- Project dams: continued operation and maintenance under existing configuration of Big Cliff and Detroit dams in the North Santiam subbasin.
  - Flow Management- targets for volume and seasonal timing of water released downstream from Big Cliff and Detroit dams.
  - Ramping Rates- targets that control how quickly water releases from Big Cliff and Detroit dams are increased or decreased, with the intent of limiting maximum nighttime downramp rates to 0.1 ft/hr and maximum daytime downramp rates to 0.2 ft/hr.

- Hatchery Program- continued production of hatchery Chinook and summer steelhead for fishery augmentation and conservation purposes; continued operation of Marion Forks Hatchery.
- Outplanting Program- trap and haul of Chinook from below Big Cliff and Detroit dams to release locations above the dams.
- Continue to operate (currently at Minto) adult fish collection facilities- possibly rebuild facility in the future, date uncertain and based on funding.
- Continued existence and maintenance of 3.87 miles of revetments
- Withdrawal and consumptive use of stream water will be facilitated through a contract water sales program

In this section, NMFS considers the effects of the Proposed Action on UWR Chinook salmon and UWR steelhead populations in the North Santiam subbasin. In general, NMFS expects that the Proposed Action would cause continued degradation of habitat downstream of the dams and continued lack of access to historical habitat, reducing abundance and productivity of these populations. NMFS expects the Proposed Action would result in some improvements in hatchery management, preventing further decline in genetic diversity from baseline conditions. NMFS concludes that the Proposed Action would continue to harm individual fish such that the North Santiam UWR Chinook salmon and UWR steelhead populations would continue to decline and critical habitat would continue to be adversely modified as a result of the Proposed Action. (See Table 5.6-4 at the end of this section)

5.6.1 Habitat Access & Fish Passage

Under the Proposed Action, Big Cliff and Detroit dams would continue to block access to and from UWR Chinook salmon and UWR steelhead spawning habitat in the North Santiam subbasin above these dams, as described in the baseline. As described in the North Santiam Baseline Section 4.6.3.1, UWR Chinook salmon access to habitat blocked by the dams in the North Santiam subbasin remains of critical importance because the remaining spawning habitat below the dams would continue to degrade under the Proposed Action, reducing abundance and productivity.

The key proposed actions related to habitat access in the North Santiam watershed that need to be evaluated for the effects on UWR Chinook salmon and UWR steelhead are the following:

- Continue to operate Big Cliff and Detroit dams, thereby continuing to block adult UWR Chinook salmon and UWR steelhead from accessing historic habitat above the dams.
- Continue to operate (and possibly rebuild or relocate) a fish trap (with associated dam that blocks passage) which is currently located at Minto (below Big Cliff and Detroit Dams),
    - Continue to collect UWR Chinook salmon at this trap, taking some fish to the Marion Forks Hatchery and releasing a portion of adult hatchery-origin returning fish into habitat above Detroit reservoir and below Big Cliff reservoir.

- Continue to collect UWR steelhead at this fish trap. These trapped non-hatchery origin UWR steelhead are released above the Minto trap, in the reach below Big Cliff Dam, where there remains some spawning opportunity.

- Continue to pass juvenile salmon downstream (progeny of those adults transported above the Detroit/Big Cliff complex) through the reservoirs and dams under current configurations.

- Conduct the Willamette System Review Study described earlier, that will evaluate, among other things, upstream and downstream passage at Big Cliff and Detroit dams, and may result in experimental fish introductions in various locations, including UWR steelhead into or above Detroit Reservoir.

The following is an assessment of adult upstream passage via the outplanting program, resulting juvenile production, and downstream juvenile fish passage through the reservoirs and dams.

5.6.1.1 Upstream Passage/Potential Utilization of Blocked Habitat

Since the early 1990s, ODFW has been collecting UWR Chinook salmon and UWR steelhead at the Minto trap and releasing all of the UWR steelhead above Minto Dam and a portion of UWR Chinook hatchery fish only above Detroit reservoir, as described in the Baseline Section 4.6.2. A primary objective of this program was to determine the feasibility of using hatchery adult salmon to restore viable populations of Chinook salmon above barriers and in other waters where native spring Chinook populations have been essentially extirpated (Beidler and Knapp 2005).

The Proposed Action calls for continued operation of the Minto trap. Fish trapped at Minto would be either:

- released immediately upstream where they may utilize the 2 mile reach between Minto Dam and Big Cliff Dam, and where they will have some opportunity to spawn and complete their life cycles;

- Transported (hatchery-origin UWR Chinook only) to release points above Detroit Reservoir;

- transported via trucks to other streams, such as the Little North Fork, where they may be able to complete their life-cycles.

- Some of the excess marked (hatchery-origin) UWR Chinook are “recycled”—trucked downstream and released to increase angling opportunities.

- Some are spawned (killed, their eggs taken, for hatchery production)

- All UWR (winter) steelhead are released upstream of Minto dam.

- Summer (non-native) steelhead are removed from the system.

Under the Proposed Action, UWR Chinook and UWR steelhead would continue to be injured, stressed, and infrequently killed (about 4% of Chinook and 1% of steelhead handled, with another 1% of each species killed during transport) as a result of continued operation of the Minto Trap. As described in the Baseline Section 4.6.3.1, the Minto Trap is outdated and is not designed to collect and hold salmon and steelhead for later release into streams for natural spawning. Although the Action Agencies propose to rebuild the Minto Trap, if funding and authorization is provided, there is no certainty that this action will be accomplished during the term of this Opinion. The Action Agencies have proposed to use new, improved transport and release protocols as part of the outplanting program, which would be expected to reduce fish stress and injury during transport, but without improved adult release sites, NMFS expects that adult UWR Chinook salmon would continue to be stressed and injured, and may be susceptible to poaching, as they are released into habitat above Detroit. Prespawning mortality would likely continue to be high, because adult fish would continue to be concentrated in the reach below Minto Trap until ODFW opens the trap, and because stressful conditions during handling, transport, and release would likely inhibit some fish from spawning.

5.6.1.2 Juvenile Production

Minto Reach (N. Santiam River below Big Cliff Dam)

There are about 4.5 miles of river between the Minto trap (a dam and fish barrier) and the base of Big Cliff Dam. UWR steelhead have been passed above Minto dam into this reach since construction, and more recently UWR Chinook, progeny of fish releases above either Minto Dam or Detroit dam, have been noted there (Beidler and Knapp 2005). Since this area is below the major reservoirs, juveniles face no unusual challenges emigrating further downstream.

Beidler and Knapp (2005) reported on juvenile Chinook production surveys in lower North Santiam below Big Cliff Dam. Juvenile Chinook salmon in this reach could represent offspring of adults released above Minto Dam as well as those transported above Detroit reservoir for spawning in the upper North Santiam River subbasin. Juvenile Chinook densities varied among years, from 14 to 143 fish per mile, in surveys from 1993 through 2004.

Upstream of Detroit Dam (N. Santiam River)

The expansive habitat upstream of Detroit remains in relatively good shape; fish are able to spawn and reproduce. Prior to the building of Detroit Dam, Mattson reported that 71% of UWR Chinook spawned above the current location of Detroit Dam (USACE 2000, p. 5-35), indicating preferred habitat that likely remains. In the North Santiam River above Detroit Dam, Beidler and Knapp (2005) note that “many redds,” from transported hatchery-origin UWR Chinook, were observed, indicating strong, but unquantified production potential for these fish in this reach. No UWR steelhead have been released into and above Detroit dam and reservoir since construction, and thus there is no recent information on UWR steelhead productivity above Detroit Reservoir (the Proposed Action calls for all UWR steelhead to be released into the 4.5 mile reach above Minto Dam.)

Upstream of Detroit Dam (Breitenbush River)

Beidler and Knapp (2005) report that aquatic habitat on the Breitenbush River is “relatively pristine,” but they do not address fish production.

Little North Fork Santiam River (Downstream of Detroit)

ODFW releases some of the non-hatchery origin UWR Chinook salmon trapped at Minto into the Little North Santiam River. This practice would continue under the Proposed Action.

Beidler and Knapp (2005) report that juvenile production and adult spawning rates are relatively low from these efforts in the Little North Santiam River.

5.6.1.3 Dam & Reservoir Survival

Reservoir Survival

- Detroit Reservoir: For juvenile salmonids emigrating through, or rearing in Detroit Reservoir, there are numerous potential predators. However, little is known of the effects of Detroit Reservoir on UWR Chinook (or UWR steelhead, were they to be introduced there). Under the Proposed Action, Detroit Dam is rarely drafted to meet mainstem temperature targets, which tends to produce very slow water movement and possibly diminishes migration cues, potentially causing juvenile salmonids to residualize (i.e., behave like resident fish) rather than migrate downstream (Giorgi et al 1997). NMFS expects that under the proposed action, an unknown proportion of juvenile offspring of adults outplanted above Detroit Reservoir would not successfully emigrate from the reservoir as a result of predation and residualism.

- Big Cliff Reservoir: About two-thirds of the 2.6 mile reach between Detroit and Big Cliff dams consists of a narrow reservoir used for tempering power peaking flow changes resulting from discharges from Detroit Dam. The Proposed Action does not contemplate placing adults of any type in this reach, thus NMFS does not expect juvenile fish production here. However, progeny of fish released above Detroit Reservoir (UWR Chinook in the Proposed Action) are present because they must emigrate through, and may possibly rear in, this section. The effects of this reservoir upon fish survival are unknown. (Effects of peaking operations on fish in the reservoir and downstream are discussed in section 5.6.2).

- Minto Reservoir: The fish trap at Minto Dam, about 4.5 miles below Big Cliff Dam, utilizes an approximately 12-foot high dam (USACE 2007a) that acts as a fish barrier. This run-of-the river fixed-crest dam creates a very small reservoir that has mostly filled with sediment. The result is that there are virtually no "reservoir effects" upon UWR Chinook and UWR steelhead above Minto Dam, presenting instead more of the appearance of a river reach.

Dam Survival

Detroit/Big Cliff Complex: Neither upstream nor downstream fish passage was planned for when the Detroit/Big Cliff dam complex was constructed. There were no upstream passage provisions (though fish can be trapped at Minto, then trucked around the dams); and the downstream routes available to fish are only via incidental entrainment over the spillway, through the turbines, or via other outlets.

The Proposed Action would continue to kill and injure juvenile UWR Chinook salmon (and UWR steelhead, if adult fish are later released above Detroit Reservoir) as they migrate downstream through unscreened turbines and other outlets at both Detroit and Big Cliff Dams. Beginning in 2000, ODFW began releasing hatchery-origin adult UWR Chinook salmon above Detroit Reservoir, because spawning habitat was available; and large numbers of hatchery produced juveniles were also released into Detroit Reservoir in 2000 and 2001. Subsequent to this, ODFW placed traps below both Big Cliff and Detroit Dams and found that 51% of the smolts captured below Detroit survived dam passage, and below Big Cliff, 69% survived

(Beidler and Knapp 2005). These fish were comprised of UWR Chinook smolts, both hatchery releases and offspring of naturally-spawning adults, as well as possibly some kokanee. The researchers indicated that more research was needed to answer many questions, but their results give some indication of the effects upon fish passing through this two-dam complex.
Minto Dam:

Downstream passage

- Minto Dam is a 12-foot high concrete dam with a semi-ogee shaped fixed spillway crest which creates a velocity and physical barrier to upstream fish migration. Fish passage downstream over this dam (UWR steelhead juveniles and adult kelts, and UWR Chinook juveniles) could be through either of two routes: 1) over the spillway crest or 2) with the supply water to the fish trap ponds and ladder. The flow over the spillway crest varies from substantial depth during higher flow periods, to shallow depth during lower flow periods. Leaky flashboards at Minto Dam present points of potential entrainment and impingement. The effects of fish passing over this dam, particularly at shallow depths, have not been assessed but may be substantial, as fish may be injured by contact with rough surfaces and by landing on hard surfaces below the dam. The Proposed Action suggests, but does not clearly commit to, the possibility of replacing or upgrading this facility. Without certainty that this facility will be improved, NMFS expects the dam would continue to stay the same, likely causing fish injury and some level of mortality, as the baseline condition.
- In addition to downstream spillway passage at Minto Dam, there is a water intake for the adjacent fish facility which could entrain juvenile downstream migrants. Entrained juvenile fish would be transported to the adult fish facility via its water system. Residence time in the fish facility would delay downstream migration and increase risk of predation, depending upon the type and size of adult fish held in the facility.

Upstream effects

- Minto Dam exists to block fish and supply water to the fish facility; there is no volitional fish passage around Minto Dam, except accidentally during very high flows when a few adult fish may be able to swim over this barrier. UWR steelhead are first incidentally trapped here (there is no reason to trap them, except that Minto Dam is a fish barrier that precludes all passage) then later released upstream of this dam into the 4.5[1] miles of stream below Big Cliff Dam. UWR Chinook are also blocked and trapped here, then trucked to various dispositions; some non-hatchery origin UWR Chinook are released above Minto Dam. Thus, an effect of Minto Dam operation is to cause trapping and handling effects associated with trap operations. Trapping and handling causes stress and mechanical injuries, and delays fish migration. The Minto trap is typically operated three times a week, thus UWR steelhead could be held in the trap for several days, before being permitted to resume their upstream migrations. UWR Chinook, which are held until they are transported by truck to release locations or the hatchery, may be delayed or may be speeded up in the migration, depending upon the time of the year and where they are being trucked to. UWR Chinook and UWR steelhead are prevented from volitionally accessing the habitat between Minto and Big Cliff dams.

[1] USACE 2000 p. 5.35 and elsewhere incorrectly under-reports this distance in many instances.

- Minto Dam serves as a collection point for hatchery-origin UWR Chinook to be collected and “recycled”—trucked back downstream to increase angling opportunities for fisherman. Some hatchery-origin UWR Chinook are “recycled” multiple times, compounding handling effects. Another effect of Minto Dam is that it serves (along with the other dams) to concentrate fish below these dam, leading to increased susceptibility to fishing pressure. (USACE 2000, p 6-101)
- Minto Dam/Trap was designed collect broodstock for hatchery production (that is, not to gently handle fish that are to be released, and that need to survive long enough to spawn in the wild.) It was not designed for live sorting of adult fish (USACE 2007a, p. 3-52) as is the current practice, and outlined in the Proposed Action. Handling effects are thus larger than there would be associated with a modern facility with adequate space and modern facilities to optimally trap, sort and hold various types of fish (hatchery-origin, non-hatchery origin, steelhead, etc.)
- Early arriving UWR Chinook are not immediately allowed entrance into the trap and ponds, but must congregate below Minto Dam until admitted into the trap and separated. An effect of Minto Dam is to prevent timely access to spawning habitat (this applies to UWR Chinook and steelhead that that are eventually permitted access above Minto Dam.
- Upstream movement of juvenile UWR Chinook and UWR steelhead is generally prevented by Minto Dam.
- Despite these effects, there are also management and scientific benefits to the Minto Dam and trap including providing a convenient place to examine fish, leading to better understanding of their status and condition, and improved management practices. Captured fish might also be medicated, increasing the likelihood of survival until spawning, or they may be marked or tagged in various ways to increase management understanding of their migrations and habitat utilization.

5.6.1.4 Summary

Under the Proposed Action, upstream and downstream passage of UWR Chinook salmon and UWR steelhead would continue to be inadequate, causing fish injuries, mortalities, pre-spawning mortalities, residualism of juvenile fish, and stress. Although these adverse effects are not clearly quantified, NMFS expects that losses would continue to be moderate for upstream passage and high for downstream passage through the reservoirs and dams. The Proposed Action would continue to prevent safe access to historical habitat above Big Cliff and Detroit dams.

5.6.2 Water Quality/Hydrograph

Under the environmental baseline, those aspects of flow and hydrology under Action Agency control do not provide properly functioning habitat for UWR Chinook salmon and UWR steelhead (section 4.6.3.2). Increasing population and water demands in the Salem, Oregon, area indicate that flow-related anadromous fish habitat will likely continue to decline in the environmental baseline for the duration of this Opinion.

The Action Agencies propose to continue flow management as conducted since 2000. This includes attempting to meet specified seasonal minimum and maximum flows, seasonal drafting and refilling, and ramping rates for changing discharge. Thus the hydrologic effects of the Proposed Action are the same as those described under the environmental baseline for the North Santiam River (Section 4.6.3.2).

5.6.2.1 Seasonal Flows

Although the USACE has committed to operating the Willamette Project in an attempt to meet seasonal flow objectives, operations modeling conducted by the USACE shows that it would not always be possible to meet the flow objectives while meeting other project priorities (Table 5.6-1).

Table 5.6-1 Estimated frequency that proposed minimum and maximum tributary flows would not be met downstream from Big Cliff Dam on the North Santiam River. Source: Donner 2008.

Dam	Period	Primary Use	Minimum Flow (cfs) [1]	Chance of Not Meeting Flow	Maximum Flow (cfs) [2]	Chance of Not Meeting Flow	
Big Cliff	Sep 1 – Oct 15	Chinook spawning	1,500	5%	3,000 through Sep 30, when possible	5%	Sep
	Oct 16 – Jan 31	Chinook incubation	1,200 [3]	2%			
	Feb 1 – Mar 15	Rearing Chinook and steelhead/adult Chinook migration	1,000	<1%			
	Mar 16 - May 31	Steelhead spawning	1,500	<1%	3,000	25%	Mar 16 - May 31
	Jun 1 – Jul 15	Steelhead incubation	1,200 [3]	<1%			
	Jul 16 – Aug 31	Chinook and steelhead rearing	1,000	<1%			

Exceedence of maximum flow objective over a 66-year record from 1936-2001 (probability figures are approximate).

1 Minimum flow will equal inflow or Congressionally authorized minimum flows, whichever is higher, when the reservoir is at a minimum conservation pool elevation. This avoids drafting the reservoir below minimum conservation pool and, where applicable, into the power pool.

2 Maximum flows are intended to minimize the potential for spawning to occur at stream elevations that might subsequently be dewatered at the specified minimum flow during incubation. It may not be possible to stay below these maxima, especially in the fall when drafting reservoirs in preparation for the flood damage reduction management period. Project operations will be managed to minimize the frequency and duration of necessary periods of exceedence.

3 When feasible, incubation flows should be no less than ½ the maximum 72-hour average discharge observed during the preceding spawning season. Efforts will be made to avoid prolonged releases in excess of the recommended maximum spawning season discharge to avoid spawning in areas that would require high incubation flows that would be difficult to achieve and maintain throughout the incubation period.

These proposed flow objectives are consistent with recommendations developed by NMFS' staff and ODFW managers familiar with fish habitat conditions in the North Santiam basin. In general, the lower the frequency that these objectives are not met, the better the conditions for salmon and steelhead survival. Because these flows closely correlate with fish management agency recommendations and the best currently available information, these proposed operations are highly protective and an improvement over conditions that prevailed prior to 2000. The high projected frequency that the flow objectives would be achieved suggests that under the PA flow-related habitat needs in the lower North Santiam River would generally be met. However, continued water withdrawals for out of stream use (e.g. irrigation) may reduce flows and reduce flow-related habitat. This issue is discussed in Section 5.6.2.4 below.

Detroit and Big Cliff operations would continue to reduce the flows in the lower North Santiam River during late winter and spring (compared to historical levels) while the reservoirs are being refilled. During this period, juveniles of both species are rearing, smoltifying, and migrating through the Willamette River system to the Pacific Ocean. Spring Chinook fry are emerging from the gravels and winter steelhead are spawning in the North Santiam River downstream from Big Cliff Dam. This flow reduction effect of the proposed action may have its largest biological effect on emigrating juvenile spring Chinook and winter steelhead. Reductions in spring flows may also interfere with recruitment of age-0 rainbow trout (*O. mykiss*) (Mitro et al. 2003). Winter flow reductions associated with active flood control operations may dewater Chinook salmon redds, reducing egg survival. These effects are expected to continue over the life of the Proposed Action.

By placing high priority on maintaining full-pool conditions at Detroit reservoir through the Labor Day weekend, sufficient water would be available in most years to meet the Chinook spawning and incubation objective downstream from Big Cliff Dam (Table 5.6-1) (see additional effects on the S. Santiam in section 5.5). However, maintaining pool levels at Detroit during summer is likely to conflict at times with achievement of target flows for rearing of juvenile salmonids in the lower North Santiam River, particularly if consumptive use of water from the lower river increases. The magnitude of this adverse effect cannot be quantified, and improved stream gauging in lower reaches of the North Santiam would identify whether flows released at Big Cliff are sufficient to protect fish habitat in both the upper and lower reaches. Additionally, studies of fish-flow relationships in multiple reaches of the North Santiam below Big Cliff are needed to better define fish habitat needs in each reach. Finally, the results of these studies should be used to adjust flow releases and reservoir management at Detroit and Big Cliff for fish habitat needs, so that the Action Agencies can assure that the needs of ESA-listed salmonids are sufficiently protected.

5.6.2.2 Frequency of Channel-forming & Over-Bank Flows

By continuing to reduce the frequency of channel-forming and over-bank flows downstream from Big Cliff Dam, project operation would continue to limit channel complexity and thereby limit rearing habitat for juvenile Chinook salmon and steelhead. Peak flow reduction may also reduce the recruitment and suitability of channel substrates for spawning salmon and steelhead. These effects are expected to continue and may worsen over the life of the Proposed Action.

Reducing peak flows during flood events could benefit spring Chinook salmon by reducing the likelihood that high flows would scour redds and disrupt incubating eggs (compared to the unregulated condition).

5.6.2.3 Flow Fluctuations

Under the Proposed Action, the USACE would continue to operate Big Cliff Dam as a reregulating facility, to dampen discharge fluctuations caused by load-following operations at the Detroit project. This action would protect juvenile salmonids in the North Santiam River downstream from Big Cliff Dam from stranding during load-following operations. However, juvenile salmonids in the river reach downstream from Big Cliff Dam would continue to be subjected to rapid discharge reductions during active flood control operations and emergency events and could become entrapped and stranded. This effect would be most pronounced immediately downstream from Big Cliff Dam and would decrease in a downstream direction, as flow from unregulated tributaries enters the river. Additionally, juvenile Chinook salmon and steelhead could be stranded in Big Cliff Reservoir during daily load-following operations, although no data are available to assess the potential magnitude of this loss.

In summary, the Proposed Action would continue to entrap and strand an unquantified number of juvenile UWR Chinook salmon and UWR steelhead in the North Santiam River downstream from Big Cliff Dam during flood control operations as well as in Big Cliff Reservoir during daily load-following operations. The number of individual fish that would be killed as a result of flow fluctuations is unknown, but NMFS expects that this repeated activity would be significant and contribute to decreased abundance and productivity of UWR Chinook salmon and UWR steelhead.

5.6.2.4 Water Contracting

Reclamation has contracted a total of 9,474 acre-feet of water stored in Detroit and Big Cliff reservoirs to irrigators along the North Santiam River (USACE 2007a), which constitutes a small fraction of the surface water withdrawals issued by OWRD. Another 1,647 acre-feet are contracted to users downstream from the confluence of the North and South Santiam rivers served by USACE reservoirs in both drainages. As part of the proposed action, Reclamation intends to issue contracts to an additional 2,796 acre-feet to users within the North Santiam basin and an additional 350 acre-feet in the lower Santiam basin. These new contracts would be wholly or partly served by water stored in USACE's North Santiam River basin projects (primarily Detroit and Green Peter). Included in the Proposed Action is the option to lease up to 95,000 acre-feet throughout the Willamette basin, an increase of 14,569 acre-feet above existing and pending contracts.[2]

USACE and Reclamation intend to continue serving these contracts with water released from storage to maintain project and mainstem minimum flows. That is, under the Proposed Action more water would be removed from the Santiam River during the irrigation season without any additional water being released from USACE's reservoirs. In general, Reclamation water contracts are supplemental to natural flow water rights held by individual water users and are only exercised when natural flows are insufficient to serve all users and meet instream water rights held by OWRD. Assuming that such conditions would occur for only about 60 days each summer, the total level of future Reclamation-supported water service could reduce flows in

[2] No specific location for these future contracts has been specified. If these contracts follow the areal distribution of current Reclamation contracts, about 21 percent or 3,059 acre-feet would be issued to serve areas in the North Santiam subbasin.

some sections of the North Santiam River by 119 cfs, and in the Santiam River mainstem by about 135 cfs, an increase of 41 cfs over existing Reclamation service. Given the existing low flow conditions common during late summer in the North Santiam River reach downstream from Stayton, Oregon, this level of Reclamation-supported water development could further exacerbate poor habitat and water quality conditions in the lower North Santiam and the mainstem Santiam rivers. Low flows and high rates of water diversion in the North Santiam River have substantially reduced habitat area and production potential for rearing juvenile anadromous fish (E&S 2002). These effects are expected to continue and worsen over the term of the Proposed Action.

5.6.2.5 Flow-related Research, Monitoring & Evaluation (RM&E)

The Action Agencies would develop and implement a comprehensive research, monitoring and evaluation program to determine compliance with, and effectiveness of, their flow management action. The RM&E program would be designed to better discern and evaluate the relationships between flow management operations and the resulting dynamics of ecosystem function and environmental conditions downstream of Willamette Project dams, and related effects on ESA-listed fish species. The recommendations for a Flow Management RM&E program would be integrated into the comprehensive program overseen by the RM&E Committee and following the principles and strategic questions developed by the committee.

5.6.3 Water Quality

Under the environmental baseline, water quality (temperature and TDG) do not provide properly functioning habitat for UWR Chinook and UWR steelhead. Under the proposed action these conditions would not improve, and could further degrade.

The Action Agencies propose to continue operating the dams under current configurations and flow regimes. No water temperature control measures are proposed in the North Santiam watershed. Potential operational changes that could be carried out under the current configuration of the dams to address temperature problems are not part of the Proposed Action but may be considered as part of the Willamette System Review Study for future implementation.

5.6.3.1 Water Temperatures

Water temperature conditions downstream from Big Cliff Dam currently limit the abundance, productivity, and life history diversity (i.e., spawning, incubation, and emergence timing) of UWR Chinook salmon and UWR steelhead in the North Santiam below Big Cliff Dam and in the mainstem Santiam River (see Section 4.6.3.3.1).

Beginning in the late 1960s, state and federal fisheries managers began to express concerns that changes in the thermal regimes downstream from the large Willamette Project dams in the McKenzie and Santiam watersheds were adversely affecting salmon and steelhead. Following Congressional authorization in 1981, the USACE (1982) produced the first in a series of reports responding to these concerns and in 1984; the USACE initiated the Willamette System

Temperature Control Study. That study produced two primary products: a Santiam sub-basin report (USACE 1988); and, a McKenzie sub-basin report (USACE 1987). The Santiam sub-basin report determined that modifying the intake tower at Detroit Dam and constructing a multilevel release system that drew water from different elevations in the reservoir could restore the natural seasonal water temperature hydrograph to the North Santiam River downstream from Big Cliff Dam.

As discussed in Section 4.6.3.3.1), an ad hoc experiment conducted in 2007 during an emergency powerhouse outage at Detroit and Big Cliff dams showed that it is possible to operate existing systems at Detroit and Big Cliff dams in a manner that substantially lessens the effects of these projects on water temperatures downstream from Big Cliff Dam (see Figure 5.6-1). These operations did cause TDG to exceed Oregon water quality criteria for a short distance downstream from the dam.

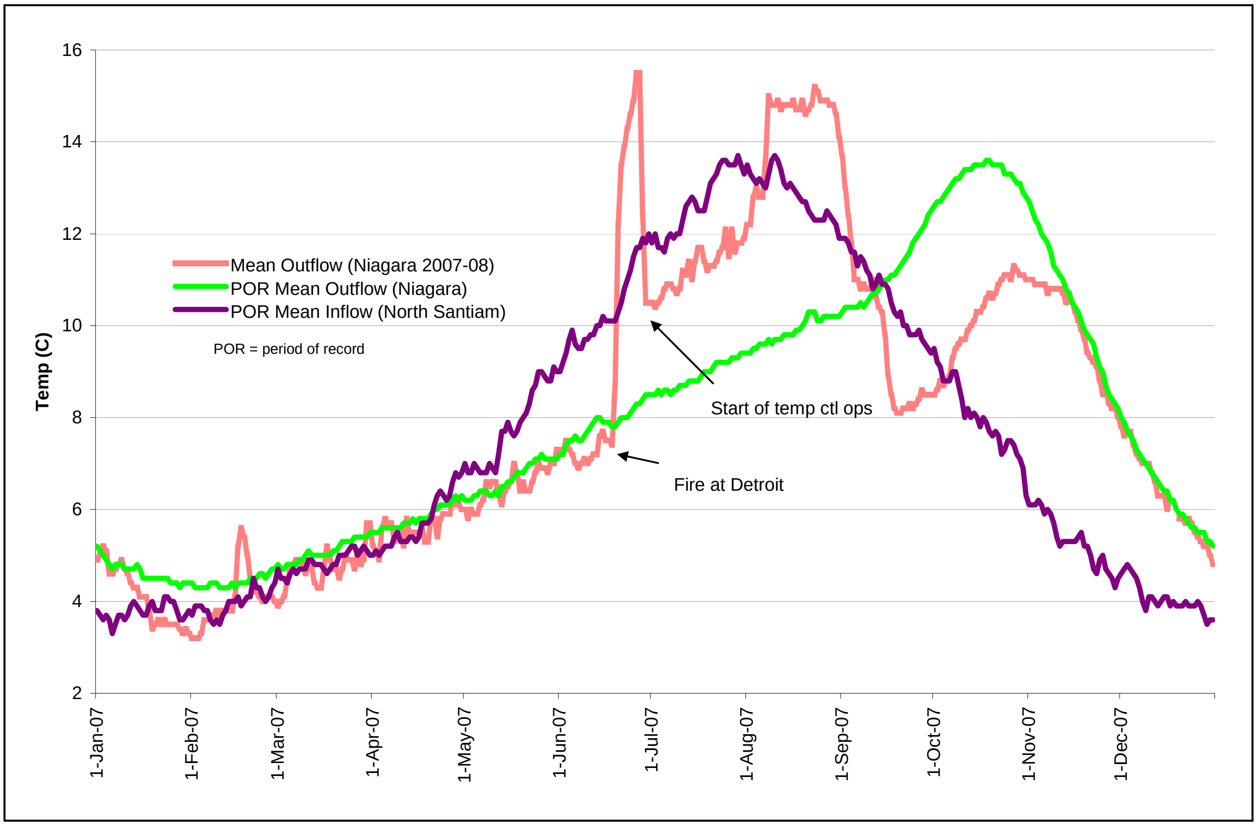

Figure 5.6-1 Temperature regime downstream of Detroit Dam (Niagara gage) and upstream of Detroit reservoir (North Santiam gage) in 2007. Operations resulted in an improvement in water temperatures below Detroit Dam (i.e. more similar to natural temperatures above Detroit reservoir).

The Action Agencies have not proposed to modify the intake towers at Detroit Dam for temperature control. However, they propose to further evaluate temperature control at dams without such facilities, including Detroit Dam, under the proposed Willamette System Review Study. The goal of that study, which would be completed in three phases, "would be to recommend for implementation those measures shown to be technically feasible, biologically justified, and cost-effective" (USACE 2007a). The Action Agencies indicate that, assuming such a project proves feasible and is funded, a facility to provide temperature control could be installed by 2017.

Although the 2007 emergency operations demonstrated that Detroit Dam, in its existing configuration, could be operated to reduce its adverse water temperature effects, the Action Agencies have not proposed further evaluation or implementation of this alternative.

Under the proposed action, correction of adverse water temperature conditions in the North Santiam would not be guaranteed and such conditions would continue to adversely affect abundance and productivity of UWR Chinook and UWR steelhead until and unless water temperature control was selected as a high priority project under the Willamette System Review Study, final design completed, and the measure implemented. The expected future conditions of water temperatures below Big Cliff are therefore expected to continue to adversely affect the survival of adult, eggs, and alevins as has been occurring in recent years (Figure 5.6-2; Figure 5.6-3).

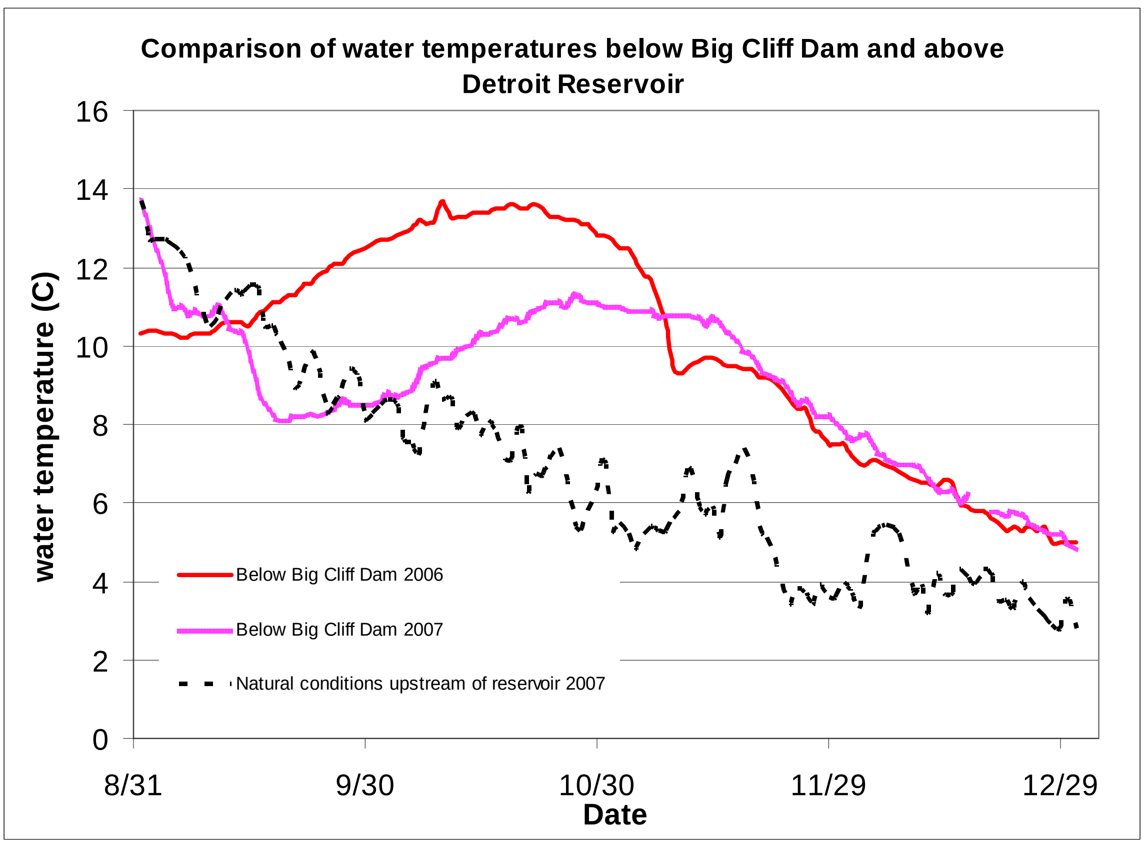

Figure 5.6-2 Comparison of observed water temperatures below Big Cliff/Detroit dams (USGS gage 14181500) and observed natural water temperatures (daily average) upstream of Detroit reservoir in the North Santiam River (USGS gage 14178000) during the spring Chinook spawning and egg incubation period.

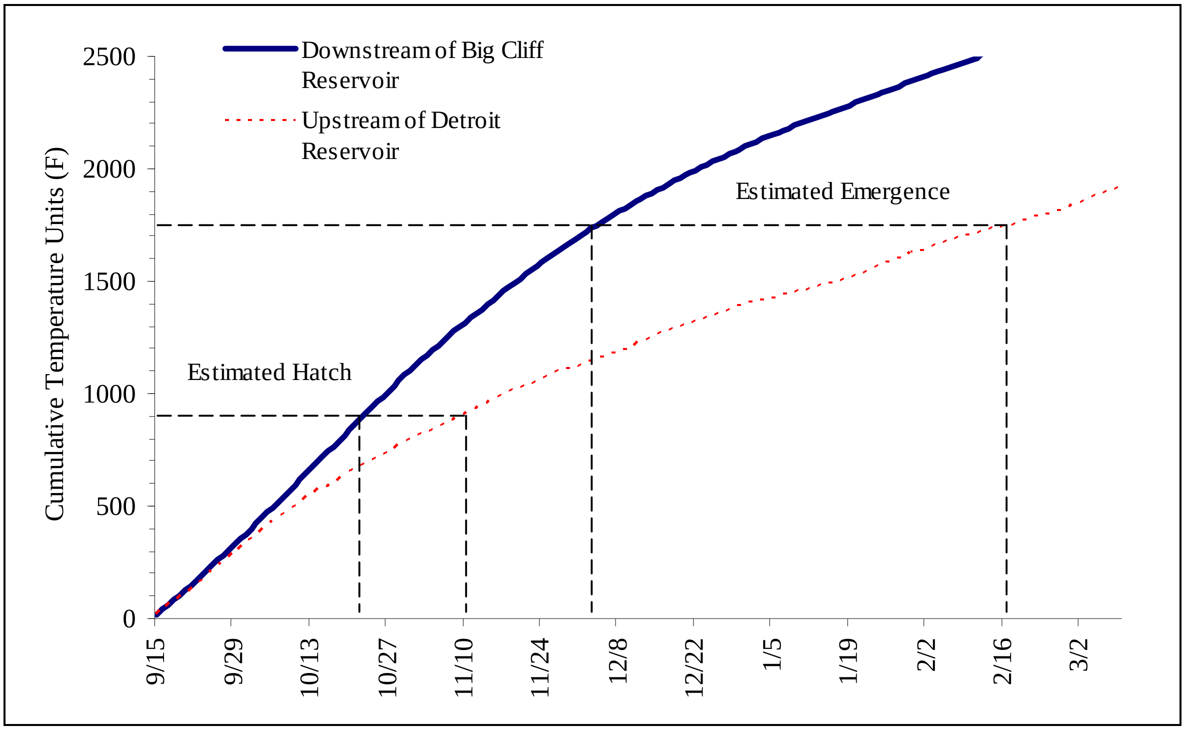

Figure 5.6-3 Estimated hatch and emergence timing of juvenile Chinook above and below Detroit/Big Cliff dams and reservoirs in 2004-2005. Source: Taylor and Garletts (2007)

5.6.3.2 Total Dissolved Gas

The Proposed Action would maintain the current dam configurations in which spill operations create TDG concentrations high enough to kill UWR Chinook salmon and UWR steelhead yolk sac larvae one mile (Willis 2008) downstream from Big Cliff Dam, potentially limiting the abundance, productivity, and juvenile outmigrant production of these North Santiam subbasin populations. The proposed operations would continue to minimize the frequency of spill operations but cannot entirely prevent them. Spill occurs primarily during high flow events during winter months, affecting UWR Chinook salmon in redds, but spill also occurs infrequently in other months when emergency events cause powerhouse shutdowns. As noted above in section 5.6.3.1, when an emergency powerhouse shutdown occurred in 2007, TDG concentrations spiked to high levels. The Proposed Action does not include any measures to develop emergency bypass valves or protocols using existing facilities to moderate this sudden increase in TDG or to quickly address potential effects on UWR Chinook salmon and UWR steelhead downstream from Big Cliff Dam.

Willis notes (Willis 2008) notes that spill over approximately 1,400 cfs generates more than 115% total dissolved gas down to approximately 1 mile below Big Cliff Dam and is projected to occur at the following frequency:

- for UWR Chinook juveniles, Oct 19%, Nov 42%, Dec 32%, Jan 39%; (Willis 2008)
- for UWR steelhead,
  - Adults: Apr 3%, May 0% (Willis 2008)
  - Juveniles: Apr 3%, May 0%, Jun 3%, Jul 0%, Aug 0% (Willis 2008)

5.6.3.3 Summary

Under the environmental baseline, operations at Detroit and Big Cliff dams have adversely affected water temperatures and TDG in the lower North Santiam River. These effects would continue under the Proposed Action, limiting abundance and productivity of UWR Chinook salmon and UWR steelhead.

5.6.4 Physical Habitat Quality

The key proposed actions related to physical habitat quality in the North Santiam River subbasin that will affect UWR Chinook salmon and UWR steelhead are listed below. As noted above, the mainstem Santiam River is considered part of the North Santiam River subbasin for the purpose of this analysis.

- Continue to operate Big Cliff and Detroit dams, blocking sediment and large wood transport from upstream reaches and tributaries into the North Santiam River below Big Cliff Dam.
- Continue to reduce peak flows as part of flood control operations at the two Project dams, preventing creation of new gravel bars, side channels, and alcoves that provide rearing habitat for anadromous salmonids
- Continue the existence and maintenance of 3.87 miles of revetments along the mainstem Santiam River, preventing channel migration and reducing channel complexity.
- Study the potential for gravel augmentation and large wood restoration projects in the North Santiam subbasin to improve salmonid habitat.
- Study effects of Project dams and revetments on downstream habitat and consider projects to restore habitat, if authorized and funding becomes available.

5.6.4.1 Substrate, Sediment Transport, Large Wood, & Channel Complexity

Under the environmental baseline, substrate, sediment transport, large wood, and channel complexity are degraded and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon and UWR steelhead (Section 4.6.3). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5-6-4 (end of this Section, 5.6) and described below.

Under the Proposed Action, operation of Big Cliff and Detroit dams for flood control would continue to store sediment and large wood in the reservoirs, prevent recruitment of large wood and sediment from streambanks, allow stabilization of formerly active bar surfaces, and prevent flows capable of creating new bars, side channels, and alcoves. As a result, already impaired habitat would continue to degrade, limiting the abundance, productivity, and juvenile outmigrant production of the North Santiam subbasin populations of UWR Chinook salmon and UWR steelhead. The Action Agencies propose to study the potential for gravel augmentation and large wood restoration projects in the North Santiam River to improve salmonid habitat (USACE 2007a), but do not identify the duration of this study nor commit to follow through with recommendations of the study. Other sections of the Proposed Action describe studies of revetments and floodplain restoration, but the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the North Santiam subbasin.

As described above in sections 4.6.3.4, operation of Detroit and Big Cliff dams has trapped gravel and large wood from 60% of the subbasin and has reduced the magnitude of peak flows. Both of these operations deprive downstream reaches of bed material and transport mechanisms needed to create new gravel bars, islands, and side channels, which are necessary components of rearing and spawning habitat for both UWR Chinook salmon and UWR steelhead. The only large tributary that enters the North Santiam downstream of Big Cliff Dam is the Little North Santiam, which cannot contribute sufficient sediment and large wood to compensate for the loss in upstream supply.

Continued existence and maintenance of the USACE revetments would prevent river migration and contribution of sediment from 3.87 miles of streambank in the mainstem Santiam River, further depriving the lower river of sediment and the ability to create new gravel bars or side channels. Reduction in peak flows would exacerbate these problems by reducing the frequency of flows with sufficient magnitude to re-shape the channel and form new habitat.

In summary, the continued degradation of habitat in the North Santiam subbasin downstream of Big Cliff and Detroit dams would likely reduce the carrying capacity of this habitat for rearing juvenile fish and spawning adults, thus reducing the number of individual UWR Chinook salmon and UWR steelhead that can be produced in this presently degraded habitat. It is likely that areas of spawning gravel in the lower river would continue to be replaced with coarse bed material unsuitable for spawning, and that rearing habitat in the form of alcoves and side channels would continue to be reduced as well. Because these populations do not have safe passage and access to historical habitat upstream of the two dams, a reduction in spawning habitat in the reach below Big Cliff could further limit spawning and contribute to overuse of redds (i.e., a second female could disrupt the eggs of one that's already spawned). Additionally, a lack of complex rearing and refugia habitat in the mainstem Santiam and lower North Santiam Rivers could limit juvenile outmigrant production in the subbasin. Aside from unspecified habitat restoration actions that may result from proposed habitat, revetment, and gravel studies, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the North Santiam subbasin. These effects would extend 46.4 miles to the confluence of the S. Santiam River affecting both juvenile and adult UWR Chinook and UWR steelhead (Willis 2008).

5.6.4.2 Riparian Vegetation & Floodplain Connectivity

Under the environmental baseline, riparian vegetation and floodplain connectivity are degraded and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon and UWR steelhead (section 4.6.3). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.6-4 and described below.

Under the Proposed Action, operation of Big Cliff and Detroit dams and continued existence and maintenance of 3.87 miles of revetments in the mainstem Santiam River would continue to degrade riparian vegetation and floodplain connectivity by preventing recruitment of large wood and sediment that create new bars and islands on which riparian vegetation can establish and by preventing peak flows that maintain stream connectivity to the floodplain. Although the Proposed Action includes study of potential habitat restoration and gravel augmentation in reaches below the dams, there is no certainty that any restoration work would be done during the term of this Opinion. Given the adverse water temperature conditions in the North Santiam River below Big Cliff Dam associated with Project operations (as described in Section 5.6.3 Water Quality), and the lack of fish passage to historical upstream habitat (as described in Section 5.6.1 Habitat Access/Fish Passage), further degradation of riparian vegetation and floodplain connectivity would result in a net reduction in the already limited habitat available to UWR Chinook salmon and UWR steelhead in the North Santiam subbasin.

The extent and composition of riparian vegetation in the North Santiam subbasin would continue to be impaired by Big Cliff and Detroit dam operations under the Proposed Action by interfering with the processes needed for new floodplain forests to establish. As described above in section 5.6.4.1, Detroit and Big Cliff dams would continue to trap sediment and large wood and reduce the magnitude of peak flows in the North Santiam and Santiam subbasins. Additionally, the continued existence and maintenance of 3.87 miles of revetments in the mainstem Santiam River would further prevent river migration and contribution of sediment and large wood from streambanks of the Santiam River. These operations would continue to deprive downstream reaches of sediment, channel-forming flows, and large wood needed to create gravel bars, islands, and floodplains on which new riparian vegetation can establish. The reduced width and continuity of riparian forests could prevent the shading of the North Santiam and Santiam rivers, rendering the rivers susceptible to increased water temperatures.

Flood control operations in the North Santiam subbasin have probably increased development within the floodplain and indirectly facilitated clearing of riparian vegetation for agricultural, residential, and urban development, and this effect would continue under the Proposed Action. However, additional development in the floodplain is at the discretion of private parties, so these effects are discussed in Chapter 6 (Cumulative Effects).

In summary, the proposed operation of Big Cliff and Detroit dams and continued existence and maintenance of revetments along the mainstem Santiam River will continue to reduce the extent, quality, and inundation frequency of riparian and floodplain forests in the North Santiam subbasin downstream of Big Cliff and Detroit dams. The reduced extent of riparian vegetation (combined with reduced peak flows and limited channel migration) hinders recruitment of large wood into the aquatic system, which is needed to deposit spawning gravel, create resting pools for migrating adults, and provide cover for rearing juveniles or outmigrating smolts. Infrequent inundation of forested floodplains due to flood control operations would reduce nutrient and organic matter exchange during flood events, and reduce the availability of complex high-water refugia for juveniles, which could limit survival of rearing juveniles. Aside from unspecified habitat restoration actions that may result from the Willamette Floodplain Restoration Study or other habitat restoration studies described in the Supplemental BA, Section 3.5.2, Offsite Habitat Restoration Actions (USACE 2007a), the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain connectivity in the North Santiam subbasin. Given the uncertainty in upstream and downstream passage to historical habitat above Big Cliff and Detroit dams (see Section 5.6.1), continued degradation of limited spawning and rearing habitat under the Proposed Action will reduce the abundance and productivity of North Santiam subbasin populations of UWR Chinook salmon and UWR steelhead.

5.6.5 Hatcheries

As described in Chapter 2, the Proposed Action is to continue to artificially propagate hatchery spring Chinook salmon (ODFW stock 021) and summer steelhead (ODFW stock 024) and release these fish into the North Santiam River at Minto Dam. Further details about these programs are described in the North Santiam spring Chinook HGMP (ODFW 2008a) and Upper Willamette summer steelhead HGMP (ODFW 2004a).

Below is an analysis of the specific effects of these actions on listed spring Chinook and winter steelhead in the North Santiam River.

5.6.5.1 Hatchery Operations

There are two hatchery-related facilities in the North Santiam watershed—1) Marion Forks Hatchery, located upstream of Big Cliff and Detroit Dams, and 2) Minto Dam facility, located about seven km below Big Cliff Dam. Spring Chinook broodstock are collected at Minto Dam and held there until spawning. The eggs are transferred to Marion Forks Hatchery upstream and reared until the fish reach smolt size. Smolts are then transferred back to a pond at Minto Dam and released. Summer steelhead are also released at Minto Dam. Broodstock for the summer steelhead program are collected at Foster Dam on the South Santiam.

As described in the “General effects of hatchery programs on ESA-listed salmon and steelhead” section 5.1 above, there are two primary concerns with the effects of hatchery facilities on listed spring Chinook and winter steelhead in the South Santiam River- 1) risk of facility failure leading to fish mortality in the hatchery (particularly progeny of wild fish), and 2) improperly screened water intakes at the hatchery facility that lead to the mortality or injury of naturally rearing listed fish. Other potential adverse of effects of the facilities or related activities are addressed below under their appropriate section (i.e. effects of disease-laden water discharges from a hatchery on listed fish downstream).

The occurrence of catastrophic loss (or unforeseen mortality events) of spring Chinook at Marion Forks Hatchery has been very low over the last several decades and of no consequence to the conservation and recovery of spring Chinook or winter steelhead. All of the normal safeguard equipment and procedures are being implemented at this hatchery. Since there have been few significant mortality accidents at this hatchery in the past, and the numbers of wild fish incorporated into the hatchery broodstocks are low, the risk of facility failure is deemed to be a low risk to wild spring Chinook and winter steelhead in the North Santiam populations at this time**.**

The water intakes for the Marion Forks Hatchery water supply are located on Horn Creek and Marion Creek. Water is gravity fed from the streams to the hatchery. These water intakes do not meet NMFS' criteria for listed juvenile salmon and steelhead. However, no listed fish are present in Horn or Marion Creeks. No critical habitat has been designated in this area.

5.6.5.2 Broodstock Collection

In the North Santiam River, the only broodstock collection is for spring Chinook at Minto Dam (approximately five km downstream from Big Cliff Dam). Hatchery summer steelhead are also collected at Minto Dam and recycled downstream and/or removed from the river. There is no effect of these collections on listed winter steelhead because trapping for Chinook and summer steelhead occurs after the run of winter steelhead is over (July through October). Winter steelhead have already spawned by this time.

There is an impact of this trapping on wild spring Chinook salmon. A proportion of the wild Chinook captured at Minto Dam are purposefully incorporated into the hatchery broodstock in order to maintain an "integrated" hatchery stock. The other wild fish not used for broodstock are outplanted into other spawning areas, like the Little North Santiam River, or released downstream of Minto Dam to spawn naturally (Schroeder et al. 2006). No wild Chinook are outplanted above Big Cliff and Detroit Dams.

Further details on the broodstock collection schedules are described in the Supplemental BA and North Santiam spring Chinook HGMP (ODFW 2008a).

At the Minto trapping facility, on an annual basis approximately 1000 UWR Chinook are observed (that is, their migration is blocked and they congregate below Minto dam); of these, 700 fish are handled. 6% of handled fish die or are injured from the procedures, primarily from May through October. In addition, of those UWR Chinook transported (that is, trucked), ~700 fish, approximately 1% die. (Willis 2008)

Approximately 1000 UWR steelhead are observed, and approximately 400 of these are handled (released immediately above Minto Dam, primarily). Of these ~400 that are handled, approximately 8 are injured and 4 are die.

5.6.5.3 Genetic Introgression

Spring Chinook

Significant genetic introgression from hatchery fish into the natural population in the North Santiam has occurred since Big Cliff and Detroit Dams were constructed and this mitigation hatchery program was initiated. Ever since all returning hatchery fish have been mass marked (adipose finclipped) so that they could be distinguished from naturally-produced fish in 2001, most of the return has been fish of hatchery-origin (see Figure 4.6.3 and Table 4.6.1 in the Environmental Baseline chapter). In addition, the majority of the fish spawning naturally below Minto Dam have been hatchery fish. The percentage of natural-origin fish recovered in carcass surveys on the spawning grounds has ranged from 3% to 33% from 2002-2006 (Table 5.6-2). Hatchery origin fish have dominated the spawning grounds and the percentage of natural-origin fish incorporated into the hatchery broodstock was low until 2006. Thus the PNI values for this population have been low since 2002—indicating hatchery fish are dominating genetic processes in this population (see Figure 5.2-3).

Table 5.6-2 Composition of spring Chinook salmon in the North Santiam subbasin[a] based on carcasses recovered. Weighted for distribution of redds among survey areas. Copied from McLaughlin et al. (2008).

	Fin-	Unclipped[b]		Percent
Run year	**clipped**	**Hatchery**	**Wild**	**Wild[c]**
2001	385	43 (43)	56	12 (6)
2002	230	44 (49)	45	14 (13)
2003	855	89 (77)	27	3 (4)
2004	321	21 (27)	56	14 (15)
2005	163	25 (24)	80	30 (30)
2006	109	12 (17)	59	33 (32)

[a]Mainstem North Santiam River from Minto to Bennett Dam, plus the Little North Santiam River.
[b] The proportion of hatchery and wild fish was determined by presence or absence of thermal marks in otoliths. Number in parentheses is percentage of unclipped fish that had a thermal mark (unclipped hatchery fish).
[c] Percentage not weighted for redd distribution is in parentheses.

Table 5.6-3 Composition of spring Chinook salmon without fin clips that were spawned as broodstock for the hatchery program in the North Santiam subbasin after collection at Minto Trap, based on the presence or absence of thermal marks in otoliths, 2002–2006. Run of wild fish is estimated from Bennett dam counts. Source: McLaughlin et al. (2008)

	Unclipped[a]		Fin-clipped	Percent wild—	
River, year	**Wild**	**Hatchery**	**hatchery**	**in broodstock**	**of run**
2002	4	7	671	0.6	0.7
2003	2	17	599	0.3	0.7
2004	12	13	541	2.1	2.4
2005[b]	18	16	470	3.6	2.7
2006	197	12	335	36.2	***c***

[a] Includes fish with partial or questionable fin-clips.
[b] Otoliths were analyzed for 21 fish (11 wild).
[c] Bennett Dam trap on the North Santiam was not operated in 2006.

In recent years, it is likely some proportion of the natural-origin fish returns are progeny of hatchery fish. Hatchery fish comprise the majority of spawning in all areas (above and below Big Cliff/Detroit dams). However, it is unknown what area (or combination of areas) are producing the wild Chinook. In the area downstream of Big Cliff/Detroit Dams, the release of warm water in the fall as the reservoirs are being drawn down for flood control causes high mortality of spring Chinook eggs incubating in the gravel. Natural production is likely to be low in this area because most of the spawning occurs in the vicinity of Minto Dam—the area most impacted by warm water releases because its only five km downstream of Big Cliff Dam. The outplanting program of releasing adult Chinook above Detroit Dam did not begin until 2000. However, releases were dramatically increased beginning in 2002; with over 1,600 fish released that year (Beidler and Knapp 2005). The recent increase in 2006 and 2007 in the percentage of wild fish returns (and greater number of wild fish even though overall returns were lower to the Willamette) may be natural production from the outplanting program. All of these uncertainties stress the need for more monitoring and evaluation to discern where natural production is currently coming from in this population.

Given these uncertainties, hatchery management should continue to outplant adults above Detroit Dam and continue to incorporate wild fish into the broodstock, according to the sliding scale matrix described in the HGMP. As more information becomes available, it may be warranted to start managing hatchery fish on the spawning grounds below Minto Dam, particularly if returns of wild fish continue to be at least several hundred fish. The long-term vision for this mitigation program, as described in the “General effects of hatchery programs on ESA-listed salmon and steelhead” section, is to gradually reduce the influence of hatchery fish in the wild as natural production increases. In the long-term it will likely be necessary to manage for low levels of hatchery fish spawning below Minto Dam, particularly when the key limiting factors with the dams are corrected, and natural production increases in the substantial amount of habitat that is still available below Big Cliff/Detroit Dams.

Winter Steelhead

There are no hatchery winter steelhead released in the North Santiam River. However, hatchery summer steelhead do spawn naturally in the same areas as winter steelhead (Schroeder et al. 2006). Since there is some overlap in the spawn timing of summer- and winter-run fish from February through March, the potential exists for summer steelhead to interbreed with winter steelhead in the North Santiam River. However, the likelihood of this occurrence is low. Most of the summer steelhead spawning occurs in January and February (Schroeder et al. 2006). The peak of the listed winter steelhead run over Willamette Falls (downstream of the South Santiam) occurs from late February through March (Myers et al. 2006).Actual spawn timing of these winter steelhead in the North Santiam has been as late as May 22nd (Taylor 2007)

The primary concerns with the hatchery summer steelhead program are predation and competition, which are addressed below.

5.6.5.4 Disease

Hatchery fish can be agents for the spread of disease to wild fish residing in the natural environment. Due to the high rearing densities of fish in the hatchery, hatchery fish can have elevated levels of certain pathogens, disease, and/or bacteria. After they are released, these fish may expose and/or transfer the disease to wild fish. Below is an assessment of these risks to the juvenile and adult life stages.

Juveniles

In the North Santiam subbasin, the risk of hatchery fish spreading disease to wild juvenile Chinook salmon and winter steelhead is unknown. Hatchery fish are released as smolts from Minto Dam in the North Santiam River. Significant juvenile fish rearing occurs in the lower river and in the mainstem Santiam River. The effects of hatchery fish interacting with other Chinook and steelhead populations downstream are addressed in the Mainstem Willamette River Effects Section 5.10.

Adults

The potential also exists for returning hatchery fish to spread diseases to wild adult fish commingled in the North Santiam River. The risk of hatchery fish spreading diseases in the North Santiam may be substantial since Chinook congregate at the base of Minto Dam throughout the summer until spawning time in September and October. There is no effect of hatchery adults on winter steelhead due to the differences in run timing.

5.6.5.5 Competition/Density-Dependence

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Information on the potential competitive interactions between hatchery and wild fish is very limited in the Willamette Basin. Below is an assessment of the likely implications on the juvenile and adult life stages.

Juveniles

Since all hatchery fish are released as smolts and are expected to emigrate quickly to the ocean, it is unlikely significant competitive interactions will occur over a period of time.

As described in the “genetic introgression” above, hatchery summer steelhead spawn naturally in winter steelhead habitat. Summer steelhead spawning has been widespread; with the number of spawners positively correlated with run strength (Schroeder et al. 2006). It is likely that progeny from these summer steelhead would negatively affect listed juvenile winter steelhead rearing in their natal habitat. It is unknown whether there is in fact a competitive interaction due to limited resources. However, any interaction between non-native summer steelhead and listed winter steelhead would be undesirable. Juvenile summer steelhead would have a competitive advantage because these fish would hatch earlier and be of larger size than winter steelhead. Monitoring and evaluation is scheduled to occur to evaluate the proportion of juvenile steelhead that are progeny of summer steelhead.

Adults

Given the problem of crowding of adult Chinook at the base of Minto Dam, there is the potential for competitive interactions for space. There is a limited amount of habitat in the holding pool at the base of the dam. It is unknown whether adult fish are displaced into suboptimal holding habitat downstream due to the high number of fish at the base of the dam. Given the primary limiting factors for this population (habitat access, temperature problems), competition is not likely one of the primary or secondary limiting factors.

5.6.5.6 Predation

Hatchery fish released into the population areas throughout the Willamette Basin can predate upon co-occurring wild fish. In general, salmonids can prey upon fish approximately 2/3 of their size. Thus there is significant potential for hatchery summer and spring Chinook to prey upon wild steelhead and Chinook. Even though information is lacking on the extent of this issue, predation by hatchery fish undoubtedly occurs. Schroeder et al. (2006) examined predation by hatchery summer steelhead and rainbow trout on Chinook fry in the McKenzie River. Predation did occur on Chinook fry by a few individual fish. However, due to the fast digestion rates of Chinook fry in the stomachs of summer steelhead and rainbow trout (e.g. one to seven hours), it was difficult to estimate the amount of predation in their sampling design. Given the primary and secondary limiting factors identified for Willamette populations, predation by hatchery fish is not likely a limiting factor and the risk to listed fish is low.

Juvenile summer steelhead (that are the progeny of naturally spawning summer steelhead in winter steelhead habitat) could also predate upon listed age-0 and age-1 juvenile winter steelhead. The extent of this potential problem is unknown at this time. However, monitoring and evaluation is scheduled to occur to evaluate the proportion of juvenile steelhead that are progeny of summer steelhead.

5.6.5.7 Residualism

All hatchery programs in the Willamette Basin release hatchery fish as smolts. The intent is to release the hatchery fish at a size and time so that they will actively emigrate to the ocean; thus minimizing the potential interaction between hatchery and wild fish. However, a percentage of the smolts do not emigrate and residualize in the river. These residual fish may emigrate to the ocean at a later time or may stay in freshwater the rest of their life.

In general, hatchery steelhead have more of a tendency to residualize than hatchery spring Chinook. In the Willamette Basin, the primary concern is with residual summer steelhead. The percentage of the smolt release of summer steelhead that do residualize is unknown. However, residual summer steelhead have been observed in all areas where hatchery fish are released. Several new actions are included in the Proposed Action that will help reduce the adverse effects of residual summer steelhead on wild winter steelhead and spring Chinook. The most beneficial is the proposal to not release any summer steelhead smolts that do not volitionally emigrate from the hatchery facility. These “non-migrants” will be collected and released into standing water bodies for trout fisheries. Previously, all of these non-migrant fish were forced out into the river. In addition, ODFW is proposing a new angling regulation that will allow the harvest of any finclipped, residual summer steelhead in all recreational fisheries. These regulation changes will decrease the number of residual hatchery fish left in the river and thus reduce adverse effects of residual fish on wild steelhead and spring Chinook.

5.6.5.8 Fisheries

As discussed in the "General effects of hatchery programs on ESA-listed salmon and steelhead" section above, the production of hatchery fish can lead to commercial and recreational fisheries that cause the overharvest of natural-origin fish. An abundance of hatchery fish can promote expanding fisheries, which may be detrimental to commingled natural-origin fish. In the Willamette, all hatchery fish have been mass marked since the 1990s. This mass marking has facilitated implementation of selective fisheries—where only hatchery fish can be harvested. Thus freshwater fishery impacts on winter steelhead and spring Chinook have been reduced substantially compared to historic harvest rates. Freshwater fishery impacts are now in the range of 1-5% for winter steelhead and 8-12% for spring Chinook populations in the Willamette Basin.

The production of Willamette hatchery fish are of no consequence to the management of ocean fisheries. In general, steelhead of natural- or hatchery-origin are rarely caught in ocean fisheries. Hatchery spring Chinook are caught in ocean fisheries, particularly in Alaska and West Coast Vancouver Island fisheries (see Figure 4.2-13). However, these hatchery fish are not a driver for fisheries management. Protection of other stocks of concern in Canada and the United States currently constrain ocean fishery quotas and regulations. In addition, harvest of Willamette spring Chinook in ocean fisheries is governed by the Pacific Salmon Treaty between the US and Canada and impacts have been typically been in the range of 10-15%.

5.6.5.9 Masking

The production of unmarked hatchery fish can have an impact on wild fish if these hatchery fish stray and intermingle with wild populations. Not knowing whether naturally spawning fish are of hatchery- or natural-origin confounds the ability to monitor the true status of the wild population. This effect has been termed "masking" by hatchery fish.

In the Willamette Basin, this concern has been eliminated because all hatchery spring Chinook, summer steelhead, and rainbow trout are adipose finclipped. In addition, all hatchery spring Chinook are otolith marked in the hatchery which provides an additional safeguard to detect hatchery fish that may have been missed during finclipping (currently <5% of all the smolt releases, McLaughlin et al. 2008).The Action Agencies are also proposing to coded wire tag (CWT) all hatchery spring Chinook salmon, which will also allow individual fish to be identified upon their return to freshwater.

5.6.5.10 Nutrient Cycling

Hatchery fish can provide essential marine-derived nutrients to the freshwater environment if they spawn naturally or are outplanted as carcasses (see "General effects of hatchery programs on ESA-listed salmon and steelhead" section above). Hatchery spring Chinook salmon and summer steelhead are known to spawn naturally throughout the Willamette Basin, thus providing benefits in terms of marine nutrients to the local environment. Thousands of hatchery Chinook are also outplanted alive above the dams in an effort to restore natural production in historic habitats. This provides benefits to aquatic and terrestrial food chains.

5.6.5.11 Monitoring & Evaluation

Monitoring and evaluation of Willamette hatchery programs under the ESA began in response to NMFS' (2000a) *Biological Opinion on the impacts from the collection, rearing, and release of listing and non-listed salmonids associated with artificial propagation programs in the Upper Willamette spring Chinook and winter steelhead ESUs.* The ODFW implemented specific monitoring and evaluation activities to collect information on the effects of hatchery programs in the Willamette. This information is summarized in Schroeder et al. (2006) and McLaughlin et al. (2008).

Monitoring and evaluation of hatchery programs in the Willamette Basin will continue to occur in order to assess whether the programs are meeting their intended goals and to evaluate the impacts on wild populations. The specific HGMPs for each program describe the monitoring and evaluation that will occur in the future.

5.6.6 Summary of Effects on the North Santiam Chinook Salmon & Steelhead Populations

Table 5.6-4 summarizes anticipated effects of the Proposed Action to VSP parameters for North Santiam populations of Chinook salmon and steelhead. These effects are described in more detail in this section.

5.6.6.1 Abundance

There have been substantial impacts of the Proposed Action on steelhead and Chinook in the North Santiam subbasins. The Proposed Action is essentially status quo management of the Projects and thus the abundance of these species are likely to remain at similar abundance levels and are not likely going to increase. NMFS is concerned particularly for Chinook since their abundance is low and their trend is clearly declining.

5.6.6.2 Productivity

Productivity of Chinook in the North Santiam has been declining over the long- and short- terms. The recent decline in abundance is of particular concern because productivity has not been increasing. The current hatchery programs represent risks to the listed populations. However, the recent returns of natural-origin fish are likely the offspring of hatchery spawners. Thus, production is so poor in this population that hatchery supplementation has to be relied upon until other limiting factors are corrected. Even though this is a high risk scenario, alternatives are limited due to the poor status of natural-origin fish. Without substantial improvements to the habitat conditions below Big Cliff/Detroit dams and adequate passage of fish above these dams into historical habitats, NMFS expects the productivity and capacity of this population to reproduce naturally will not improve but will remain at a very low level. The Proposed Action lacks certainty that any improvements would be carried out during the term of this Opinion.

5.6.6.3 Spatial Structure

The Proposed Action continues to limit Chinook and steelhead access to historic habitats above Big Cliff and Detroit dams. Access is dependent upon trap and haul at Minto Dam (a few miles downstream of Big Cliff Dam). Success of the outplanting program has been mixed for Chinook salmon; with high prespawning mortality rates in outplanted fish in most years. Restoring production above Big Cliff/Detroit Dams, with appropriate survival of adult and juveniles, is needed to increase the spatial distribution of the population and increase the capacity of the population to respond to fluctuating environmental conditions. However, the Proposed Action would not provide safe upstream and downstream passage.

5.6.6.4 Diversity

Many aspects of the North Santiam populations have been and will continue to be impacted by the Proposed Action. Since the impacts have been substantial, there has undoubtedly been changes in the diversity of the Chinook and steelhead in the North Santiam. Population traits are now not as diverse as the historic populations, and this decreases the ability of salmon to respond and survive in response to fluctuating environmental conditions. The habitat changes that have occurred by the Proposed Action downstream of the Projects have affected the population in an unquantifiable manner. The influence of hatchery fish on the wild population also represents risk to the diversity of the natural-origin population.

5.6.7 Effects of the Proposed Action on Designated Critical Habitat

The North Santiam River and many of its tributaries have been designated as critical habitat for UWR Chinook salmon and UWR steelhead. The PCEs identified in this portion of critical habitat include sites for spawning, rearing, and migration. Table 5.6-4 summarizes anticipated effects of the Proposed Action to these PCEs. The effects are attributable to a lack of functional fish passage at USACE dams, the effects these dams and their reservoirs have on water quality and physical habitat conditions in the lower reaches of the North Santiam River, and continued existence and maintenance by the USACE of 3.87 miles of revetments. The following PCEs will be adversely affected by the Proposed Action:

- Freshwater spawning sites above Detroit and Big Cliff dams, with flow regimes, water quality conditions, and substrates well suited to the successful spawning, incubation, and larval development of UWR Chinook and UWR steelhead, will remain marginally accessible to these fish. Spawning habitat will remain accessible to these fish below Big Cliff (and the Minto Trap), but much of this habitat is degraded as a result of ongoing Project operation. Flow releases from the dams during late summer and fall will continue to create adverse temperature conditions for UWR Chinook, contributing to elevated pre-spawning mortality and causing delayed spawning, embryo mortality, and accelerated incubation in the habitat below Big Cliff. This habitat is further degraded by the Project’s interruption of sediment transport, such that new gravels needed for spawning are not replacing those that move downstream during high flows. Additionally, continued existence and maintenance of revetments downstream of Big Cliff prevent channel formation processes that might otherwise allow for new gravels and spawning habitat to be created.

- The quantity and quality of freshwater rearing sites for juvenile UWR Chinook and UWR steelhead will remain limited and degraded in the fully accessible portion of the mainstem North Santiam River below Big Cliff, and may continue to decline. Diminished peak flows, lack of sediment and LWD delivery from areas above Project dams, and revetments contribute to losses of off-channel rearing habitat and impair processes that might otherwise create complex habitats along main channel areas. Sudden reductions in outflows below Project dams will, when flows are relatively low, continue to pose risks of juvenile stranding and loss.
- Historically important migratory corridors will continue to be obstructed by Detroit and Big Cliff dams and reservoirs. Under current conditions, and those that will prevail under the Proposed Action, these obstructions preclude the re-establishment of self-sustaining UWR Chinook and UWR steelhead runs in the upper North Santiam subbasin.

In aggregate, these effects will continue to diminish habitat availability and suitability within the North Santiam subbasin for juvenile and adult lifestages of UWR Chinook and UWR steelhead. These adverse effects to the functioning of designated critical habitat within the subbasin will limit the habitat's capacity to serve its conservation role supporting large, productive, and diverse populations of these fish.

Table 5.6-4 Effects of the Proposed Action on populations (VSP column) and Critical Habitat (PCE column) in the North Santiam. Modified from USACE 2007a, Table 6-1

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on the PCES
Freshwater migration corridors	Habitat Access	Physical Barriers	Proposed action would continue to limit access to historical habitat for UWR Chinook salmon and UWR steelhead above Big Cliff and Detroit dams.	Upstream passage will continue to be inadequate unless the Action Agencies firmly commit to rebuild Minto trap; downstream passage will continue to kill and injure juvenile fish unless the Action Agencies complete studies and commit to improve survival at the dams to levels comparable to that at other dams in the NW. Fish will continue to lack access to historical habitat.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (flow/hydrology)	Change in Peak/Base Flow	Improved ramping rates and flow conditions below Big Cliff Dam will reduce risks to ESA-listed fish species. The improved ramping and flow conditions could result in improved ecosystem health and function, expanded rearing habitat, higher egg-to-smolt survival, improved migration conditions, and improved overall productivity. As a result, local population abundance also may increase. Biological monitoring will document changes in local habitat conditions and in local population productivity resulting from a combination of Action Agency actions.	Flow-related components of habitat quality for UWR Chinook will be improved in the near-term within areas downriver of the USACE dams in the subbasin. Longer term effects of diminished flood events on channel processes that help create or maintain channel complexity will continue.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on the PCES
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Initially, no change in effect from existing unfavorable conditions for spawning, incubation, and emergence of UWR Chinook. If and when WTC capability is developed and implemented, population abundance and productivity would increase. Habitat quality in the natural production area below Foster would improve. Spawning activity and egg-to-fingerling survival is expected to increase for UWR Chinook, resulting in the potential for improved abundance and productivity. Biological monitoring would document realized changes.	Continued adverse effect on spawning and rearing habitat caused by water temperatures released from Project dams that shifts temperatures from natural thermal regime, reducing habitat suitability.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/Turbidity	No effect.	No effect.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on the PCES
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical contamination/nutrients	Operation of USACE dams and reservoirs will continue to help dilute pollutants downstream during periods of lowest flow. The consequences of this particular benefit are likely minor relative to the substantially negative effect that unnaturally warm temperatures below Big Cliff and Detroit dams during fall have on the spawning success and emergence timing of UWR Chinook salmon.	No change in effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	No effect.	No effect.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on the PCES
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	Occasional spills may elevate TDG to levels sufficient to harm incubating UWR Chinook embryos in the mainstem North Santiam River below Big Cliff Dam.	Continued unfavorable effect during spill events on spawning/early rearing habitat immediately below Foster Dam.
Freshwater spawning sites	Habitat elements	Substrate	Continued lack of new gravels to existing spawning habitat downstream of the canyon below Big Cliff Dam would reduce abundance and productivity of UWR Chinook salmon and UWR steelhead by limiting and degrading available habitat.	Operation of Big Cliff and Detroit dams would continue to block sediment transport to downstream reaches, further increasing substrate coarsening, and thereby degrading limited spawning habitat. Study of gravel augmentation would not guarantee that sediment would be placed below Big Cliff Dam at adequate levels to restore fully functioning habitat.
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris (LWD)	Continued lack of large wood reduces abundance and productivity of UWR Chinook salmon and UWR steelhead in the North Santiam Subbasin because holding and rearing habitat below the dams would continue to degrade and would not be replaced.	Operation of Project dams would continue to block transport of large wood from reservoirs to downstream habitat, revetments would continue to prevent floodplain connectivity, reducing large wood recruitment from streambanks, resulting in less structure available to create complex channel habitat, gravel bars and large pools. Study of stockpiling LWD would not guarantee new LWD will be placed in reaches below the dams.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on the PCES
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Continued degradation of pool habitat would reduce rearing and adult holding habitat, resulting in lowered productivity and abundance	Continued low frequency of pools and poor pool quality downstream of the canyon below Big Cliff Dam. Operation of Project dams and continued existence and maintenance of revetments would continue to prevent peak flows and block sediments and large wood, preventing channel movement that would allow for new pools to form.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-channel Habitat	Continued lack of off-channel habitat would reduce rearing habitat, resulting in lowered productivity and abundance.	Continued reduced off-channel habitat in the North Santiam River downstream of the canyon below Big Cliff Dam and in the mainstem Santiam River. Project operation would continue to reduce peak flows, limiting overbank flows and channel forming processes. Although studies may consider special operations to provide peak flows, the Action Agencies provide no certainty that this operation would occur during the term of this Opinion, nor that the operation would open up off-channel habitat.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on the PCES
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/Depth Ratio	Continued degraded channel conditions would reduce rearing habitat, resulting in lowered productivity and abundance.	Project operation would continue to reduce peak flows and block large wood and sediment transport, limiting pool formation. Although studies may consider stockpiling LWD for later placement to create habitat complexity and funding habitat restoration projects, the Action Agencies provide no certainty that these measures would occur during the term of this Opinion.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Streambank Condition	Degraded streambanks would inhibit channel forming processes that create complex habitat essential for juvenile rearing, adult spawning and holding, resulting in lowered productivity and abundance.	Project operation and continued existence and maintenance of revetments would continue to prevent streambanks from supporting natural floodplain function downstream of the canyon in the lower North Santiam River below Big Cliff Dam and in the mainstem Santiam River. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve streambank conditions, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on the PCES
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain Connectivity	Continued lack of floodplain connectivity reduces availability of off-channel habitat, limiting available rearing habitat, including reduced macroinvertebrate production as a food supply, resulting in lowered productivity and abundance.	Project operation and continued existence and maintenance of revetments would continue to prevent overbank flow and side channel connectivity in the North Santiam River downstream of the canyon below Big Cliff Dam. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve off-channel habitat, restoring normative ecosystem functions, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	Continued degradation of riparian habitat would reduce large wood available for channel complexity, thereby reducing already limited rearing, holding, and spawning habitat, resulting in lowered abundance and productivity.	Project operation and continued existence and maintenance of revetments would continue to prevent formation of new gravel bars on which riparian vegetation could grow in the North Santiam River downstream of the canyon below Big Cliff Dam and in the mainstem Santiam River. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially restore riparian vegetation, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.

Chapter 5.7
Molalla Subbasin
Effects

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5.7 Molalla Subbasin: Summary of the Effects of the Proposed Action on Listed UWR Chinook Salmon & UWR Steelhead Populations in the Molalla Subbasin

Summary of the Effects of the Proposed Action

- The effects of the Proposed Action on Molalla populations of UWR Chinook salmon and UWR steelhead would be relatively small compared to baseline conditions, but would contribute to continued degradation of habitat along the mainstem Molalla River, causing minor reduction in abundance and productivity of these two populations and adversely modifying critical habitat. The Proposed Action would result in:
    - Degraded physical habitat elements in the lower Molalla River
    - Continued release of an out-of-basin hatchery Chinook stock from the South Santiam Hatchery resulting in genetic risks to the Molalla Chinook population.

Introduction

For the Molalla River populations of UWR Chinook salmon and UWR steelhead, the Proposed Action includes the following on-the-ground actions:

- Hatchery Program - Release approximately 100,000 hatchery Chinook from South Santiam Hatchery.
- Revetments - Continued existence and maintenance of 2.49 miles of revetments along the Molalla River

In this section, NMFS considers the effects of the Proposed Action on the Molalla UWR Chinook salmon and UWR steelhead populations. In general, NMFS expects that the Proposed Action would cause minor increments of continued degradation of habitat due to ongoing maintenance of revetments, resulting in small reductions in abundance and productivity of these populations. NMFS expects the Proposed Action would have substantial genetic risks to Chinook from the continued release of an out-of-basin hatchery stock. NMFS concludes that the Proposed Action would continue to degrade critical habitat.

5.7.1 Habitat Access & Fish Passage

The Proposed Action would have minimal effect on habitat access and fish passage because there are not Project dams on the Molalla River. However, there are some minor adverse effects due to continued maintenance of revetments precludes fish access to side channels and complex habitat. (See section 5.7.4 below).

5.7.2 Water Quantity/Hydrograph

The Proposed Action would have no effect on water quantity or on the baseline hydrograph in the Molalla subbasin because there are no Project dams on the Molalla River.

5.7.3 Water Quality

The Proposed Action would have a very small adverse effect on the baseline water quality conditions as a result of continued maintenance of 2.49 miles of revetments in the lower Molalla River. By reducing riparian vegetation and stream processes that enable formation of complex habitats and deep pools, maintenance of revetments would result in small increases in summer water temperatures, particularly in the lower part of the Molalla watershed.

5.7.4 Physical Habitat Quality

The key proposed actions related to physical habitat quality in the Molalla River subbasin that would affect UWR Chinook salmon and UWR steelhead are listed below.

- Continue the existence and maintenance of 2.49 miles of revetments along the Molalla River, preventing channel migration and reducing channel complexity.
- Study effects of Project revetments on downstream habitat and consider projects to restore habitat, if authorized and funding becomes available.

5.7.4.1 Substrate, Sediment Transport, Large Wood & Channel Complexity in the Molalla River Subbasin

Under the environmental baseline, substrate, sediment transport, large wood, and channel complexity are degraded and do not support adequate rearing and holding habitat for UWR Chinook salmon and UWR steelhead (section 4.7.2.3). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.7-2 and described below.

Under the Proposed Action, the Action Agencies would continue the existence and maintenance of about 2.49 miles of revetments in the lower Molalla River. Although this length comprises a small percentage of the total revetments and length of this stream, the effect of this action will be to continue to restrict channel migration and prevent recruitment of large wood and sediment from streambanks, inhibiting natural processes that create and maintain channel complexity. As described in the baseline section 4.7.3 and 4.7.6, the middle and lower reaches of the Molalla River are more heavily impacted by land use practices, including channelization and revetments, that have caused coarsening and siltation of substrate, low levels of large wood, and reduced channel complexity. The Proposed Action would cause minor reductions in juvenile rearing and adult holding habitat, further limiting abundance and productivity of the Molalla populations of UWR Chinook salmon and UWR steelhead in this already impaired habitat.

The Action Agencies propose to conduct a general study of USACE revetments in the Willamette basin, including consideration habitat restoration projects, but the Action Agencies do not propose specific measures that would restore large wood, sediment transport, and channel complexity in the Molalla subbasin.

In summary, although the revetments maintained by the Action Agencies in the Molalla subbasin are a small percentage of total river length, they would contribute to continued degradation of habitat and would likely cause additional small reductions in the carrying capacity of this habitat for rearing juvenile fish and holding adults, thus reducing the number of individual UWR Chinook salmon and UWR steelhead that can be produced in this presently degraded habitat. Aside from unspecified habitat restoration actions that may result from proposed habitat and revetment studies, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the Molalla subbasin.

5.7.4.2 Riparian Vegetation & Floodplain Connectivity

Under the environmental baseline, riparian vegetation and floodplain connectivity are degraded and do not support adequate rearing and holding habitat for UWR Chinook salmon and UWR steelhead (section 4.7.2.3). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.7-2 and described below.

Under the Proposed Action, the Action Agencies would continue the existence and maintenance of about 2.49 miles of revetments in the lower Molalla River. Although this length of revetments comprises a small percentage of the total revetments and length of this stream, this action would continue to prevent overbank flows, river migration, and contribution of sediment and large wood from streambanks. Infrequent inundation of forested floodplains reduces nutrient and organic matter exchange during flood events and reduces the availability of high-water refugia for juveniles, which could limit over-wintering survival of rearing juveniles. Additionally, the Proposed Action would continue to prevent establishment of riparian vegetation in the lower Molalla subbasin by interfering with the processes needed for new floodplain forests to establish. The reduced extent of riparian vegetation and lack of floodplain connectivity hinders recruitment of large wood into the aquatic system and reduces off-channel refugia, both habitat features needed to create resting pools for migrating adults and provide cover for rearing juveniles. The Proposed Action, although limited in extent in the Molalla subbasin, would continue to degrade this already impaired habitat, reducing juvenile rearing and adult holding habitat, with minor effects on abundance and productivity of the Molalla populations of UWR Chinook salmon and UWR steelhead. Although the Proposed Action includes study of revetments in the Willamette basin and potential habitat restoration, there is no certainty that any restoration work would be done in the Molalla River subbasin during the term of this Opinion.

In summary, the proposed continued existence and maintenance of revetments in the Molalla River would be a factor in the continued degradation of riparian and floodplain forests and floodplain connectivity. Aside from unspecified habitat restoration actions that may result from revetment and habitat restoration studies described in the Proposed Action, the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain connectivity in the Molalla River subbasin. Continued degradation of juvenile rearing and adult holding habitat under the Proposed Action would cause a small reduction in the abundance and productivity of Molalla subbasin populations of UWR Chinook salmon and UWR steelhead.

5.7.5 Hatcheries

The only hatchery fish currently being released into the Molalla River are spring Chinook salmon from the South Santiam hatchery program.

5.7.5.1 Hatchery Operations

There are no hatchery facilities within the Molalla watershed. See the South Santiam hatchery operations section 5.5.5 above for further details on how South Santiam Hatchery is operated.

5.7.5.2 Broodstock Collection

The broodstock used for the Molalla River program is the South Santiam hatchery stock (ODFW stock # 24). See the South Santiam broodstock collection section 5.5.5 for details on how broodstock are collected.

5.7.5.3 Genetic Introgression

The Molalla River historically supported an independent population of spring Chinook salmon. The current wild run is extremely depressed; with most of the Chinook observed on the spawning grounds being of hatchery origin (Table 5.7-1). The current hatchery stock of Chinook released into the Molalla River is from South Santiam Hatchery (an out of population stock). There are two concerns with the current hatchery management within this population. First, since the wild population is extremely depressed, a supplementation hatchery program may be warranted. However, an out-of-population stock is not the best option for supplementation purposes based on the scientific literature (Nickum et al. 2004; Araki et al. 2007). Secondly, if it was desirable to maintain South Santiam hatchery stock releases in the Molalla for harvest augmentation purposes, then the scientific literature recommends that few of these hatchery fish should spawn naturally in the wild (<5% of the population for a segregated hatchery stock; HSRG 2004). Due to the very low numbers of wild fish present in the Molalla River, it would not be possible to reduce hatchery fish spawning to less than 5% of the spawners with current production levels and the harvest regimen.

Table 5.7-1 Spawning ground survey data for Molalla River spring Chinook. Data compiled from Schroeder et al. (2003, 2005) and Schroeder and Kenaston (2004) annual reports.

				Carcasses		% natural-origin Fish (best case scenario)
Year	**Reach**	**Length (mi)**	**Redds**	**No fin clip**[1]	**Finclipped**	
2002	Trout Creek to Old Gawley Creek Bridge	7	16	3	16	0.16
	Old Gawley Bridge to Bull Creek	3.9	22	4	71	0.05
	Bull Creek To Copper Creek	4	11	0	8	0.00
	North Fork: Mile 2 to old 151 Bridge	1.4	3	0	0	NA
	Total	**16.3**	**52**			
2003	Baybarn Creek to Bull Creek	2.3	1	0	0	
	Bull Creek to Old Gawley Bridge	3.9	9	4	12	0.25
	Old Gawley Creek Bridge to Pine Creek Bridge	5.3	5	1	7	0.13
	Total	**11.5**	**15**			
2004	Haybarn Creek to Trout Creek	16.1	44	4	4	.050

5.7.5.4 Disease

Hatchery fish can be agents for the spread of disease to wild fish residing in the natural environment. Due to the high rearing densities of fish in the hatchery, hatchery fish can have elevated levels of certain pathogens, disease, and/or bacteria. After they are released, these fish may expose and/or transfer the disease to wild fish. Below is an assessment of these risks to the juvenile and adult life stages.

Juveniles
In the Molalla subbasin, the risk of hatchery Chinook spreading disease to wild juvenile Chinook salmon and winter steelhead is unknown. Hatchery fish are released as smolts at various locations in the mainstem Molalla River. Significant juvenile fish rearing occurs in the Molalla River. The effects of hatchery fish interacting with other Chinook and steelhead populations downstream are addressed in the section “Mainstem Willamette River”.

Adults
The potential also exists for returning hatchery fish to spread diseases to the few wild adult Chinook commingled in the Molalla River. The risk of hatchery fish spreading diseases in the Molalla is likely to be lower than in other Willamette populations due to the lower numbers of returning adults. However, since the Molalla River gets warmer during the summer months than other rivers, the potential may be exuberated. There is little risk of hatchery Chinook spreading diseases to adult winter steelhead due to the differences in run and spawn timing.

[1] Otoliths have not yet been read to determine the proportion of wild and hatchery fish.

5.7.5.5 Competition/Density-Dependence

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Information on the potential competitive interactions between hatchery and wild fish is very limited in the Willamette Basin. Below is an assessment of the likely implications on the juvenile and adult life stages.

Juveniles
Since all hatchery Chinook are released as smolts and are expected to emigrate quickly to the ocean, it is unlikely significant competitive interactions will occur over a period of time.

Adults
Given the low returns of hatchery and wild Chinook to the Molalla River, it is unlikely there are competitive interactions for holding and spawning habitat.

5.7.5.6 Predation

It is unlikely that hatchery Chinook have a significant predation impact on wild juvenile Chinook or winter steelhead. It is more likely that wild steelhead would predate upon the hatchery Chinook. There may be a positive benefit to steelhead.

5.7.5.7 Residualism

All hatchery programs in the Willamette Basin release hatchery fish as smolts. The intent is to release the hatchery fish at a size and time so that they will actively emigrate to the ocean; thus minimizing the potential interaction between hatchery and wild fish. However, a percentage of the smolts do not emigrate and residualize in the river. These residual fish may emigrate to the ocean at a later time or may stay in freshwater the rest of their life. Spring Chinook do not have the tendency to residualize like steelhead, thus this risk is deemed to be very low in the Molalla River.

5.7.5.8 Fisheries

As discussed above in Effects section 5.1, “General effects of hatchery programs on ESA-listed salmon and steelhead,” the production of hatchery fish can lead to commercial and recreational fisheries that cause the overharvest of natural-origin fish. An abundance of hatchery fish can promote expanding fisheries, which may be detrimental to commingled natural-origin fish. In the Willamette, all hatchery fish have been mass marked since the 1990s. This mass marking has facilitated implementation of selective fisheries—where only hatchery fish can be harvested. Thus freshwater fishery impacts on winter steelhead and spring Chinook have been reduced substantially compared to historic harvest rates. Freshwater fishery impacts are now in the range of 1-5% for winter steelhead and 8-12% for spring Chinook populations in the Willamette Basin.

The production of Willamette hatchery fish are of no consequence to the management of ocean fisheries. In general, steelhead of natural-origin or hatchery-origin are rarely caught in ocean fisheries. Hatchery spring Chinook are caught in ocean fisheries, particularly in Alaska and West Coast Vancouver Island fisheries (NMFS 2003e). However, these hatchery fish are not a driver for fisheries management. Protection of other stocks of concern in Canada and the United States currently constrain ocean fishery quotas and regulations. In addition, harvest of Willamette spring Chinook in ocean fisheries is governed by the Pacific Salmon Treaty between the US and Canada and impacts have been typically been in the range of 10-15%.

5.7.5.9 Masking

The production of unmarked hatchery fish can have an impact on wild fish if these hatchery fish stray and intermingle with wild populations. Not knowing whether naturally spawning fish are of hatchery- or natural-origin confounds the ability to monitor the true status of the wild population. This effect has been termed "masking" by hatchery fish.

In the Willamette Basin, this concern has been eliminated because all hatchery spring Chinook, summer steelhead, and rainbow trout are all adipose finclipped. In addition, all hatchery spring Chinook are otolith marked in the hatchery which provides an additional safeguard to detect hatchery fish that may have been missed during finclipping (currently <5% of all the smolt releases; McLaughlin et al. 2008). The Action Agencies are also proposing to coded wire tag (CWT) all hatchery spring Chinook salmon, which will also allow individual fish to be identified upon their return to freshwater.

5.7.5.10 Nutrient Cycling

Hatchery fish can provide essential marine-derived nutrients to the freshwater environment if they spawn naturally or are outplanted as carcasses (see "General effects of hatchery programs on ESA-listed salmon and steelhead" section above). Hatchery spring Chinook salmon and summer steelhead are known to spawn naturally throughout the Willamette Basin, thus providing benefits in terms of marine nutrients to the local environment. Thousands of hatchery Chinook are also outplanted alive above the dams in an effort to restore natural production in historic habitats. This provides benefits to aquatic and terrestrial food chains.

5.7.5.11 Monitoring & Evaluation

Monitoring and evaluation of Willamette hatchery programs under the ESA began in response to NMFS (2000a) *Biological Opinion on the impacts from the collection, rearing, and release of listing and non-listed salmonids associated with artificial propagation programs in the Upper Willamette spring Chinook and winter steelhead ESUs.* The ODFW implemented specific monitoring and evaluation activities to collect information on the effects of hatchery programs in the Willamette. This information is summarized in Schroeder et al. (2006) and McLaughlin et al. (2008).

Monitoring and evaluation of hatchery programs in the Willamette Basin will continue to occur in order to assess whether the programs are meeting their intended goals and to evaluate the impacts on wild populations. The specific HGMPs for each program describe the monitoring and evaluation that will occur in the future.

5.7.6 Summary of Effects on Population Traits

The Proposed Action has limited effects in the Molalla subbasin. The primary concern is the continued release of an out-of-basin hatchery Chinook stock in the Molalla. Given that Molalla spring Chinook are currently at very high risk of extinction, the hatchery program should be reformed and/or eliminated. Recent data suggests that the current hatchery program cannot manage hatchery fish spawning to acceptable levels (<5%). Therefore significant hatchery reform actions are necessary to help reduce genetic risks.

The continued existence and maintenance of about 2.49 miles of revetments by the USACE would result in minor effects on UWR Chinook salmon and UWR steelhead. These effects include continued degradation of juvenile rearing and adult holding habitat, resulting in a small reduction in the abundance and productivity of Molalla subbasin populations.

5.7.7 Effects of the Proposed Action on Designated Critical Habitat

The mainstem Molalla River and a number of its tributaries have been designated as Critical Habitat for UWR Chinook salmon and UWR steelhead. Table 5.7-2 identifies the anticipated effects of the Proposed Action on the PCEs of this habitat. All of the effects of the Proposed Action are attributable to the continuing existence of 2.49 miles of revetments the USACE will maintain along the mainstem Molalla.

The revetments limit natural channel migration and the formation of complex and diverse salmonid habitats, including off-channel areas that are particularly important to juvenile fish during periods of high winter flows. They also impede the establishment and growth of riparian vegetation that might otherwise provide shade (to prevent unfavorable temperature increases) and contribute LWD. Across all of the areas affected within the Molalla subbasin and elsewhere, continued existence and maintenance of these structures will continue to assure diminished habitat suitability for multiple lifestages of UWR Chinook and UWR steelhead, and to limit the habitat's capacity to support large and productive populations of these fish.

Table 5.7-2. Effects of the Proposed Action on UWR Chinook salmon and UWR steelhead populations (VSP column) and critical habitat (PCE column) in the Molalla River subbasin.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater migration corridors	Habitat access	Physical barriers	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in peak/base flow	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Minor effect of elevated water temperatures could decrease survival and/or growth of juvenile UWR Chinook salmon and steelhead and increase prespawning mortality of adult Chinook and steelhead.	Minor effect of revetments, by reducing riparian vegetation and stream processes that enable formation of complex habitats and deep pools, that contribute to elevated summer water temperatures, particularly in the lower part of the Molalla watershed.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination /Nutrients	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	No effect	No effect

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Total Dissolved Gas (TDG)	No effect	No effect
Freshwater spawning sites	Habitat elements	Substrate	Very small effect of Proposed Action on substrate in the Molalla that prevents formation of new gravels, but lower Molalla not historically used for spawning, and thus effect is mainly to reduce invertebrate productivity on which rearing fish feed. Minimal reduction in abundance and productivity of Molalla populations of UWR Chinook salmon and UWR steelhead due to small length of revetment in the Molalla.	Continued existence and maintenance of 2.49 miles of revetments would prevent channel migration, limiting production of new gravel bars and substrate.
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Large Woody Debris	Very small effect of Proposed Action on continued lack of large wood; would cause small reduction in abundance and productivity of UWR Chinook salmon in the Molalla subbasin because adult holding and juvenile rearing habitat would continue to degrade and would not be replaced.	Continued existence and maintenance of 2.49 miles of revetments would continue to prevent floodplain connectivity, reducing large wood recruitment from streambanks, resulting in less structure available to create complex channel habitat, gravel bars and large pools. Habitat restoration studies would not guarantee new LWD would be placed in the Molalla River.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Very small effect of Proposed Action on continued degradation of pool habitat; would cause small reduction in rearing and adult holding habitat, resulting in small reduction in productivity and abundance of Molalla populations of UWR Chinook salmon and steelhead.	Continued low frequency of pools in lower Molalla River. Continued existence and maintenance of 2.49 miles of revetments would continue to prevent peak flows and block sediments and large wood, preventing channel movement that would allow for new pools to form.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-channel Habitat	Very small effect of Proposed Action on continued lack of off-channel habitat, which would cause small reduction in juvenile refugia and rearing habitat, resulting in small reduction in productivity and abundance of Molalla populations of UWR Chinook salmon and steelhead.	Continued existence and maintenance of 2.49 mi. of revetments would contribute to continued reduced off-channel habitat in the lower Molalla River. Although studies may consider habitat restoration projects that could provide access to off-channel habitat, the Action Agencies provide no certainty that such projects would be funded and carried out in the Molalla subbasin.
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/depth ratio	Very small effect of Proposed Action on continued degradation of width/depth ratio; would cause small reduction in rearing habitat, resulting in small reduction in productivity and abundance of Molalla populations of UWR Chinook salmon and steelhead.	Continued existence and maintenance of 2.49 mi. of revetments would continue to facilitate channel cutting and deepening, reducing width/depth ratio and limiting formation of complex habitats. Although studies may consider habitat restoration projects, the Action Agencies provide no certainty that these measures would occur during the term of this Opinion.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Streambank Condition	Very small effect of Proposed Action on streambank condition, by inhibiting channel forming processes that create complex habitat essential for juvenile rearing and adult holding; would result in small reduction in productivity and abundance of Molalla populations of UWR Chinook salmon and steelhead	Continued existence and maintenance of 2.49 miles of revetments would continue to prevent streambanks from supporting natural floodplain function in the lower Molalla River. Although studies may consider habitat restoration projects to improve streambank conditions, the Action Agencies provide no certainty that these changes would be funded or carried out in the Molalla River during the term of this Opinion.
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain Connectivity	Very small effect of Proposed Action on continued lack of floodplain connectivity reduces availability of off-channel habitat, which would cause small reduction in available refugia and juvenile rearing habitat, resulting in small reduction in productivity and abundance of Molalla populations of UWR Chinook salmon and steelhead.	Continued existence and maintenance of 2.49 mi. of revetments would continue to prevent overbank flow and side channel connectivity in the lower Molalla River. Although studies may consider habitat restoration projects that could provide access to off-channel habitat, the Action Agencies provide no certainty that such projects would be funded and carried out in the Molalla subbasin.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	Very small effect of Proposed Action on continued degradation of riparian forests, which would cause small reduction in large wood recruitment, furthering limiting juvenile rearing and adult holding habitat, resulting in small reduction in productivity and abundance of Molalla populations of UWR Chinook salmon and steelhead.	Continued existence and maintenance of 2.49 mi. of revetments would continue to constrain the channel and prevent overbank flow, limiting extent and quality of riparian forests in the lower Molalla River. Although studies may consider habitat restoration projects that could potentially restore riparian vegetation, the Action Agencies provide no certainty that such projects would be funded and carried out in the Molalla subbasin.

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Chapter 5.8
Clackamas Subbasin Effects

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5.8 CLACKAMAS SUBBASIN

SUMMARY OF THE EFFECTS WITHIN THE CLACKAMAS SUBBASIN OF THE PROPOSED ACTION ON LISTED SALMON & STEELHEAD POPULATIONS

- The Proposed Action would continue the existence and maintenance of about 1.6 miles of revetments along the lower Clackamas River. When repairs to these revetments occur, direct effects on the subbasin's populations of UWR Chinook, LCR Chinook, LCR Coho, and LCR steelhead would be minor, and there would be small, indirect adverse effects on the habitat of these fish. These adverse effects would be relatively small compared to baseline conditions, but would contribute to continuing losses of habitat function along the mainstem Clackamas River, and to the diminished abundance and productivity of the four populations identified.

Introduction

Within the Clackamas subbasin the Proposed Action includes the following action:

- Revetments – Continued existence and maintenance of 1.6 miles of revetments along the lower Clackamas River.

In this section, NMFS considers the effects of the Proposed Action within the Clackamas subbasin on UWR Chinook salmon, LCR Chinook salmon, LCR coho salmon, and LCR steelhead, and critical habitat. In general, NMFS expects that the Proposed Action would cause minor degradation of habitat due to continued existence and maintenance of revetments, resulting in small reductions in abundance and productivity of the populations of these fish found in the Clackamas subbasin.

5.8.1 Habitat Access & Fish Passage

The Willamette Project does not affect habitat access or fish passage within the Clackamas subbasin.

5.8.2 Water Quantity/Hydrograph

The Willamette Project has no effect on streamflows within the Clackamas subbasin.

5.8.3 Water Quality

The Proposed Action would have a very small effect on water quality conditions as a result of continued existence and maintenance of 1.6 miles of revetments along the lower Clackamas River. By reducing riparian vegetation and stream processes that enable formation of complex habitats and deep pools, the revetments would result in small increases in summer water temperatures in the lower Clackamas River.

The Proposed Action would also have minor, short-term effects on the turbidity of the lower Clackamas River should repairs be needed at the USACE revetments. Such repairs would be subject to additional environmental review and appropriate mitigation measures, and thus unlikely to cause reductions in water quality sufficient to harm listed anadromous salmonids.

5.8.4 Physical Habitat Quality

Proposed actions related to physical habitat quality in the Clackamas subbasin that would affect UWR Chinook salmon, LCR Chinook salmon, LCR coho salmon, and UWR steelhead are listed below.

- Continued existence and maintenance of 1.6 miles of revetments along the lower Clackamas River, preventing channel migration and reducing channel complexity.
- Study effects of Project revetments on downstream habitat and consider projects to restore habitat, if authorized and funding becomes available.

5.8.4.1 Substrate, Sediment Transport, Large Wood, & Channel Complexity

Under the environmental baseline, substrate, sediment transport, large wood, and channel complexity are degraded and do not support adequate rearing and holding habitat for ESA-listed anadromous salmonids (Section 4.8.6). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.8-1 (end of this section, 5.8) and described below.

Under the Proposed Action, the Action Agencies would continue the existence and maintenance of about 1.6 miles of revetments on the lower Clackamas River. Although this length comprises only a small portion of the total revetments and length of this stream, this action would continue to restrict channel migration and prevent recruitment of large wood and sediment from streambanks, inhibiting natural processes that create and maintain channel complexity. As described in the baseline section 4.8.3.4, the lower Clackamas River is more heavily impacted by land use practices, including channelization and revetments, that have caused coarsening and siltation of substrate, low levels of large wood, and reduced channel complexity. The Proposed Action would cause minor reductions in juvenile rearing and adult holding habitat, further limiting abundance and productivity of the Clackamas populations of UWR Chinook salmon, LCR Chinook salmon, LCR coho salmon, and LCR steelhead.

The Action Agencies propose to conduct a general study of USACE revetments in the Willamette basin, including consideration of habitat restoration projects, but the Action Agencies do not propose specific measures that would restore large wood, sediment transport, and channel complexity in the Clackamas subbasin.

In summary, although the revetments maintained by the Action Agencies in the Clackamas subbasin are a small percentage of total river length, they would contribute to a continued loss of habitat function and would likely cause a minor reduction in the carrying capacity of this habitat for rearing juvenile fish and holding adults, thus reducing the number of individual ESA-listed salmonids that can be produced in this presently degraded habitat. Aside from unspecified habitat restoration actions that may result from proposed habitat and revetment studies, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the Clackamas subbasin.

5.8.4.2 Riparian Vegetation & Floodplain Connectivity

Under the environmental baseline, riparian vegetation and floodplain connectivity are degraded and limit rearing and holding habitat for UWR Chinook salmon, LCR Chinook salmon, LCR coho salmon, and LCR steelhead (section 4.8.3.4). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.8-1 and described below.

Under the Proposed Action, the Action Agencies would continue the existence and maintenance of about 1.6 miles of revetments in the lower Clackamas River. Although this length of revetments comprises a small percentage of the total revetments and length of this stream, this action would continue to prevent overbank flows, river migration, and contribution of sediment and large wood from streambanks. Infrequent inundation of forested floodplains reduces nutrient and organic matter exchange during flood events and reduces the availability of high-water refugia for juveniles, which could limit over-wintering survival of rearing juveniles. Additionally, the Proposed Action would continue to prevent establishment of riparian vegetation in the lower Clackamas subbasin by interfering with the processes needed for new floodplain forests to establish. The reduced extent of riparian vegetation and lack of floodplain connectivity hinders recruitment of large wood into the aquatic system and reduces off-channel refugia, both habitat features needed to create resting pools for migrating adults and provide cover for rearing juveniles. The Proposed Action, although limited in extent in the Clackamas subbasin, would continue to degrade this already impaired habitat, further reducing juvenile rearing and adult holding habitat, with minor effects on abundance and productivity of the Clackamas populations of UWR Chinook salmon, LCR Chinook salmon, LCR coho salmon, and LCR steelhead. Although the Proposed Action includes study of revetments in the Willamette basin and potential habitat restoration, there is no certainty that any restoration work would be done in the Clackamas subbasin during the term of this Opinion.

In summary, the continued existence and maintenance of revetments in the Clackamas River under the Proposed Action would have a negative effect by continuing to degrade riparian and floodplain forests and floodplain connectivity. Aside from unspecified habitat restoration actions that may result from revetment and habitat restoration studies described in the Supplemental BA, Section 3.5.2, Offsite Habitat Restoration Actions (USACE 2007a), the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain connectivity in the Clackamas subbasin. Continued degradation of juvenile rearing and adult holding habitat under the Proposed Action would cause a very small reduction in the abundance and productivity of Clackamas subbasin populations of UWR Chinook salmon, LCR Chinook salmon, LCR coho salmon, and LCR steelhead.

5.8.5 Hatcheries

The Proposed Action includes no hatchery programs in the Clackamas subbasin, but adult salmon and steelhead of hatchery origin from USACE programs upstream of Willamette Falls may stray into the natural spawning areas of the UWR Chinook salmon and LCR steelhead populations in the subbasin. To the degree that this occurs and that the stray spawners are successful at spawning in the wild, such straying would likely have a small, adverse effect on the abundance and productivity of the affected ESA-listed populations.

5.8.6 Summary of Effects on ESA-Listed Anadromous Fish Populations in the Clackamas River Subbasin

The Proposed Action would have limited effects on ESA-listed salmonids within the Clackamas subbasin, as summarized in Table 5.8-1. Continued existence and maintenance of about 1.6 miles of revetments would result in minor adverse effects on UWR Chinook, LCR Chinook, LCR Coho, and LCR steelhead. These effects include continued degradation of juvenile rearing and adult holding habitat, resulting in very small reductions in the abundance and productivity of Clackamas subbasin populations.

5.8.7 Effects of the Proposed Action on Designated Critical Habitat

The mainstem Clackamas River and many of its tributaries have been designated as Critical Habitat for UWR Chinook salmon, LCR Chinook salmon, LCR coho salmon, and LCR steelhead. Table 5.8-1 identifies the anticipated effects of the Proposed Action on the PCEs of this habitat. All of the effects are attributable to the continued existence and maintenance of 1.6 miles of revetments along the mainstem Clackamas by the USACE.

The USACE revetments limit natural channel migration and the formation of complex and diverse salmonid habitats, including off-channel areas that are particularly important to juvenile fish during periods of high winter flows. They also impede the establishment and growth of riparian vegetation that might otherwise provide shade (to prevent adverse temperature increases) and contribute LWD. Across all of the areas affected within the Clackamas subbasin and elsewhere, continued existence and maintenance of these structures will continue to assure diminished habitat suitability for multiple lifestages of UWR Chinook, LCR Chinook, LCR coho salmon, and LCR steelhead, and to limit the habitat's capacity to support large and productive populations of these fish.

Table 5.8-1 Effects of the Proposed Action on ESA-listed anadromous salmonid populations (VSP column) and critical habitat (PCE column) in the Clackamas River subbasin.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater migration corridors	Habitat access	Physical barriers	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in peak/base flow	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Minor adverse effect of elevated water temperatures could effect a very small decrease survival and/or growth of juvenile UWR Chinook salmon, LCR Chinook salmon, LCR coho, or LCR steelhead and increase pre-spawning mortality of adult Chinook.	Minor adverse effect of revetments, by reducing riparian vegetation and stream processes that enable formation of complex habitats and deep pools, which contributes to elevated summer water temperatures in the lower Clackamas River.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination /Nutrients	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	No effect	No effect

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Total Dissolved Gas (TDG)	No effect	No effect
Freshwater spawning sites	Habitat elements	Substrate	Very small adverse effect of Proposed Action on substrate in the Clackamas that prevents formation of new gravels for spawning. Very small reduction in abundance and productivity of Clackamas populations of UWR Chinook salmon, LCR Chinook, LCR coho, and LCR steelhead due to small length of revetment in the Clackamas.	Continued existence and maintenance of 1.6 miles of revetments would prevent channel migration, limiting production of new gravel bars and substrate.
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Large Woody Debris	Very small effect of Proposed Action on continued lack of large wood; would cause very small reduction in abundance and productivity of ESA-listed salmonid populations in the Clackamas subbasin because adult holding and juvenile rearing habitat would continue to degrade and would not be replaced.	Continued existence and maintenance of 1.6 miles of revetments would continue to prevent floodplain connectivity, reducing large wood recruitment from streambanks, resulting in less structure available to create complex channel habitat, gravel bars and large pools. Habitat restoration studies would not guarantee new LWD would be placed in the Clackamas River.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Very small effect of Proposed Action on continued degradation of pool habitat; would cause small reduction in rearing and adult holding habitat, resulting in very small reduction in productivity and abundance of ESA-listed salmonid populations.	Continued diminished frequency of pools in lower 1.6 miles of revetments would continue to prevent channel movement that would allow for new pools to form.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-channel Habitat	Very small effect of Proposed Action on continued lack of off-channel habitat, which would cause small reduction in juvenile refugia and rearing habitat, resulting in very small reduction in productivity and abundance of Clackamas populations of ESA-listed salmon and steelhead.	Continued existence and maintenance of 1.6 mi. of revetments would contribute to continued reduced off-channel habitat along the lower Clackamas River. Although studies may consider habitat restoration projects that could provide access to off-channel habitat, the Action Agencies provide no certainty that such projects would be funded and carried out in the Clackamas subbasin.
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/depth ratio	Very small effect of Proposed Action on continued degradation of width/depth ratio; would cause small reduction in rearing habitat, resulting in very small reduction in productivity and abundance of Clackamas populations of ESA-listed salmon and steelhead.	Continued existence and maintenance of 1.6 mi. of revetments would continue to facilitate channel cutting and deepening, reducing width/depth ratio and limiting formation of complex habitats. Although studies may consider habitat restoration projects, the Action Agencies provide no certainty that these measures would occur during the term of this Opinion.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Streambank Condition	Very small effect of Proposed Action on streambank condition, by inhibiting channel forming processes that create complex habitat essential for juvenile rearing and adult holding; would result in very small reduction in productivity and abundance of Clackamas populations of ESA-listed salmon and steelhead	Continued existence and maintenance of 1.6 miles of revetments would continue to prevent streambanks from supporting natural floodplain function in the lower Clackamas River. Although studies may consider habitat restoration projects to improve streambank conditions, the Action Agencies provide no certainty that these changes would be funded or carried out in the Clackamas River during the term of this Opinion.
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain Connectivity	Very small effect of Proposed Action on continued lack of floodplain connectivity reduces availability of off-channel habitat, which would cause small reduction in available refugia and juvenile rearing habitat, resulting in very small reduction in productivity and abundance of Clackamas populations of ESA-listed salmon and steelhead.	Continued existence and maintenance of 1.6 mi. of revetments would continue to prevent overbank flow and side channel connectivity in the lower Clackamas River. Although studies may consider habitat restoration projects that could provide access to off-channel habitat, the Action Agencies provide no certainty that such projects would be funded and carried out in the Clackamas subbasin.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	Very small effect of Proposed Action on continued degradation of riparian forests, which would cause small reduction in large wood recruitment, further limiting juvenile rearing and adult holding habitat, resulting in very small reduction in productivity and abundance of Clackamas populations of ESA-listed salmon and steelhead.	Continued existence and maintenance of 1.6 mi. of revetments would continue to constrain the channel and prevent overbank flow, limiting extent and quality of riparian forests in the lower Clackamas River. Although studies may consider habitat restoration projects that could potentially restore riparian vegetation, the Action Agencies provide no certainty that such projects would be funded and carried out in the Clackamas subbasin.

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Chapter 5.9
Coast Fork Willamette & Long Tom Subbasins Effects

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5.9 COAST FORK WILLAMETTE & LONG TOM SUBBASINS

SUMMARY OF THE EFFECTS OF THE PROPOSED ACTION

- Coast Fork Willamette Subbasin: The Proposed Action would result in continued degradation of juvenile rearing and refugia habitat in lower reaches of the Coast Fork Willamette River, causing relatively minor decline in abundance and productivity of Middle Fork Willamette and McKenzie populations of UWR Chinook salmon.

- Long Tom Subbasin: The Proposed Action would result in continued degradation of juvenile rearing and refugia habitat in lower reaches of the Long Tom River, causing relatively minor decline in abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations of UWR Chinook.

Introduction/Populations Affected

Coast Fork Willamette Subbasin
Although UWR Chinook salmon were likely once produced naturally in the Coast Fork Willamette, the WLCTRT did not identify these fish as a historical demographically independent population (Myers et al. 2006). However, in multiple years since 1998, ODFW has released adult Chinook salmon from the Willamette Hatchery into Mosby Creek, a tributary of the Row River in the Coast Fork Willamette subbasin. The effectiveness of this release has not been determined, though initial monitoring indicates high pre-spawning mortality (Moberly 2008).

Steelhead were not historically produced in the Coast Fork Willamette, and the WLCTRT did not identify a demographically independent population of UWR steelhead in this subbasin.

Long Tom River Subbasin
The WLCTRT did not identify demographically independent populations of UWR Chinook salmon or UWR steelhead in this subbasin. However, based on catches of juvenile Chinook in screw traps in the lower Long Tom River (Schroeder and Kenaston 2004), some juvenile UWR Chinook salmon from the Middle Fork Willamette (including Fall Creek) and McKenzie subbasins probably overwinter in the lower Long Tom River (section 4.9.2.1). Juvenile Chinook salmon have been caught in screw traps in the lower reach of the Long Tom during winter (Schroeder and Kenaston 2004).

UWR Chinook salmon and UWR steelhead are likely to be affected by the following elements of the Proposed Action:

Coast Fork Willamette

- Current configuration, continued operation, and maintenance of Dorena and Cottage Grove dams in the Row River and upper Coast Fork Willamette River, respectively.
- Revetments – continued maintenance of 4.26 mi. of revetments along the Coast Fork Willamette River and 0.43 mi. in the Row River.

Long Tom subbasin

- Current configuration, continued operation, and maintenance of Fern Ridge Dam and other several other small dams in the Long Tom River.

In this section, NMFS considers the effects of the Proposed Action on UWR Chinook salmon and UWR steelhead that occupy the Coast Fork Willamette and Long Tom for portions of their life cycles. NMFS expects that the Proposed Action would cause continued degradation of habitat downstream of the dams. However, because there are no independent populations of either Chinook salmon or steelhead in these subbasins, the effects on listed populations would be limited to reducing juvenile rearing/overwintering habitat for McKenzie, Calapooia, and Middle Fork Willamette populations of UWR Chinook. Because no critical habitat was designated for listed salmonid populations in the Long Tom and Coast Fork Willamette subbasins, the Proposed Action would not affect PCEs in these subbasins.

5.9.1 Habitat Access & Fish Passage

Coast Fork Willamette River Subbasin

Cottage Grove and Dorena dams prevent access to 80 miles of historic habitat (USACE 2000, 5-72). However, because Chinook salmon and steelhead were virtually extirpated from this basin prior to Project construction, neither dam was constructed with fish passage facilities. Under the Proposed Action, the Action Agencies would include an assessment of fish passage feasibility at these dams in the Willamette System Review Study (USACE 2007a, p. 3-138). Given the existing problems with mercury contamination (see section 4.9.3.3.6) in the reservoirs and habitat further upstream and NMFS' determination that the Coast Fork does not support a demographically independent population of Chinook salmon or steelhead, fish passage and access to historic habitat in this subbasin is a low priority for actions to increase the viability of UWR Chinook salmon.

In summary, the effect of the Proposed Action on habitat access in the Coast Fork for UWR Chinook salmon is negligible. In the future, if NMFS were to determine that the Coast Fork should be used to reestablish a population of UWR Chinook salmon, then Project effects on habitat access in the Coast Fork would be reassessed.

Long Tom River

Although there are no passage facilities at Fern Ridge Dam on the Long Tom River, the project does not block access to historic habitat for UWR Chinook salmon (individual Chinook salmon are known to use only the lower reaches of the Long Tom River for juvenile rearing/overwintering). UWR Chinook and UWR steelhead have never made much use of this river due to high summer water temperatures (USACE 2000, p. 5-78; USACE 2007a, p. 5-36). Thus, the Proposed Action on the Long Tom River would have little effect on UWR Chinook or UWR steelhead.

Summary
The Proposed Action would not adversely affect fish passage in the Coast Fork Willamette and Long Tom subbasins

5.9.2 Water Quantity/Hydrology

Coast Fork Willamette River Subbasin
Under the Proposed Action, the Dorena and Cottage Grove projects would continue to be used for flood control and to meet mainstem Willamette flow objectives at Albany and Salem. These operations would reduce the magnitude and frequency of peak flows in the Row and Coast Fork Willamette rivers, simplifying the channel and restricting connectivity to the floodplain, which in turn would reduce refugia and complex habitat for juvenile UWR Chinook salmon that use lower reaches of the Coast Fork Willamette River near its mouth. However, because this habitat is used for a short duration by individuals of the Middle Fork Willamette and McKenzie populations, NMFS expects the effect of this habitat degradation and loss to be relatively small compared to adverse effects of similar elements of the Proposed Action in eastside subbasins.

Long Tom River Subbasin
Under the Proposed Action, Fern Ridge Dam would continue to be used for flood control and to meet mainstem flow objectives. These operations would reduce the magnitude and frequency of peak flows in the Long Tom River, simplifying the channel and restricting connectivity to the floodplain, which in turn, would reduce refugia and complex habitat for juvenile UWR Chinook salmon rearing in lower reaches of the Long Tom River. However, because this habitat tends to be used seasonally by individual fish (most likely from Middle Fork Willamette, Calapooia, and McKenzie UWR Chinook salmon populations), NMFS expects the effect of this habitat degradation and loss to be relatively small compared to effects of similar elements of the Proposed Action in eastside subbasins.

5.9.3 Water Quality

Water Temperature

Coast Fork Willamette River Subbasin
Under the Proposed Action, no changes would be made to the structure or operation of Dorena or Cottage Grove dams to restore normative water temperatures downstream (described in Baseline section 4.9.3.3.1). Thus, the effect of the proposed action would be to maintain the current degraded water temperature condition, limiting the value of the lower reaches of the Coast Fork Willamette and Row rivers as potential spawning habitat for UWR Chinook salmon.

Long Tom River Subbasin
Under the Proposed Action, no changes would be made to the structure or operation of Fern Ridge Dam to restore normative water temperatures downstream (described in Baseline section 4.9.3.3.1). Thus, the effect of the proposed action would be to maintain the current degraded water temperature condition.

Some juvenile UWR Chinook overwinter in the lower Long Tom before emigrating from the system the following spring. The ODEQ (2002) CWA 303(d) database indicates that temperatures are within recommended limits for salmonid rearing during the winter period.

5.9.4 Physical Habitat Quality

5.9.4.1 Large Wood, Sediment Transport, & Channel Complexity

Coast Fork Willamette Subbasin

As described in section 4.9.3.4, operation of Cottage Grove and Dorena dams has trapped gravel and large wood from 50% of the subbasin and has reduced the magnitude of peak flows in the Coast Fork Willamette subbasin. Both of these operations deprive downstream reaches of bed material and transport mechanisms needed to create new gravel bars, islands, side channels, and pools, which provide habitat for rearing and migrating anadromous salmonids. Additionally, the continued maintenance of USACE revetments would prevent river migration and sediment contribution from 4.26 miles of streambank in the lower Coast Fork Willamette, further depriving the river of sediment and the natural ability to restore complex channels with diverse habitat features. Andrus and Walsh (2002) reported a 69% decrease in gravel bars in the lower 4 miles of the Coast Fork Willamette River.

Under the Proposed Action, operation of Dorena and Cottage Grove dams and maintenance of 4.26 miles of revetments would continue to store sediment and large wood in the reservoirs, prevent recruitment of large wood and sediment from streambanks, allow stabilization of formerly active bar surfaces, and prevent flows capable of creating new bars, side channels, and pools. This would result in reduced amount and quality of habitat for juvenile UWR Chinook salmon that rear in lower reaches of the Coast Fork Willamette River near its mouth. However, because this habitat appears to be used only seasonally during winter (most likely by individuals from Middle Fork Willamette and McKenzie UWR Chinook salmon populations), NMFS would expect the effects of this habitat degradation and loss to be relatively small compared to effects of similar elements of the Proposed Action in eastside subbasins. Aside from unspecified habitat restoration actions that are expected to result from the Willamette Floodplain Restoration Study, the Action Agencies do not propose measures that would restore large wood, sediment, and channel complexity in the Coast Fork subbasin.

Long Tom Subbasin

As described in sections 4.9.3.4, operation of Fern Ridge Dam in the Long Tom has trapped gravel and large wood from 60% of the subbasin and has reduced the magnitude of peak flows in the subbasin. Both of these operations deprive downstream reaches of bed material and transport mechanisms needed to create new gravel bars, islands, side channels, and pools, which provide habitat for rearing salmonids.

Under the Proposed Action, operation of Fern Ridge Dam would continue to store sediment and large wood in the reservoir, prevent recruitment of large wood and sediment from streambanks, allow stabilization of formerly active bar surfaces, and diminish high flows that might otherwise be capable of creating new bars, side channels, and pools. This would result in reduced amount and quality habitat for juvenile UWR Chinook salmon that rear in lower reaches of the Long Tom River. However, because this habitat is used seasonally (most likely by individuals from Middle Fork Willamette, Calapooia and McKenzie UWR Chinook salmon populations), NMFS would expect the effects of this habitat degradation and loss to be relatively small compared to effects of similar elements of the Proposed Action in eastside subbasins. Aside from unspecified habitat restoration actions that are expected to result from the Willamette Floodplain Restoration

Study, the Action Agencies do not propose any measures that would restore large wood, sediment, and channel complexity in the Long Tom subbasin.

5.9.4.2 Riparian Vegetation & Floodplain Function

Coast Fork Willamette Subbasin

As described in the previous subsection (5.9.4.1), operation of Cottage Grove and Dorena dams has trapped gravel and large wood and reduced peak flows in the Coast Fork and Row rivers. Together with maintenance of 4.26 miles of revetments in the lower Coast Fork Willamette River, these actions restrict new gravel bar formation and floodplain surfaces, on which riparian vegetation can become established, and reduce inundation of forested floodplains, limiting the availability of high-water refugia for juveniles.

Under the Proposed Action, operation of Cottage Grove and Dorena dams and maintenance of revetments would continue to store sediment and large wood in the reservoirs, prevent recruitment of large wood and sediment from streambanks, allow stabilization of formerly active bar surfaces, and prevent flows capable of inundating floodplains and creating new bars and islands on which vegetation can establish. This would result in reduced amount and quality of habitat for juvenile UWR Chinook salmon that rear in lower reaches of the Coast Fork Willamette. However, because this habitat is used only seasonally (most likely by individual fish from Middle Fork Willamette and McKenzie UWR Chinook salmon populations), NMFS would expect the effects of this habitat degradation and loss to be relatively small compared to effects of similar elements of the Proposed Action in eastside subbasins. Aside from unspecified habitat restoration actions that are expected to result from the Willamette Floodplain Restoration Study, the Action Agencies do not propose any measures that would riparian vegetation and floodplain function in the Coast Fork Willamette subbasin.

Long Tom Subbasin

Operation of Fern Ridge Dam has trapped gravel and large wood and reduced peak flows in the Long Tom River subbasins. This has limited formation of new gravel bars and floodplain surfaces on which riparian vegetation can become established and reduced inundation of forested floodplains, limiting the availability of high-water refugia for juveniles.

Under the Proposed Action, operation of Fern Ridge Dam would continue to store sediment and large wood in the reservoirs, prevent recruitment of large wood and sediment from streambanks, allow stabilization of formerly active bar surfaces, and prevent flows capable of inundating floodplains and creating new bars and islands on which vegetation can establish. This would result in reduced amount and quality of habitat for juvenile UWR Chinook salmon that rear in lower reaches of the Long Tom River. However, because this habitat is used only seasonally (most likely by individual fish from Middle Fork Willamette, Calapooia and McKenzie UWR Chinook salmon populations), NMFS would expect the effects of this habitat degradation and loss to be relatively small compared to effects of similar elements of the Proposed Action in eastside subbasins. Aside from unspecified habitat restoration actions that are expected to result from the Willamette Floodplain Restoration Study, the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain function in the Long Tom subbasin.

5.9.5 Hatcheries

There are no hatchery facilities or hatchery fish releases in the Coast Fork Willamette and Long Tom subbasins, with the exception of a few adult Chinook salmon outplants in Mosby Creek in the Coast Fork Willamette subbasin). All hatchery fish releases occur in the Middle Fork, McKenzie, South Santiam, North Santiam, and Molalla rivers. All hatchery Chinook salmon and summer steelhead are released as smolts. The intent is for these hatchery fish to actively emigrate to the ocean, thus minimizing the period of time hatchery fish are potentially interacting with naturally rearing listed fish downstream of the hatcheries. It is very unlikely any of the hatchery Chinook or summer steelhead would migrate into the Coast Fork Willamette and Long Tom subbasins and interact with any listed fish that may be present.

5.9.6 Summary of Effects on ESA-Listed Anadromous Fish in the Coast Fork Willamette & Long Tom Subbasins

Table 5.9-1 summarizes anticipated effects of the Proposed Action on ESA-listed anadromous salmonids within the Coast Fork and Long Tom subbasins. The Proposed Action would have small adverse effects within the lower Coast Fork and Long Tom subbasins on fish from the Middle Fork Willamette, McKenzie, and Calapooia populations of UWR Chinook. These effects would result from continued reductions in the amount and quality of habitat for rearing/overwintering of UWR Chinook below dams in the lower reaches of each system. The result would be a continuation of minor, unquantifiable reductions in abundance, productivity, diversity, and spatial structure for the identified populations.

5.9.7 Effects of the Proposed Action on Designated Critical Habitat

NMFS did not designate critical habitat in the Coast Fork Willamette or Long Tom subbasins.

Table 5.9-1 Effects of the Proposed Action on abundance, productivity, spatial structure, and/or diversity of UWR Chinook in the Coast Fork Willamette and Long Tom subbasins.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters
Freshwater migration corridors	Habitat Access	Physical Barriers	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in Peak/Base flow	*Coast Fork and Long Tom*: Project dams would continue to alter hydrology and reduce peak flows, limiting off-channel refugia for UWR Chinook that may rear near mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	*Coast Fork and Long Tom*: Project dams would continue to affect temperatures in the lower Coast Fork and Row rivers, contributing to an unfavorable spawning environment for UWR Chinook. Juvenile UWR Chinook from populations that spawn in nearby subbasins may rear near mouths of these tributaries, but Project effects on stream temperatures there would have limited effect on the abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total suspended Solids/ Turbidity	No effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination/ Nutrients	*Coast Fork:* Project dams would continue to block mercury transport from upstream mine tailings and sediment deposits. Mercury levels in UWR Chinook salmon rearing in lower river may be above normal but would have minor effect on the abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations. *Long Tom:* No effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	No effect.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	No effect
Freshwater spawning sites	Habitat elements	Substrate	*Coast Fork and Long Tom*: Project dams would continue to block sediment transport, reducing quality and quantity of rearing habitat for UWR Chinook juveniles that may rear near mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris (LWD)	*Coast Fork and Long Tom*: Project dams would continue to block large wood, reducing quality and quantity of complex rearing habitat for UWR Chinook juveniles that may rear near mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	*Coast Fork and Long Tom*: Project dams would continue to block large wood and sediment, reducing pool frequency and quality used as rearing habitat by UWR Chinook juveniles near the mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat elements	Off-channel habitat	*Coast Fork and Long Tom*: Proposed Action would continue to block large wood and sediment, reducing off-channel habitat used as refugia by UWR Chinook juveniles near the mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/depth Ratio	*Coast Fork and Long Tom*: Proposed Action would continue to restrict channel forming processes, reducing width/depth ratio, and limiting complex habitat used by UWR Chinook juveniles rearing near the mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Streambank Condition	*Coast Fork and Long Tom*: Proposed Action would continue to restrict channel forming processes, increasing streambank armoring and resulting in habitat simplification, thus limiting complex habitat used by UWR Chinook juveniles rearing near the mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain Connectivity	*Coast Fork and Long Tom*: Proposed Action would continue to restrict floodplain connectivity, limiting refugia and complex habitat used by UWR Chinook juveniles rearing near the mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	*Coast Fork and Long Tom*: Proposed Action would continue to reduce riparian reserves, limiting habitat used by UWR Chinook juveniles rearing near the mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.

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Chapter 5.10
Mainstem Willamette Effects

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5.10 MAINSTEM WILLAMETTE RIVER: EFFECTS OF THE WILLAMETTE PROJECT PROPOSED ACTION ON UWR CHINOOK SALMON, UWR STEELHEAD, LCR CHINOOK SALMON, LCR STEELHEAD, LCR COHO SALMON & INTERIOR SPECIES USING THE MAINSTEM WILLAMETTE RIVER

SUMMARY OF THE EFFECTS OF THE PROPOSED ACTION

- The effects of the Proposed Action in the mainstem Willamette River on populations of UWR Chinook salmon and UWR steelhead above the Falls will be that baseline conditions will generally continue, causing further decline in these populations. The Proposed Action will continue to:
  - Reduce the frequency and magnitude of peak flows, reducing floodplain connectivity, riparian forests, and habitat complexity in the mainstem Willamette River above the Falls, and to a lesser extent near the mouth.
  - Eliminate sediment and large wood transport from 27% of the watershed and restrict channel movement with revetments, degrading substrate, large wood, and channel complexity in the mainstem Willamette above the Falls, and to a lesser extent near the mouth.
  - Improve water quality in the mainstem Willamette above and below the Falls, by maintaining flows at Salem, Oregon to meet NPDES standards and by maintaining spring flows at Willamette Falls of around 15,000 cfs (see Table 5.10-2) to provide safe passage for steelhead smolts.
- For populations of UWR chinook and steelhead below the Falls, as well as LCR chinook, coho salmon, and steelhead and Interior species that may use the lower Willamette River near the mouth for rearing and holding, the Proposed Action may harm individual fish by continuing to degrade rearing and holding habitat, but not to the extent that NMFS expects effects at the population level for any of these populations.

In this section, the mainstem Willamette River is considered in two geographical reaches: above Willamette Falls (Falls) at RM 26.6 upstream to the confluence of the Coast Fork and Middle Fork Willamette rivers, and below the Falls downstream to the mouth at the confluence with the Columbia River. Although there are no separate populations of listed salmonids designated for the mainstem Willamette River, all of the salmonid populations and ESUs considered in this Opinion use these reaches to varying extents for parts of their life cycles and are potentially affected by the Proposed Action in these reaches. Table 5.10-1 identifies which reaches of the mainstem Willamette are used by each population.

Table 5.10-1 Listed salmonid populations that use reaches of the mainstem Willamette River.

ESU/DPS	Population	Mainstem Willamette River above Willamette Falls	Mainstem Willamette River below Willamette Falls or near mouth
UWR Chinook salmon	Middle Fork Willamette	X	X
UWR Chinook salmon	McKenzie	X	X
UWR Chinook salmon	Calapooia	X	X
UWR Chinook salmon	North Santiam	X	X
UWR Chinook salmon	South Santiam	X	X
UWR Chinook salmon	Molalla		X (primarily)
UWR Chinook salmon	Clackamas		X
UWR steelhead	Calapooia	X	X
UWR steelhead	North Santiam	X	X
UWR steelhead	South Santiam	X	X
UWR steelhead	Molalla		X
UWR steelhead	Westside tribs		X
UWR steelhead	Clackamas		X
LCR Chinook salmon	Clackamas		X
LCR coho salmon	Clackamas		X
LCR steelhead	Clackamas		X
Other LCR populations[1]			X
Interior ESUs/DPSs[2]			X

Notes:

1 Only LCR populations that spawn in tributaries of the Columbia River upstream of Willamette River (LCR Chinook salmon, LCR coho, LCR steelhead, and Columbia River Chum)

2 "Interior ESUs/DPSs" as used in this Opinion means UCR Chinook salmon, UCR steelhead, MCR steelhead, SR spring/summer chinook salmon, SR fall chinook salmon, SR sockeye salmon, SR steelhead, and CR chum salmon.

The Proposed Action includes the following actions that would be likely to affect listed fish populations using the mainstem Willamette River for juvenile rearing, adult holding, and migration:

- Project dams: continued operation and maintenance under existing configuration of 13 Project dams in major tributaries of the Willamette River.
    - Flow Management - targets for mainstem Willamette River and tributary minimum flows and releases from Project dams to attempt to meet these targets.
    - Ramping Rates - targets that control how quickly water releases from Project dams are increased or decreased.
    - Flow-related RM&E measures.

- Revetments: continued existence and maintenance of 22.68 miles of revetments along the mainstem Willamette River.
- Hatchery program: continued production of hatchery Chinook and summer steelhead that contribute to recreational fisheries in the mainstem.
- Water contract program: continued issuance of contracts by Reclamation for withdrawal of stored water from major tributaries and mainstem for irrigation use.

In this section, NMFS considers the effects of the Proposed Action on populations of UWR Chinook salmon, UWR steelhead, LCR Chinook salmon, LCR coho salmon, LCR steelhead, and the Interior species that use the mainstem Willamette River. In general, the Proposed Action would cause continued degradation of habitat in the mainstem Willamette above Willamette Falls, and to a lesser extent below the Falls near the mouth. This habitat degradation would continue at about the same rate as in recent baseline years and would likely reduce habitat available for juvenile rearing and adult holding primarily for the UWR Chinook and UWR steelhead populations above the Falls, reducing abundance and productivity of these populations. The Proposed Action would continue to harm fish in the mainstem Willamette River above the Falls such that UWR Chinook salmon populations from the Middle Fork Willamette, Calapooia, McKenzie, North and South Santiam, and Molalla rivers and UWR steelhead populations from the North and South Santiam and Calapooia rivers would continue to decline and critical habitat will continue to be adversely affected as a result of the Proposed Action. Anadromous fish in the other ESUs and DPSs below the Falls may also be harmed as a result of the Proposed Action, but to a lesser extent, likely not enough to reduce abundance and productivity of these other populations. (See Table 5.10-3)

5.10.1 Habitat Access & Fish Passage

The Proposed Action would not affect fish passage at barriers on the mainstem Willamette because there are no federal dams on the mainstem. The effects of reservoir water storage and Project flow releases on fish migration are discussed in section 5.10.2.

5.10.2 Water Quantity/Hydrograph

Under the Proposed Action, flow and hydrology would continue not providing properly functioning habitat for UWR Chinook salmon and UWR steelhead (Section 4.10.3.2) in the mainstem Willamette River.

The Action Agencies propose to continue flow management as conducted since 2000. This includes attempting to meet specified seasonal minimum flows at Salem. Thus, the hydrologic effects of the Proposed Action would be the same as those described under the environmental baseline for the mainstem Willamette River (Section 4.10.3.2). These effects are described in the following sections. NMFS does not anticipate that the flow management activities within the Proposed Action would harm the other ESUs (LCR and Interior species) or adversely modify critical habitat designated for those species, except to the extent that reduced peak flows limit physical habitat values described in section 5.10.4 below.

5.10.2.1 Seasonal Flows

Under the Proposed Action, the Willamette Project would continue to reduce spring flows as the storage reservoirs are refilled. The significance of this flow reduction varies with the prevailing hydrologic conditions during individual years (e.g., wet, dry, or average). The primary effect of reducing spring flows in the mainstem Willamette River would be a decrease in the survival of outmigrating juvenile UWR steelhead. Steelhead juvenile survival in the Willamette River is known to be affected by water temperatures which are increased by reducing flows.

To mitigate these effects, the Action Agencies propose to manage system releases to provide a high probability of maintaining minimum flows at Salem known to benefit juvenile UWR steelhead survival (Table 5.10-2). This proposal represents a substantial improvement in the protection of UWR steelhead over conditions that occurred prior to 2000, and a continuation of favorable flow conditions in place since that time. However, the frequency of achieving these flows is reduced by Project refill operations.

Table 5.10-2 Mainstem Willamette Flow Objectives

Time Period	7-Day Moving Average 1 Minimum Flow at Salem (cfs)	Instantaneous Minimum Flow at Salem (cfs)	Minimum Flow at Albany (cfs) 2
April 1 - 30	17,800	14,300	---
May 1 - 31	15,000	12,000	---
June 1 - 15	13,000	10,500	4,500 2
June 16 - 30	8,700	7,000	4,500 2
July 1 – 31	---	6,000 1	4,500 2
August 1 – 15	---	6,000 1	5,000 2
August 16 – 31	---	6,500 1	5,000 2
September 1 – 30	---	7,000 1	5,000 2
October 1 – 31	---	7,000	5,000

[1] An average of the mean daily flows in cubic feet per second (cfs) observed over the prior 7-day period.
[2] Congressionally authorized minimum flows (House Document 531). September flows were extended into October.

5.10.2.2 Frequency of Channel-Forming & Over-Bank Flows

By continuing to reduce the frequency of channel-forming and over-bank flows in the mainstem Willamette River through flood-control operations, the Willamette Project would continue to limit channel complexity and thereby limit rearing habitat for juvenile UWR Chinook salmon and UWR steelhead. Rearing juvenile spring Chinook salmon and steelhead are known to use the mainstem Willamette River for rearing in all months. The channel simplifying effects of peak flow reduction (e.g., loss of side channels and floodplain connectivity, loss of low velocity habitats, and loss of riparian community complexity) are expected to continue and may worsen over the life of the Proposed Action as land development expands into the river's floodplain. These channel simplifying effects would be exacerbated by continued existence and maintenance of channel revetments and levees (see section 5.10.4).

The Proposed Action includes studies intended to identify opportunities to modify project operations to enhance tributary ecosystem function, including channel forming functions. To the extent that any future modification of project operations undertaken to improve tributary channel function results in improved mainstem channel complexity, benefits would likely accrue to UWR Chinook and steelhead juveniles and their critical rearing habitats.

5.10.2.3 Flow Fluctuations

Due to the size of the mainstem Willamette River and the distance from Project dams, it is unlikely that project operations currently cause substantial flow fluctuations in the mainstem Willamette River and resulting entrapment and stranding events. This would continue under the Proposed Action.

5.10.2.4 Water Use on the Mainstem Willamette River

Under baseline conditions, there are a total of 49 long-term Reclamation stored water contracts in effect to divert stored water from Project dams at sites along the mainstem Willamette River. Cumulatively, these 49 contracts can withdraw a maximum of 10,971 acre-feet of stored water for irrigation.

In addition, there are 35 applications pending for stored water contracts to divert from the mainstem Willamette. While awaiting resolution of this Opinion, Reclamation has entered into short-term contracts in some of these cases. These requests, if approved as long-term contract obligations, would authorize withdrawal of an additional 25,507 acre-feet of stored water from the mainstem Willamette, beyond the 10,971 acre-feet under current long-term contract. Upon execution of these contracts, the water marketing program would then include 84 active long-term contracts for annual withdrawals of up to 36,478 acre-feet of stored water from the mainstem Willamette River.

Besides those diversions on the mainstem itself, however, flow on the mainstem Willamette is affection by reductions in inflow from contracts that divert water in tributaries below Project dams. Under baseline conditions, a total of 205 long-term Reclamation water service contracts are in effect as a result of the Willamette Project. Cumulatively, these 205 contracts can divert up to a maximum of 50,231 acre-feet of stored water for irrigation, reducing the total flow that enters the Willamette mainstem. There are 62 pending applications that, if approved, would divert an additional 30,200 acre-feet of stored water. Upon execution of these contracts, the Reclamation water contract program will include 267 active long-term contracts for annual irrigation with up to 80,431 acre-feet of stored water; approximately 5% of the active conservation storage space available in project reservoirs.[1]

Under the Proposed Action, Reclamation would cap its water marketing program at 95,000 acre-feet for the term of this Opinion. Taking both existing contracts and pending contract applications into account, 14,569 acre-feet would remain available to meet future irrigation demands under the duration of the Opinion. In the event that future irrigation demand exceeded

[1] The 205 contracts presently in force cover approximately 3% of the available conservation storage space.

the 95,000 acre-feet, Reclamation and the USACE would reevaluate the availability of water from conservation storage for the water marketing program and would consult with the Services prior to marketing additional water.

USACE intends to serve these contracts with water released from storage needed to maintain tributary and mainstem minimum flows. That is, under the Proposed Action more water would be removed from the Willamette River and its tributaries during the irrigation season without any additional water being released from USACE's reservoirs. In general, Reclamation water contracts are supplemental to natural flow water rights held by individual water users and are only exercised when natural flows are insufficient to serve all users and meet instream water rights held by OWRD. Assuming that such conditions would occur for only about 60 days each summer, the total level of future Reclamation-supported water service could reduce flows in some sections of the Willamette River by about 798 cfs, an increase of 376 cfs over existing baseline Reclamation service. Because USACE attempts to maintain flows of 6,000 to 7,000 cfs at Salem during the late summer, this level of Reclamation-supported water use would reduce late summer flows by 13 percent or less.[2] This is a 'worst-case' projection and project-related flow reductions would likely be much less.

Such flow reductions may slightly reduce the habitat area available to rearing juvenile salmon and steelhead during the late summer. Reducing the flow in the river would reduce the mass of water subject to atmospheric heating, causing water temperatures to increase slightly, which might also adversely affect rearing salmonids. This small level of project-induced water development is unlikely to substantially affect the survival of UWR Chinook and UWR steelhead in the mainstem Willamette River. However, when combined with non-project water developments (e.g., OWRD has issued natural flow water rights totaling almost 25,000 cfs in the basin), it must be noted that total water use in the basin is beginning to create conflicts between instream needs (e.g., fish habitat, water quality) and out-of-stream water uses (e.g., domestic, municipal, and irrigation). Ongoing regional planning efforts are focusing on this emerging issue.

This effect is expected to continue and worsen throughout the life of the Proposed Action. Although the USACE proposes to continue its efforts to cooperate with other regional entities to resolve water use conflicts, it does not propose any actions to investigate or reduce the effects of project-supported water use on Willamette River winter steelhead or spring Chinook in the mainstem Willamette River.

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[2] By assuming a short period of water use, and by assuming that all contracted water would be diverted and completely consumed when the river is at its lowest regulated levels, this brief analysis somewhat exaggerates the likely outcome of Reclamation water marketing in the Willamette basin. Under the Proposed Action, USACE would operate the projects to maintain at least 6,000 cfs in the Willamette River at Salem, Oregon, regardless of the level of actual water use.

5.10.2.5 Flow-Related Research, Monitoring & Evaluation (RM&E)

In the mainstem Willamette River and its major tributaries affected by USACE dams, the Action Agencies would conduct studies to characterize functional relationships between anadromous fish habitats and migrations and flows. These studies will focus on multiple aspects of fish distribution (e.g., habitat use) and behavior (e.g., migration timing) in relation to rates of discharge by time of year. The Action Agencies, in cooperation with the Services and the FM Committee, would use this information to better inform and balance tributary and mainstem flow management. Based on the new information, the Action Agencies would, with the agreement of the Services, modify the mainstem flow objectives presented in Table 5.10-2.

This RM&E measure is integral to an ongoing adaptive management program. NMFS strongly supports this type of adaptive management as it improves the likelihood of achieving the ESA's goals of ensuring long-term survival and protection of critical habitat for listed species.

Conclusions

Flow patterns in the mainstem Willamette River have been substantially altered by operations at the USACE's Willamette Project dams and reservoirs. These operations have altered flow regimes in ways that address water pollution, flood control, water supply, and other societal concerns, but have had both positive and negative effects on ESA-listed populations of UWR Chinook and UWR steelhead. All populations of both UWR Chinook and UWR steelhead migrate through the mainstem Willamette River and are known to rear in the river at times. The combined effects of reduced winter peak flows and channel revetments reduce the PCEs of freshwater rearing and migration corridors. A flow-related RM&E program included as part of the Proposed Action will help guide flow management that is favorable for ESA-listed salmonids, particularly as the potential for conflicts between human and salmon needs for water increase over time.

5.10.3 Water Quality

Under the environmental baseline, water quality does not provide properly functioning habitat for UWR Chinook salmon (section 4.10.3.3). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as described below.

5.10.3.1 Water Temperatures

The beneficial effect of ongoing mainstem flow augmentation from Willamette Project reservoirs on late summer mainstem temperatures is expected to continue under the Proposed Action. Small, adverse, late summer water temperature effects would be increased by additional water deliveries through Reclamation's water marketing program. Maximum summer water temperatures would probably continue to exceed NMFS' criteria for migrating and rearing Chinook salmon and steelhead.

Insufficient information is available to fully identify Project effects on mainstem Willamette water temperatures. Mainstem water temperatures are a substantial contributor to juvenile UWR steelhead mortality through their influence on disease susceptibility and virulence. By reducing spring flows during reservoir refill operations under baseline conditions, the Project has allowed slight increases in water temperature that likely contributed to disease-caused juvenile migrant mortality in the mainstem Willamette. This adverse effect would be reduced by the provision of maintaining minimum flows in the mainstem (Table 5.10-2) under the Proposed Action.

5.10.3.2 Dissolved Oxygen

Ongoing mainstem flow augmentation from Willamette Project reservoirs would also continue to benefit late summer dissolved oxygen levels. However, water column dissolved oxygen levels would still fluctuate below NMFS' criteria for migrating and rearing Chinook salmon and steelhead. The operation of the Willamette Project dams has increased dissolved oxygen concentrations in the lower mainstem Willamette through increased summer flows, and this beneficial effect is also expected to continue under the Proposed Action. Overall, dissolved oxygen in the mainstem would be improved by the Proposed Action.

5.10.4 Physical Habitat Quality

The key Proposed Actions related to physical habitat quality in the mainstem Willamette River subbasin that would affect UWR Chinook salmon and UWR steelhead, and to a lesser extent, LCR Chinook salmon, LCR coho salmon, and LCR steelhead, are listed below.

- Continued operation of 13 Project dams, blocking sediment and large wood transport from upstream reaches and tributaries into the downstream subbasins and ultimately into the mainstem Willamette River.

- Continued reduction in peak flows as part of flood control operations at the two Project dams, restricting floodplain connectivity and preventing creation of new gravel bars, side channels, and alcoves that provide rearing habitat for anadromous salmonids

- Continued existence and maintenance of 22.68 miles of USACE revetments along the mainstem Willamette River (all above Willamette Falls), preventing channel migration and reducing channel complexity.

- Study of effects of Project dams and revetments on mainstem Willamette River habitat and consider projects to restore habitat if authorized and funding becomes available.

5.10.4.1 Substrate, Sediment Transport, Large Wood & Channel Complexity in the Mainstem Willamette River

Under the environmental baseline, substrate, sediment transport, large wood, and channel complexity are degraded and do not support adequate rearing and holding habitat for UWR Chinook salmon and UWR steelhead throughout the mainstem Willamette River (Section 4.10.4). For LCR Chinook salmon, LCR coho salmon, LCR steelhead, and Clackamas River and Molalla River populations of UWR Chinook salmon and steelhead, which are present in the Willamette River downstream of Willamette Falls, and possibly for the Interior salmonid ESUs/DPSs, which may spend limited periods of time rearing near the mouth of the Willamette River, baseline conditions for these habitat features are also degraded. NMFS expects that conditions would not improve, and could degrade further under the Proposed Action, as shown in Table 5.10-3 (end of this section 5.10) and described below.

Under the Proposed Action, operation of the 13 Project dams for flood control would continue to store sediment and large wood in the reservoirs, trapping sediment and large wood from 27% of the Willamette Basin as measured at Salem. Additionally, Project operation would continue to reduce the magnitude and frequency of flood flows capable of recruitment of large wood and sediment from floodplains and of creating new bars, side channels, and alcoves. Finally, continued existence and maintenance of 22.68 miles of revetments along the mainstem Willamette River above Willamette Falls would prevent river migration and contribution of sediment, further depriving the river of sediment and the ability to create new gravel bars or side channels.

Several undammed tributaries enter the Willamette and transport large wood and gravel into the mainstem Willamette. However, many drain the Coast Range mountains, which do not contain sediment of the same size or quantity as the regulated rivers draining the Cascades. As described in Baseline section 4.10.3.4, additional sediment enters the mainstem Willamette as a result of land use activities such as road building, agriculture, and forestry; however, this sediment is primarily silts and fine particle sediments that increase turbidity and settle over coarser gravel, reducing habitat quality for rearing salmonids and the invertebrates on which they feed. Thus, other sources of sediment would not replace the lack of coarse gravels that are blocked by Project dams.

As a result of these actions, already impaired juvenile rearing and adult holding habitat, primarily in the mainstem Willamette River above Willamette Falls, would continue to degrade, limiting the abundance and productivity of all populations of UWR Chinook salmon and UWR steelhead. This adverse effect would likely cause more harm to the Middle Fork Willamette and McKenzie River UWR Chinook salmon populations than the other populations because these upper basin populations most likely relied on the once-extensive complex rearing habitat in the middle reaches of the mainstem Willamette for juvenile rearing. A lack of complex rearing and high-water refugia habitat in the mainstem Willamette River could limit juvenile production in the basin.

Although continued Project operation would also limit sediment and large wood transport and reduce flood magnitude and frequency into the lower mainstem below Willamette Falls, it would not be likely to significantly alter this reach that is naturally constrained by basaltic trenches. However, reduced flood frequency and magnitude would likely continue to prevent channel forming and overbank flows near the mouth of the Willamette River, where complex habitat once provided refugia for rearing juveniles of all 5 ESUs (UWR Chinook salmon, UWR steelhead, LCR Chinook salmon, LCR coho salmon, LCR steelhead). The magnitude and extent of juvenile rearing near the mouth of the Willamette River by other ESUs (Interior and other LCR species) is unknown, but it is likely that a small portion of juveniles rear in this habitat. Project operation would thus be expected to reduce available rearing habitat in this area due to reduced flood flows, resulting in channel simplification and fewer side channels and alcoves.

Conclusion

The Proposed Action would result in continued degradation of complex habitat in the mainstem Willamette River above Willamette Falls, likely reducing the carrying capacity of this habitat for rearing juvenile fish, thereby reducing the number of UWR Chinook salmon and UWR steelhead that can be produced in this presently degraded habitat. Although less severe, the Proposed Action would likely reduce channel forming flows needed to maintain and create complex habitat in the lower Willamette River near its mouth. This reduced channel complexity would reduce available habitat for rearing juveniles of UWR and LCR ESUs, and potentially Interior and other LCR populations that may rear in this reach during part of their outmigration. Aside from unspecified habitat restoration actions that may result from gravel, large wood, and habitat restoration studies, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the mainstem Willamette River.

5.10.4.2 Riparian Vegetation & Floodplain Connectivity in the Mainstem Willamette River

Under the environmental baseline, riparian vegetation and floodplain connectivity are degraded and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon and UWR steelhead (Section 4.10.3.4). For LCR Chinook salmon, LCR coho salmon, and LCR steelhead, and the Clackamas UWR Chinook salmon and steelhead populations, species present in the Willamette River downstream of Willamette Falls, baseline conditions for these habitat features are also degraded. NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.10-3 and described below.

Under the Proposed Action, operation of the Project dams for flood control, and continued existence and maintenance of 22.68 miles of USACE revetments along the mainstem Willamette River above Willamette Falls (and none below) would continue to degrade riparian vegetation and floodplain connectivity by preventing recruitment of large wood and sediment that create new bars and islands on which riparian vegetation can establish and by preventing peak flows that maintain stream connectivity to the floodplain. Although the Proposed Action includes study of potential Project flow releases to simulate peak flows, as well as habitat restoration studies, there is no certainty that project outflows would be modified or habitat restoration work would be done during the term of this Opinion.

The extent and function of the mainstem Willamette River's riparian vegetation and floodplains have been and would continue to be impaired by operation of the Willamette Project under the Proposed Action. As described in section 4.10.6, USACE Willamette Project revetments replaced about 46 miles of riparian vegetation along the mainstem Willamette River. Under the Proposed Action, the USACE retains maintenance responsibility for 22.68 miles of these revetments. These operations would continue to deprive downstream reaches of sediment, channel-forming flows, and large wood needed to create gravel bars, islands, and floodplains on which new riparian vegetation can establish. Reduced inundation of forested floodplains reduces nutrient and organic matter exchange during flood events and reduces the availability of high-water refugia for juveniles, which could limit over-wintering survival of rearing juveniles.

Because Project dams restrict fish access to upper tributary reaches, alter temperature regimes, and interrupt sediment and large wood from maintaining complex habitat in the lower reaches of the Middle Fork Willamette, McKenzie, North and South Santiam rivers, there is less juvenile rearing habitat in these tributaries for UWR Chinook salmon and UWR steelhead. This increases the important role of mainstem rearing for juvenile abundance and productivity and places even more emphasis on the need to maintain hydrologic processes that protect and restore rearing habitat in the mainstem Willamette River.

These adverse effects would likely cause more harm to listed anadromous fish in the Middle Fork Willamette, McKenzie, Calapooia, and North and South Santiam populations of UWR Chinook salmon and the North and South Santiam and Calapooia populations of UWR steelhead than the other populations because flood flows in the mainstem Willamette above Willamette Falls historically provided more opportunity for floodplain connectivity than in the bedrock-constrained reach below the Falls. Molalla and Clackamas UWR Chinook populations, and Molalla, Westside tributary and Clackamas UWR steelhead populations, as well as individuals of LCR Chinook salmon, coho salmon, and steelhead populations in the lower Willamette River, and potentially Interior ESUs that may rear at the mouth of the Willamette River during part of their outmigration, would be adversely affected to a lesser degree as a result of less frequent flooding in this lower river reach.

Conclusion

The Proposed Action would continue to reduce the extent, quality, and inundation frequency of riparian and floodplain forests in the mainstem Willamette River above Willamette Falls. The reduced extent of riparian vegetation (combined with reduced peak flows and limited channel migration) hinders recruitment of large wood into the aquatic system, which is needed to deposit spawning gravel, create resting pools for migrating adults, and provide cover for rearing juveniles or outmigrating smolts. Infrequent inundation of forested floodplains due to flood control operations would reduce nutrient and organic matter exchange during flood events, and reduce the availability of complex high-water refugia for juveniles, which could limit survival of rearing juveniles. These adverse effects would likely reduce the carrying capacity of habitat for rearing juvenile fish, thereby reducing the number of individual UWR Chinook salmon and UWR steelhead that can be produced in this presently degraded habitat. Although less severe, the Proposed Action would likely reduce floodplain connectivity and riparian forest creation and maintenance in the lower Willamette River near its mouth. This would reduce available habitat for rearing juveniles of UWR and Clackamas River populations of LCR ESUs, and potentially individuals of Interior and other LCR populations that may rear in this reach. For the populations of Interior and other LCR ESUs, because the duration of individual exposure is low and the percentage of the populations that might rear in this affected habitat is likely very low, NMFS does not expect the effects of the Proposed Action to reduce abundance and productivity of these other populations. Aside from unspecified habitat restoration projects and potential Project peak flow releases that may be recommended by the Willamette Floodplain Restoration Study or other habitat restoration studies described in the Supplemental BA, Section 3.5.2, Offsite Habitat Restoration Actions (USACE 2007a), the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain connectivity in the mainstem Willamette River.

5.10.5 Hatcheries

There are no hatchery facilities or hatchery fish releases in the mainstem Willamette River. Therefore, the specific effects of the hatchery facilities are evaluated in the specific subbasin where the hatchery is located. The effects of hatchery programs on broodstock collection, genetic introgression, masking, and nutrient cycling are evaluated also in each specific population area.

All hatchery spring Chinook and summer steelhead are released as smolts. The intent is for these hatchery fish to actively emigrate to the ocean, thus minimizing the period of time hatchery fish are potentially interacting with naturally rearing listed fish downstream of the hatcheries. The primary effects of the hatchery programs in the mainstem that needs to be assessed are the interaction between hatchery fish and natural-origin fish as they emigrate through the mainstem Willamette on their way to the ocean and 2) the interaction between hatchery and natural-origin fish upon their return as adults in the mainstem Willamette River. The following discusses these effects.

5.10.5.1 Disease

Hatchery fish can be agents for the spread of disease to wild fish. Due to the high rearing densities of fish in the hatchery, hatchery fish can have elevated levels of certain pathogens, disease, and/or bacteria. After they are released, these fish may expose and/or transfer the disease to wild fish. Below is an assessment of these risks to the juvenile and adult life stages.

Juveniles
In the mainstem Willamette River, the risk of hatchery fish spreading disease to wild juvenile Chinook salmon and winter steelhead is unknown. Hatchery fish are released as smolts from the hatchery facilities in the tributaries and are supposed to actively emigrate to the ocean. Available data suggests that smolt emigrations from any Willamette Basin hatchery to the lower Columbia River probably occur in less than a week (Friesen et al. 2007; Schreck et al. 1994). Therefore even though significant juvenile fish rearing does occur in the mainstem Willamette River (Schroeder et al. 2006), the likely exposure time between actively-migrating hatchery fish and naturally-rearing fish is likely to be minimal.

Adults
The potential also exists for returning hatchery fish to spread diseases to wild adult fish commingled in the mainstem Willamette River. The risk of hatchery fish spreading diseases in the Willamette River may be substantial since hatchery Chinook outnumber natural fish 10 to one. There is likely no effect of hatchery adults on winter steelhead due to the differences in run timing.

5.10.5.2 Competition/Density-Dependence

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Information on the potential competitive interactions between hatchery and wild fish is very limited in the Willamette Basin. Below is an assessment of the likely implications on the juvenile and adult life stages.

Juveniles
Since all hatchery fish are released as smolts and are expected to emigrate quickly to the ocean, it is unlikely significant competitive interactions will occur. In the mainstem Willamette, the habitat used by naturally rearing fish is primarily along the shorelines (Schroeder et al. 2006). For actively migrating hatchery smolts, they are traveling in the thalweg of the main river, thus using different habitats.

Adults
Given the problem of prespawning mortality in the Willamette Basin, it is possible that large numbers of returning hatchery adults could be causing an adverse effect on natural-origin fish. However, in the mainstem Willamette, this is unlikely because the fish are actively migrating upstream and there are no barriers to migration until the fish move into the tributaries. Without physical barriers, there is less chance that fish will be concentrated in one spot in the mainstem Willamette, reducing the chance that diseases could be spread laterally from hatchery to natural-origin fish. Therefore, adverse effects of competition and density-dependence factors of hatchery fish on natural-origin adults in the mainstem Willamette are likely to be small but unquantifiable.

5.10.5.3 Predation

Hatchery fish migrating through the mainstem Willamette probably eat some co-occurring natural-origin fish. In general, salmonids can prey upon fish approximately 2/3 of their size. Thus there is significant potential for hatchery summer and spring Chinook to prey upon wild steelhead and Chinook. Even though information is lacking on the extent of this issue, predation by hatchery fish undoubtedly occurs. Schroeder et al. (2006) examined predation by hatchery summer steelhead and rainbow trout on Chinook fry in the McKenzie River. Predation did occur on Chinook fry by a few fish. However, due to the fast digestion rates of Chinook fry in the stomachs of summer steelhead and rainbow trout (e.g., one to seven hours), it was difficult to estimate the amount of predation in their sampling design. Given the primary and secondary limiting factors identified for Willamette populations, predation by hatchery fish is not likely a limiting factor and the risk to listed fish is low.

Juvenile summer steelhead that are the progeny of naturally spawning summer steelhead in winter steelhead habitat could also predate upon listed age-0 and age-1 juvenile winter steelhead. The extent of this potential problem is unknown at this time. However, monitoring and evaluation is scheduled to occur to evaluate the proportion of juvenile steelhead that are progeny of summer steelhead.

5.10.5.4 Residualism

All hatchery programs in the Willamette Basin release hatchery fish as smolts. The intent is to release the hatchery fish at a size and time so that they will actively emigrate to the ocean; thus minimizing the potential interaction between hatchery and wild fish. However, a percentage of the smolts do not emigrate and residualize in the river. These residual fish may emigrate to the ocean at a later time or may stay in freshwater the rest of their life.

In general, hatchery steelhead have more of a tendency to residualize than hatchery spring Chinook. In the Willamette Basin, the primary concern is with residual summer steelhead. The percentage of the smolt release of summer steelhead that do residualize is unknown. However, residual summer steelhead have been observed in all areas where hatchery fish are released. Several new actions are included in the Proposed Action that would help reduce the adverse effects of residual summer steelhead on wild winter steelhead and spring Chinook. The most beneficial is the proposal to not release any summer steelhead smolts that do not volitionally emigrate from the hatchery facility. These “non-migrants” would be collected and released into standing water bodies for trout fisheries. Previously, all of these non-migrant fish were forced out into the river. In addition, ODFW is proposing a new angling regulation that will allow the harvest of any fin-clipped, residual summer steelhead in all recreational fisheries. These changes in hatchery management and ODFW angling regulations will decrease the number of residual hatchery fish left in the river and thus reduce adverse effects of residual fish.

5.10.6 Fisheries

As discussed in the “General effects of hatchery programs on ESA-listed salmon and steelhead” section above, the production of hatchery fish can lead to commercial and recreational fisheries that cause the overharvest of natural-origin fish. An abundance of hatchery fish can promote expanding fisheries, which may be detrimental to commingled natural-origin fish. In the Willamette, all hatchery fish have been mass marked since the 1990s. This mass marking has facilitated implementation of selective fisheries—where only hatchery fish can be harvested. Thus freshwater fishery impacts on winter steelhead and spring Chinook have been reduced substantially compared to historic harvest rates. Freshwater fishery impacts are now in the range of 1-5% for winter steelhead and 8-12% for spring Chinook populations in the Willamette Basin.

The production of Willamette hatchery fish are of no consequence to the management of ocean fisheries. In general, steelhead of natural- or hatchery-origin are rarely caught in ocean fisheries. Hatchery spring Chinook are caught in ocean fisheries, particularly in Alaska and West Coast Vancouver Island fisheries (see Figure 4.2-13). However, these hatchery fish are not a driver for fisheries management. Protection of other stocks of concern in Canada and the United States currently constrain ocean fishery quotas and regulations. In addition, harvest of Willamette spring Chinook in ocean fisheries is governed by the Pacific Salmon Treaty between the US and Canada and impacts have been typically been in the range of 10-15%.

5.10.7 Summary of Effects on Population Traits

Below is a summary of the effects of the Proposed Action in the mainstem Willamette on the four Viable Salmonid Population (VSP) parameters (abundance, productivity, spatial structure, and diversity) for all of the listed fish populations and ESUs that use the mainstem Willamette River for portions of their life cycles. These VSP parameters are described in detail in the Rangewide Status Chapter (section 3). Each subbasin section of the Effects Chapter (sections 5.2 through 5.9) summarizes effects of the Proposed Action for each population. This summary considers only the effects that occur in the mainstem Willamette that, together with effects of the Proposed Action in the subbasin, determine effects on each population and ultimately at the ESU level. Table 5.10-3 also summarizes the VSP effects.

5.10.7.1 Abundance

The majority of the natural-origin populations of UWR Chinook salmon have very low current abundances (less than a few hundred fish in each of the Molalla, North Santiam, South Santiam, Calapooia, and Middle Fork Willamette), with only the Clackamas and McKenzie populations exceeding 1000 spawners and possibly showing an increasing trend in abundance (Section 3.2.1.3). UWR steelhead abundance in the four populations (Molalla, North Santiam, South Santiam, Calapooia) is moderate, though depressed from historical levels (Section 3.2.2.3).

Minimum flows and their effects on water quality in the mainstem Willamette would result in some increased abundance of UWR Chinook salmon and UWR steelhead. However, the Proposed Action would also cause decreased abundance of these ESUs associated with lost fry and juvenile rearing habitat in the mainstem Willamette due to ongoing maintenance of revetments and lack of channel-forming peak flows. Abundance would be most unfavorably affected for UWR Chinook salmon and UWR steelhead populations that would use off-channel rearing habitat and complex habitat above Willamette Falls.

5.10.7.2 Productivity

The Proposed Action would have both beneficial and negative effects on productivity of populations of UWR Chinook salmon and UWR steelhead in the mainstem Willamette. Minimum flows and their effects on water quality would support productivity, while continued degradation and loss of juvenile rearing habitat caused by revetment maintenance and reduction in channel-forming and over-bank flows would reduce productivity. These negative effects would be greatest for the populations spawning above Willamette Falls, namely steelhead from the Molalla, North Santiam, South Santiam, and Calapooia, and Chinook salmon from those subbasins plus the McKenzie and Middle Fork Willamette. Without substantial improvements in rearing habitat conditions in the mainstem Willamette, and in the near term, before passage is provided to suitable rearing habitat above Project dams, NMFS expects the productivity of these populations to remain at low levels or continue to decrease. Habitat enhancements in the mainstem that provide complex juvenile rearing habitat and off-channel refugia are needed in the near term to prevent further decline in productivity. The Proposed Action lacks certainty that such improvements would be carried out during the term of this Opinion.

5.10.7.3 Spatial Structure

In the mainstem Willamette, the Proposed Action does not affect spatial structure of any of the listed ESUs, except to the extent that it restricts access to off-channel refugia and rearing habitats.

5.10.7.4 Diversity

Population traits for all of the ESUs considered in this Opinion are now not as diverse as they were in historic populations, and this decreases the ability of salmon and steelhead to respond and survive in response to fluctuating environmental conditions. NMFS expects the Proposed Action to continue to degrade habitat, and limit fry and juvenile rearing habitat in the mainstem Willamette, especially in reaches above Willamette Falls. This reduction in mainstem rearing habitat reduces diversity by selecting for life history types that either spend most of its freshwater rearing in tributaries or that quickly migrate downstream to rear in the estuary. By reducing the diversity of life history types, populations are more at risk because catastrophic events in the remaining habitat can destroy a larger proportion of the population and without segments of the population using different life history strategies (such as mainstem rearing), the population's resiliency to these events is low.

The effects of hatchery fish production on diversity are described in the specific subbasin sections where hatchery facilities are located (Sections 5.2 Middle Fork Willamette, 5.3 McKenzie, 5.5 South Santiam, and 5.6 North Santiam).

Conclusion for UWR steelhead from the Molalla, North Santiam, South Santiam, and Calapooia, and UWR Chinook salmon from those subbasins plus the McKenzie and Middle Fork Willamette:

For these UWR Chinook salmon and steelhead populations that migrate through and rear in the mainstem Willamette from above Willamette Falls, the Proposed Action would have both positive (related to increased summer flows, improving water quality) and negative (related to reduced rearing habitat associated with revetment maintenance and lack of peak channel-forming flows) effects. In the near term under the Proposed Action, passage at Project dams in the Middle Fork Willamette, McKenzie, South Santiam, and North Santiam would remain inadequate to address spatial structure and the need to access upstream habitat to realize increases in abundance and productivity. To prevent further declines in these populations in the near term, efforts are needed to improve and restore mainstem Willamette rearing habitat. However, under the Proposed Action, NMFS expects that continued maintenance of revetments and reduction in peak flows would lead to further decline in abundance and productivity due to loss of rearing habitat.

Conclusion for UWR Chinook salmon from the Clackamas, as well as populations of LCR Chinook salmon, LCR coho salmon, and LCR steelhead and Interior ESUs/DPS that may use the lower Willamette River below Willamette Falls:

The Proposed Action would not be likely to have a measurable effect on these populations and additional ESUs/DPSs that may use the lower Willamette mainstem for juvenile rearing and migration. The USACE has identified no revetments in this lower reach that are maintained by the Action Agencies. Although the Project's reduced flood flows would likely limit channel forming processes near the confluence of the Willamette and Columbia rivers, this effect would be small and overshadowed by ongoing landuse development activities and Columbia River operations.

5.10.8 Effects of the Proposed Action on Designated Critical Habitat

The mainstem Willamette River from its mouth to its origin at the confluence of the Middle Fork and Coast Fork at RM 187 has been designated as critical rearing/migration habitat for UWR Chinook salmon and UWR steelhead. Table 5.10-3 shows the anticipated effects of the Proposed Action on VSP parameters for UWR Chinook salmon and UWR steelhead and on the PCEs of Critical Habitat for these species.

The Proposed Action would have both positive and negative effects on critical habitat in the mainstem Willamette River. Proposed minimum flows for the mainstem Willamette would continue to benefit rearing and migration habitat by providing improved summer water quality (lower water temperatures, higher dissolved oxygen, and lower concentrations of pollutants) than under the baseline without the Project-controlled flows. The minimum flows would also continue (relative to the recent past) to aid in downstream migration of juvenile salmonids during spring, particularly UWR Chinook salmon and UWR steelhead from the Middle Fork Willamette, McKenzie, North Santiam, and South Santiam populations, all of which migrate from upper basin tributaries. Upstream migration of adult Chinook salmon from these same populations is also benefitted by the minimum flows' effect of reducing thermal blockages. However, continued existence and maintenance of 22.68 miles of revetments and reduced flood flows would continue to harm rearing habitat by preventing channel-forming events that create and maintain complex rearing habitat and overbank flows that allow access to off-channel rearing habitats. This continued loss in rearing habitat is most damaging to critical habitat in the mainstem Willamette River above Willamette Falls, designated for UWR Chinook salmon and UWR steelhead. For that critical habitat designated for LCR Chinook salmon, Coho salmon and steelhead, the Proposed Action's reduced flood flows would likely have little effect on rearing and migration habitat in the lower Willamette, including once-complex habitat near the confluence of the Willamette and Columbia rivers.

Table 5.10-3 PCE Effects of PA on populations (VSP column) and Critical Habitat (PCE column) in the Mainstem Willamette River subbasin. Modified from USACE 2007a, Table 6-7.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater migration corridors	Habitat access	Physical barriers	The proposed action does not cause any physical barriers to migrations within the mainstem Willamette River.	None
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quantity (flow/hydrology)	Change in peak/base flow, revetment maintenance	By interrupting sediment transport from the tributary source areas into the mainstem corridor, the proposed action would slightly reduce the availability of spawning substrates within the mainstem Willamette River. Through the continued existence and maintenance of revetments and the control of peak flows, the proposed action would reduce channel complexity, continuing the already reduced juvenile rearing habitats in the mainstem. By reducing spring flows during reservoir refill, the proposed action would contribute slightly to juvenile UWR steelhead migrant mortality. This effect is minimized by the proposed action's commitment to maintain streamflow levels known to minimize these adverse effects.	Reduces spawning habitat. Mainstem spawning is minor to inconsequential. Reduce freshwater rearing habitat. Mainstem rearing habitat may be seasonally important. Reduce suitability of migratory corridor.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Temperature	May affect the seasonal use of mainstem Willamette by rearing salmon and steelhead. By reducing spring flows during reservoir refill, the proposed action would slightly increase temperature, making juvenile UWR steelhead migrant more susceptible to disease, and more likely to die. This effect is minimized by the proposed action's commitment to maintain minimum flow levels that will reduce the adverse effects of reservoir refill on mainstem Willamette water temperature.	During spring flows, reservoir refill would continue to reduce mainstem flows, resulting in small increased temperature that adversely affects rearing and migration habitat. Minimum flows would partially offset this adverse effect. During summer months, the Proposed Action slightly reduces temperature compared to baseline conditions, resulting in improved rearing and migration habitat.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Total suspended solids/turbidity	The reduction in turbidity may reduce juvenile survival by making them more susceptible to predation.	By reducing peak flows, capturing most incoming bedload sediments, and reducing downstream settleable solids concentrations, the tributary projects likely reduce mainstem turbidity and sediment transport. Sediment transport is discussed in Water Quantity above.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Chemical contamination/nutrients	No effect	No effect

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Dissolved oxygen (DO)	Proposed Action slightly offsets other human-caused actions that decrease DO, to avoid incremental loss of abundance and productivity of UWR Chinook salmon and steelhead and LCR Chinook salmon, coho salmon, and steelhead.	Continued improvement of DO in lower Willamette resulting from higher summer flows
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Total dissolved gas (TDG)	No effect	No effect
Freshwater spawning sites	Habitat elements	Substrate	Continued lack of new gravels to existing habitat in the mainstem Willamette above Willamette Falls would reduce abundance and productivity of UWR Chinook salmon and UWR steelhead by limiting and degrading available juvenile rearing habitat. LCR Chinook salmon, coho, and steelhead and Interior species would be affected to a lesser degree due to continued loss of habitat near the mouth of the Willamette River.	Operation of Project dams would continue to block sediment transport from 27% of the Willamette basin, reducing gravel bar creation in the mainstem Willamette, and thereby limiting stream functions that create complex habitat for rearing juveniles.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Large woody debris (LWD)	Continued lack of large wood reduces abundance and productivity of UWR Chinook salmon and UWR steelhead in the mainstem Willamette above Willamette Falls because holding and rearing habitat would continue to degrade and would not be replaced. LCR Chinook salmon, coho, and steelhead and Interior species would be affected to a lesser degree due to continued loss of habitat near the mouth of the Willamette River.	Operation of Project dams would continue to block transport of large wood from 27% of the Willamette basin and 22.68 miles of revetments would continue to prevent floodplain connectivity, reducing large wood recruitment from streambanks, resulting in less structure available to create complex channel habitat, gravel bars and large pools.
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Pool frequency and quality	Continued degradation of pool habitat would reduce juvenile rearing and adult holding habitat, resulting in lowered productivity and abundance of UWR Chinook salmon and UWR steelhead in the mainstem Willamette above Willamette Falls. LCR Chinook salmon, coho, and steelhead and Interior species would be affected to a lesser degree due to continued loss of habitat near the mouth of the Willamette River.	Operation of Project dams and continued existence and maintenance of revetments would continue to prevent peak flows and block sediments and large wood, preventing channel movement that would allow for new pools to form.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat elements	Off-channel habitat	Continued lack of off-channel habitat would reduce rearing habitat, resulting in lowered productivity and abundance of UWR Chinook salmon and UWR steelhead in the mainstem Willamette above Willamette Falls. LCR Chinook salmon, coho, and steelhead and Interior species would be affected to a lesser degree due to continued loss of habitat near the mouth of the Willamette River.	Continued reduced off-channel habitat in the mainstem Willamette, primarily in the reach above Willamette Falls as well as near the mouth. Project operation would continue to reduce peak flows, limiting overbank flows and channel forming processes. Although studies may consider special operations to provide peak flows, the Action Agencies provide no certainty that this operation would occur during the term of this Opinion, nor that the operation would open up off-channel habitat.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing	Channel conditions and dynamics	Width/depth ratio	Continued degraded channel conditions would reduce rearing habitat, resulting in lowered productivity and abundance of UWR Chinook salmon and UWR steelhead in the mainstem Willamette above Willamette Falls. LCR Chinook salmon, coho, and steelhead and Interior species would be affected to a lesser degree due to continued loss of habitat near the mouth of the Willamette River.	Project operation would continue to reduce peak flows and block large wood and sediment transport, limiting pool formation. Although studies may consider special operations to provide peak flows and funding habitat restoration projects, the Action Agencies provide no certainty that these measures would occur during the term of this Opinion.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Streambank condition	Degraded streambanks would inhibit channel forming processes that create complex habitat for juvenile rearing and adult holding, resulting in lowered productivity and abundance of UWR Chinook salmon and UWR steelhead in the mainstem Willamette above Willamette Falls. LCR Chinook salmon, coho, and steelhead and Interior species would be affected to a lesser degree due to continued loss of habitat near the mouth of the Willamette River.	Project operation and continued operation and maintenance of revetments would continue to prevent streambanks from supporting natural floodplain function in the mainstem Willamette River. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve streambank conditions, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Floodplain connectivity	Continued lack of floodplain connectivity reduces availability of off-channel habitat, limiting available rearing habitat, including reduced macroinvertebrate production as a food supply, resulting in lowered productivity and abundance of UWR Chinook salmon and UWR steelhead in the mainstem Willamette above Willamette Falls. LCR Chinook salmon, coho, and steelhead and Interior species would be affected to a lesser degree due to continued loss of habitat near the mouth of the Willamette River.	Project operation and continued operation and maintenance of revetments would continue to prevent overbank flow and side channel connectivity in the mainstem Willamette River, especially in the reach above Willamette Falls and in the reach near the mouth. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve off-channel habitat, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed conditions	Riparian reserves	Continued degradation of riparian habitat would reduce large wood available for channel complexity, thereby reducing already limited rearing and holding habitat, resulting in lowered abundance and productivity of UWR Chinook salmon and UWR steelhead in the mainstem Willamette above the Falls. LCR Chinook salmon, coho, and steelhead and Interior species would be affected to a lesser degree due to continued loss of habitat near the mouth of the Willamette River.	Project operation and continued operation and maintenance of revetments would continue to prevent formation of new gravel bars on which riparian vegetation could grow in the mainstem Willamette River above the Falls and near the mouth. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially restore riparian vegetation, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.

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Section 5.11
Lower Columbia River, Estuary & Coastal Ocean Effects

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5.11 LOWER COLUMBIA RIVER, ESTUARY & COASTAL OCEAN

SUMMARY OF THE EFFECTS OF THE PROPOSED ACTION

- All populations of Columbia basin salmon and steelhead use the lower Columbia River, estuary, and plume as a migration corridor and some species use the lower river and estuary for rearing. The Proposed Action would:
  - Affect flows in the lower Columbia River, with very small decreases during spring and small increases during fall and winter.
  - Reduce inputs of large wood and sediments/turbidity from the Willamette River.
- The Proposed Action is likely to have very small (unmeasurable) negative effects on juvenile migration and rearing habitats, the abundance or productivity of the listed species, and the PCEs water quantity, safe passage, floodplain connectivity, and cover.

This section considers the effects of the Proposed Action on listed fish and fish habitat characteristics in the lower Columbia River and estuary, from the confluence of the Willamette River near Portland, Oregon, (Columbia RM 100) to the mouth, and in coastal areas occupied by Southern Resident killer whales influenced by Willamette Project operations (i.e., within the Columbia River plume). All of the salmonid populations and ESUs/DPSs considered in this Opinion use these reaches to varying extents for parts of their life cycles.

The Proposed Action includes the following actions that would be likely to affect listed salmonid populations using the lower Columbia mainstem for juvenile rearing and juvenile and adult migration:[1]

- Project dams: continued operation and maintenance under existing configuration of 13 Project dams in major tributaries of the Willamette River including seasonal drafting and refilling operations.
- Water contract program: continued issuance of contracts by Reclamation for withdrawal of water released from storage for irrigation use.
- Hatchery Mitigation: large numbers of hatchery-produced anadromous salmonids, including spring Chinook and summer steelhead from the Willamette Hatchery program, pass through the lower Columbia River and estuary as juveniles and adults.

In this section, NMFS considers the effects of the Proposed Action on all populations of listed salmon and steelhead using the lower Columbia River, estuary, and plume.[2] In general, Project flow management operations and water contracting would continue to have small effects on

[1] Habitat requirements and adult use of the estuary are unknown (Fresh et al. 2005).
[2] NMFS has determined that the Proposed Action and the RPA are not likely to adversely affect the Southern Resident killer whale or the Southern DPS of green sturgeon (Section 1.1; Consultation History and Appendices A and B).

flows in the lower Columbia River, estuary, and plume, but would not affect conditions elsewhere in the coastal ocean.

5.11.1 Water Quantity/Hydrograph

The Proposed Action would continue to reduce average monthly Columbia River flows below the Willamette confluence from February through May by a range of less than 1% to 3% (Table 4.11-3), These very small reductions are likely to have a slight to negligible negative effect in terms of increased travel time and thus susceptibility to predators for spring migrating juvenile UWR Chinook, UWR steelhead, LCR coho, CR chum, UCR spring Chinook, SR spring/summer Chinook, SR sockeye salmon, LCR steelhead, MCR steelhead, UCR steelhead, and SR steelhead. Under the environmental baseline, the Action Agencies will relocate Caspian terns from East Sand Island to sites outside the estuary by 2010, and are continuing efforts to control predation by Northern pikeminnows (NMFS 2008a). Both of these actions will reduce the risk of predation in this portion of the action area.

From June through January, the Proposed Action would increase average monthly flows in the lower Columbia River by a range of less than 1% to 4.5% (Table 4-11-3). These flow increases are small, but could be relatively substantial during low flow years. The effect would be a slight to negligible decrease in travel time (corresponding to a slight to negligible increase in survival) for juvenile salmonids that migrate through the lower Columbia River during summer (LCR fall Chinook, SR fall Chinook, and subyearling emigrants from the UWR Chinook ESU), or use the lower river and estuary to rear (LCR fall Chinook and CR chum and subyearling UWR Chinook).

5.11.2 Physical Habitat

By reducing peak spring flows in the Willamette River, the Proposed Action would have a very small negative effect on the frequency of channel-forming and over-bank flows that create off-channel habitat and maintain floodplain connectivity in the lower Columbia River. The Proposed Action is also expected to have a very small negative effect on inputs of large woody debris and sediment/turbidity, trapped in Project reservoirs, to the mainstem lower Columbia. Effects on salmonids and their habitat are likely to be slight to negligible (Section 5.11.1). In addition, the Action Agencies are providing funding to implement a 10-year estuary habitat restoration program that addresses limiting factors as part of the RPA for FCRPS hydrosystem operations (NMFS 2008a). This program, which is part of the environmental baseline for this consultation, will further reduce any slight to negligible effects of the proposed action on habitat in the lower Columbia River and estuary.

5.11.3 Hatchery Mitigation Program

General effects of hatchery programs on species viability are discussed in Section 4.11.2 and in Appendix C to NMFS (2008b). Large numbers of hatchery produced salmon and steelhead including spring Chinook and summer steelhead from the Willamette hatchery mitigation program pass through the estuary as both juveniles and adults. There is evidence of density-dependent effects on salmon and steelhead growth and survival, but whether the underlying factor or factors include competition with hatchery-origin fish remains poorly understood. Nickelson (2003) suggested an alternate mechanism, that predators are attracted to large aggregations of hatchery fish making natural-origin fish in the same area are more susceptible to piscivorous fish, birds, and mammals. However, evidence for these effects is inferential at this time.

5.11.4 Summary of Effects on Salmonids

Effects of Willamette Project operations on flow in this part of the action area are likely to be very small and effects on habitat features and thus on the abundance, productivity, spatial structure, or diversity of any of the 13 species of salmonids considered in this consultation are likely to be slight to negligible. For species with subyearling juvenile emigrants (juvenile LCR fall Chinook and CR chum and subyearlings from the UWR Chinook ESU), the Proposed Action is not expected to affect floodplain connectivity, channel complexity, or the availability of shallow, low velocity rearing habitat (Table 5.11-1). The Proposed Action is therefore not expected to have a measurable effect on population abundance, productivity, and spatial structure of species that only interact with the Action in this part of the action area (i.e., do not spawn and rear in the Willamette Basin). In addition, relocating terns from the estuary, and the habitat restoration projects described in Section 4.11.4, are expected to improve juvenile survival compared to conditions in recent years. The Proposed Action is not expected to affect habitat conditions for salmonids in the coastal ocean (including the Columbia River plume).

5.11.5 Effects of the Proposed Action on Designated Critical Habitat

Due to its importance as a migratory corridor, the lower Columbia River from the Willamette River confluence to the mouth has been designated as critical habitat (migration corridor) for 12 species of salmon and steelhead in the Columbia basin. As described above, the Proposed Action is expected to have slight to negligible effects on the functioning of habitat elements that correspond to PCEs of critical habitat (water quantity, safe passage, floodplain connectivity, and natural cover) in this portion of the action area (Table 5.11-1).

Table 5.11-1. Effects of Willamette Project Proposed Action on ESA-listed salmon and steelhead populations (VSP column) and the primary constituent elements of critical habitat (PCE column) in the lower Columbia River, estuary, and plume/coastal ocean. Modified from Table 6-7 in USACE 2007a.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing Freshwater migration corridors	Water quantity (flow/hydrology)	Change in peak/base flow, revetment maintenance	Very small reductions in spring flows (February-May) during reservoir refill with slight to negligible effects on abundance or productivity. Very small reductions in channel complexity in the lower Columbia River and estuary during spring with slight to negligible effects on abundance or productivity.	Very small reductions in water quantity and safe passage in the migration corridor during spring. Slight to negligible reductions in water quantity, floodplain connectivity, and natural cover in freshwater/estuarine rearing areas.
Freshwater rearing Freshwater migration corridors	Water quality	Turbidity	Slight to negligible reduction in turbidity corresponds to a slight to negligible reduction in juvenile survival (i.e., susceptibility to predation) and thus on abundance or productivity.	Slight to negligible reduction in safe passage.
Freshwater rearing Freshwater migration corridors	Water quality	Chemical contamination/ nutrients	No effect.	No effect.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing Freshwater migration corridors	Water quality	Dissolved oxygen (DO)	No effect.	No effect.
Freshwater rearing Freshwater migration corridors	Water quality	Total dissolved gas (TDG)	No effect.	No effect.
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Large woody debris (LWD)	Slight to negligible reduction in the delivery of LWD to the lower Columbia River and estuary with slight to negligible effects on the abundance or productivity of ocean-type Chinook ESUs rearing in this part of the action area (juvenile LCR fall Chinook and CR chum and subyearling emigrants from the UWR Chinook ESU).	Slight to negligible negative effect on cover in juvenile rearing areas.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Pool frequency and quality	No effect.	No effect.
Freshwater rearing Freshwater migration corridors	Habitat elements	Off-channel habitat	Slight to negligible effect on the development and maintenance of off-channel habitat in the lower Columbia River and estuary with slight to negligible effects on the abundance and productivity of ocean-type Chinook ESUs rearing in the area (juvenile LCR fall Chinook and CR chum and subyearling emigrants from the UWR Chinook ESU).	Slight to negligible effect on cover in juvenile rearing areas.
Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Width/depth ratio	No effect.	No effect.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Streambank condition	No effect.	No effect.
Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Floodplain connectivity	Slight to negligible effect on the development and maintenance of floodplain connectivity in the lower Columbia River and estuary with slight to negligible effects on the abundance or productivity of ocean-type Chinook ESUs rearing in this portion of the action area (juvenile LCR fall Chinook and CR chum and subyearling emigrants from the UWR Chinook ESU).	Slight to negligible effect on floodplain connectivity in juvenile rearing areas.

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Chapter 6
Cumulative Effects

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6 CUMULATIVE EFFECTS

As part of the Court-ordered collaboration process for the 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (NMFS 2008a), the State of Oregon provided information on various ongoing and future or expected projects that NMFS has determined are reasonably certain to occur and will affect recovery efforts in the Willamette and lower Columbia basins (see Table 17-5 in Chapter 17 in USACE 2007b [FCRPS Comprehensive analysis]). All of these actions are either completed or ongoing and are thus part of the environmental baseline, or are reasonably certain to occur.[1] They address protection and/or restoration of existing or degraded fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect stream habitat. Significant actions and programs include growth management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, support of voluntary measures to restore instream flows and to protect sensitive areas, stormwater and discharge regulation, and Total Maximum Daily Load (TMDL) implementation. Responsible agencies include the Oregon Departments or Divisions of Fisheries and Wildlife, Environmental Quality, State Lands, Forestry, Agriculture, and Land Conservation and Development and the Oregon Watershed Enhancement Board. Many of these actions will have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of the listed salmon and steelhead populations and the functioning of PCEs in designated critical habitat in the Willamette portion of the action area. These activities are likely to have cumulative effects that will significantly improve conditions for UWR Chinook and steelhead. These effects can only be considered qualitatively.

Similarly, both the states of Oregon and Washington provided information on ongoing and future or expected projects that NMFS has determined are reasonably certain to occur that are located in the lower Columbia River portion of the action area. These are similar in nature to those identified above, and will improve conditions for all of the species of salmon and steelhead considered in this Opinion.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can be considered reasonably certain to occur in the future because they occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area for the PA, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights) and land use practices. In the estuary and the coastal ocean, private activities are primarily associated with commercial and sport fisheries, construction, and marine pollution. Although these factors are ongoing to some extent (see Chapter 3, Rangewide Status, and Chapter 4, Environmental Baseline) and likely to

[1] The State of Oregon identified potential constraints (e.g., funding, staffing, landowner cooperation) for many of its projects submitted as reasonably certain to occur.

continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments or in the case of pollution, additional safeguards. Therefore, although NMFS finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities, it is not possible to quantify these effects.

Chapter 7
Summary of Effects of the Proposed Action on UWR Chinook & UWR Steelhead

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7 SUMMARY OF EFFECTS OF THE PROPOSED ACTION ON UWR CHINOOK & UWR STEELHEAD

SUMMARY OF THE EFFECTS OF THE PROPOSED ACTION

The predominant adverse effects of the Willamette Project are reduced viability of populations and functioning of PCEs for UWR Chinook and steelhead. This chapter summarizes the degree to which the Proposed Action would address these adverse effects.

Upper Willamette Chinook

The Proposed Action will continue to have significant adverse impacts on many Upper Willamette Chinook salmon populations and their critical habitat, in particular, effects on adult holding and spawning and juvenile rearing to the smolt stage. Additional improvements needed to mitigate for these adverse effects include:

- Fish passage above and below dams,
- Improved temperature and flow regimes below dams,
- Improved hatchery practices to minimize genetic interference, and
- Improved rearing and migration habitat.

Upper Willamette Steelhead

The Proposed Action would continue to have significant adverse effects on this steelhead population and its habitat, in particular, effects on UWR Steelhead in the North Santiam with limited stream habitat and altered water temperatures below the dams. Additional improvements needed to mitigate for these adverse effects include:

- Fish passage above and below dams,
- Improved temperature and flow regimes below dams,
- Improved hatchery practices to minimize genetic interference, and
- Improved rearing and migration habitat.

7.1 INTRODUCTION

As described in Effects of the Proposed Action (Chapter 6), the predominant adverse effects of the Willamette Project are reduced viability of populations and functioning of PCEs for UWR Chinook and steelhead. The purpose of this chapter is to summarize the degree to which the Proposed Action would address these adverse effects. This analysis summarizes information on historical effects of the project (Chapter 4, Environmental Baseline) and the analysis of effects of the Proposed Action (Chapter 5). The information in this chapter provides part of the rationale for the Conclusions for these two species in Chapter 8.

7.2 UWR CHINOOK SALMON

7.2.1 Current Status

Five of the seven populations in this ESU are facing critically high extinction risks and the risk of extinction is moderate even for the two populations with high numbers of natural-origin spawners (Clackamas and McKenzie; Figure 3-5). Short- and long-term trends in numbers of natural-origin fish are significantly downward for every population, with the exception of a positive short-term (20-30 years) trend for the Clackamas Chinook population. The status of PCEs of designated critical habitat for these populations is also poor, although the degree to which this habitat is deficient varies among the subbasins (see Tables 4.2-8, 4.3-4, 4.4-2, 4.5-5, 4.6-8, 4.7-4, and 4.8-1).

7.2.2 Effects of the Proposed Action on Population Viability & PCEs of Critical Habitat

NMFS' analysis of the effects of the Proposed Action in Chapter 5 included both quantitative and qualitative information with which to assess effects on the affected VSP parameters for a population and the PCEs of critical habitat. This analysis summarizes those effects in terms of the habitat requirements of two critical Chinook life stages that take place within the Willamette Basin: adult holding and spawning and juvenile rearing to the smolt stage.

7.2.2.1 Adult Holding & Spawning

Spring runs are unique among Chinook populations because they reside and mature in freshwater three to four months before spawning (Myers et al. 1998). Thus, they require cool stream temperatures, typically found in or near headwater areas where flows are predominately snowmelt driven, to survive holding and subsequently, for successful reproduction (Torgersen et al. 1999).

In the McKenzie and Clackamas watersheds, adult spring Chinook have volitional access to most of the historically occupied headwater habitat where they oversummer and spawn. These populations have exhibited the lowest prespawning mortality rates for Chinook in the Willamette Basin over a decade of study (McLaughlin et al. 2008). Both occupy large watersheds that receive substantial summertime snowmelt discharge from the headwaters of the Cascade Mountain Range. Even though some impassable dams (e.g., Blue River, Cougar, and Carmen-Smith in the McKenzie, Oak Grove in the Clackamas) were built on their tributaries, each has lost less than 5% of its historical adult holding and spawning habitat (Table 7.1). The USACE intends to construct an adult trap below Cougar Dam in 2009 and the Action Agencies propose to begin passage operations in 2010.

Three other spring Chinook populations (Middle Fork Willamette, South Santiam, and North Santiam), which historically numbered in the tens of thousands but are now at high risk of extinction, are significantly impacted by the Willamette Project. In the watersheds occupied by these populations, most of the historical holding and spawning habitat is now upstream of the Willamette Project dams. Mattson (1948) estimated that 98, 85, and 71% of the historical oversummering and spawning habitat was above the sites of Willamette Project dams built in the Middle Fork Willamette, South Santiam, and North Santiam watersheds, respectively (Table 7.1). Once the dams were built, spring Chinook were no longer able to access the cooler headwater habitats for oversummering and spawning. The remaining fish reside below the dams where prespawning mortality rates are substantial (McLaughlin et al. 2008), riparian and channel habitat conditions are significantly degraded, and seasonal water temperature regimes are altered by Project operations (see Chapter 5).

As described above, five of the seven populations have been directly impacted by the Willamette Project. There are no federal dams within the watersheds occupied by remaining two populations (Molalla and Calapooia). The headwaters for both of these watersheds are at lower elevations on the west slope of the Cascades and lack the sustained and cool late-season flows associated with watersheds that extend higher into the mountains. Historically, the Molalla and Calapooia watersheds supported relatively small Chinook populations (Nicholas 1995). Even before development, they did not have the capacity to support stronghold or core populations and their smaller populations may therefore have been even less resistant to land and water development and the historical harvest rates.

Table 7.1 Key characteristics of UWR Chinook salmon populations affected by impassable dams in the basin. Note for the Clackamas population, all dams referenced are not part of the Willamette Project, but owned and operated by Portland General Electric. In the Molalla and Calapooia populations, there are no Willamette Project dams. (NA = not available)

				Above and Below Willamette Project Dams				
ESU	Species	Population	Total Basin size (mi^2)	Percent population area lost above impassable dams (Mattson 1948)	Miles of mainstem tributary habitat downstream of lowermost impassable dam	Number of reservoirs & dams for smolts going downstream	Relative mortality in habitat below dams	Observed natural production downstream of dam(s)
UWR	Chinook	Clackamas	1503	<5	>60	2 (passable)	low	NA
		Molalla	1413	0	NA	0	NA	NA
		North Santiam	1184	>71	34	2	high	low
		South Santiam	1030	>85	36	2	medium	medium
		Calapooia	602	0	NA	0	NA	NA
		McKenzie	2092	>2	62	1	low	high
		Middle Fork	2172	98	17	4	high	low

7.2.2.2 Juvenile Rearing Habitat

Juvenile Chinook salmon require freshwater rearing areas with adequate flows and floodplain connectivity, water quality, forage, natural cover to support juvenile survival and growth and development. Juveniles also require safe passage through migration corridors to assure completion of the anadromous life cycle. As discussed in Chapter 5, in subbasins with Willamette Project dams (Coast Fork and Middle Fork Willamette, McKenzie, Long Tom, and South and North Santiam), operations alter the seasonal hydrograph and water temperatures, block the transport of gravel and large wood, and separate the channel from its floodplain. Flow operations also reduce the productivity of rearing habitat at the channel margins and ramping operations have the potential to strand and entrap fry in shallow areas. In subbasins without Project dams (Calapooia, Molalla, and Clackamas), revetments cause some of the same problems with respect to floodplain habitat and channel structure as flow operations, although these are relatively local in scale.

7.2.3 Actions Needed to Improve Population & ESU Viability & the Conservation Value of Critical Habitat

NMFS is consulting on the continued operation of the Willamette Project including the maintenance of 42 miles of revetments and the associated hatchery mitigation program, as described in Chapter 2. This section focuses on whether the Proposed Action addresses the effects of the Project by eliminating, reducing, or offsetting effects on UWR Chinook and the PCEs of critical habitat. The following is a subbasin-by-subbasin rationale for the major actions that would address the effects of the Project, based upon the assessment above and in Chapters 4 (historical effects of the Project) and 5 (effects of the Proposed Action). These actions are compared with those in the Proposed Action (Chapter 2).

Middle Fork Willamette

- The Middle Fork Willamette Chinook population is at a high risk of extinction. Key limiting factors include loss of access to 95% of the historical oversummering and spawning habitat above Willamette Project dams, elevated late-summer and fall temperatures in the mainstem below Dexter Dam and in the lower reaches of Fall Creek, and the risk of genetic introgression from hatchery-origin Chinook interbreeding with the natural-origin population.
- The limited spawning habitat below the dams does not produce significant numbers of Chinook due to the effects of elevated late-summer and fall temperatures (high prespawning and embryo mortality, premature hatching and emergence). *The Proposed Action does not include temperature control at these projects.*
- The existing facilities for trap and haul at Fall Creek and broodstock collection below Dexter Dam must improve so that more adult Chinook survive to spawn in the high quality habitat upstream. The Supplemental BA recognizes the need for these improvements, but *the Proposed Action does not include an implementation schedule.*
- Juvenile salmon survival through the reservoirs and dams must increase, but *the Proposed Action does not set an implementation schedule for downstream passage improvements at any of the Middle Fork projects.*

- Hills Creek Reservoir will continue to be managed to meet or exceed minimum outflows and Fall Creek and Dexter reservoirs will be managed to meet minimum and maximum outflows, protecting adult access to downstream spawning habitat, eggs deposited during spawning, and rearing habitat. These operations will depend on available reservoir storage and inflow and will be consistent with flood damage reduction and public safety requirements. The Proposed Action includes compliance and effectiveness monitoring for instream flows, *but insufficiently defines NMFS' role in ensuring that any changes in these objectives meet the habitat needs of anadromous fish*.
- Specific hourly and daily ramp-down rates will be followed at Hills Creek, Lookout Point, and Fall Creek dams to prevent desiccation of redds and entrapment and stranding of juvenile Chinook. These operations will be consistent with other project purposes such as those for flood damage reduction.

McKenzie

- The McKenzie Chinook population is at a moderate risk of extinction. It is currently the largest in the ESU, with thousands of natural-origin fish returning on average. At present, the risk of genetic introgression by hatchery-origin fish and the loss of access to historical habitat above Cougar Dam are the two key limiting factors for this population that are related to the Willamette Project.
- To protect and conserve genetic integrity within the natural-origin population, the percentage of hatchery-origin Chinook spawning with natural-origin fish must be reduced. The best location to remove hatchery fish is at Leaburg Dam, located downstream from the areas with the majority of the natural spawning. *The Proposed Action does not set an implementation schedule for constructing a trap at Leaburg Dam.*
- Historically, the South Fork of the McKenzie River produced a significant number of Chinook. All of this production was eliminated by the Willamette Project (Cougar Dam). Improvements to the adult trap-and-haul program and to downstream juvenile survival through the reservoir and dam will be necessary to sustain production over the long-term. The Proposed Action does include a commitment to build and operate a new adult trap at Cougar Dam during FY2008 (revised to 2009 due to change in construction schedule), but *does not include an implementation schedule for improving juvenile reservoir and project passage.*
- Historically, the spawning habitat in the South Fork McKenzie below Cougar Dam did not produce significant numbers of Chinook due to the effects of elevated late-summer and fall temperatures (high prespawning and embryo mortality, premature hatching and emergence). The USACE completed construction of a water temperature control tower at Cougar in December 2004 which has been fully operational since 2005. Under the Proposed Action, the Action Agencies will continue to operate the Cougar Water Temperature Control tower.
- Blue River Reservoir will continue to be managed to meet or exceed minimum outflows and Cougar Reservoir will be managed to meet minimum and maximum outflows, protecting adult access to downstream spawning habitat, eggs deposited during spawning, and rearing habitat. These operations will also depend on available reservoir storage and inflow and will be consistent with flood damage reduction and public safety requirements. The Proposed Action includes compliance and effective monitoring for instream flows, *but insufficiently*

defines NMFS' role in ensuring that any changes in these objectives meet the habitat needs of anadromous fish.

- Specific hourly and daily ramp-down rates will be followed at Blue River and Cougar dams to prevent desiccation of redds and entrapment and stranding of juvenile Chinook. These operations will be consistent with other project purposes such as those for flood damage reduction.

Calapooia

- The Calapooia Chinook population is at a high risk of extinction. The risk of genetic introgression due to a high proportion of hatchery strays spawning with natural-origin Chinook is a key limiting factor. However, all releases of hatchery-origin Chinook in the subbasin were discontinued after 2003.
- Habitat in the lower reaches is affected by revetments, which reduce the functioning of rearing habitat, but there are no Project dams in the subbasin.

South Santiam

- The South Santiam Chinook population is at a high risk of extinction. At present, the risk of genetic introgression by hatchery-origin fish, the loss of access to 85% of the historical habitat oversummering and spawning habitat above Foster and Green Peter dams, and elevated late-summer and fall water temperatures in the mainstem below Foster are the key limiting factors for this population that are related to the Willamette Project.
- The spawning habitat below the dams will not produce significant numbers of Chinook due to the effects of elevated late-summer and fall temperatures (high prespawning mortality, premature hatching and emergence). *The Proposed Action does not include temperature control at these projects.*
- The existing facilities for trap and haul at Foster Dam must improve so that more adult Chinook can reproduce successfully in the higher quality habitat upstream. The Supplemental BA (USACE 2007a) recognizes the need for rebuilding the Foster collection facility, but *the Proposed Action does not set an implementation schedule*.
- Juvenile Chinook survival through Foster Dam and reservoir must also increase, and passage at Green Peter must be evaluated. The Proposed Action includes continuation of a one-month spring spill program at Foster Dam, which provides higher survival than through the turbines, but *does not include measures to address reservoir and dam passage survival throughout the juvenile migration period*.
- Foster Reservoir will continue to be managed to meet minimum and maximum outflows, protecting adult access to downstream spawning habitat, eggs deposited during spawning, and rearing habitat. These operations will also depend on available reservoir storage and inflow and will be consistent with flood damage reduction and public safety requirements. The Proposed Action includes compliance and effective monitoring for instream flows, *but insufficiently defines NMFS' role in ensuring that any changes in these objectives meet the habitat needs of anadromous fish*.
- Specific hourly and daily ramp-down rates will be followed at Foster Dam to prevent desiccation of redds and entrapment and stranding of juvenile Chinook. These operations will be consistent with other project purposes such as flood damage reduction operations.

North Santiam

- The North Santiam Chinook population is at a high risk of extinction. The risk of genetic introgression by hatchery-origin fish, the loss of access to 71% of the historical habitat oversummering and spawning habitat above Big Cliff and Detroit dams, and elevated late-summer and fall temperatures in the mainstem below Big Cliff are the key limiting factors for this population that are related to the Willamette Project.
- Based on the number of miles available, the North Santiam River below Project dams has a high potential for re-establishing natural Chinook production. However, elevated late-summer and fall temperatures result in high prespawning and embryo mortality and premature hatching and emergence. *The Proposed Action does not include temperature control at these projects.*
- The existing facilities for broodstock collection and adult trap and haul at the Minto barrier dam must improve so that adult Chinook can be successfully outplanted in the higher quality habitat upstream. Under the Proposed Action, construction on an upgraded facility will begin in FY 2010.
- Concurrently, actions must be implemented to increase juvenile salmon survival through the Detroit and Big Cliff reservoirs and dams. The Proposed Action includes studies, but *without an implementation schedule for either the studies or for providing juvenile passage at either dam.*
- Big Cliff Reservoir will continue to be managed to meet minimum and maximum outflows, protecting adult access to downstream spawning habitat, eggs deposited during spawning, and rearing habitat. These operations will also depend on available reservoir storage and inflow and will be consistent with flood damage reduction and public safety requirements. The Proposed Action includes compliance and effective monitoring for instream flows, *but insufficiently defines NMFS' role in ensuring that any changes in these objectives meet the habitat needs of anadromous fish*.
- Specific hourly and daily ramp-down rates will be followed at Detroit Dam to prevent desiccation of redds and entrapment and stranding of juvenile Chinook. These operations will be consistent with other project purposes such as flood damage reduction operations.

Molalla

- The Molalla Chinook population is at a high risk of extinction. The risk of genetic introgression by an out-of-basin hatchery stock is a key limiting factor for this population.
- The most important short-term action that could be taken to increase the viability of this population is to eliminate the use of an out-of-population hatchery broodstock and then to implement a better designed supplementation program for 2-3 generations to boost spawning escapement. Eventually, the hatchery program would be discontinued so that the viability of the naturally-produced population could be determined in the absence of artificial propagation. This problem is *not addressed in the Proposed Action*.
- Habitat in the lower reaches is affected by revetments, which reduce the functioning of rearing habitat, but there are no Project dams in the subbasin.

Clackamas

- The Clackamas Chinook population is at a moderate risk of extinction.
- Habitat in the lower reaches is affected by revetments, which reduce the functioning of rearing habitat, but there are no Project dams in the subbasin.

Coast Fork Willamette

- The Coast Fork Willamette does not support an independent population of Chinook. Some outplanted hatchery-origin Chinook have successfully reproduced in Mosby Creek, a tributary to the Row River below Dorena Dam.
- Specific hourly and daily ramp-down rates will be followed at Cottage Grove and Dorena dams to protect juvenile outmigrants from Mosby Creek and juvenile rearing habitat in the lower reaches whenever possible, consistent with other project purposes such as flood damage reduction.

Long Tom

- Chinook use of the Long Tom is limited to juvenile Chinook rearing and overwintering.
- Specific hourly and daily ramp-down rates will be followed at Fern Ridge Dam to protect juvenile rearing habitat in the lower reaches whenever possible, consistent with other project purposes such as flood damage reduction.

Mainstem Willamette River

- The Proposed Action would continue to operate the Project to meet minimum and maximum mainstem flow objectives at Albany and Salem including both the statutorily authorized minimum flows for June through October and new “fish flow” objectives for April through June. Risks associated with meeting multiple uses for Willamette Basin flow and storage, including the needs of ESA-listed fish species, will be balanced during water years deemed as having “insufficient” or “deficit” volumes available.
- The Proposed Action would continue to adversely affect mainstem Willamette River Chinook rearing and migration habitat. Operation of the dams to control floods and maintaining revetments would continue to disconnect the floodplain from the mainstem river over most of its length. Aquatic habitat within the remaining stream channel is degraded by lack of complexity from large wood, sediment transport, and channelization.
- The Proposed Action includes an evaluation of floodplain restoration, but *does not include actions that would restore floodplain connections, protect the highest quality riparian habitat, or otherwise restore habitat quality in the mainstem.*
- The Proposed Action includes an evaluation of the biological impacts of revetments, but *without an implementation schedule for habitat improvement or restoration.*
- The Proposed Action includes an evaluation of the biological impacts of revetments, in the occupied subbasins and in the mainstem Willamette, but *without an implementation schedule for habitat improvement or restoration.*

Lower Columbia River, Estuary, Plume & Coastal Ocean

- Effects of the Proposed Action are limited to very small changes in river discharge with slight to negligible effects on flow-related fish habitat.

7.3 UWR STEELHEAD

7.3.1 Current Status

The four populations in the UWR steelhead DPS are currently at moderate risk of extinction (Figure 3-7). However, there are wide confidence intervals around the viability estimates for each population due to uncertainty in the data on their status (Section 3.2.2.3). Long-term trends in abundance suggest declining populations (Table 3-9), but short-term trends are positive (McElhany et al. 2007). The status of PCEs of designated critical habitat is poor, although the degree to which habitat is deficient varies among subbasins (see Tables 4.4-2, 4.5-5, 4.6-8, and 4.7-4).

7.3.2 Effects of the Proposed Action on Population Viability & PCEs of Critical Habitat

Significant differences in the life histories and habitat requirements of winter steelhead versus spring Chinook explain why the winter steelhead populations are in better shape with respect to viability. As described above, spring Chinook evolved using streams that receive substantial snowmelt from headwaters in the Cascade Mountains. They held and spawned in cold water, a component of their life-history now made difficult in several subbasins by Project dams without passage, altered thermal regimes below these dams, or both. In contrast, winter steelhead, migrate to their natal streams in late winter/early spring and spawn almost immediately. Spawning streams range in size from very small streams to larger rivers. With spawning and rearing distributed over a larger area, the adverse effects of Willamette Project influence a smaller proportion of each steelhead population's habitat than is the case for spring Chinook.

Two of the four steelhead populations in the Upper Willamette River DPS are directly affected by Willamette Project dams and reservoirs. The North Santiam and South Santiam are large watersheds, and the steelhead in these tributaries were identified as "core" populations by the WLCTRT. The other two subbasins supporting independent populations of UWR steelhead (Molalla and Calapooia) do not contain large, high-head, USACE dams, but experience minor effects of the Project due to maintenance of revetments.

The South Santiam steelhead population currently ranks as having the lowest risk of extinction in the DPS. The South Santiam has the largest amount of steelhead habitat volitionally accessible, with over 930 miles of stream habitat accessible below and above Foster Dam (Maher et al. 2005). Most of this spawning and juvenile rearing habitat is located in tributaries to the South Santiam River below the Project dams (Thomas, Crabtree, and Wiley creeks). In addition, the trap and haul program for natural-origin steelhead at Foster Dam has been in operation since the dam was constructed, which has allowed steelhead to use the historical habitat upstream for natural production. Even though the upstream passage facilities at Foster Dam need upgrading to reduce rates of injury and mortality (Section 4.5.3.1), some of these adults spawn successfully because significant numbers of steelhead smolts emigrate downstream. Improvements to the upstream and downstream passage facilities and operations at Foster Dam would increase the productivity of the natural-origin steelhead spawning in the upper South Santiam as well as the survival of kelts migrating back to the ocean.

In contrast, steelhead in the North Santiam only have access to about 400 miles of stream habitat, all below Detroit and Big Cliff dams. Almost 620 miles of historical stream habitat above Big Cliff/Detroit dams (Maher et al. 2005) are currently inaccessible, but no steelhead are passed upstream. Other than the mainstem below these dams, only one large tributary, the Little North Santiam River, provides significant steelhead habitat. The continued operation of the Willamette Project under the Proposed Action would continue to exclude steelhead from much of the historical habitat above Detroit/Big Cliff dams and to expose incubating eggs and young fry to colder water temperatures below the dams, which delays emergence and reduces growth.

The Molalla and Calapooia populations face a different suite of limiting factors and threats compared to those in the Santiam system (see Chapter 4 and ODFW 2007a). The Calapooia subbasin is relatively small and thus steelhead habitat is relatively limited. In addition, the lower elevations of the Calapooia are surrounded by agricultural land (Maher et al. 2005). Land management activities associated with timber harvest and agriculture are the primary threats to this population. A similar situation exists in the Molalla subbasin. However, the Molalla is a much larger watershed, which currently has over 870 miles of stream habitat available to steelhead (Maher et al. 2005) and therefore a much greater production potential. For both of these populations, protection of the highest quality remaining habitat, combined with habitat restoration, will be necessary to improve their status. Incidental fishery harvest rates (typically 1-3%, including hook-and-release mortality) are already reduced to a very low level.

7.3.3 Actions Needed to Improve Population & DPS Viability & the Conservation Value of Critical Habitat

This section focuses on whether the Proposed Action addresses the effects of the Project by eliminating, reducing or offsetting effects of UWR steelhead and the PCEs of critical habitat. The following is a subbasin-by-subbasin rationale for the major actions that would address the effects of the Project, based upon the assessment above and in Chapters 4 (historical effects of the Project) and 5 (effects of the Proposed Action). These actions are compared with those in the Proposed Action (Chapter 2).

Calapooia

- The Calapooia steelhead population is at a moderate risk of extinction.
- Habitat in the lower reaches is affected by revetments, but there are no Project dams in the subbasin.

South Santiam

- The South Santiam steelhead population is at a moderate risk of extinction and is one of the largest in the DPS. The trap and haul program at Foster Dam has allowed natural-origin fish to continue to use most of their historical upstream habitat (although approximately 17% remains blocked by Green Peter Dam).

- The ladder, trap, and methods for handling fish at the collection facility at Foster Dam cause delay, injury, and stress. These problems are compounded by the overlap in run timing of natural-origin steelhead with those of hatchery Chinook and steelhead. The facility therefore must be upgraded to allow more efficient capture and handling of listed steelhead. The Supplemental BA (USACE 2007a) recognizes the need for rebuilding the Foster Trap, but the Proposed Action *does not set an implementation schedule*.
- Actions must also be taken to increase downstream juvenile steelhead and kelt survival through Foster Reservoir and Dam. The Proposed Action includes continuation of a one-month spring spill program at Foster Dam, which provides higher survival than through the turbines, but *does not include measures to address reservoir and dam survival throughout the juvenile migration period and when kelts are likely to be moving downstream*.
- Colder than normal water temperatures during spring delay hatching and emergence of juvenile steelhead in the mainstem South Santiam below Foster. The Proposed Action *does not include temperature control at Green Peter or Foster Dam*.
- Foster Reservoir will continue to be managed to meet minimum and maximum outflows, protecting adult access to downstream spawning habitat and eggs deposited during spawning. These operations will depend on available reservoir storage and inflow and will be consistent with flood damage reduction and public safety requirements. The Proposed Action includes compliance and effectiveness monitoring for instream flows, *but insufficiently defines NMFS' role in ensuring that any changes in these objectives meet the habitat needs of anadromous fish*.
- Specific hourly and daily ramp-down rates will be followed at Foster to prevent entrapment and stranding of juvenile steelhead. These operations will be consistent with other project purposes such as flood damage reduction operations.
- The risks to population viability associated with the hatchery summer steelhead program must be reduced. The Proposed Action includes studies of the proportion of natural-origin juvenile steelhead that are the progeny of summer steelhead and a commitment to assess the summer steelhead recycling protocol, but lacks the specific measures needed to address these problems.

North Santiam

- The North Santiam steelhead population is currently at a moderate risk of extinction. Key threats and limiting factors related to the Willamette Project include loss of access to historical spawning and rearing habitat above Big Cliff/Detroit dams and risks associated with the out-of-basin summer steelhead hatchery program.
- Unmarked winter steelhead captured at Minto are released upstream of the barrier dam, but below Big Cliff. Cold water temperatures during spring delay hatching and emergence and elevated gas levels from flow operations can adversely affect the eggs, larvae, and fry. The Proposed Action *does not include temperature control at Detroit/Big Cliff dams or measures to reduce the frequency and duration of elevated gas levels*.
- At present, steelhead have not been reintroduced back into historical habitat blocked by Project dams. A risk/benefit assessment should be completed to assess whether reintroduction efforts would increase the viability of this population *but the Proposed Action does not include a commitment to this effort*.

- Big Cliff Reservoir will continue to be managed to meet minimum and maximum outflows, protecting adult access to downstream spawning habitat, eggs deposited during spawning, and rearing habitat. These operations will depend on available reservoir storage and inflow and will be consistent with flood damage reduction and public safety requirements. The Proposed Action includes compliance and effectiveness monitoring for instream flows, *but insufficiently defines NMFS' role in ensuring that any changes in these objectives meet the habitat needs of anadromous fish*.
- Specific hourly and daily ramp-down rates will be followed at Detroit Dam to prevent entrapment and stranding of juvenile steelhead. These operations will be consistent with other Project purposes such as flood damage operations.
- The risks to population viability associated with the hatchery summer steelhead program must be reduced. The Proposed Action includes studies of the proportion of natural-origin juvenile steelhead that are the progeny of summer steelhead and a commitment to scale back summer steelhead recycling efforts no later than 2008, which will reduce the potential for adverse interactions with native winter steelhead.

Molalla

- The Molalla steelhead population is at a moderate risk of extinction.
- Habitat in the lower reaches is affected by revetments, which reduce the functioning of rearing habitat, but there are no Project dams in the subbasin.

Mainstem Willamette River

- The Proposed Action would continue to operate the Project to meet minimum and maximum mainstem flow objectives at Albany and Salem including both the statutorily authorized minimum flows for June through October and new "fish flow" objectives for April through June. Risks associated with meeting multiple uses for Willamette Basin flow and storage, including the needs of ESA-listed fish species, will be balanced during water years deemed as having "insufficient" or "deficit" volumes available.
- The Proposed Action would continue to adversely affect mainstem Willamette River steelhead rearing and migration habitat. Operation of the dams to control floods and maintaining revetments would continue to disconnect the floodplain from the mainstem river over most of its length. Aquatic habitat within the remaining stream channel is degraded by lack of complexity from large wood, sediment transport, and channelization.
- The Proposed Action *does not include actions that would restore floodplain connections, protect the highest quality riparian habitat, or otherwise restore habitat quality in the mainstem*.
- The Proposed Action includes an evaluation of the biological impacts of revetments, in the occupied subbasin and in the mainstem Willamette, but *without an implementation schedule for habitat improvement or restoration*.

Lower Columbia River, Estuary, Plume, and Coastal Ocean

- Effects of the Proposed Action are limited to modest changes in river discharge and changes in flow-related fish habitat. While small, these effects affect all of the species considered in this Opinion, including UWR steelhead.

- Effects of the Proposed Action add to much larger effects of other water developments in the Columbia basin on fish and fish habitat in the lower Columbia River, estuary, and plume.

7.4 Summary of Effects of the Proposed Action on UWR Chinook Salmon & UWR Steelhead

The Proposed Action does not adequately address the effects of the Willamette Project on UWR Chinook or steelhead. Principal deficiencies are:

- Chinook and steelhead populations important to the viability of their respective ESU/DPSs will be limited to use degraded spawning and rearing habitat below Project dams where space, water temperatures, and physical habitat conditions do not meet the species biological requirements
- Inadequate plan for upgrading adult collection facilities
- No plan for developing adequate downstream passage facilities for juveniles of either species and for steelhead kelts
- Lack of measures to improve rearing habitat affected by Project revetments
- Inadequate plan for reducing straying of hatchery-origin UWR Chinook into the area reserved for natural production above Leaburg Dam in the McKenzie subbasin
- Lack of specific measures to address the adverse effects of the summer steelhead hatchery program on listed fish

NMFS considers these deficiencies in its jeopardy analyses for UWR Chinook and steelhead in Sections 8.1 and 8.2.

7.5 Summary of Effects of the Proposed Action on Critical Habitat for UWR Chinook and UWR Steelhead

The Proposed Action does not adequately address the effects of the Willamette Project on critical habitat for UWR Chinook or steelhead. Principal deficiencies are:

- Spawning and rearing habitat will not have adequate water quality, floodplain connectivity, forage, and natural cover for the conservation of the species
- Inadequate plan for providing safe passage at adult collection facilities
- No plan for developing safe downstream passage facilities for juveniles of either species
- Lack of measures to improve floodplain connectivity and natural cover in rearing habitat affected by Project revetments

NMFS considers these deficiencies in its adverse modification (of critical habitat) analyses for UWR Chinook and steelhead in Sections 8.1 and 8.2.

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Chapter 8
Conclusions

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8 CONCLUSIONS

The standards for determining jeopardy are set forth in Section 7(a)(2) of the ESA as defined by 50 C.F.R. Part 402 (the consultation regulations). Procedures for conducting consultation under section 7 of the ESA are further described in the Services' Consultation Handbook (USFWS and NMFS 1998). Jeopardy is defined as to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species. Therefore it must determined, (a) whether the species can be expected to survive with an adequate potential for recovery under the effects of the action, the effects of the environmental baseline, and any cumulative effects, and (b) whether affected designated critical habitat is likely to remain functional (or retain the ability to become functional) to serve the intended conservation role for the species in the near and long term under the effects of the action, environmental baseline and any cumulative effects.

The analysis in the preceding sections of this Biological Opinion forms the basis for conclusions as to whether the Proposed Action, the ongoing operation and maintenance of the Willamette Project, including the mitigation hatchery program and maintenance of 42 miles of revetments, satisfies the standards of ESA Section 7(a)(2). To satisfy those standards, the Proposed Action must not be likely to jeopardize the continued existence of any listed species or destroy or adversely modify the designated critical habitat of such species. Chapter 3 of this opinion defines the current status of each of the 13 listed salmonid species and the status of critical habitat designated for 12 of the salmonid species. Chapter 4 evaluates the condition of the environmental baseline. Chapter 5 describes the likely effects of the Proposed Action on habitat condition, critical habitat, and the abundance, productivity, spatial structure, and genetic diversity of populations in the action area. Chapter 6 considers the cumulative effects of relevant non-Federal actions reasonably certain to occur within the action area. Chapter 7 synthesizes all of the relevant information in the baseline, effects, and cumulative effects chapters to assess effects of the Proposed Action on the listed species as a whole across its range and life cycle, and effects on designated critical habitat. On the basis of this information and analysis, NMFS draws its conclusions about the effects of the Proposed Action for the Willamette Project on the likelihood of survival and recovery of the 13 listed salmonid species that occupy the action area, and the likelihood that the Proposed Action will destroy or adversely modify designated critical habitat.

8.1 UPPER WILLAMETTE RIVER CHINOOK SALMON

Currently, the UWR Chinook ESU is at a high risk of extinction. Numbers of natural-origin spawners are low and long- and short-term productivity trends are negative. Five of the seven populations are at a very high risk of extinction. Primary limiting factors have been flood control and hydropower, hatcheries, harvest, habitat degradation (tributary, mainstem, and estuarine), predation, and ocean and climate conditions. Total allowable harvest rates are 12% in the ocean and 15% in freshwater fisheries.

Within the freshwater portion of the action area, the species' viability (as described by the abundance, productivity, spatial structure, and genetic diversity of its component populations) has been limited by factors associated with the Willamette Project: flood control and hydropower operations have prevented access to historical habitat; water storage contracting has exacerbated poor habitat and altered natural water temperature patterns; and large numbers of hatchery-origin fish spawning with those of natural origin have created a risk of genetic introgression. Other threats include land use, especially the development of low elevation riparian areas for agriculture and urbanization and operations at FERC-licensed projects on the mainstem Santiam River and in the McKenzie basin. The former will continue into the future, although non-federal habitat-related actions and programs that NMFS has determined are reasonably certain to occur will minimize adverse effects. Conditions at the FERC projects are improving based on section 7 consultations in recent years.

Within the lower Columbia River and estuary (i.e., below the confluence of the Willamette), used for rearing by subyearling Chinook from this ESU, riparian and wetland functions have been reduced by Federal Columbia River Power System (FCRPS) flow management. The 2008 FCRPS RPA (NMFS 2008a) requires the implementation of habitat projects that address limiting factors (e.g., protecting and restoring riparian areas, protecting remaining high quality off-channel habitat, breaching or lowering dikes and levees to improve access to off-channel habitat, and reducing noxious weeds). The sport reward fishery for Northern pikeminnow will continue to control this predator, and Caspian terns will be relocated from the estuary. However, predation by other colonial waterbirds such as double-crested cormorants and by pinnipeds will continue. In the coastal ocean, ongoing private activities include construction and associated marine pollution.

Under the Proposed Action, many of the significant adverse effects on the species and its critical habitat in the freshwater portion of the action area, which contributed to its current high risk of extinction, will continue without providing needed measures including effective passage, or adequate temperature control. In addition, the Proposed Action will continue the adverse effects on the functioning of PCEs that have impaired the ability of critical habitat to serve its conservation role for the species. Therefore, NMFS concludes that the proposed operation of the Willamette Project and associated hatchery mitigation program are likely to jeopardize the continued existence of this ESU and to destroy or adversely modify its designated critical habitat.

8.2 UPPER WILLAMETTE RIVER STEELHEAD

Currently, the UWR steelhead DPS is at a moderate risk of extinction. Numbers of natural-origin spawners are moderate and short-term trends in productivity are upward. Primary limiting factors have been flood control and hydropower, hatcheries, harvest, habitat degradation (tributary, mainstem, and estuarine), predation, and ocean and climate conditions. Ocean harvest is assumed to be zero and less than 2% of natural-origin fish are harvested in freshwater.

Limiting factors and effects of the proposed action on the species and its habitat are similar to those described above for UWR Chinook salmon. In this case, two of the four populations occupy watersheds where habitat has been significantly degraded by Willamette Project operations. The Proposed Action will continue to prevent access to some of the important areas used historically for spawning, incubation, and larval growth and development and will impair of water quantity and quality. The Proposed Action will also continue hatchery practices that represent substantial risk to the development of self-sustaining populations. The improvements implemented under the Proposed Action will not provide needed measures including effective passage, or adequate temperature control.

When taking into account the current status of the species and its critical habitat, the degraded condition of the environmental baseline, and cumulative effects, the Proposed Action will not address the effects of the Willamette Project such that the DPS is likely to survive with an adequate potential for recovery. In addition, the Proposed Action will continue the adverse effects on the functioning of PCEs that have impaired the ability of critical habitat to serve its conservation role for the species. Therefore, NMFS concludes that the Proposed Action is likely to jeopardize the continued existence of this DPS and to destroy or adversely modify its designated critical habitat.

8.3 Lower Columbia River Steelhead, Chinook Salmon & Coho Salmon

All of the populations in these listed DPS and ESUs spawn outside the action area, but use the habitat in the lower Columbia River, from the confluence of the Willamette downstream to the estuary and plume, for rearing (for Lower Columbia River Chinook populations with subyearling migrants) and during their adult and juvenile migrations. Within the action area, the viability of these species has been limited by harvest, hatchery production, land management practices, the effects of the FCRPS, and the operations of other federally- and privately-owned hydroprojects, including water diversions and are further threatened by potential climate change and adverse ocean conditions (NMFS 2008a). With respect to the FCRPS, effects on these species are addressed by the 2008 FCRPS RPA (NMFS 2008a); many of the adverse effects of the FERC-licensed hydroprojects also have been addressed in recent consultations (Sections 3.2.3.1 through 3.2.3.3). Proposed Willamette Project flow operations could reduce the quantity and quality of rearing habitat in the lower river, estuary, and plume, including critical habitat designated for two of these species. These effects are likely to be minor because flows from the Willamette River are a relatively small proportion of those in the lower Columbia. Therefore, when taking into account the current status of the species and their critical habitat, the condition of the environmental baseline within the action area, and cumulative effects, NMFS concludes that the Proposed Action is not likely to jeopardize the continued existence of Lower Columbia River Chinook, steelhead, or coho salmon, nor adversely modify or destroy critical habitat designated for Lower Columbia River Chinook or steelhead.

8.4 Columbia River Chum Salmon

Columbia River chum salmon spawn outside the action area but use habitat in the lower Columbia River, from the confluence of the Willamette downstream to the estuary and plume for rearing and during their adult and juvenile migrations. Within the action area, the viability of the species has been limited by land management practices and the effects of the Federal Columbia River Power System (FCRPS), which have impaired water quality and quantity, forage, riparian vegetation, and space in estuarine areas used for growth and development. The species is threatened by potential climate change and adverse ocean conditions. The effects of the FCRPS are addressed by the 2008 FCRPS RPA (NMFS 2008a). Proposed Willamette Project flow operations could affect the quantity and quality of rearing habitat in the lower river, estuary, and plume, including designated critical habitat. These effects are likely to be minor because flows from the Willamette River are a relatively small proportion of those in the lower Columbia. Therefore, when taking into account the current status of the species and its critical habitat, the condition of the environmental baseline within the action area, and cumulative effects, NMFS concludes that the Proposed Action is not likely to jeopardize the continued existence of Columbia River chum salmon nor adversely modify or destroy its designated critical habitat.

8.5 MIDDLE COLUMBIA RIVER STEELHEAD

All of the populations in this DPS spawn outside the action area, but occupy the lower Columbia River, from the confluence of the Willamette downstream to the estuary and plume, during their adult and juvenile migrations. Within the action area, the viability of the species has been limited by land management activities and FCRPS operations (NMFS 2008a), which contributed to the loss of riparian cover. Steelhead are susceptible to predation by colonial waterbirds, fish, and pinnipeds, and the species is further threatened by potential climate change and adverse ocean conditions. Proposed Willamette Project flow operations could affect the quantity and quality of rearing habitat in the lower river, estuary, and plume, including designated critical habitat. These effects are likely to be minor because flows from the Willamette River are a relatively small proportion of those in the lower Columbia. Therefore, when taking into account the current status of the species and its critical habitat, the condition of the environmental baseline within the action area, and cumulative effects, NMFS concludes that the Proposed Action is not likely to jeopardize the continued existence of Middle Columbia River steelhead nor adversely modify or destroy its designated critical habitat.

8.6 SNAKE RIVER STEELHEAD, SPRING/SUMMER CHINOOK SALMON, FALL CHINOOK SALMON & SOCKEYE SALMON

All of the populations in these ESUs spawn outside the action area, but occupy the lower Columbia River in the action area from the mouth of the Willamette downstream to the estuary plume during their adult and juvenile migrations. Within the action area, the viability of the species has been limited by land management activities and FCRPS operations (addressed by the FCRPS RPA [NMFS 2008a]), which contributed to the loss of riparian function. Steelhead, Chinook, and sockeye are susceptible to predation by colonial waterbirds, fish, and pinnipeds, and these species are further threatened by potential climate change and adverse ocean conditions. Proposed Willamette Project operations could affect the quantity and quality of rearing habitat in the lower river, estuary, and plume, including designated critical habitat for these species, but these effects are likely to be minor because flows from the Willamette River are a relatively small proportion of those in the lower Columbia. Therefore, when taking into account the current status of the species and its critical habitat, the condition of the environmental baseline within the action area, and cumulative effects, NMFS concludes that the Proposed Action is not likely to jeopardize the continued existence of Snake River steelhead, sockeye salmon, spring/summer or fall Chinook salmon, nor adversely modify or destroy their designated critical habitat.

8.7 UPPER COLUMBIA RIVER STEELHEAD & CHINOOK SALMON

All of the populations in the Upper Columbia River steelhead DPS and Chinook ESU spawn outside the action area, but occupy the lower Columbia River, from the confluence of the Willamette downstream to the estuary and plume, during their adult and juvenile migrations. Within the action area, the viability of the species has been limited by land management activities and FCRPS operations (addressed by the 2008 FCRPS RPA [NMFS 2008a]), which contributed to the loss of riparian function. Steelhead and Chinook are susceptible to predation by colonial waterbirds, fish, and pinnipeds, and these species are further threatened by potential climate change and adverse ocean conditions. Proposed Willamette Project flow operations could affect the quantity and quality of rearing habitat in the lower river, estuary, and plume, including designated critical habitat. These effects are likely to be minor because flows from the Willamette River are a relatively small proportion of those in the lower Columbia. Therefore, when taking into account the current status of the species and their critical habitat, the condition of the environmental baseline within the action area, and cumulative effects, NMFS concludes that the Proposed Action is not likely to jeopardize the continued existence of Upper Columbia River steelhead or Chinook salmon nor adversely modify or destroy their designated critical habitat.

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Chapter 9
Reasonable & Prudent Alternative

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9 REASONABLE & PRUDENT ALTERNATIVE

INTRODUCTION

In Section 8, NMFS concluded that the Proposed Action would jeopardize the continued existence of UWR Chinook salmon and UWR steelhead, and destroy or adversely modify their designated critical habitat. NMFS reached no jeopardy and no adverse modification conclusions for the 11 other listed salmonid species, and NLAAs for green sturgeon and southern resident killer whale. Therefore, NMFS is providing the Action Agencies with the following reasonable and prudent alternative (RPA) to avoid jeopardizing the continued existence of UWR Chinook salmon and UWR steelhead, and avoid destroying or adversely modifying their critical habitat, as required by ESA section 7(b)(3)(A).

An RPA is an action, identified during formal consultation, that can be carried out consistent with the purpose of the action, is within the scope of the action agency's legal authority, is economically and technologically feasible, and would avoid jeopardy to listed species and the destruction or adverse modification of designated critical habitats (50 CFR 402.02). The measures NMFS is providing in the RPA fit the regulatory requirements of an RPA. The measures fall into the general categories of substantive measures for fish passage, water quality, flows, water contracts, habitat, and hatcheries. There are also measures for coordination, studies, and monitoring related to the substantive measures. These measures have time frames for each action. The RPA measures are within the project purposes because fish and wildlife protection is a project purpose. The Action Agencies have legal authority to carry out these measures because the statutes that authorize the project include project purposes for fish and wildlife protection, and in some cases already include specific provisions for some of the measures.

These general categories of the measures in the RPA, fish passage, water quality, flow, water contracts, habitat, and hatcheries, are all measures in the PA that, when considered with the environmental baseline and cumulative effects and the rangewide status of UWR Chinook salmon and UWR steelhead, did not result in survival with an adequate potential for recovery for these species. In addition, they were inadequate to avoid the destruction or adverse modification of designated critical habitat. NMFS' RPA includes the measures in the PA, adds new measures, and modifies others in the PA. A general concept behind most of NMFS additional measures and modifications is to build on the studies in the PA by adding on-the-ground measures that the Action Agencies will complete to address Project effects on listed anadromous fish. Therefore, NMFS' RPA specifically lists measures that the Action Agencies will carry out after the necessary studies and designs are completed to verify feasibility. NMFS' assessment of effects regarding the RPA's avoidance of jeopardy and destruction or adverse modification of critical habitat is based on the benefits attributed to successful completion of these measures.

Structural and operational changes at Project dams and improvements in Action Agency programs that affect salmonid habitat downstream of the dams and that allow upstream and downstream fish passage are needed to address the effects of the Willamette Project, thereby increasing the viability of the affected populations and the functioning of the PCEs of their designated critical habitat. Specifically, construction and operation of new facilities for effective up- and downstream fish passage at Project dams, installation of water temperature control

(WTC) at Project dams, more normative discharge patterns downstream of these dams, mitigation of ongoing effects of the dams and continued existence and maintenance of revetments on the physical characteristics of downstream salmonid habitats, and hatchery programs more strongly focused on species conservation, are needed to address project effects on listed fish in multiple subbasins. The Action Agencies' proposed measures in the PA provide improvements to the existing system and operations, but do not adequately address project effects on listed fish and their habitat. Many of those measures lacked deadlines for beginning and completing work. This lack of certainty and specificity was one of the reasons that NMFS made the jeopardy and adverse modification of critical habitat determinations in Section 8. Another reason was that there were not enough specific on-the-ground measures to adequately address project effects and avoid jeopardy and destruction and adverse modification of critical habitat. In order to assure timely progress toward implementing critical on-the-ground actions, NMFS' RPA establishes deadlines for completing studies, structural and operational improvements at the dams and hatcheries, and for implementing habitat restoration programs. Specific projects are identified that must be completed in the short term, while other, larger projects must be completed during later years of the term of the Opinion. In the RPA, certain specific fish passage and temperature control measures will be completed by 2023, the end of the Opinion term. Additionally, significant progress will be made toward identifying future passage and temperature control measures that could be implemented after 2023 under a subsequent consultation.

A number of the RPA measures will provide benefits in the short-term, reducing each species' short-term risk of extinction, including measures to improve downstream habitat by changing flows and temperature, updating hatchery operations and facilities, improving irrigation diversions and water contracts, upgrading fish collection facilities and outplanting procedures, and conducting habitat improvement projects. These measures will immediately (during the first one-to-seven years of this Opinion) improve population viability and reduce the short-term risk of extinction. This is especially important for UWR Chinook salmon, for which the risk of extinction is "high."[1] Project operations have had a key role in degrading habitat conditions downstream, which in the North and South Santiam, South Fork McKenzie, and Middle Fork Willamette are the only areas still accessible to Chinook for spawning, incubation, and early rearing. The Action Agencies began new reservoir operations in 2000 to meet mainstem and tributary flow objectives for both listed Chinook and steelhead. These, and operations that began in 2005 at the new Water Temperature Control facility at Cougar Dam, are already able to have a positive influence on adult Chinook returns. Under the RPA, interim temperature control operations at Detroit will improve water temperatures in the North Santiam, increasing the survival of eggs, juveniles, and pre-spawning adults of both species and thus population productivity. All of these measures will reduce extinction risk in the short term as well as contributing to long-term viability.

Decision-making for all of the final actions and implementation of measures included in the RPA must comply with all applicable statutes and regulations. Among those the Action Agencies must consider are NEPA, the Clean Water Act and the Northwest Power Planning Act. In so doing, the criteria the Action Agencies will apply are whether the action is: (1) biologically feasible and

[1] The WLCTRT (McElhany et al. 2007) estimated the risk of extinction over 100 years for UWR Chinook ("high;" see Figure 3-5 in Section 3.2.1.3). The TRT did not estimate the species' short-term extinction risk.

beneficial; (2) technically feasible; and (3) cost effective. These criteria would not necessarily apply to interim decision points and to information gathering requirements. In addition, the Action Agencies' Configuration/Operation Planning (COP) study process will outline the costs of specific projects, their biological benefits, and a reasonable array of potential alternatives to achieve the desired results.

The measures in this RPA are additive to the Action Agencies' Proposed Action (USACE 2007a). That is, the two sets of measures combined create the complete RPA that NMFS will analyze. For the sake of brevity, the RPA measures provided below only include measures that are not in the PA, and PA measures that are changed in some way. In the event there are inconsistencies between the PA and RPA, this RPA will take precedence.

9.1 COORDINATION

The RPA measures in this section are based on Section 3.1 of the Supplemental BA (USACE 2007a). In that section, the Action Agencies propose to organize the WATER group, prepare a charter, and establish various subcommittees. In recent years, the USACE has informally coordinated flow management and project operation issues with other federal agencies, state agencies, local government, and other organizations, but there were no guidelines for how this coordination should take place or what would happen if technical participants could not agree. The Action Agencies proposed the WATER group to formalize this process and to ensure consistent coordination and decision-making. NMFS supports the Action Agencies' proposal, but we include it here with minor revisions to clarify the decision-making process and agency roles. This clarification is needed in the RPA because most of the actions that will be taken to avoid and minimize effects on listed salmonids and critical habitat rely on either in-season management (mainstem and tributary flows, response to emergency operations), review of RM&E studies (e.g., downstream fish passage measures) and review of engineering design alternatives (e.g., adult fish collection facilities, temperature control facilities. In order to ensure these ongoing decisions are implemented in a fashion consistent with the analysis in this Opinion, the following measures are needed:

RPA 1 Coordination

1.1 **Charter of WATER: By December, 2008, the Action Agencies, in coordination with the Services, other federal and state agencies with fisheries and water resource management responsibilities in the Willamette River Basin, and affected Tribes, will complete a Charter for a collaborative advisory body to be known as the Willamette Action Team for Ecosystem Restoration (WATER). Once the Charter is completed, the Action Agencies will coordinate with the WATER on operation of the Willamette Project consistent with the Charter. The WATER will be a formalized, collaborative body to advise the Action Agencies in the coordinated implementation of the environmental protection and conservation measures described in the Proposed Action, RPA, and other actions that may develop while operating the project.**

Rationale/Effect of RPA 1.1: This measure clarifies that the Action Agencies and the Services, other federal agencies, state agencies, and tribes will complete a charter for WATER by December, 2008, and will operate according to the charter. The Proposed Action had stated it would be done within one year of completion of the Supplemental BA (i.e., by June 2008), but that date has now passed.

The effect of this measure will be to improve and inform the Action Agencies' and Services' decision making, provide a forum for various points of view, share scientific and technical information, and coordinate actions by the parties. This coordination and sharing of information will ultimately reduce the time needed to address the effects of the Project on population viability and the functioning of PCEs of designated critical habitat.

1.2 **<u>Technical Sub-Committees of WATER</u>: The Action Agencies will establish technical coordinating committees as part of the WATER to provide review and recommendations of Action Agencies' products. Technical experts from applicable state agencies and the Tribes may participate on committees based on the subject matter of each committee and the scope of each organization's respective areas of responsibility and expertise. Other parties may participate on the subcommittees depending on the subject area and agreement by the Action Agencies and Services. The number, responsibilities, and scope of the technical committees formed will be determined by the Action Agencies and the Services through development of a charter for WATER. However, at a minimum, these will address flow management; fish passage and hatchery management; environmental coordination for construction projects; water quality/temperature control; habitat restoration; and research, monitoring, and evaluation.**

Rationale/Effect of RPA 1.2: NMFS adds this measure in place of the detailed description of each subcommittee proposed by the Action Agencies in Section 3.1 and Figure 3-1 of the Supplemental BA (USACE 2007a). The specific number, function, and membership of each subcommittee should be developed through development of the charter rather than pre-supposed in the Proposed Action. While NMFS encourages active participation by a variety of organizations and individuals on these issues, timely decisions on fish protection measures such as fish passage facilities and necessary RM&E to support those decisions need to be made by entities with fish management authority. The charter must be clear that the committees will play an advisory role only and will not replace the Action Agencies' responsibilities to carry out measures required by the Proposed Action and this RPA.

1.3 **<u>WATER Decision-Making Process</u>: The Action Agencies will ensure that the Charter for WATER and its technical coordinating committees describes a decision-making process that recognizes the unique role played by NMFS and USFWS in decisions related to measures covered in their respective Biological Opinions. In this process, the Action Agencies will prepare initial proposals for operations, studies, or structural changes and will seek review and comment by the applicable WATER subcommittee. Committee members, including NMFS and USFWS, will provide feedback to the Action Agencies within a maximum 60-day period, or less,**

depending on the magnitude and complexity of the proposal. The Action Agencies will then modify the proposal as they determine necessary to address committee members' comments and to meet their ESA responsibilities. NMFS or USFWS (or both, depending on the subject and what species might be affected) will review the final document and inform the Action Agencies whether they agree with it. If NMFS or USFWS disagrees with a proposal based on concerns that the proposal may adversely affect species within their respective authorities or be inconsistent with their respective Biological Opinions[2], the Action Agencies will either modify the proposal to address the Services' concerns, elevate the decision following a process described in the Charter, or seek reinitiation of consultation.

Rationale/Effect of RPA 1.3: This measure specifies that the WATER process must use this decision-making process to ensure that measures required by this Opinion are carried out effectively and in a timely manner, with adequate opportunity for review and comment. The Action Agencies retain ultimate responsibility for completing required actions. Adaptive management decisions need to be made with written supporting documentation. NMFS and USFWS will inform the Action Agencies whether they agree or disagree with the decisions, or if specific decisions are inconsistent with their respective Opinions. If the NMFS or FWS disagree, the Action Agencies must either modify decisions, seek dispute resolution, or reinitiate consultation.

1.4 <u>**Role of Services in decision-making (agreement with Action Agencies):**</u> **The Action Agencies will provide NMFS, USFWS, or both, as appropriate depending on the action and species affected, with draft documents for comment. The Action Agencies will address comments received from NMFS and USFWS when finalizing a document. If the Services do not agree with the final document, then they will elevate the issues for resolution, if appropriate.**

Rationale/Effect of RPA 1.4: This new measure is needed to clarify that the Services play a unique role during the implementation phase of measures required by their respective Opinions. Unlike many other Section 7 ESA consultations that address specific, short-term projects and that require specific mitigation measures that are used during and directly after construction, this consultation involves many measures that are not clearly defined yet and are awaiting study results and design feasibility analyses before specific decisions can be made. For instance, in the fish passage measures below (section 9.4), NMFS requires that downstream fish passage be carried out at Cougar Dam by a specific year, but until field studies are completed and design alternatives analyzed, NMFS cannot predict what sort of system or set of operations this will be. NMFS anticipates that it will be closely involved in review of all facets of these studies and analyses to ensure that decisions made are consistent with the statement and intent of this Opinion. The effect of this dispute resolution provision will be to preserve both the Action Agencies' and Services' authorities.

[2] This measure does not broaden either of the Services authority to engage in issues outside of each agency's authority, except that it does provide for both agencies to engage in issues that affect species listed by both agencies.

9.2 FLOW MANAGEMENT

The measures in this section are based on Section 3.3 of the Supplemental BA (USACE 2007a). In that section, the Action Agencies propose to do the following: 1) organize a Flow Management Committee of the WATER group; 2) develop a protocol for notification when Project operations cause deviations from flow and ramping objectives; 3) operate to make every effort to meet or exceed minimum mainstem Willamette flow objectives; 4) operate to make every effort to meet or exceed minimum tributary flow objectives; 5) operate to follow hourly and daily ramp-down rates under normal operating conditions; 6) release spill at Foster Dam during spring for downstream fish passage; and 7) develop and carry out a comprehensive RM&E program to evaluate and monitor these flow management actions.

NMFS generally supports the Action Agencies' flow management proposals, but the following measures are needed to improve the decision-making process, increase the likelihood and frequency of meeting flow and ramping rate objectives, and define agency roles. This clarification is needed in the RPA because most of the actions that will be taken in the short-term to avoid and minimize effects on listed salmonids rely on either in-season management (mainstem and tributary flows, response to emergency operations), review of RM&E studies (e.g., downstream fish passage measures) and review of engineering design alternatives (e.g., adult fish collection facilities, temperature control facilities).

RPA 2 Flow Management

2.1 **<u>WATER Flow Management Committee</u>: The USACE will establish a Flow Management (FM) Committee under WATER to advise USACE on streamflow management issues related to operation and maintenance of the Willamette Project. The USACE will take a leadership role in the administration of this committee, providing for coordination, administration costs, and meeting space. The USACE, with review by the FM Committee, will develop and implement the annual Willamette Conservation Plan,[3] and coordinate on all issues related to listed fish with the Services and with Federal and state agencies, Tribes, and entities throughout each flow management season.**

Rationale/Effect of RPA 2.1: This measure modifies a similar action described in section 3.3.3 of the Supplemental BA (USACE 2007a) by assigning responsibility for managing and funding the committee to the USACE. The role of the committee is advisory to the USACE. Coordination throughout the flow management season should maximize benefits to listed fish, consistent with authorized Project purposes and giving due consideration to the relative importance of each.

The effect of this measure will be to improve decision-making regarding flow management and ensure that the USACE will operate the Project to minimize adverse Project effects on listed fish, consistent with other authorized Project purposes.

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[3] The Annual Willamette Conservation Plan is reviewed and revised each year. It describes minimum and maximum mainstem and tributary flow objectives that guide the Action Agencies' operation of the 13-dam Willamette Project, and it includes specific operational priorities for the given year.

Indirectly, this measure will help improve survival of juvenile and adult fish during migration through the mainstem Willamette and Project-affected tributaries by ensuring that timely decisions regarding Project flow releases are made and issues quickly resolved during in-season management. Likewise, this measure will help improve productivity of UWR Chinook salmon and UWR steelhead that spawn below Project dams by ensuring that local biologists are queried to provide real-time data regarding fish presence and that timely decisions are made to reduce impacts to redds once adults have spawned.

2.2 **Protocol for Notification of Deviations:** **The Action Agencies will notify the Services when turbine units, regulating outlets, and spillway gates malfunction or are placed out of service for an emergency which results in an unscheduled outage that may have an impact on ESA-listed fish species. The Action Agencies will follow the notification protocol described in RPA measure 4.3 (Willamette Fish Operations Plan) below.**

Rationale/Effect of RPA 2.2: This measure is described in RPA measure 4.3 below.

2.3 **Minimum Mainstem Flow Objectives:** **The USACE will operate the system in a manner to meet or exceed minimum mainstem flow objectives listed in Table 9.2-1 as measured at Salem and Albany, Oregon, following the framework described in Appendix D and in collaboration with the Services and other entities as provided in RPA measures 1 and 2.1. Based on RM&E results (RPA measure 9 in section 9.9 below) and operational experience, and with the approval of the Services and review by the FM Committee, the USACE will amend mainstem flow objectives (Table 9.2-1) in its Annual Willamette Conservation Plan.**

Rationale/Effect of RPA 2.3: This measure is based on a similar action described in section 3.3.5 of the Supplemental BA (USACE 2007a). The minimum mainstem flow objectives are the same as in the Proposed Action, and NMFS adopts Appendix D, which recognizes that these flow objectives will likely not be met in water years that are not “adequate” or “abundant” as defined in Appendix D. The primary difference from the Proposed Action measure is that this measure requires approval by the Services of any changes in Table 9.2-1 flow objectives, while the Proposed Action simply required the Action Agencies to consider recommendations from NMFS and other FM Committee members.

The effect of this measure is that it will better ensure adequate flows for UWR Chinook salmon and UWR steelhead that migrate and rear in the mainstem Willamette River than provided by the Proposed Action. In the Mainstem Willamette Effects section 5.10, NMFS found that the proposed mainstem flow objectives were sufficient based on existing data. These flow objectives would be expected to aid downstream migration of juvenile steelhead by reducing the likelihood of disease outbreaks based on flow and water temperature relationships. Additionally, minimum flow objectives during summer months would provide water quality benefits to rearing juvenile Chinook and steelhead and upstream migrating adult Chinook. However, NMFS noted that additional data are needed to better define fish flow needs in the mainstem Willamette. This measure gives the Services approval authority over any proposed changes in the flow objectives. In the event that the RM&E studies required by measure 9 in section 9.9 indicate that different flow objectives should be established, the Action Agencies and NMFS would work together to identify flow objectives that protect ESA-listed fish species and their critical habitats.

Table 9.2-1 Mainstem Willamette Flow Objectives for "Adequate" & "Abundant" Years.[1]

TIME PERIOD	7-DAY MOVING AVERAGE [2] MINIMUM FLOW AT SALEM (CFS) USGS 14191000[4]	INSTANTANEOUS MINIMUM FLOW AT SALEM (CFS) USGS 14191000	MINIMUM FLOW AT ALBANY (CFS) [3] USGS 14174000[5]
April 1 - 30	17,800	14,300	---
May 1 - 31	15,000	12,000	---
June 1 - 15	13,000	10,500	4,500 [3]
June 16 - 30	8,700	7,000	4,500 [3]
July 1 - 31	---	6,000 [3]	4,500 [3]
August 1 - 15	---	6,000 [3]	5,000 [3]
August 16 - 31	---	6,500 [3]	5,000 [3]
September 1 - 30	---	7,000 [3]	5,000 [3]
October 1 - 31	---	7,000	5,000

[1] Appendix D defines "Adequate" and "Abundant" water years, and also describes how flow objectives can be decreased in "Deficit" water years.
[2] An average of the mean daily flows in cubic feet per second (cfs) observed over the prior 7-day period.
[3] Congressionally authorized minimum flows (House Document 531). September flows were extended into October.
[4] USGS gage 14191000 Willamette River at Salem, OR
[5] USGS gage 14174000 Willamette River at Albany, OR

2.4 **Tributary Flow Objectives –Project Release Minimums: The USACE will operate Willamette project dams as described in this subsection to meet or exceed minimum tributary flow objectives listed in Table 9.2-2 to ensure adult fish access to existing spawning habitat below USACE dams, protect eggs deposited during spawning, and provide juvenile rearing and adult holding habitat for listed salmonids and other fishes within system constraints described in Appendix D. If, during annual operations, the system of Willamette Projects is unable to meet both mainstem and tributary flow objectives, the Action Agencies will notify NMFS and will coordinate through WATER to determine a suitable course of action to protect priority fish habitat needs. Consistent with Appendix D, USACE will operate to meet interim draft limits.**

Rationale/Effect of RPA 2.4: This measure is based on a similar action described in section 3.3.6 of the Supplemental BA (USACE 2007a). The minimum and maximum tributary flow objectives are the same as in the Proposed Action. NMFS also recognizes that it will not be possible to meet these flow objectives under all hydrologic conditions.

However, NMFS does not agree with the Action Agencies that other project purposes (i.e. recreation), as expressed by the proposed drafting priority (Table 2-6, in Chapter 2), should take priority over meeting tributary and mainstem flow objectives. For this reason, we include RPA measure 2.4.4 to identify opportunities to manage available water resources in a manner that improves the likelihood of providing flows known to be protective of salmon and steelhead and their critical habitats (see Section 5.5.2.1). The primary difference from the Proposed Action measure is that this measure emphasizes the fisheries objectives for these flows. This measure also requires the Action Agencies to notify NMFS when they are unable to meet both mainstem and tributary flow objectives, and emphasizes that NMFS will provide guidance on fish protection priorities.

The effect of this measure is that it will better ensure adequate flows for UWR Chinook salmon and UWR steelhead that migrate and rear in Project-affected tributaries (Middle Fork Willamette, McKenzie, South Santiam, and North Santiam subbasins) than provided by the Proposed Action. In the various Effects sections for these subbasins (sections 5.2 through 5.6), NMFS found that the proposed tributary flow objectives were sufficient based on existing data. However, NMFS noted that flows released from Project dams for fish protection purposes should be protected throughout the tributary reaches where such flows are needed for spawning, rearing, holding or migration. The Proposed Action limits the Action Agencies' obligation to flow rates at the lowermost Project dam on each tributary, but does not establish flow requirements for reaches downstream from the dams to the mouth of the tributaries because the Action Agencies do not have enforcement authority over water diversions. NMFS adds sub-measures 2.4.1 through 2.4.4 below to address this issue for the lower tributary reaches. Studies required by RPA measure 2.10 below will guide decisions to modify these flow objectives to better protect ESA-listed fish species.

Table 9.2-2 Minimum & Maximum Tributary Flow Objectives below Willamette Dams (USACE 2007a; Donner 2008)

DAM	PERIOD	PRIMARY USE	MINIMUM FLOW (CFS) [1]	PERCENT OF TIME FLOW IS EQUALED OR EXCEEDED[4]	MAXIMUM FLOW (CFS) [2]	PERCENT OF TIME FLOW IS EQUALED OR EXCEEDED[4]
Hills Creek	Sep 1 - Jan 31	Migration & rearing	400	99.9		
	Feb 1 - Aug 31	Rearing	400	99.9		
Fall Creek	Sep 1 - Oct 15	Chinook spawning	200	95	400 through Sep 30, when possible	25
	Oct 16 - Jan 31	Chinook incubation	50 [3]	99.9		
	Feb 1 - Mar 31	Rearing	50	99.9		
	Apr 1 - May 31	Rearing	80	99.9		
	Jun 1 - Jun 30	Rearing/adult migration	80	99.9		
	Jul 1 - Aug 31	Rearing	80	95		
Dexter	Sep 1 - Oct 15	Chinook spawning	1200	99.9	3,500 through Sep 30, when possible	10

DAM	PERIOD	PRIMARY USE	MINIMUM FLOW (CFS) [1]	PERCENT OF TIME FLOW IS EQUALED OR EXCEEDED[4]	MAXIMUM FLOW (CFS) [2]	PERCENT OF TIME FLOW IS EQUALED OR EXCEEDED[4]
	Oct 16 - Jan 31	Chinook incubation	1200 [3]	99.9		
	Feb 1 - June 30	Rearing	1200	99.9		
	Jul 1 - Aug 31	Rearing	1200	99.9		
Big Cliff	Sep 1 - Oct 15	Chinook spawning	1500	95	3,000 through Sep 30, when possible	5
	Oct 16 - Jan 31	Chinook incubation	1200 [3]	98		
	Feb 1 - Mar 15	Rearing/adult migration	1000	99.9		
	Mar 16 - May	Steelhead spawning	1500	99.9	3,000	25
	Jun 1 – Jul 15	Steelhead incubation	1200 [3]	99.9		
	Jul 16 - Aug 31	Rearing	1000	99.9		
Foster	Sep 1 - Oct 15	Chinook spawning	1500	75	3,000 through Sep 30, when possible	1
	Oct 16 - Jan 31	Chinook incubation	1100 [3]	80		
	Feb 1 - Mar 15	Rearing	800	95		
	Mar 16 - May	Steelhead spawning	1500	80	3,000	30
	May 16 - Jun 30	Steelhead incubation	1100 [3]	95		
	Jul 1 - Aug 31	Rearing	800	99		
Blue River	Sep 1 - Oct 15	Chinook spawning	50	99.9		
	Oct 16 - Jan 31	Chinook incubation	50	99.9		
	Feb 1 - Aug 31	Rearing	50	99.9		
Cougar	Sep 1 - Oct 15	Chinook spawning	300	99.9	580 through Sep 30, when possible	60
	Oct 16 - Jan 31	Chinook incubation	300	99.9		
	Feb 1 - May 31	Rearing	300	99.9		
	Jun 1 - Jun 30	Rearing/adult migration	400	99.9		
	Jul 1 - Jul 31	Rearing	300	99.9		
	Aug 1 - Aug 31	Rearing	300	99.9		

[1] When a reservoir is at or below minimum conservation pool elevation, the minimum outflow will equal inflow or the congressionally authorized minimum flows, whichever is higher.
[2] Maximum flows are intended to minimize the potential for spawning to occur in stream areas that might subsequently be dewatered at the specified minimum flow during incubation.
[3] The USACE will attempt to avoid prolonged releases in excess of the recommended maximum spawning season discharge to avoid spawning in areas that would require high incubation flows that would be difficult to achieve and maintain throughout the incubation period. When maximum flow objectives are exceeded for a period of 72 hours or longer, the WATER Flow Management Committee will review available monitoring information (e.g., regarding redd deposition in relation to flow rates), projected runoff, and reservoir storage, and will formulate a recommendation for an appropriate and sustainable incubation flow rate prior to the initiation of the subsequent incubation period.
[4] Flow duration estimates are based on HEC-ResSim model output data for the Biop operation. Period of Record of model data is Water Years 1936-2004.

In order to improve the likelihood of meeting tributary minimum flow objectives, the Action Agencies will complete the following actions:

2.4.1 **Lower River Gages: The USACE will establish and operate gage stations at locations near the mouths of the tributaries listed below in this paragraph, by July 1, 2009, and will operate the stations through the term of this Opinion to develop relationships between release flows and gage flows. The plan will initially assess the adequacy of existing gages, if any, and need for new gages where none exist, in the lower reaches of the**

- **North Santiam River**
- **South Santiam River**
- **McKenzie River**
- **Middle Fork Willamette River below Dexter**
- **Middle Fork Willamette River below Hills Creek, and**
- **Fall Creek**

The need for each gage will be determined based on fish use of lower river habitat and number of consumptive water diversions in each tributary. The USACE will complete a plan identifying the number and specific location of existing and new gages that are needed, in coordination with and review by the Services,[4] by January 1, 2009. At a minimum, river stage and water temperature will be measured at those sites where gages are needed. Stage-flow relationships will be developed and maintained for accuracy. Unless good cause is given, USACE will work with U.S. Geological Survey to ensure that these stations will be part of the USGS' water data program and maintained in USGS' Real-Time data system.

Rationale/Effect of RPA 2.4.1: This measure is not in the Proposed Action. NMFS includes it here as a first step in determining whether flows released from Project dams are available for fish habitat needs in downstream tributary reaches. Presently, minimum flow targets are set at the dam, but biologically, they are needed throughout the reach. For example, if Project release flows in a given tributary are only needed for adult fish spawning in the first mile below the dam, then it is likely that those release flows are available throughout that one mile reach. On the other hand, if Project release flows are intended to provide juvenile rearing habitat in the tributary from the dam all the way downstream to its confluence with the Willamette River, then it is possible that existing, proposed, and future consumptive water users may divert these flows, resulting in inadequate habitat for juvenile rearing (or other fish habitat needs, depending on the tributary, specific reach, and species and life stages present).

NMFS acknowledges that the Action Agencies are not authorized to enforce State water rights. However, if data obtained from stream gages indicates that flows

[4] See RPA 1.3 & 1.4 for elaboration of decision making process.

are lower than needed in specific tributary reaches, then the Action Agencies could modify flow releases at dams in those tributaries to compensate consumptive water withdrawals. (See RPA 2.4.3 and 2.4.4 for this subsequent action).

The effect of this measure is that the lower river gages will allow the Action Agencies to correlate dam releases to downstream flows, such that in the future, dam releases could be adjusted, if necessary, to ensure sufficient flows are provided to the reaches where they are needed for fish spawning, rearing, passage, and holding.

2.4.2 <u>Tributary Instream Flow Studies</u>**: In coordination with the Services, the Action Agencies will develop a detailed study plan by December 2008 to conduct instream flow studies in 2009 and 2010. The primary goal of these studies will be to identify the relationships between river flow rates and habitat conditions for adult passage, holding, and spawning and juvenile rearing in the following tributaries: N. Santiam, S. Santiam, Fall Creek, Middle Fork Willamette, SF McKenzie, and McKenzie (listed in priority order).**

Rationale/Effect of RPA 2.4.2: As noted above in RPA 2.4 and 2.4.1, existing tributary minimum flow objectives are based on the best available data, but that in most of the tributaries, flow requirements are based on protecting a single life stage in a specific reach, such as steelhead spawning in a few miles below a Project dam. Incomplete information exists regarding fish flow needs for other life history stages when Chinook salmon and steelhead spend time in the tributaries, such as adult holding, juvenile rearing, and adult and juvenile migration. These studies need to take place in the first few years of the Opinion's term to determine fish flow needs for all life stages that use the tributaries. This information can then be used in Project operational modeling, as described in RPA 2.4.3 below, to determine if storage water is available in Project reservoirs to release needed fish flows, or if not, how reservoir operations could be optimized to best protect salmon and steelhead. Additionally, the study information would be used with gage data from RPA 2.4.1 to determine if Project release flow objectives are adequate to meet fish flow needs in lower tributary reaches.

The effect of this measure, when considered together with RPA measures 2.4.1, 2.4.3, and 2.4.4, will be to improve flow management for fish habitat needs based on current scientific analyses.

2.4.3 <u>Revise Minimum Flow Objectives Table</u>**: Following completion of the studies specified in RPA measure 2.4.2 above, the USACE, in coordination with the Services, will determine if the minimum and maximum flow objectives in Table 9.2-2 are appropriate. If the studies suggest that fish protection goals can be better met with different flow levels than those specified in Table 9.2-2, then USACE, consistent with 2.4.4 below, will recommend any changes in**

flow objectives in applicable tributaries to improve benefits to listed fish while continuing to meet Project purposes. The Services will inform the USACE whether they agree[5] with the modified flow objectives. By January 2011, the USACE will revise its annual water management plan to include the revised flow objectives indicated by studies in RPA measure 2.4.2, provided these flows are acceptable to the Services and that the flows can be released from Project reservoirs within existing system constraints. By January 2011, the USACE will use these flow objectives in operating the Project to the extent possible.

Rationale/Effect of RPA 2.4.3: This measure is the logical progression from RPA measures 2.4.1 and 2.4.2, by using information collected from stream gauging and instream flow studies to revise Table 9.2-2 and the annual water management plan. NMFS recognizes, however, that the flow studies may indicate the need for flow levels that could drain reservoirs and create conflicts with other Project purposes and subsequent instream water needs. For this reason, NMFS does not expect that the Action Agencies will be able to carry out preferred fish flows throughout the basin by 2011. Instead, NMFS intends that this measure will require the Action Agencies to develop a revised plan that identifies fish flow objectives, while recognizing that these flows may not be met at all times in all hydrologic conditions.

The effect of this measure will be to provide improved flows by providing guidance for flow management for fish habitat needs.

2.4.4 **<u>Modify Project Operations</u>: Following completion of the studies specified in RPA measure 2.4.2 above and determination of revised minimum flow objectives as described in RPA measure 2.4.3 above, the USACE will complete system operational modeling and NEPA analyses, if appropriate, including consideration of all project purposes, to identify modified project operations that optimize dam operations to best meet tributary and mainstem minimum flows needed to protect fish. The USACE will conduct these analyses as high-priority element of the COP (RPA measure 4.13 below). The USACE will carry out alternatives deemed feasible, as selected by the COP analysis, by January 2012.**

Rationale/Effect of RPA 2.4.4: This measure completes the studies and management plan revisions that are required by RPA measures 2.4.1, 2.4.2, and 2.4.3. These analyses will be a high priority in the COP because the information is needed to ensure that existing flow objectives are providing the expected fish benefits and, if needed, to identify alternative operations that could more effectively achieve the same benefits. The cost of the outcomes of the analyses should not require large capital investments. The purpose of this measure is to direct the USACE to complete evaluations, such as system operational modeling

[5] See RPA 1.3 & 1.4 for elaboration of decision making process.

and NEPA analyses, if necessary, to determine how to best meet revised tributary and mainstem flow objectives for fish, consistent with authorized Project purposes, and to revise system operations accordingly. By allowing an optimization routine to operate the system without arbitrary drafting priorities (see Table 2-6, in Chapter 2), the flow objectives would be met more frequently.

The effect of this analysis is to ensure that project operations are designed to manage available water resources in a manner that best protects anadromous fish and their critical habitats. This measure may require the completion of a NEPA analysis.

2.5 **Tributary Flows –Project Release Maximums:** **During winter steelhead and spring Chinook salmon spawning seasons, the USACE will maintain tributary flows below the specified maximum flow objectives listed in Table 9.2-2 to the extent practical when the reservoirs are below their respective rule curves. The USACE will notify the Services when maximum flow rates are exceeded according to the protocol described in measure 2.2 above.**

Rationale/Effect of RPA 2.5: This measure is similar to a related measure in section 3.3.6 of the Supplemental BA (USACE 2007a). The only difference is that this measure makes clear that the USACE will notify the Services when maximum flow objectives are exceeded. This notification is necessary to provide NMFS the opportunity to conduct a site evaluation to assess whether the high flows are causing adverse effects to listed fish and if so, to propose emergency measures to minimize these effects.

The effect of this measure is to avoid high tributary flows during spawning seasons to prevent fish from spawning at relatively high channel elevations that would likely be dewatered later in the season when flows drop. This measure will reduce the likelihood of redd desiccation and improve egg-to-fry survival.

2.6 **Ramping Rates:** **When project outflows are less than those in Table 9.2-3, the USACE will restrict down-ramping (the rate at which outflows are decreased) to the hourly and daily rates listed in Table 9.2-4 to minimize stranding of juvenile fish and aquatic invertebrates and desiccation of redds. NMFS' goal is for down-ramping rates not to exceed 0.1 ft/hour during nighttime hours and 0.2 ft/hour during daytime hours. Table 9.2-4 shows the increment of flow estimated to achieve a 0.1 ft/hour nighttime and 0.2 ft/hour daytime rampdown rates for a range of outflow rates.**

2.6.1 **When system operations or equipment limits prevent USACE from meeting rampdown rates at all projects, USACE will place priority on achieving ramping rates at those projects marked in Table 9.2-4 as high priority for fish protection.**

2.6.2 **The USACE will identify mechanical, operational, or equipment modifications needed to achieve these ramping rates. The Action Agencies**

will evaluate structural modifications in the COP[6] study, where indicated, to improve their ability to meet ramping rates.

2.6.3 **During active flood damage reduction operations, the USACE may deviate from the ramping rates in Table 9.2-4. However, the USACE will comply again with these ramping rates as soon as the flood risk has abated. The USACE must follow the protocol for deviations from Table 9.2-4 described in RPA measures 2.2 and 4.3.**

2.6.4 **As noted in RPA measure 2.10 below, the Action Agencies will conduct research, monitoring and evaluation of ramping rate restrictions to determine if the Table 9.2-4 ramping rates are effectively protecting fish and macroinvertebrates from stranding and redds from dewatering. Additionally, these studies will assess the effect of higher ramping rates that are presently permitted at flows greater than those in Table 9.2-3, to determine if these higher ramping rates are causing harm to ESA-listed fish or the critical habitat on which they depend. The Action Agencies will recommend appropriate changes to applicable ramping rates in Table 9.2-4 if indicated by results of the studies and consistent with authorized Project purposes. The Services will inform the Action Agencies whether they agree[7] with the modified ramping rates. The Action Agencies will implement modified ramping rates as soon as studies are completed, but no later than January 2011.**

Table 9.2-3 Project outflow rates: below these rates, down-ramping limits in Table 9.2-4 apply.

PROJECT	PROJECT OUTFLOW (CFS)
Hills Creek	1500
Dexter	3000
Fall Creek	700
Dorena	1000
Cottage Grove	800
Cougar	1200
Blue River	700
Fern Ridge	300
Foster	2000
Detroit	2000

[6] (C)onfigurations (O)peration (P)lan is Action Agencies' study and feasibility process described in section 9.4.
[7] See RPA 1.3 & 1.4 for elaboration of decision making process.

Table 9.2-4 Maximum Ramping Rates During Flow Level Changes below Upper Willamette Basin Dams (cfs)

Nighttime Rampdown Rates to Achieve 0.1 ft/hour [1, 2, 4, 5, 6]

HCR[5]		LOP[5]		FAL[5]		DOR		COT		CGR[5]		BLU[5]		FRN		FOS[5]		DET[5]	
Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change
400		1200		50				50		400		50		30		800		1000	
600	60 [3]	1500	125	100	20 [3]	100		300	30 [3]	500	80 [3]	250	30 [3]	80	20 [3]	900	100	1200	100
1000	75 [3]	2000	145	300	40 [3]	500	50 [3]	500	40 [3]	1200	100 [3]	500	50 [3]	150	30 [3]	1900	150	1500	110
1500	90 [3]	2500	150	500	50	1000	60 [3]	800	50	2400	150	700	60 [3]	300	40	2000	155	2000	130
1700	100	3000	170	700	60	3700	100					2300	100	1000	50				

Highlighted flows are higher than the minimum flows needed to protect ESA species, but are included to represent the lowest flow rate at which 0.1 ft/hr ramp rate is currently possible at these dams.

Daytime Rampdown Rates to Achieve 0.2 ft/hour [1, 2, 4, 5, 6]

HCR[5]		LOP[5]		FAL[5]		DOR		COT		CGR[5]		BLU[5]		FRN		FOS[5]		DET[5]	
Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change
400		1200		50				50		400		50		30		800		1000	
600	120	1500	250	100	40 [3]	100		300	60	500	160	250	60 [3]	80	40	900	200	1200	200
1000	150	2000	290	300	80	500	100	500	80	1200	200	500	100	150	60	1900	300	1500	220
1500	180	2500	300	500	100	1000	120	800	100			700	120	300	80	2000	310	2000	260
		3000	340	700	120									1000	100				

[1] Avoid a flow volume reduction of more than 50% per hour or the lesser of 1 foot or 50% per 24 hours. Ramping listed are decrements in release that approximately yield the resulting change in flow of 0.1 foot/hour or 0.2 foot/hour.
[2] Operations prevent USACE from meeting rampdown rates at all projects, USACE will place priority on achieving ramp rates at these projects noted as high priority for fish protection.
[3] USACE cannot achieve ramping rates at low flows due to adjustment limits of existing equipment.
[4] NMFS prefers using 0.1 ft/hour during all hours from January 1 through March 31 because mostly fry-aged fish are present then and are less able to avoid ramping effects.
[5] High priority because of the presence of ESA listed salmon and steelhead. Rates listed are for reservoir operation other than when reducing project outflow to manage for downstream flood damage reduction.
[6] Change in flow at flows higher than those listed are less critical for protecting ESA species because of proportionally smaller flow volume change.

Rationale/Effect of RPA 2.6: The objective of this measure is to minimize project effects of entrapment and stranding of juvenile salmon and steelhead in Project-affected tributaries, and to minimize the adverse effects of Project-caused discharge fluctuations on stream biota. Unregulated rivers rarely have drops in stage in excess of two inches per hour (except during floods) whereas regulated rivers can have greater and more frequent stage changes. Thus, aquatic life is not well adapted to stage drops in excess of one or two inches per hour. Fish stranding is one of the greatest negative impacts of excessive stage change. The incidence of stranding is affected by fish size, species, time of day, substrate type, channel contour, magnitude of flow change, and rate of flow change (Hunter 1992). Redd dewatering, reduced invertebrate productivity, fish emigration, and exclusion from spawning habitat can also occur. These are all adverse effects to critical habitat as well as to population numbers.

Measure 2.6.1 recognizes that equipment limits at some of the dams prevents the USACE from making fine adjustments to reservoir discharge, particularly at very low flows. This limits their ability to guarantee that they will meet ramping rate limits specified in Table 9.2-4 at all times. Despite these restrictions, the Action Agencies will to make every effort to meet the Table 9.2-4 ramping rates within existing equipment restrictions, as stated in the Proposed Action.

NMFS includes Measure 2.6.2 to require the Action Agencies to identify modifications that could be made to existing equipment and operations to enable them to meet Table 9.2-4 ramping rates at low flows. The list of modifications should be evaluated in the COP study to identify priorities for making such changes and to seek funding for this work.

Measure 2.6.3 is necessary because during high flow periods, the risk of floods increases, and the Action Agencies need more flexibility to quickly modify reservoir discharges to minimize flood risk. This extra flexibility will not harm UWR Chinook salmon and UWR steelhead because down-ramping at high flows is less likely to cause fish to strand and redds to be dewatered than downramping at lower flows. This reduced impact results from the general relationship that at high flows, large decreases in flows can result in relatively small changes in water depth, while at low flows, a change in flow can result in relatively large changes in water depth, increasing the risk of fish stranding. During flood damage reduction operations, the USACE will attempt to meet the Table 9.2-4 ramp rates, but will not be required to meet these rates.

Measure 2.6.4 references flow-related RM&E actions that are necessary as part of the RPA and Proposed Action. Project-specific ramping rate studies have not been done at Willamette Project dams, and the extent of stranding over a range of ramping rates has not been determined. These RM&Es are needed to assess whether the Table 9.2-4 ramping rates are effectively preventing fish stranding and other harm to stream biota, as well as to determine if assumptions regarding reduced risk at higher flow levels and during flood operations are valid. This measure includes a process that the Action Agencies will use to modify ramping rates and flows at which they apply, if indicated by study results.

The effect of measure 2.6 and its subcategories, 2.6.1 through 2.6.4 is that these measures will minimize entrapment and stranding of UWR Chinook salmon and UWR steelhead juvenile fish and dewatering of their redds in Project-affected tributaries and will minimize the adverse effects of Project-caused discharge fluctuations on stream biota and critical habitat. Actions will be taken to correct existing equipment that prevents the Action Agencies from meeting Table 9.2-4 ramping rates at very low flows, and studies will evaluate the effectiveness of these ramping rates and may identify revised rates that will further reduce fish entrapment and stranding. Structural modifications and changes to ramping rates will be considered and carried out where feasible and necessary to minimize adverse effects on ESA-listed fish.

2.7 **Environmental Flow[8]/Pulse Flow Components: The Action Agencies will work through the WATER Flow Management Committee and with the Services, and other aquatic scientists with expertise in Willamette basin fish ecology and fluvial geomorphology, and stakeholders, to identify environmental flow improvement opportunities for the mainstem Willamette River and the lower reaches of tributaries with USACE dams. The Action Agencies will design, test, and carry out modifications to flow releases from USACE dams to improve channel morphology in a manner that would create and sustain new, and improve existing, fish habitat through changes in project operations, while still addressing other authorized Project purposes. For each tributary, the process will begin by identifying fluvial morphology components[9] important to ESA-listed salmonids and other biota that are currently underrepresented in the watershed. Following identification of these morphological conditions, the Action Agencies will examine the potential for improving these conditions through modification of project operations, as the Sustainable Rivers Project has done for the Middle Fork Willamette River in an effort summarized by Gregory et al. (2007). The Action Agencies will identify weak or missing morphological characteristics and, where feasible, will incorporate remedies to these conditions into one or more flow modification proposals. The Action Agencies will then submit proposals to the Flow Management Committee of WATER, which will recommend adjustments, if appropriate. The Services will inform the Action Agencies if they agree with the proposals. The Action Agencies will then carry out these flow modification proposals, initially as pilot studies and then, if determined feasible, as part of its regular water management operations. The Action Agencies will monitor the effectiveness of each environmental flow operation at achieving specific ecological objectives beneficial to ESA-listed**

[8] "Environmental flows" are used in this context to refer to a full range of pulses or high flows that accomplish various fish habitat maintenance and creation through mechanisms such as sediment distribution, channel forming processes, overbank flows, maintaining access to side or off-channel habitat.
[9] Such components may include appropriate seasons, magnitudes, durations, or rates of change in specific components of the annual hydrograph, including fall transition flows, small fall pulses in flow, winter bankfull flow pulses, small or larger floods above bankfull river levels, spring pulse flows, spring-to-summer transitions in flow, and summer baseflows.

salmonids and/or other aquatic biota. The Action Agencies will complete appropriate NEPA evaluation for alternatives being considered

Flow changes that may result from this measure could fall into one of three implementation types: (1) flow volume and timing adjustments that are within the operational flexibility of the USACE under current project authorizations and water control manuals; (2) larger scale adjustments that may fall within current operational flexibility and authority but whose implementation requires detailed evaluation of tradeoffs; and (3) major changes in operation which are clearly outside of the USACE's operational discretion and would require a thorough feasibility evaluation and possible reauthorization action. The USACE will begin implementing proposals for Type 1 environmental flow modifications on the lower Middle Fork Willamette, below Dexter Dam, in FY 2009, and explore with the Services and the Flow Management Committee of WATER any needs and opportunities to implement Type 2 or 3 flow modifications there in subsequent years. The Action Agencies will develop and carry out proposals for environmental flow modifications below other USACE dams in the Willamette Basin during the term of this Biological Opinion, with priorities among rivers identified by the Flow Management Committee. Within this period, a full effort will be made to optimize USACE management of flows in the tributaries and mainstem so as to achieve improved fish habitat benefits that are not incompatible with other purposes of the dams.

Rationale/Effect of RPA 2.7: Natural patterns of variation in flow exert significant influence on the habitat and ecology of UWR Chinook, UWR steelhead, and other aquatic organisms native to the Willamette Basin. Flow alteration by the system of USACE dams in the Willamette Basin has contributed to profound changes in the freshwater habitat of UWR Chinook and UWR steelhead. Requirements elsewhere in this Biological Opinion for seasonal minimums and maximums in flow, and for limits on down-ramp rates, do not fully address historical changes to natural patterns of variation in flow or to channel forming flows that may at present constrain the abundance and productivity of these ESA-listed anadromous fish.

The effect of this measure is to initially make minor improvements to existing spawning and juvenile rearing habitat downstream of Dexter Dam in the Middle Fork Willamette and below Dorena and Cottage Grove in the Coast Fork Willamette River. As the Action Agencies begin to release Type 1 flow modifications in other Project-affected subbasins, there will also be minor improvements to existing spawning and juvenile rearing habitat due to increased flushing of sediments, cleaning out small particles and moving new gravels into usable habitat. Over the next 15 years, Type 2 and possibly Type 3 flow modifications that will be carried out in the Middle Fork Willamette and at Project dams in other subbasins will improve or create and sustain new juvenile rearing habitat in complex habitat, side channels, or other morphological features. These actions will increase available rearing habitat and make existing spawning and rearing habitat below Project dams more suitable, resulting in increased productivity and abundance. Adverse effects on critical habitat in reaches below dams will be reduced because this measure will improve existing rearing and spawning habitat and may create and maintain new rearing habitat.

2.8 <u>Foster Spring Spill:</u> **The USACE will continue to spill at Foster Dam between 0.5 and 1.5 feet of water (approximately 92 to 238 cfs), depending upon inflow and forebay elevation fluctuations, over the spillway fish weir[10]. This operation will occur from 0600 through 2100 hours daily during the primary fish passage season, April 15 through May 15. The Action Agencies will evaluate the effectiveness of this operation on downstream fish passage as part of RM&E (RPA measure 2.10) and COP studies (RPA measure 4.13). Based on the results of these studies, the Action Agencies will recommend modifications to this spill operation or new downstream fish passage facilities or operations. If modified operations are warranted and can be carried out within existing physical and operational constraints, the Action Agencies will begin to carry out these operations consistent with RPA measure 4.8, Interim Downstream Fish Passage. If more extensive modifications are needed, the Action Agencies will follow the process described in the COP study, RPA measure 4.13.**

Rationale/Effect of RPA 2.8: This measure would continue an existing spill program that provides better downstream juvenile steelhead passage survival than turbine passage at Foster Dam (see South Santiam Baseline section 4.5.3.1). Although based on a similar action described in section 3.3.8 of the Supplemental BA (USACE 2007a), NMFS includes a requirement that this measure be evaluated as part of the RM&E (RPA measure 2.10) and COP studies (RPA measure 4.13), and that the Action Agencies will modify this measure if indicated by study results.

The effect of this spill operation will be improved survival of juvenile steelhead, and likely Chinook salmon, emigrating from above Foster Dam as a result of the outplanting program.

2.9 <u>Protecting Stored Water Released for Fish</u>**: In coordination with the OWRD and ODFW, the Action Agencies will facilitate conversion of stored water to an instream flow water right. Oregon adopted minimum perennial streamflows for Willamette tributaries in Oregon's Willamette Basin Program (Table 1 in ORS 690-502). After being converted to water rights under Oregon law, OWRD can protect the minimum perennial stream flows from illegal diversion. The State of Oregon is solely responsible for administering and enforcing state water rights.**

Additionally, the Action Agencies will identify stored water in addition to the minimum perennial streamflows that could be allocated from reservoirs to enhance salmon and steelhead survival. The Action Agencies will proceed with necessary actions to allocate and protect water for this purpose. In particular, USACE and

[10] To provide a measure of downstream fish passage, Foster dam employs an overflow weir immediately upstream of one tainter gate (which is raised, out of service, when the fish weir is employed). This fish weir provides a surface oriented flow that better attracts and conveys fish than turbine flow.

Reclamation will coordinate with OWRD on several tasks to accomplish this measure: 1) identify current water storage at USACE reservoirs that could be allocated to instream flow for ESA listed fish; 2) determine how to legally transfer flow for instream purposes; and 3) proceed with the necessary analyses to implement the agreed upon transfers. The tasks necessary to accomplish this action may require approval from Congress. This effort will begin immediately. By the end of 2009, the Action Agencies will have coordinated with all appropriate agencies and determined the path forward in order to accomplish this action.

Rationale/Effect of RPA 2.9: Water use and development in the Willamette basin are expected to continue to grow, making it very important to preserve adequate water for fish, particularly in the tributaries. Although the Action Agencies have agreed to release minimum flows from Project dams to support fish life in tributary reaches, they cannot guarantee that these flows will be maintained throughout the reach because the State (OWRD), not the Action Agencies, has enforcement authority over water rights. Current Oregon water law allows holders of natural flow water rights in the Willamette basin to divert stored water released from Project dams when this water is not obligated by existing Reclamation contracts. Thus, even though the Action Agencies intend for some of the stored water that is released to provide fish benefits, OWRD is not authorized to protect these flows from diversion by water users because this water is not currently obligated by a contract. In early 2008, NMFS participated in staff-level meetings with OWRD, Reclamation, BPA, and USACE to identify available mechanisms for protecting these minimum flow releases for fish purposes. As a result of these meetings, the Action Agencies agreed to investigate and carry out steps to achieve this purpose of protecting a certain amount of stream flows for fish. The exact steps that the Action Agencies will take have yet to be determined, but they must first request from OWRD a transfer of portions of the existing irrigation storage water rights to another use, such as multi-purpose or fish protection.

The effect of this measure is that the flows released from Project dams for fish protection purposes will remain instream and provide intended biological benefits. Although the Action Agencies cannot guarantee what action the State of Oregon may take, this measure requires the Action Agencies to take steps within their authorities to protect these flows.

2.10 **<u>Flow Related Research, Monitoring and Evaluation</u>: As part of the RM&E plan described in RPA measure 9 below, the Action Agencies will plan and carry out studies and monitoring of mainstem and tributary flow rates and Project ramping rate restrictions necessary to protect fish and aquatic habitat, as well as other evaluations required by measures in this section. The flow and ramping rate studies will be considered high priority and field studies should begin in 2009, with initial results available to inform modified flows and ramping rates by January 2011.**

Rationale/Effect of RPA 2.10: This measure is needed to evaluate the effectiveness of mainstem and tributary flows, ramping rate restrictions, and other flow-related measures such as Foster Spring Spill (RPA measure 2.8). Flow and ramping rate evaluations are high priority studies because they will provide the information necessary to identify any necessary changes in project operations to protect UWR Chinook salmon and UWR steelhead. If studies indicate that different flows or ramping rates would be more effective at protecting fish, then the Action Agencies could carry out such changes as quickly as possible to ensure fish protection during this interim period.

The effect of this measure is that study results will be used to modify project operations and flows to improve UWR Chinook salmon and UWR steelhead survival in the tributaries below Project dams and in the mainstem Willamette River. Life stages affected will be fry and juveniles from stranding, smolting juveniles during migration, adults during migration and holding, and eggs in redds from dewatering associated with Project ramping.

9.3 WATER CONTRACT PROGRAM

One of the authorized purposes of the Willamette Project is the distribution of stored water to users who have contracts with Reclamation for irrigation use. As described in Effects Section 5.1, diversion of water to serve these contracts can adversely affect UWR Chinook and UWR steelhead by reducing the amount of stream flow available for use by all life stages and by entraining juveniles into water diversions. These RPA measures are intended to minimize the effects of diverting water served by Reclamation contracts on listed species by limiting the volume of new contracts that can be issued, requiring existing contract diversions to install screens and other fish passage devices within specified timeframe, requiring screening of all new contract diversions, ensuring that water released to serve contracts does not diminish water available to meet minimum flow objectives, and reducing the volume of stored water diverted to contract holders in low water years to ensure minimum objectives are met. These measures will also minimize destruction and adverse modification of critical habitat due to water diversions because they limit the total amount of water that can be diverted and require fish protection measures at the diversions.

RPA 3 Bureau of Reclamation Water Contract Program

Reclamation and the USACE will continue the existing irrigation contract water marketing program for the Willamette Project. Reclamation will issue new contracts, except as specified in RPA measure 3.1 below regarding new contracts in the N. and S. Santiam subbasins, and provided that the total water marketing program, including existing contracts, does not exceed a total of 95,000 acre feet. In the event that future irrigation demand exceeds 95,000 acre-feet, Reclamation and the USACE will reevaluate the availability of water from conservation storage for the water marketing program and reinitiate consultation with the Services if they propose to issue additional contracts.

In addition, all contracts will be subject to the availability of water, as determined by USACE. Therefore water may not be available for some or all of each year in order to meet ESA requirements and other project obligations for instream flows (e.g. minimum flows to protect water quality). Reclamation

may issue notices, orders, rules, or regulations governing water service as necessary to comply with the requirements of the ESA, including appropriate biological opinions and Incidental Take Statements.

Rationale/Effect of RPA 3: This measure builds on a similar action described in section 3.9 of the Supplemental BA (USACE 2007a). NMFS describes the effects of the Action Agencies' Proposed Action in the General Effects Section 5.1. In that section, NMFS finds that in most years and in most of the Project-affected tributaries, sufficient water is available to meet fish flow needs and still supply a water marketing program of up to 95,000 acre-feet and that Reclamation's contract language affords it the ability to curtail irrigation water deliveries when insufficient water is available to meet both instream flow needs and irrigation demand. (Measure 3.1 addresses NMFS' finding that there is insufficient water available to meet both fish flow and contract needs in the North Santiam and South Santiam rivers in most years). This measure specifies that as new contracts are issued and existing ones are renewed, Reclamation must make sure that the total amount of contracted water stays at or below 95,000 acre-feet. If future demand is for more than the existing total, then Reclamation and USACE must reinitiate consultation prior to issuing contracts that would exceed the 95,000-acre-foot limit.

The effect of this measure is to ensure that adequate water is available for possible use for protection of listed fish in the tributaries and mainstem Willamette. This measure also minimizes adverse effects on critical habitat by providing enough water so that minimum flows needed for properly functioning habitat are not precluded by the contract program.

3.1 **New Contract Issuance: Reclamation will not issue irrigation water service contracts in the North Santiam River and the South Santiam River that would in total exceed the current total of 11,574 ac ft (85 cfs) and 1,096 ac ft (7 cfs) respectively.**

The USACE will update its flow exceedance models (similar to Appendix C of the Supplemental BA; USACE 2007a) every five years, and, together with results of fish flow studies, determine whether additional water is available during most years for new irrigation contracts based on this information. If, based on these analyses and other information, the USACE determines that additional water is available to serve irrigation demand (beyond the volumes specified above) without adversely affecting listed fish and their critical habitats, then the USACE will inform Reclamation and seek the written agreement of the Services. The Services will inform the USACE in writing whether they agree[11] with the USACE's determination. If the result of this process is an affirmative determination that additional water is available, Reclamation may issue new contracts based on and limited by the USACE's determination.

Rationale/Effect of RPA 3.1*:* NMFS includes this measure to prevent further reductions in streamflow in the North and South Santiam rivers until and unless a showing is made

[11] See RPA 1.3 & 1.4 for elaboration of decision making process.

that additional water is available. The North and Santiam rivers are core population areas for UWR Chinook and UWR steelhead. As described in RPA 2.4, tributary minimum flows are needed to provide adequate rearing, spawning, holding and migration habitat for UWR Chinook salmon and UWR steelhead. Analysis conducted by the USACE and summarized in tables 5.5-2 (South Santiam Effects section) and 5.6-1 (North Santiam Effects section) indicates that minimum tributary flows are not met during certain months of the year. In the South Santiam, USACE estimates a 25% chance of not meeting the 1500 cfs minimum flow for Chinook spawning from September 1 through October 15, a 20% chance of not meeting the 1100 cfs Chinook incubation flows from October 16 through January 31, and a 20% chance of not meeting the 1500 cfs steelhead spawning flows from March 16 through May 15. In the North Santiam, Chinook spawning flows of 1500 cfs are not likely to be met about 5% of the time.

Additionally, as described in the North Santiam Effects section 5.6.2.1 and in RPA measure 2.4 (tributary minimum flows), the Action Agencies release minimum flows at the dams, but have no authority to enforce these minimums through tributary reaches. In the North Santiam, although the chance of not meeting summer rearing flows of 1000 from July 16 through August 31 is less than or equal to 1% at Big Cliff Dam, the likelihood that this flow will be sustained through the reach downstream to the confluence with the South Santiam is low. OWRD has issued water rights for up to 2,730 cfs from the N. Santiam River between Big Cliff Dam and the South Santiam confluence (about half of which is used for hydroelectric power and affects a short stretch of river). While total diversions seldom if ever reach this total permitted amount, diminished flows have been identified as a limiting factor for UWR Chinook and UWR steelhead in the basin.

Based on this information, it is clear that permitting additional water to be diverted from the stream would further reduce the likelihood of meeting minimum flows and result in less habitat available for rearing, spawning, and incubation. Because OWRD has determined that natural flow is unavailable in the North Santiam River, this curtailment of further water service contract issuance effectively protects the river from further flow reduction.

The effect of this measure is that streamflow in the North and South Santiam rivers would not be further reduced by diversions permitted with new Reclamation contracts. This measure would not improve fish habitat, but it would prevent further degradation. The amount of rearing habitat available to juvenile UWR Chinook and steelhead would continue to be reduced from points of diversion serviced by contracts to the confluence of the mainstem Santiam River with the Willamette during July and August of each year.

3.2 **Existing Contracts: All existing contracted diversions will be required, as a condition of continuing to receive project water, to have fish protection devices that comply with NMFS design criteria, and are approved by NMFS.[12] While this clause is primarily about fish screens, it is not limited to fish screening. Based on the**

[12] Projects that have had, within the last 15 years, site-specific ESA Section 7 consultations performed with respect to fish protection devices are deemed compliant.

effect of the diversion on anadromous fish, fish protection devices could include upstream passage at dams, exclusion of fish from irrigation water return channels, and other fish hazards presented by water diversion practices. Contractors that do not comply with Reclamation's notice or otherwise fail to obtain certification by NMFS as having adequate fish protection devices will not be eligible to continue to receive irrigation water service from the Project and their contract may be subject to termination. The compliance deadline is April 1, 2010, unless a later date is authorized by NMFS.[13]

1. **By October 1, 2008, Reclamation will send written notification to all existing contractors notifying them that in order for them to continue receiving irrigation water service from the Project, their diversions must have fish protection devices that comply with current NMFS fish protection requirements,[14] and are approved by NMFS. Contractors will be required to request assessment by entities listed in the Bureau's written notification letter. Within the time frame specified by Reclamation in its notice, contractors will be required to provide Reclamation with written assessment[15] that their diversions conform to NMFS criteria. Reclamation will assemble this information and provide it to NMFS. NMFS will then make a determination as to whether NMFS agrees that the fish protection measures are sufficient to protect ESA-listed fish, and will advise the water user and Reclamation of this determination. NMFS may ask for additional information, or may need to visit the diversions in order to make its determination. If NMFS requests a site visit, NMFS will inform Reclamation.[16]**
2. **While contractors proceed with the fish protection device installation or modification and approval process, they may continue to divert water under the terms and conditions of their existing contracts, as long as they meet the deadline provided to them by Reclamation.**
3. **As another condition of receiving water, every five to seven years, contractors must re-confirm that their diversions are still in conformance with NMFS design guidelines.**

Rationale/Effect of RPA 3.2: This measure requires screening or other appropriate fish passage devices at diversions with existing Reclamation contracts that will not be renewed for a number of years. In most cases, fish entrainment into a diversion is lethal. Measure 3.3 below ensures that these protections will be required at renewal, but does not require immediate screening of all existing diversions.

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[13] Reasons for extending this date might include challenging design requirements, or atypically large and complicated projects.
[14] See Anadromous Salmonid Passage Facility Design, National Marine Fisheries Service, Northwest Region, February 2008, NMFS 2008e
[15] NMFS will accept assessments by ODFW, Reclamation, or others, based on a Memoranda of Understanding between these Agencies and NMFS with respect to technical acceptance criteria.
[16] Initially, all diversions will require a site inspection by NMFS; ideally, however, Reclamation and NMFS will develop a protocol to avoid site visits for every pumped, diversion, particularly small ones.

The effect of this measure is that losses of juvenile Chinook and steelhead due to entrainment or ineffective passage at existing diversions will only continue until April 1, 2010.

3.3 <u>New & Renewed Contracts – Conditions</u>: **Reclamation will require renewed and new contracts to meet all of the following:**

1. **Compliance with NMFS fish protection criteria, as required for existing diversions in 3.2, above.**
2. **Surface water diversions must have lockable headgates that are capable of easily starting, adjusting and stopping[17] the flow of water.[18]**
3. **Diversions greater than 3 cfs must have devices to enable measurement of the instantaneous rate of water delivery, within 5% accuracy.[19] Diversions over 10 cfs must also have a flow totalizer that calculates total volume of water diverted.**
4. **Reclamation will include provisions to curtail or cease entirely all water deliveries in specific areas, if certain flows are necessary to protect listed species and their critical habitats.**

Rationale/Effect of RPA 3.3: This measure is included to ensure that new and renewed contracts include conditions to protect fish from entrainment into diversions and to ensure that rate and volume of water diverted can be easily and accurately controlled. In most cases, fish entrainment into a diversion is lethal. The OWRD now requires new surface water right permittees in the Willamette basin to screen their diversions to avoid entrainment; however, an unknown number of diversions using older federal water service contracts are unscreened.

This effect of this measure is to minimize loss of UWR Chinook salmon and steelhead at diversions that acquire a new or renewed Reclamation contract. During the 15-year term of this Opinion, about 48 of the 205 existing contracts will be eligible for renewal. Harm will be reduced by requiring screens to be installed and operated at contract diversions. Contract conditions requiring headgate flow controls, measurement, and water curtailment will reduce adverse effects on listed fish due to reduced river flow.

3.4 <u>**Annual Availability of Contract Water for Irrigation**</u>**: Contract fulfillment is subject to the USACE's annual operating plan for the Willamette Basin Project in which the USACE determines availability of water for Reclamation contracts. If USACE determines that a shortage will occur, or is forecasted to occur, USACE can designate this shortage to specific tributary subbasins,**

[17] To less than 1.0 cfs.
[18] Pumped diversions are presumed to inherently possess this capability.
[19] Any of the measurement methods described in the *Reclamation Water Measurement Manual* for measuring instantaneous flow rate shall be acceptable, but generally for surface water diversions, and pumps that discharge to canals, this will likely be a flume; for flows entirely within conduit, a pipeline flow meter is presumed. Indirect methods based upon pump(s) electrical power consumption require field calibration (USBR 2001a) and an engineer's certification of the correlation between electrical power consumption and flow.

certain reaches, or throughout the Willamette basin, limiting the availability of the contract water supply. Reclamation will notify contractees of storage water shortages as described below. Appendix D further describes how water years are designated and is hereby incorporated into this RPA by reference.

Each year on or before April 1, the USACE will determine availability of water for irrigation contracts based on the best information available at that time.

DEFICIT YEARS:

(a) In "deficit" water years (as defined in Appendix D), the USACE will inform Reclamation that either (1) a specified partial supply or (2) no supply is available for the upcoming irrigation season in specific tributaries and will include this determination in the annual operating plan. The April 1 determination will remain in effect until October 31. The USACE may revise its "deficit" water year determination after April 1 if forecasts change significantly toward a wet year, and may make additional stored water available to meet irrigation contracts.

(b) Reclamation will notify affected contractees that water deliveries will be ceased or curtailed under these circumstances. Reclamation may apply the curtailment or cessation of water deliveries to specific tributaries where it is needed, but not in others, depending on water availability and storage capacity in each basin's reservoirs. Reclamation will also inform the OWRD of such actions.

(c) If the USACE determines initially that a partial supply is available for contractees, but later forecasts indicate even less water is available, in order to protect fish habitat the USACE will release additional flow from the applicable dams to offset the amounts diverted by contractees, based on the partial use that had been permitted on April 1. This additional flow will not be released if, based on coordination through WATER, it is determined these additional flows would impact ability to meet Table 9.2-1 (mainstem) and 9.2-2 (tributary) minimum flows during other seasons.

INSUFFICIENT, ADEQUATE, & ABUNDANT YEARS:

(a) In these water years (as defined in Appendix D), the USACE will usually not make a determination that would curtail contractees' use of water.

(b) Instead, the USACE will release additional flow (over the Table 9.2-2 flow rates) to offset the amount of flow diverted by

contractees, as estimated in Table 3-26 of the Proposed Action (USACE 2007a) (or based on updated estimates by Reclamation of actual use). This measure does not apply to the Coast Fork or Long Tom subbasins.

(c) The schedule for when and if to begin and end additional flow releases will be annually determined through the WATER Flow Management Committee, which will consider fish flow needs, Reclamation's estimate of contract water usage, and reservoir storage available for meeting tributary and mainstem flow objectives throughout the water year.

(d) In tributaries and reaches where the sum total of existing and new contracts is less than 20 cfs or otherwise beyond adjustment capabilities at each project dam, the USACE will attempt to release these additional increments. However, downstream gage data may not detect relatively small increases in flow over Table 9.2-2 releases.

(e) The USACE will not be required to make RPA measure 2.2 deviation reports where contracted flow is less than 20 cfs; NMFS will consider requests to waive RPA measure 2.2 deviation reports in other situations, as well, on a case-by-case basis.

Rationale/Effect of RPA 3.4: Under the Proposed Action, USACE would not increase the discharge rate at individual projects to meet Reclamation contracts, reasoning that established project minimum discharge rates are sufficient to meet those needs and contract diversions take a *de minimus* volume of water. Because the tributary minimum flows established in RPA measure 2.4 are designed to protect listed fish throughout the stream reaches downstream from Project dams, diverting water under Reclamation contracts while Willamette Project dams are discharging to meet minimum flows could put listed fish at risk. This RPA measure requires Reclamation to curtail contract diversions in Deficit water years, and, in all other water years, it requires USACE to release additional water above the minimum flow levels to ensure that contract users do not take water intended for fish purposes.

As a means to reduce risk to contractors, USACE will identify the likelihood of curtailment by April 1, prior to the irrigation season through the development of the Willamette Conservation Plan. Such early notification would assist water users to plan appropriately for a water shortage. In the event that the USACE's forecast is incorrect, and a forecast that appeared adequate (not requiring any curtailments) on April 1st changes to one predicting a "deficit" water year, the USACE will release additional flow at its dams to make up for the contracted amounts. This would protect contractors from interrupted water service mid-season, when it could result in excessive crop damage, but would ensure that streamflows are not further reduced due to contract withdrawals in such flow years.

Curtailments under this measure could be for one or more individual tributaries or the entire basin and could be in force for only a few weeks or the entire irrigation season.

Innovative solutions to minimize impacts to water users, such as rotational diversion timing, may be proposed by Reclamation and OWRD and may be adopted by NMFS.

The effect of this RPA measure is that losses to listed fish species from low stream flows will be reduced while allowing the Action Agencies to continue serving other project purposes to the extent practical. Adverse effects on critical habitat will be reduced because this measure will provide for flows necessary to support listed fish.

9.4 FISH PASSAGE

The Proposed Action included studies to consider passage at Project dams, but did not include specific passage measures and time frames associated with the measures. As discussed in the Effects (Chapter 5) and Summary of Effects (Chapter 7) sections of this Opinion, for UWR Chinook salmon and UWR steelhead, lack of passage is one of the single most significant adverse effects on both the fish and their habitat. In its jeopardy and destruction and adverse modification of critical habitat analyses, NMFS identified the need for more specific measures with associated time frames. Specific passage measures are necessary to address the effects of the Project. Therefore, NMFS includes specific passage measures to be completed and operational by set deadlines. NMFS also includes a measure to ensure that the Action Agencies continue to work toward providing more specific passage measures, if appropriate, past the time frame of RPA.

RPA 4 Fish Passage

4.1 <u>Adult Chinook Salmon Outplanting</u>: **The Action Agencies will continue capturing spring Chinook salmon below USACE dams and transporting them into habitat above the following dams:**

- **Detroit Dam in the North Santiam River basin;**
- **Foster Dam in the South Santiam River basin;**
- **Cougar Dam in the South Fork McKenzie River basin;**
- **Lookout Point and Hills Creek dams in the upper Middle Fork Willamette River subbasin; and**
- **Fall Creek Dam in the Fall Creek River basin.**

Additionally, if NMFS, after coordination with the Fish Passage and Hatchery Management Committee (FPHM) of WATER, determines it is necessary to evaluate passage at Green Peter Dam, then the Action Agencies will also release Chinook salmon above that dam in the South Santiam.

The Outplant Program will provide upstream fish passage for adults via "trap and haul" facilities while USACE carries out studies to assess upstream and downstream fish passage alternatives at these dams and reservoirs (see RPA measures 4.10, 4.11, and 4.12 below). The interim operational guidelines and protocols for outplanting fish will be as described in section 3.4.5 of the Supplemental BA (USACE 2007a),

NMFS (2006f) and section 15 of each ODFW (2003, 2007a, 2008a, and 2008b).[20] The Outplant Program will be carried out consistently with the guidelines, protocols, and criteria specified in the Willamette Fish Operations Plan (see RPA measure 4.3 below) and annual revisions to this plan (see RPA measure 4.4 below). (See also RPA measure 6.2.3 below, which references this same Outplant Program as part of the hatchery-related measures).

Rationale/Effect of RPA 4.1: This measure is generally consistent with section 3.4.5.3 of the Proposed Action (USACE 2007a), in which the Action Agencies propose to continue the Outplant Program consistent with a philosophy described in detail in section 3.4.4.5 of the Proposed Action. The outplant program is a first step to provide UWR Chinook salmon and UWR steelhead access to historical habitat above Project dams, but by itself won't be sufficient. The major distinction between the PA and RPA for the outplanting program is that harm to listed fish should be decreased by following guidelines developed to minimize effects on the fish.

As described in the Effects sections for the major subbasins (Middle Fork Willamette, section 5.2; McKenzie, section 5.3; South Santiam, section 5.5; and North Santiam, section 5.6), the outplanting measures in the PA do not provide safe passage. Therefore, improvements in fish trapping, handling, transport, and release are needed to minimize stress and injury to adult fish. The interim guidelines and protocols, as implemented by the Action Agencies, will help to reduce fish stress and injury.

The Outplant Program, as modified based on monitoring and evaluation and with improved trapping facilities described in RPA measure 4.6, will provide adequate temporary upstream passage to ensure fish access to historical habitat. In most situations where fish passage at a dam is needed, NMFS would consider volitional passage via a fish ladder or other fishway as its first choice alternative. However, for the Willamette Project dams, in this case, sufficient improvements in upstream passage can be achieved in the short term with improved fish trap and transport facilities while efforts are focused on achieving safe downstream fish passage through the dams and reservoirs. Once downstream fish passage facilities are completed and demonstrated to provide safe and timely passage, then NMFS will reconsider whether volitional upstream passage is needed at certain Project dams.

This measure requires the Action Agencies to transport listed fish to the described locations. Fish habitat above dams was historically preferred for spawning and rearing. Since dam construction, remaining fish habitat below dams has been degraded by dam and reservoir operations, as well as other actions such as land use and agricultural and industrial water pollution. Lack of access to good habitat is considered a major reason for the decline in productivity of UWR Chinook, and most of the good habitat, and hope for restoring productivity, lies above project dams.

[20] Hatchery and Genetic Management Plans (ODFW 2003, 2004a, 2005, 2007a, 2008a, and 2008b) are described in the salmon and steelhead 4(d) rule as a mechanism for addressing "take" of ESA-listed species that may occur as a result of artificial propagation activities.

The effect of this measure will be to require efforts to restore productivity of listed fish. Restoration of productivity is key to adequately addressing the effects of the Project because the extremely low numbers of wild fish caused by lack of or inadequate access to historical habitat are the major factor contributing to the species' decline. Lack of access to good habitat above the dams, injury and mortality associated with inadequate passage facilities, and restriction to degraded habitat below the dams has caused steep declines in numbers and has reduced the functioning of PCEs of critical habitat.

4.2 <u>Winter Steelhead Passage:</u> **The Action Agencies will continue to trap adult winter steelhead at Foster Dam in the South Santiam River and transport them to release sites above Foster reservoir. If NMFS and the Action Agencies, in coordination with the FPHM of WATER, determine it necessary for evaluation of winter steelhead passage at Green Peter Dam, then the Action Agencies will release some portion of the winter steelhead captured at the Foster Dam trap above Green Peter reservoir in the South Santiam. Additionally, if NMFS and the Action Agencies, in coordination with the FPHM, determine it necessary for evaluation of steelhead passage at Detroit and Big Cliff dams, then the Action Agencies will trap winter steelhead at the Minto Trap or other locations in the North Santiam River below Big Cliff Dam and release them above Detroit and/or Big Cliff dams, as directed by NMFS.**

Rationale/Effect of RPA 4.2: The Outplant Program described above in RPA measure 4.1, has focused on upstream passage of UWR Chinook salmon, but UWR steelhead access to historical habitat in the South and North Santiam rivers is also needed. In the South Santiam subbasin, the Action Agencies have continued to pass UWR steelhead above Foster Dam since dam construction, relying on a surface spill program to flush juvenile steelhead from the reservoir during the peak migration period. As described in Section 4.5.3 (Baseline South Santiam), upstream passage at Green Peter Dam was discontinued in 1988 because adults were not attracted to the cold water from the ladder and a low percentage of downstream migrants were collected in the downstream fish collection facility. This measure requires the Action Agencies to continue to pass UWR steelhead above Foster Dam, and possibly, above Green Peter Dam.

In the North Santiam subbasin, steelhead passage to historical habitat above Big Cliff and Detroit dams was blocked in 1953, when construction of the dams without fish passage facilities was completed (see section 4.6.3, Baseline North Santiam). As described in Effects Section 5.6, UWR steelhead spawn in the North Santiam below Big Cliff Dam. Although water quality and sediment transport are degraded in this reach due to continued dam operation, this population is considered to be at "moderate" risk of extinction. (UWR Chinook salmon, on the other hand, are at a "very high" risk of extinction). Because there is not a hatchery component of winter steelhead, NMFS is reluctant to release winter steelhead above Big Cliff and Detroit until downstream fish passage is shown to be safe with existing structures or until new facilities are installed that provide safe passage. RM&E studies will evaluate potential benefits of steelhead passage at Big Cliff and Detroit. Based on the results of the studies, NMFS, after coordination with the FPHM, may determine that passage of UWR steelhead is appropriate during the term of this Opinion.

The effect of this RPA will be to ensure that UWR steelhead are provided safe upstream passage in the North and South Santiam subbasins, if determined feasible and necessary based on RM&Es. Lack of passage was a significant factor in the species' decline, and assuming passage is determined effective at Detroit and Big Cliff on the North Santiam and at Foster and Green Peter on the South Santiam, these populations will likely increase in abundance and productivity by allowing steelhead to use good spawning and rearing habitat above the dams.

4.3 **<u>Willamette Fish Operations Plan</u>: The Action Agencies will complete a Willamette Fish Operations Plan (WFOP) by October 1, 2008. The Action Agencies will coordinate with the Services when preparing the WFOP. This Plan and its annual revisions will be consistent with this Opinion and incidental take statement, and will take into account and be coordinated with related biological opinions issued by the USFWS to the fullest extent practicable. The Action Agencies will carry out measures identified in the WFOP and in annual revisions to the WFOP. The WFOP will include, but not be limited to, the following:**

1. **Identify optimal operating criteria for Green Peter, Foster, Detroit, Big Cliff, Cougar, Fall Creek, Dexter, Lookout Point, and Hills Creek dams to minimize adult and juvenile fish injury and mortality to the extent possible with existing facilities and operational capabilities;**

2. **Identify protocols for optimal handling, sorting, and release conditions for ESA-listed fish collected at USACE-funded fish collection facilities, including but not limited to those at Minto fish facility, Foster Dam fish collection facility, McKenzie Hatchery, Fall Creek fish facility, Dexter Dam fish collection facility, and at the new facilities at Cougar and Leaburg dams, when they are constructed;**

3. **Identify the number, origin, and species of fish to be released into habitat upstream of USACE dams, incorporated into the hatchery broodstock, or taken to other destinations;**

4. **Describe scheduled and representative types of unscheduled maintenance of existing infrastructure (dams, transmission lines, fish facilities, etc) that could negatively impact listed fish, and describe measures to minimize these impacts;**

5. **Describe procedures for coordinating with federal and state resources agencies in the event of scheduled and unscheduled maintenance.**

6. **Describe protocols for emergency events and deviations:**

a) <u>Protocol Development</u>: The USACE will establish a formal, written procedure for taking actions to prevent or minimize adverse impacts to ESA-listed fish, including water quality impacts, during unusual events/conditions. These protocols will guide the actions of project personnel.

b) In the event of an emergency outage or malfunction, the Action Agencies will inform the Services of the emergency by phone or email, as soon as practical, but not later than 24 hours after the event. This process will also apply whenever the Action Agencies carry out flood reduction operations that result in deviations from the flow measures described in this section.

c) The Action Agencies may initiate work prior to notifying the Services, when delay of the work will result in an unsafe situation for people, property, or fish. For each occurrence of unscheduled maintenance and each flood damage reduction operation that results in a deviation from minimum mainstem flow objectives, minimum and maximum tributary flow objectives, ramping rates, spill at Foster Dam, or adverse TDG and water temperature conditions, the USACE will inform the Services in writing (or email) within 24 hours, and include a description of the problem, type of outage required, potential impact on ESA-listed fish, estimated length of time for repairs or flood damage reduction operation, and proposed measures to minimize effects on fish or their habitat. This approach will be taken only if it is not possible to coordinate with the Services prior to starting the maintenance event or flood damage reduction operation.

Rationale/Effect of RPA 4.3: The WFOP will replace the Action Agencies' proposed Willamette Fish Passage and Management Plan, identified in the Proposed Action, 2007 Supplemental BA at sections 3.2.2 (p. 3-18) and 3.4.5.3 (p. 3-48). All of the features of the Action Agencies' proposed plan will be included in the WFOP, but it will also include important operational requirements not directly related to fish passage such as outflow protocols during emergencies to protect fish spawning in habitat below Project dams. The WFOP is a critical link between measures required by the Proposed Action and this RPA and on-the-ground implementation activities. The WFOP will guide Project personnel, including contractors and other agencies responsible for carrying out fish hatchery and passage measures, and will help to ensure that fish facilities are operated based on best practices and consistent with the terms of this Opinion.

By including emergency operations within the WFOP, field staff will have a single manual to rely on for all fish-related protocols, including steps that should be taken in emergency situations to minimize adverse fish effects. The notification protocols measure (number 6 in the list above) adds reporting details to a similar action described in section 3.3.4 of the Supplemental BA (USACE 2007a), and requires the Action Agencies to notify the Services within 24 hours of an unscheduled event rather than the

48 hours required by the Proposed Action measure. NMFS requires timely notification and reporting of these events in order to initiate damage assessments and to advise the Action Agencies on a preferred course of action to minimize adverse fish impacts.

The effect of this measure will be to reduce stress, injury, and mortality to adult fish caused by the Outplant Program by ensuring field personnel have clear instructions for carrying out this Program. The Plan will also minimize fish injury and mortality caused by emergency operations by providing clear directions to field staff for dealing with emergencies in a manner that is protective for listed fish. Additionally, NMFS will be able to quickly assist the Action Agencies in defining measures they should take to minimize and avoid fish losses, and NMFS will be able to assess losses when needed.

4.4 **Annual Revision of Willamette Fish Operations Plan (WFOP): The Action Agencies will annually revise and update the WFOP, including the "Fish Disposition and Outplant Protocol" sections of each chapter to describe how and where outplanted fish will be collected, held, marked, sampled, transported, and released and to incorporate changes in operations needed to protect fish. The WFOP will be revised annually based on results of RM&E activities, construction of new facilities, recovery planning guidance, predicted annual run size, and changes in hatchery management. Annual revisions will be submitted to the Services by January 15 of each year for review and comment; the Services will inform the Action Agencies by February 15, whether they agree[21] with the revised WFOP. The Action Agencies will release a final updated WFOP by March 14 of each year. Annual revisions will be considered an "Annual Milestone" as defined below in RPA measure 4.13.**

Rationale/Effect of RPA 4.4: As described above for RPA measure 4.3, the WFOP builds upon the Willamette Fish Passage and Management Plan that the Action Agencies proposed. This measure specifies dates by which the Action Agencies will release a draft plan for review by the Services, a process for review and comment on the draft plan, and a deadline for completion of the updated WFOP. This will ensure timely completion of this manual prior to the primary fish passage season each year. It will also require coordination with NMFS to ensure that proposed changes are consistent with the intent of this Opinion.

The effect of the measure is that the WFOP will be kept up-to-date with information learned from previous years' operations as well as results of RM&E studies. This new information will ensure that revised practices for handling, sorting, transporting, and releasing fish will be carried out within the next year, or sooner, after such changes are indicated by new information. As a result, UWR Chinook salmon and UWR steelhead that are collected and released above Project dams will experience less stress, injury, and mortality, and fish abundance and productivity will increase due to improved fish passage to historical habitat. Similarly, annual updates will ensure the latest information is

[21] See RPA 1.3 & 1.4 for elaboration of decision making process.

incorporated in the WFOP, and will result in reduced fish injury and mortality caused by emergency operations.

4.5 <u>**Employee Training for Fish Protection Operations at Project Dams and Fish Facilities**</u>**: The Action Agencies will ensure that fish facility personnel, operators, and managers responsible for operating and maintaining fish facilities at each project complete an annual employee environmental awareness training program. The training will include a review of the status of ESA listed aquatic species, the WFOP, and each fish facility's standard operation procedures (SOPs). Prior to conducting the annual training, the Action Agencies will coordinate with the WATER and appropriate natural resource agencies to identify any specific resource issues that should be addressed or emphasized at that time. The Action Agencies will maintain records of the training including agendas, attendance lists, and any handout materials.**

Rationale/Effect of RPA 4.5: The Proposed Action does not explicitly require staff training in how to operate fish facilities and how to handle emergencies to minimize harm to listed fish. Although hatchery personnel presently are trained to operate fish collection and transport facilities, other Project staff should be trained in emergency procedures for on-site fish facilities. If a water supply line to a fish holding pond broke and no hatchery personnel were able to respond quickly, simple directions could be given to an on-site Project operator or maintenance staff to open emergency water supply systems or otherwise provide temporary relief to trapped fish until hatchery personnel are available. The effect of this measure will be to ensure that all staff responsible for carrying out measures in the RPA and Proposed Action are well-trained in safe fish handling procedures and are able to knowledgeably and safely use mechanical equipment. The training will also ensure that fish facility personnel, as well as other Project staff, are able to quickly respond to emergencies to minimize effects on listed fish and fish habitat.

4.6 <u>**Upgrade Existing Adult Fish Collection and Handling Facilities**</u>**: The Action Agencies will design, construct, install, operate and maintain new or rebuilt adult fish collection, handling and transport facilities at the sites listed below. The Services will inform the Action Agencies whether they agree[22] with each facility's planned configuration and operation. The Action Agencies will design each facility with and incorporate NMFS' Anadromous Salmonid Passage Facility Design (NMFS 2008e) and the best available technology. During the design phase, the Action Agencies will coordinate[23] with the Services to determine if the design should accommodate possible later connection to a fish ladder, if determined necessary in future years beyond 2015.**

The Action Agencies will complete all necessary interim steps in a timely fashion to allow them to meet the following deadlines for completing construction and beginning operation of the facilities listed below. These steps may include completing a DDR and plans and specifications. The Action Agencies will give

[22] See RPA 1.3 & 1.4 for elaboration of decision making process.
[23] See RPA 1.3 & 1.4 for elaboration of decision making process.

NMFS periodic updates on their progress. The order in which these facilities are completed may be modified based on interim analyses and biological priorities, and with agreement[24] of NMFS and USFWS.

1. **North Santiam Fish Facility (currently at Minto Pond) – complete construction no later than December 2012; begin operation no later than March 2013.**
2. **Foster Fish Facility – complete construction by December 2013; begin operation by March 2014.**
3. **Dexter Ponds Fish Facility – complete construction by December 2014; begin operation by March 2015.**
4. **Fall Creek Dam Trap – complete construction by December 2015; begin operation by March 2016.**

Rationale/Effect of RPA 4.6: The Action Agencies proposed to evaluate and modify these fish facilities in Section 3.6.3 of the Supplemental BA (USACE 2007a), but did not provide certainty in when the improvements would be made or whether funding would be available to do the work. NMFS makes clear that facility improvements or replacement are required, and establishes dates to complete work and begin operation. In some cases, work could be initiated sooner than listed above, and NMFS expects the Action Agencies to make these improvements as soon as possible.

Improvements in fish trapping are needed at each of the fish collection facilities to minimize stress and injury to adult fish, as described in the Effects sections for the major subbasins (Middle Fork Willamette, section 5.2; McKenzie, section 5.3; South Santiam, section 5.5; and North Santiam, section 5.6). Although there is no single known cause of pre-spawning mortality, stress induced during fish collection and handling is likely one component of this mortality that can be lessened by redesigning these trapping facilities using latest fish handling design criteria. Because these facilities will be used in lieu of volitional fish passage to provide access to historical habitat above the dams, this measure is an essential first step toward addressing low population numbers caused by decreased spatial distribution, which is a limiting factor for UWR Chinook salmon and UWR steelhead. This measure also addresses the critical habitat PCE factor of providing freshwater migration corridors free of obstruction, despite the fact that traps and transportation will be used to provide a migration corridor past some of the Project dams. The improvements to the fish facilities will also allow hatchery fish to be acclimated before release, a practice that will improve survival and reduce straying.

The effect of this measure is that improved collection and release of adult fish will minimize fish stress and injury, resulting in improved upstream fish passage to historical habitat. Upstream fish passage is the initial step toward restoring productivity of listed fish by using large reaches of good quality habitat above Project dams. Lack of access to good habitat above the dams, injury and mortality associated with inadequate passage facilities, and restriction to degraded habitat below the dams has caused steep declines in numbers and has reduced the functioning of PCEs of critical habitat.

[24] See RPA 1.3 & 1.4 for elaboration of decision making process.

4.7 **<u>Adult Fish Release Sites above Dams:</u> The Action Agencies, working in coordination with the U.S. Forest Service (USFS) or other applicable landowners,[25] will:**

- **Complete a site/concept study by February 28, 2009, that will identify at least four to six potential locations suitable for new adult fish release sites for Chinook salmon above Detroit, Foster, Lookout Point, Hills Creek, Fall Creek, and Cougar reservoirs. Sites located above Foster Reservoir will be suitable for releasing both Chinook salmon and winter steelhead; site(s) above Detroit and Green Peter dams should also be suitable for winter steelhead, should adult steelhead be released in these locations in future years.**
- **The Action Agencies will work with the USFS and the Services to prioritize and design each release site, which may include infrastructure to minimize stress and injury of adults (e.g., piping systems, vehicle ramps, etc). The release sites will be prioritized in the context of the Configuration Operation Plan (COP) (see RPA measure 4.13). The Services will inform the Action Agencies whether the sites as designed are consistent with the Opinion.**
- **The Action Agencies will complete construction of all selected sites by June 2012. If another entity, by December 2010, takes on the responsibility for constructing or improving these sites, the Action Agencies will not be responsible for construction of those sites completed by another entity. Additionally, if, based on results of the COP, additional sites are warranted, construction of additional sites will be completed as soon as possible after identified by the COP. Construction of the sites will be contingent upon availability of funds (which may include a non-federal cost-sharing requirement) and cooperation of landowners. Prior to construction, the Action Agencies will need to complete processes to ensure compliance with all applicable statutes and regulations not provided by this or other ESA consultations, as required by applicable law.**

Rationale/Effect of RPA 4.7: This measure builds upon one proposed by the Action Agencies in Section 3.4.5.3 of the Supplemental BA (USACE 2007a, p 3-51), but NMFS has added a minimum requirement of 4 to 6 sites, as well as dates for completion of construction and a requirement that sites above the Santiam dams be made compatible for steelhead as well as Chinook salmon release.

Improvements in release of outplanted adult fish are needed to minimize fish stress and injury, as described in the Effects sections for the major subbasins (Middle Fork Willamette, section 5.2; McKenzie, section 5.3; South Santiam, section 5.5; and North

[25] NMFS acknowledges that establishment of release sites above reservoirs may be contingent upon securing funds and agreement with non-Action Agency landowners/land managers such as USFS and BLM. NMFS also understands that some entities such as USFS and BLM may elect to undertake work on the property they manage themselves, in which case Action Agencies would cooperate with them, including funding the work, if necessary. Environmental permitting not provided by this or other ESA consultations may also be required before this work can be accomplished.

Santiam, section 5.6). This is one more component (in addition to trapping facilities and handling and transport protocols described in RPA measures above) that is likely to help decrease the rate of pre-spawning mortality. Many of the existing release sites have relatively poor river access, forcing drivers to release fish using methods such as sliding fish on tarps or using collapsible hoses that elevate stress or cause direct or delayed injury or mortality. Some sites are located at river access points that experience heavy recreational pressure, leading to disturbance, harassment, or poaching of outplanted fish. New release sites will be chosen to allow safe transfer of fish from the truck, adequate recovery in pools without recreational pressure or poaching, and reasonable proximity to quality holding and spawning habitat.

The effect of this measure will be to reduce stress and associated pre-spawning mortality, ultimately increasing the percent of adult fish that successfully spawn, leading to increased productivity above the dams. This measure will also decrease adverse effects on critical habitat by providing a component of safe passage.

4.8 **Interim Downstream Fish Passage through Reservoirs and Dams: Until permanent downstream passage facilities are constructed or operations are established at Project dams and reservoirs in subbasins where outplanting of UWR Chinook salmon and steelhead is underway, the Action Agencies will carry out interim operational measures to pass downstream migrants as safely and efficiently as possible downstream through Project reservoirs and dams under current dam configurations and physical and operational constraints, and consistent with authorized Project purposes.**

Near-term operating alternatives will be identified, evaluated, and implemented if determined to be technically and economically feasible and biologically justified by the Action Agencies and Services, within the framework of the Annual Operating Plan updates and revisions and in coordination with the WATER Flow Management Committee.[26]

The Action Agencies will evaluate potential interim measures that require detailed environmental review, permits, or Congressional authorization as part of the COP (see RPA 4.13 below). The Action Agencies will complete this component of the COP by April 2011, including seeking authorization (if necessary) and completing design or operational implementation plans for those operations selected by the COP. The measures that will be considered in the COP include, but are not limited to, partial or full reservoir drawdown during juvenile outmigration period, modification of reservoir refill rates, and using outlets, sluiceways, and spillways that typically are not opened to pass outflow. The Services will inform the Action Agencies whether they agree[27] **with the interim downstream passage measures. The Action Agencies will begin to carry out measures selected by the COP by May 2011, contingent on funding, authorization, and compliance with all applicable**

[26] See RPA 1.3 & 1.4 for elaboration of decision making process.

[27] See RPA 1.3 & 1.4 for elaboration of decision making process.

statutes and regulations. One specific measure is listed below, and others may be developed in coordination with the WATER, if appropriate.

Rationale/Effect of RPA 4.8: The Proposed Action describes a formidable series of studies that would be required before the Action Agencies could construct downstream fish passage structures or make major operational changes to improve downstream fish passage at Project dams and reservoirs. Although it will take many years to investigate, design, and install structural downstream fish passage facilities at those Project dams where such facilities are determined necessary and feasible, there are some fish protective measures that can be carried out in the near future without requiring significant modification to existing structures or operations. Alternative interim measures that need to be considered include short-term operations such as reservoir drawdown, pulsing flow releases, opening various valves, or spill to safely pass fish downstream through a reservoir and dam.

The magnitude of effect of these interim measures is difficult to predict because insufficient data is available to determine where these measures would take place and how successful they would be in providing downstream fish passage for juvenile Chinook and juvenile and kelt steelhead. Such measures would likely be initiated for a short time period as part of an RM&E study to determine potential effectiveness of the measure before an annual or longer term commitment is made. Studies at some non-Project dams have shown that relatively large proportions of downstream migrants pass via spill or sluiceways (see discussion of Willamette Falls Hydroelectric Project in section 4.10, Mainstem Willamette Baseline). However, until interim measures are evaluated to assess fish passage effectiveness, NMFS can only assume that these measures will result in an unquantified improvement in fish survival. This increased survival would benefit the populations of UWR Chinook and UWR steelhead in the subbasins where interim measures are used (possible in any of the following: North Santiam, South Santiam, McKenzie, Fall Creek, and Middle Fork Willamette). Improved downstream survival would help to address the spatial access VSP parameter by increasing the likelihood that the Outplant Program will result in sustainable production above the dams. Sustainable production above the dams would also improve productivity and abundance of populations by increasing the total available habitat while limiting dam-related losses. This measure will also decrease adverse effects on critical habitat by providing a component of the PCE, “migration corridors free of obstruction,” while more permanent passage options are being developed.

4.8.1 **<u>Fall Creek Drawdown</u>: Beginning in Water Year 2008, the Action Agencies will adjust timing of storage and release of flow at Fall Creek Reservoir to promote downstream passage of juvenile Chinook salmon through the reservoir and dam. Drawdown will be to at least elevation 714.0 by the end of November each year, and the Action Agencies will hold the reservoir at this elevation during all of December and January except during flood events, and possibly longer. The Action Agencies will conduct monitoring and evaluation studies to determine the effectiveness of the operation and to assist in deciding whether or not to continue the operation in future years.**

The depth and timing of the drawdown may be adjusted in subsequent years, based upon monitoring results, with NMFS' agreement.[28] During this operation, when inflow is less than Project minimum flow objectives and the reservoir is at or below 714.0', then outflow will equal inflow and this will not be considered a deviation from flow objectives.

Rationale/Effect of RPA 4.8.1: Past studies have indicated that juvenile spring Chinook salmon migrate from Fall Creek Reservoir primarily during November, and that smolts passing through the regulating outlet under conditions of lower reservoir elevations survived at higher levels than when the reservoir was held high (see Section 4.2.3 Middle Fork Willamette Baseline). Also, smolts migrating late in the season under conditions of very low head appeared to sustain lower injury or mortality rates compared to passage under high reservoir levels. If the reservoir is drawn down to an elevation below minimum conservation pool, NMFS would expect increased survival of juvenile Chinook salmon emigrating during November.

The effect of this measure will be to improve downstream fish passage survival through Fall Creek dam and reservoir, increasing productivity of the Fall Creek Chinook salmon population and ultimately resulting in increased abundance and improved spatial distribution. Another effect of this measure will be to minimize adverse effects on critical habitat by providing a component of the PCE, "migration corridors free of obstruction."

4.9 **<u>Head-of-Reservoir Juvenile Collection Prototype</u>: The Action Agencies will plan, design, build, and evaluate a prototype head-of-reservoir juvenile collection facility above either Lookout Point or Foster reservoir. If Foster reservoir is chosen for testing the prototype, the Action Agencies will design for collecting both juvenile salmonids and steelhead kelt. The Action Agencies will complete construction by September 2014. As an interim step, the Action Agencies will complete feasibility studies as part of the COP (described in RPA measure 4.13) near the end of 2010. At that time, the Action Agencies will make a "go/no go" decision on the feasibility of the prototype facility(s) and the preferred location(s) and design(s) for construction of the prototype(s). The Action Agencies will make the go/no go decision in coordination with the FPHM, and after agreement by NMFS.**

After construction is completed, the Action Agencies will conduct biological and physical evaluations of the head-of-reservoir prototype collection facilities in 2015 and 2016, with opportunities for review and comment by the FPHM and RM&E committee of study proposals and draft reports. After receiving comments, including the Services' statements regarding whether they agree[29] with the draft report, the Action Agencies will make necessary revisions to the draft report and issue a final report by December 31, 2016, on the effectiveness of the facilities, including recommendations for installing full-scale head-of-reservoir facilities at

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[28] See RPA 1.3 & 1.4 for elaboration of decision making process.
[29] See RPA 1.3 & 1.4 for elaboration of decision making process.

this and other reservoirs. If the report concludes that head-of-reservoir facilities are technically feasible, capable of safely collecting downstream migrating fish, and capable of increasing the overall productivity of the upper basins, then the Action Agencies will include such facilities in the design alternatives that they consider in the COP studies described in RPA measure 4.13 below.

Rationale/Effect of RPA 4.9: This measure addresses the lack of effective downstream fish passage facilities described in the Effects sections for the major subbasins with Project dams (Middle Fork Willamette, section 5.2; McKenzie, section 5.3; South Santiam, section 5.5; and North Santiam, section 5.6). Past monitoring of downstream juvenile migration through the reservoirs and dams was minimal, although in some reservoirs (e.g., Green Peter, South Santiam, section 5.5) studies indicated that juvenile fish were not successfully migrating through the reservoir to collection facilities at the face of the dam. Regardless of whether this was caused by predation, lack of attraction to collection facilities, or another reason, these results support the notion that collecting fish near the head of a reservoir might be an effective means to achieve safe downstream passage.

Because the head-of-reservoir fish collection concept is virtually untested, it would be imprudent to require such facilities without prior field studies, design, and prototype testing to validate the concept. For this measure, NMFS defines “prototype” to refer to temporary facilities intended for concept evaluation, not long-term operations. Further, “prototype” does not necessarily refer to a single concept; multiple concepts may be experimented with simultaneously. The FPHM subcommittee of the WATER group, comprised of fish biologists and engineers with experience in fish passage design, will be an appropriate forum in which to develop concepts. NMFS’ current thinking on possible means to accomplish this is 1) floating collectors in the reservoir near the mouths of tributaries and 2) fish collection facilities on tributaries above the reservoir pools. After several years of field monitoring and conceptual design review, the Action Agencies will identify a Major Milestone (MM2) (as described in RPA measure 4.13 below) near the end of 2010 in conjunction with completion of the DDR. The major decision associated with that milestone will be "go/no go" on the feasibility of the prototype facility(s), after coordination with the FPHM and agreement by NMFS. If the decision is to construct and evaluate the prototype(s), the focus of the decision will potentially be focused on alternative location(s) and design(s) for the prototype facility(s). Among the questions to be answered are whether such a device could capture enough fish to be biologically useful, and whether it could be operated during periods of high flow and debris loading.

The effects of this measure would be to initially demonstrate whether this concept is feasible, and if so, to use head-of-reservoir facilities in Project reservoirs where indicated to increase downstream fish survival. Safe and timely downstream passage of juvenile Chinook salmon and juvenile and kelt steelhead is a critical component to the success of the Outplant Program. In order to restore access to historical habitat above Project dams, and address the spatial distribution VSP parameter, the juvenile fish produced from adults released above the dams need to safely pass through reservoirs and dams on their downstream migration. Sustainable production above the dams would improve productivity and abundance of populations by increasing the total available habitat while limiting dam-related losses. Providing access will also benefit critical habitat because lack of access was a limiting factor.

4.10 **Assess Downstream Juvenile[30] Fish Passage through Reservoirs: The Action Agencies will, in coordination with and review by the Services, assess juvenile fish passage through the following Project reservoirs:**

1. **Cougar**
2. **Lookout Point and Dexter**
3. **Detroit and Big Cliff**
4. **Green Peter and Foster**
5. **Fall Creek**
6. **Hills Creek**

These evaluations will be developed consistent with the RM&E process described below in RPA measure 9 (RM&E). The Action Agencies must seek NMFS' review of evaluation proposals. Comments submitted by NMFS on draft evaluation proposals must be reconciled by the Action Agencies in writing to NMFS' satisfaction prior to initiating any research-related activities anticipated in this RPA.[31] The proposals must identify annual anticipated incidental take levels by species, life stage, and origin[32] for each year. The Services will inform the Action Agencies whether they agree[33] with the proposed studies, reports, and NEPA alternatives. The Action Agencies will begin these studies in 2008; field investigations, study reports, and NEPA analyses, if necessary, will be completed by December 31, 2015.

Rationale/Effect of RPA 4.10: Juvenile fish (and kelts) need to emigrate through reservoirs, or be transported around them, in order to continue their downstream migration and complete their life cycles. Effects are unique at each reservoir: fish may pass satisfactorily through some reservoirs, but have problems, such as loss by predation or residualism (failure to continue migrating) at others. For instance, preliminary results at Fall Creek and Cougar indicated juvenile Chinook salmon were able to safely migrate through the reservoirs, yet studies at Green Peter in the 1980s showed few fish released near the head of the reservoir reached the dam.

There is little information on fish use, migration rates, and survival in the Willamette Project reservoirs.[34] Most of the information on Project reservoir fish passage has been

[30] Include downstream steelhead kelt passage in Santiam studies through Detroit, Big Cliff, Green Peter, and Foster.
[31] See RPA 1.3 & 1.4 for elaboration of decision making process.
[32] That is, hatchery-origin or non-hatchery origin fish.
[33] See RPA 1.3 & 1.4 for elaboration of decision making process.

[34] This RPA does not include small reservoirs such as at Minto and those with the Long Tom dams.

inferred from fish traps placed below reservoirs. The kinds of studies that are needed would vary among reservoirs, depending on existing information and characteristics of each reservoir and the species that use it. If studies show that fry use a reservoir for rearing before migrating downstream as juveniles or smolts, then juvenile collection facilities at or near the face of the dam would be preferred over head-of-reservoir collection facilities. On the other hand, if juvenile fish are exposed to heavy predation while in the reservoir, then efforts would need to be directed at either head-of-reservoir collection, reducing predators or predator habitat, or reservoir operations that would encourage juvenile fish to quickly migrate downstream. In large reservoirs, currents may also be found to influence juvenile migration (vertical and horizontal distribution through the reservoir), and fish collection facilities would need to be located to take advantage of such currents. These examples show that downstream fish passage decisions regarding alternative operational and facility designs must be based on site-specific data regarding passage through reservoirs. Without this information, downstream passage facilities could be ineffective due to poorly located facilities or lack of understanding of reservoir use.

The effect of this measure will be to provide site-specific information regarding juvenile fish passage and use of Project reservoirs, informing key decisions related to downstream fish passage facilities and reservoir operations, and possibly predator management. Improved downstream fish passage will ultimately increase spatial distribution by providing safe access to and from historical habitat. This will, in turn, increase numbers of listed fish, which is needed to address the effects of the Project (depressed abundance and productivity).

4.11 <u>Assess Downstream Juvenile Fish Passage through Dams:</u> **At Cougar, Lookout Point and Dexter, Detroit and Big Cliff; Foster and Green Peter, Fall Creek, and Hills Creek dams, the Action Agencies will, in coordination with and review[35] by the Services, do the following:**

1. **Assess passage survival and efficiency through all available downstream routes, including turbines, spillways, regulating outlets, hatchery water supplies, etc., noting injury and mortality through each route.**
2. **Identify and propose alternatives for reducing juvenile mortality passing through the routes noted above, including, but not limited to, operational and structural modifications.**
3. **The Action Agencies will begin these studies in 2008 and will complete all field investigations, study reports, and NEPA analyses, if necessary, by December 31, 2015 (except as noted below for Cougar, Lookout Point, and Detroit in RPA measure 4.12, which have earlier completion dates).**
4. **These evaluations will be developed consistent with the RM&E process described below in RPA measure 9. The Action Agencies must seek NMFS' review of evaluation proposals. Comments submitted by NMFS on draft**

[35] See RPA 1.3 & 1.4 for elaboration of decision making process.

evaluation proposals must be reconciled by the Action Agencies in writing to NMFS' satisfaction prior to initiating any research-related activities anticipated in this RPA. The proposals must identify anticipated take levels of each species and life stage for each year. The Services will inform the Action Agencies whether they agree with the proposed studies, draft reports, and alternatives.

5. **The Action Agencies will conduct additional studies in anticipation of additional passage measures constructed and operated beyond 2023.**

Rationale/Effect of RPA 4.11: The effect of lack of effective downstream fish passage facilities is described in the Effects sections for the major subbasins with Project dams (Middle Fork Willamette, section 5.2; McKenzie, section 5.3; South Santiam, section 5.5; and North Santiam, section 5.6). However, there is little existing information on downstream fish passage through various routes at Project dams. Studies are needed to determine the proportion of fish moving through existing outlets (turbines, regulating outlets, spillways, sluiceways), and their survival and injury rates through each outlet. In order to determine the likely effectiveness of downstream fish passage alternatives, studies are needed to evaluate vertical and horizontal distribution of fish as they reach the face of the dam, and to evaluate biological, technical and engineering issues associated with design of passage facilities.

The information is key to designing effective passage facilities. The kinds of studies that are needed would vary among dams, depending on existing information and characteristics of each dam and the species that use it. The focus of studies would be to develop and evaluate alternative fish passage concepts that would guide site-specific decisions and identify priorities among Project dams on the most effective downstream passage methods at each dam where it is deemed feasible and likely to be effective. If studies show that fry use a reservoir for rearing before migrating downstream as juveniles or smolts, then juvenile collection facilities.

The effect of this RPA will be to provide site-specific information regarding downstream fish passage at Project dams, informing key decisions related to downstream fish passage facilities. This information is a necessary first step in fish passage design. Improved downstream fish passage will ultimately increase spatial distribution by providing safe access to and from historical habitat.

4.12 <u>Long-Term Fish Passage Solutions</u>**: Based on the best available scientific information at the time of development of this RPA, additional structural and operational modifications are needed to allow safe fish passage and access to habitat above and below Willamette project dams.**

The Action Agencies will complete this work as part of the COP described in RPA measure 4.13 below and according to the schedule in Figure 9.4-1. The dates for completing interim steps are guidance. However, the dates for completion and operation are fixed. Measures 4.12.1 through 4.12.3 identify dates for making

structural modifications (or biologically equivalent operational measures), based on the best available information at the time of development of the RPA.

These structural or operational modifications will be analyzed and developed as high priority measures in the Willamette Configuration Operation Plan (COP) (see RPA measure 4.13). The COP will evaluate a range of structural and operational alternatives for improving fish passage and water quality conditions associated with the Willamette dams. The three alternatives described below in RPA measures 4.12.1, 4.12.2 and 4.12 .3 will be priority actions evaluated in the COP to determine whether they are biologically and technically feasible. The Action Agencies, FWS, and NMFS will evaluate the information gathered through the COP, NEPA, RM&E measures, and any other sources of information such as ESA recovery planning (including life cycle modeling developed as part of the recovery planning process), university studies, local monitoring efforts and public comment, to determine whether the scheduled action, or an alternative, will provide the most cost-effective means to achieve benefits to ESA-listed fish. If the information gathered confirms that the scheduled action is best suited to addressing the effects of the Project, the Action Agencies will proceed with implementation. If the information shows that an alternative action would provide similar biological benefits, is technically feasible, and would be more cost-effective, then the Action Agencies will implement the alternative action.[36] The Action Agencies may need to complete appropriate NEPA analyses and obtain authorization and appropriation before implementation. The Action Agencies will present specific implementation plans to NMFS, and NMFS will evaluate whether the actions proposed in the implementation plans meet the biological results NMFS relied on in its 2008 biological opinion. NMFS will notify the Action Agencies as to whether the proposal is consistent with the analysis in the biological opinion.

The Action Agencies will analyze additional structural and operational measures for downstream fish passage (beyond the three listed in measures 4.12.1 through 4.12.3 below) as part of the COP. The measures will be investigated in the same manner as for the three measures listed below. The time frame for construction and operation of these additional passage measures may extend beyond the time frame of this Opinion. However, the Action Agencies must begin certain actions, such as investigating feasibility, completing plans, conducting NEPA, if necessary, and requesting authorization, during the term of this Opinion. These studies will be included in the COP.

[36] See RPA 1.3 & 1.4 for elaboration of decision making process.

Figure 9.4-1 Willamette Project Implementation Schedule. Revised Gantt chart from the Action Agencies (USACE 2008a).

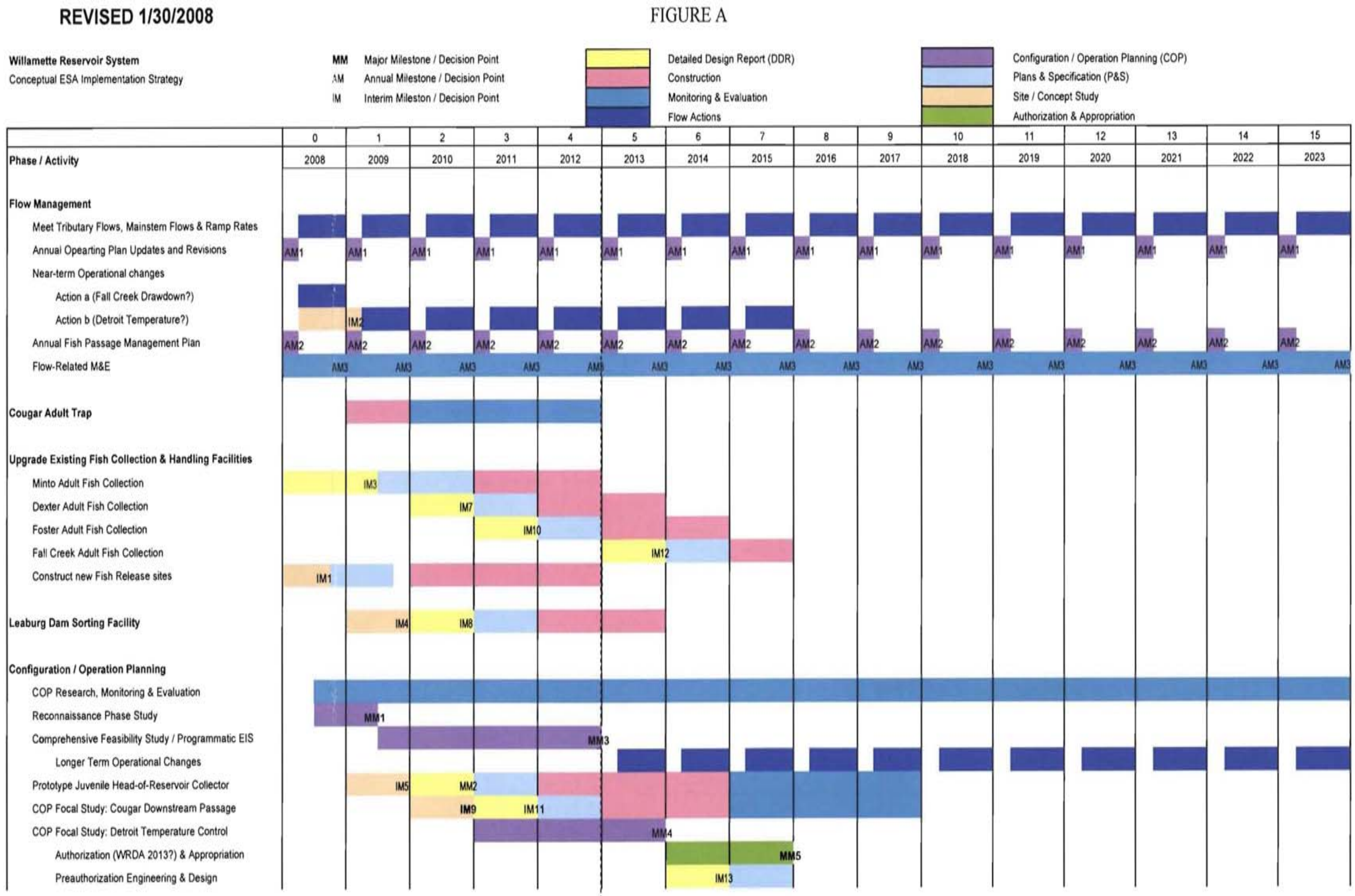

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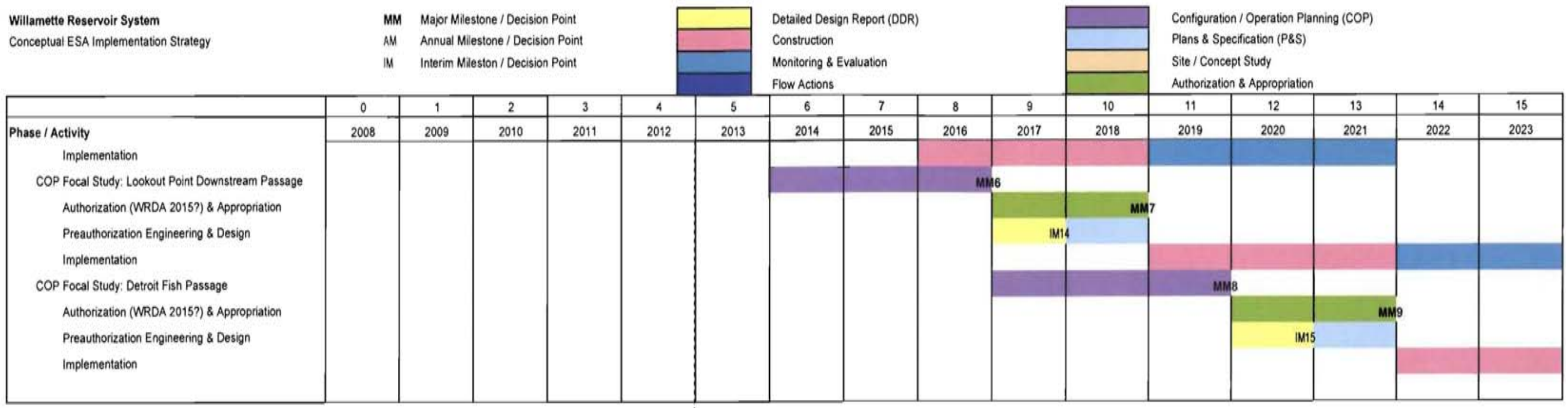
FIGURE A



Rationale/Effect of RPA 4.12**:** This measure ensures that three major fish passage actions will be taken by the Action Agencies by specified dates. As stated elsewhere in this Opinion, lack of passage is the most significant limiting factor to the viability of the affected populations of UWR Chinook salmon and UWR steelhead. This measure addresses that effect of the PA.

NMFS chose the three sites listed in the RPA for the first three passage facilities, based on the best available information at the time of this Opinion. The choice of location of the passage facility, as well as the method of passage may change based on additional information. If information shows a different location or passage method, then the Action Agencies must coordinate with the FPHM and receive NMFS' agreement on the proposed change. Also, passage methods may vary based on the specific requirements needed at each site, as well as how the fish behave at that location.

These three passage facilities are not all that the Action Agencies will ever need to construct to address access limitation, but are sufficient in the next 15 years to begin to address the effects of the Project. By improving downstream fish passage at Cougar, Lookout Point, and Detroit dams, survival will increase for three of the four UWR Chinook populations (McKenzie, Middle Fork, and N. Santiam) and one of the two UWR steelhead populations (N. Santiam) directly affected by Project dams. However, the Action Agencies need to continue studying the next location for passage during the next 15 years so they are ready to construct and operate the next facility soon after completion of the term of this Opinion, and possibly the next one after that. Additionally, measures in an RPA must be within the Action Agencies' ability to implement. The pace of completion of passage measures is as fast as the Action Agencies can proceed.

NMFS recognizes that where fish passage was not previously authorized, the Action Agencies may need to complete appropriate NEPA analyses and obtain congressional authorization before implementation. Further, regardless of whether fish passage was previously authorized, the Action Agencies will need to obtain appropriations before project construction activities can begin.

The effect of this measure will be to ensure that passage happens at three locations within the next 15 years. This will greatly help increase numbers of UWR Chinook salmon and steelhead because they will have access to upstream habitat, and the juveniles will have access downstream to the ocean for growth to maturity. With respect to critical habitat, this measure will address the Habitat Access pathway by improving access past physical barriers, and thereby improving the status of PCEs for spawning, rearing, and migration of UWR Chinook salmon and UWR steelhead populations.

Improved downstream fish passage with will also benefit critical habitat because lack of migration corridor access was a limiting factor.

4.12.1 **<u>Cougar Dam Downstream Passage</u>: The Action Agencies will investigate the feasibility of improving downstream fish passage at Cougar Dam through structural modifications as well as with operational alternatives, and if found feasible they will construct and operate the downstream fish passage facility.**

- **The Action Agencies will take necessary initial steps beginning no later than 2010, which may include a site/concept study, design report, plans and specifications, if appropriate.**
- **The Action Agencies will establish a Major Milestone (MM2) (described in measure 4.13 below) near the end of 2010, in conjunction with completion of the Cougar Site/Concept Study and DDR. The Action Agencies will make "go/no go" decisions on the feasibility of Cougar downstream passage facilities. In the case of the decision to move forward on implementation, the decision will potentially be focused on alternative locations and designs for downstream passage facilities and operations. (NMFS assumes that fish passage improvements at Cougar Dam will not require further authorization because passage was specifically authorized and constructed as part of the original Cougar Dam plans[37]; NMFS also assumes that the proposed Cougar trap will be used for upstream fish passage.)**
- **The Action Agencies will complete construction of any structural fish passage facilities by Dec. 2014; and by 2015, begin operating downstream fish passage facilities at Cougar Dam. Any necessary NEPA compliance required for implementation of the proposed facilities will occur in conjunction with development of the DDR.**

Rationale/Effect of RPA 4.12.1-Cougar Downstream: The Proposed Action identifies a series of field studies, alternatives analyses, and reports that will be completed, if funding is available, to assess the feasibility of downstream fish passage facilities at Cougar Dam and other Project dams, however, the Action Agencies provide no certainty that fish passage improvements will be made. As noted in Section 5.3, McKenzie Subbasin Effects, lack of access to historical spawning and rearing habitat above Cougar Dam is one of the limiting factors affecting population numbers and spatial distribution for the McKenzie Chinook salmon population. This population is at "moderate risk" of extinction and is considered a "core" and "genetic legacy" population (McElhany et al. 2007). Efforts to increase the viability of this population are essential, because it has the potential to be the stronghold for the ESU and is therefore likely to be targeted for "high" or "very high viability" in the recovery plan.

In addition to the population's status within the ESU, NMFS considers achieving safe fish passage at Cougar Dam a priority because this dam was originally authorized for fish passage, presumably making it easier for the Action Agencies to request and receive funding for this purpose. Cougar Dam originally incorporated fish passage measures, but these were abandoned due to the Project's effect on downstream water temperatures that

[37] Due to temperature changes caused by construction of the reservoir, original passage efforts failed. Since 2005, however, temperature problems have been largely solved, and passage is once again feasible.

inhibited returning adults from reaching and entering a trap at the base of the dam. Cougar Dam was upgraded in 2005 with new temperature control facilities which now make, for the first time in 40 years, collection of adults feasible below the dam. USACE plans to construct a new adult fish trap at the base of Cougar Dam in 2009. Once adults are captured in the new trap and transported above the dam, their juvenile progeny will need to emigrate out to complete their life cycles, hence the need for downstream passage at Cougar.

The effect of this measure will be to provide improved downstream fish passage at Cougar Dam, increasing spatial distribution by providing safe access to and from historical habitat. By addressing the primary impediment to population growth and spatial distribution for the McKenzie Chinook salmon population, this measure will support increased abundance and productivity of this core population, reducing the likelihood that the Proposed Action will cause jeopardy.

With respect to critical habitat, this measure will address the Habitat Access pathway by improving access past a physical barrier, and thereby improve the status of PCEs for spawning, rearing, and migration of the McKenzie Chinook salmon population.

4.12.2 **Lookout Point Dam Downstream Passage: The Action Agencies will investigate the feasibility of improving downstream fish passage at Lookout Point Dam, and if found feasible, they will construct and operate downstream fish passage facilities there. The Action Agencies will take necessary initial steps, beginning no later than 2012, which may include feasibility studies, a design report, authorization and appropriation, and plans and specifications, if appropriate.**

- **The Action Agencies will complete construction of any structural fish passage facilities by December 2021.**
- **By March 2022, the Action Agencies will begin operating downstream fish passage facilities at Lookout Point that will enable collection and transport of fish from above Lookout Point to habitat downstream of Dexter.**
- **The Action Agencies will establish a Major Milestone (MM6) near the end of 2014 in conjunction with completion of the Lookout Point Feasibility Study. The major decision associated with that milestone will be "go/no go" decisions on the feasibility of Lookout Point fish passage facilities. Another Major Milestone (MM7) may be needed near the end of 2016 pending actions on authorization and appropriation of proposed facilities.**

Rationale/Effect of RPA 4.12.2: The Proposed Action identifies a series of field studies, alternatives analyses, and reports that would be completed, if funding is available, to assess the feasibility of downstream fish passage facilities at Lookout Point and Dexter dams, however, the Action Agencies provide no certainty that fish passage improvements will be made. As noted in Section 5.2, Middle Fork Willamette Subbasin Effects, lack of access to historical spawning and rearing habitat above Project dams restricts spatial distribution for the Middle Fork Willamette population to a few miles of habitat below

Dexter Dam that is unsuitable for spawning and juvenile fish production due to Project effects on downstream water temperature and habitat complexity. This restricted spatial distribution is likely the most important factor limiting abundance and productivity of the Middle Fork Willamette Chinook salmon population, and without significant improvements in spatial distribution this population may be lost. Improvements to the fish collection facility at Dexter will address the upstream component of habitat access, but safe downstream fish passage past Lookout Point and Dexter is essential to ensure that the Outplant Program can successfully reestablish fish production above these dams.

The effect of this measure will be to provide improved downstream fish passage past Lookout Point and Dexter dams, increasing spatial distribution by providing safe access to and from historical habitat. By addressing the primary impediment to spatial distribution for the Middle Fork Willamette Chinook salmon population, this RPA will support increased abundance and productivity of this population, increasing the likelihood that this population will trend toward a "viable" status rather than be lost. As a result, by protecting and restoring this population, there is reduced risk that the Proposed Action will cause jeopardy to the UWR Chinook salmon ESU.

With respect to critical habitat, this RPA will address the Habitat Access pathway by improving access past a physical barrier, and thereby improve the status of PCEs for spawning, rearing, and migration of the Middle Fork Willamette Chinook salmon population.

4.12.3 **<u>Detroit Dam Downstream Passage</u>: The Action Agencies will investigate the feasibility of improving downstream fish passage at Detroit Dam and if found feasible they will construct and operate downstream passage facilities. Temperature control will also be considered in designing the passage facility.**

- **The Action Agencies will take necessary initial steps beginning no later than 2015, which may include feasibility studies, a design report, authorization and appropriation, and plans and specifications, if appropriate.**
- **The Action Agencies will establish a Major Milestone (MM8) near the end of 2017 in conjunction with completion of the Feasibility Study. The major decision associated with that milestone will be "go/no go" on the feasibility of fish passage facilities at Detroit Dam. Another Major Milestone (MM9) may be needed near the end of 2019 pending actions on authorization and appropriation of proposed facilities.**
- **The Action Agencies will complete construction of any structural fish passage facilities by December 2023. (This measure may be completed earlier in conjunction with Detroit temperature control efforts, as described in RPA measure 5.2 below).**
- **By March 2024, the Action Agencies will begin operating downstream fish passage facilities at Detroit that would enable collection and transport of fish from above Detroit to habitat downstream of Big Cliff Dam. Any necessary**

NEPA compliance required for implementation of proposed facilities will occur in conjunction with preparation of the Feasibility Report.

Rationale/Effect of RPA 4.12.3: The Proposed Action identifies a series of field studies, alternatives analyses, and reports that would be completed, if funding is available, to assess the feasibility of downstream fish passage facilities at Detroit and Big Cliff dams, however, the Action Agencies provide no certainty that fish passage improvements will be made. As noted in Section 5.6, North Santiam Subbasin Effects, lack of access to historical spawning and rearing habitat above Project dams restricts spatial distribution for the North Santiam populations of Chinook salmon and steelhead to habitat below Big Cliff Dam. This downstream habitat is degraded by ongoing Project operations that continue to interrupt sediment transport, alter downstream water temperatures, and modify the rate and seasonality of downstream flows. Rebuilding the fish collection facility at Minto Dam below Big Cliff Dam will address the upstream component of habitat access, but downstream passage facilities are entirely lacking. Safe downstream fish passage past Detroit and Big Cliff is essential to ensure that the Outplant Program can successfully reestablish fish production above these dams.

Although NMFS has given a lower priority to this downstream passage facility than for similar facilities at Cougar and Lookout Point/Dexter dams, NMFS would prefer that this RPA be completed earlier than 2023. As described below in RPA measure 5.2, Water Quality, water temperature control facilities at Detroit Dam are scheduled to be constructed by 2018. These two measures should be evaluated and designed concurrently to ensure the design for temperature control does not preclude viable options for downstream passage. Moreover, the Action Agencies would likely achieve cost-savings and reduce operational and environmental adverse effects of construction by planning and constructing both facilities at the same time.

The effect of this measure will be to provide improved downstream fish passage past Detroit and Big Cliff dams, increasing spatial distribution by providing safe access to and from historical habitat. By addressing the primary impediment to spatial distribution for the North Santiam populations of Chinook salmon and steelhead, this RPA will support increased abundance and productivity, increasing the likelihood that these populations will trend toward a “viable” status. As a result, by protecting and restoring this population, there is reduced risk that the Proposed Action will cause jeopardy to the UWR Chinook salmon and UWR steelhead ESUs.

With respect to critical habitat, this RPA will address the Habitat Access pathway by improving access past a physical barrier, and thereby improve the status of PCEs for spawning, rearing, and migration of the North Santiam populations of Chinook salmon and steelhead.

4.13 **Willamette Configuration Operation Plan (COP): The Action Agencies will carry out the COP, a multi-year, multi-level study process, to evaluate a range of potentially beneficial actions for listed fish species at Project dams and reservoirs. Figure 9.4-1 identifies specific measures, studies, and milestones that will be**

accomplished through the COP. The interim steps will be completed in a timely manner; however, the dates shown in Figure 9.4-1 for interim steps are not firm. Regardless of the timing of interim steps, the Action Agencies will complete each Project measure no later than the final date listed for each measure. The Action Agencies will keep the Services appraised of their progress.

The Action Agencies will evaluate in the COP a variety of potential actions intended to benefit ESA-listed fish, including but not limited to, the following measures:

- **Upstream fish passage facilities, other than the collection facilities described in RPA measure 4.6, above;**
- **Adult fish release sites that require detailed study, as described in RPA measure 4.7, above;**
- **Interim operations for downstream fish passage that require detailed study, as described in RPA measure 4.8, above;**
- **Head-of-reservoir juvenile collection facilities that require detailed study, as described in RPA measure 4.9, above;**
- **Downstream passage facilities or operations, as described in RPA measure 4.12, above;**
- **Temperature control facilities or operations, described in RPA measure 5.2, below;**
- **Interim operations for temperature control that require detailed study, described in RPA measure 5.1, below; and**
- **System-wide operational changes, including "balancing" reservoir refill and release rates, to meet tributary and mainstem flow targets, as described in RPA measure 2.4, above.**

1. ***Definition of Milestones:*** **The COP and related actions will rely on a series of established milestones at key decision points at which the Action Agencies will coordinate and review key decisions with the Services. There will also be regular, continuous coordination between the Action Agencies, NMFS, USFWS, and other affected agencies and Tribes through the WATER process throughout implementation of proposed measures.**

There are three types of milestones identified in this RPA and defined below:

<u>Annual Milestones (AM)</u> for interagency coordination of annual and recurring activities associated with planning and implementation of ongoing ESA Measures related to operations, including completion of annual Willamette Fish Operations Plan (WFOP) revisions, and annual review of research, monitoring and evaluation (RM&E) results.

<u>Interim Milestones (IM)</u> for interim decision points in the planning and development of specific actions, including completion of site/concept studies, detailed design reports, and other key steps in the decision-making process. Interim

Milestones will include decision points on the scope, scale, and location of ESA measures under consideration with NMFS and USFWS review and comment.

Major Milestones (MM) are forecasted key points in the planning, design and implementation process involving decisions on the feasibility of major elements of the RPA and Proposed Action. They may include "go/no go" decisions on implementation of proposed major structural elements, such as fish passage or temperature control facilities, and/or significant operational changes. They may also involve decisions to shift efforts to different alternatives or priorities. Depending on decisions reached regarding the feasibility of proposed measures, it may be necessary to identify other alternatives or reinitiate ESA Section 7 consultation as a result of new information produced through the COP and related studies and coordinated through the Major Milestones.

2. ***Research, Monitoring and Evaluation:*** **RM&E will be a substantial component of the COP. The focus will be on collection and evaluation of biological and physical information required to determine the feasibility of alternative structural and operational measures under consideration in interim and major milestones. The COP RM&E program will be initiated in FY 08 and continue through the term of the Opinion. The Action Agencies will conduct an Annual Review of the Willamette COP and other related RM&E programs to review the results from previous years and revise RM&E program for upcoming years.**

3. ***Reconnaissance Phase Study:*** **The Action Agencies will initiate Phase I of the COP, the Reconnaissance Study (USACE 2007a, Section 3.6.4.3) by September 2008 and complete it by October 2009. The Reconnaissance Report will identify the range of structural and operational alternatives to be evaluated, establish preliminary basin priorities, define biological and other criteria to be used in evaluating alternatives, and provide the detailed Statement of Work for the COP Feasibility Phase. The Action Agencies will establish a Major Milestone (MM1) at the completion of the Reconnaissance Report. The primary purpose of this milestone will be to seek interagency review and concurrence on the scope and content of the subsequent Feasibility Phases. One of the key decision points at this milestone will be to review and possibly refine the priority of long term fish passage and water quality solutions for the COP (described in RPA measures 4.12 and 5.2, respectively).**

4. ***Comprehensive Feasibility Study:*** **The Action Agencies will initiate the Comprehensive Feasibility Study (USACE 2007a, Section 3.6.4.4) by October 2009 and will complete it by September 2012. The Comprehensive Feasibility Study will consider and incorporate relevant results of any life-cycle modeling developed as part of the Upper Willamette recovery planning process. If needed, the Action Agencies will complete appropriate NEPA coverage addressing the range of structural and operational alternatives addressed as part of the COP Comprehensive Study Phase. The Feasibility Report will reflect Action Agency preliminary determinations regarding the feasibility of fish passage, temperature control and other related structural and operational alternatives in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette basins. It is expected to provide specific recommendations for improvements to highest**

priority subbasins and/or features and to include recommendations for major operational changes. It will also evaluate the "high priority actions" (long term fish passage and water quality solutions described in RPA measures 4.12 and 5.2, respectively), and may suggest modifying the scope or timelines of these "high priority actions" based on the outcome of RM&E efforts.

The Action Agencies will establish a major milestone (MM3) at the completion of the COP Comprehensive Feasibility Study. At this point the Action Agencies will have completed initial studies and evaluations on a number of major alternatives, including prototype head-of-reservoir fish collection, downstream passage at Cougar Dam, and temperature control at Detroit Dam. The key decisions at this milestone are whether or not to continue toward fish passage and temperature control modifications of the dams as described in RPA measures 4.12 and 5.2, to evaluate whether or not the correct priorities were established for these measures 4.12 and 5.2, and whether other alternatives are determined more feasible. If the downstream fish passage improvements at Cougar Dam and other locations are determined not likely to be feasible at this milestone, then the Action Agencies may identify other alternatives that would be implemented within the same timelines as those identified in this RPA, or agree to reinitiate Section 7 consultation.

The Action Agencies will present specific implementation plans to NMFS, and NMFS will evaluate whether the actions proposed in the implementation plans are likely to have the biological results that NMFS relied on in this Opinion. NMFS will notify the Action Agencies as to whether the proposal is consistent with the analysis in this Opinion.

Rationale/Effect of RPA 4.13: Section 3.6.4 of the Supplemental BA (USACE 2007a) describes the Willamette System Review Study, the Action Agencies' proposal to undertake a series of studies to evaluate the feasibility and relative benefits of structural and related operational modifications to the Willamette dams designed to improve survival and productivity of ESA-listed aquatic species. The Action Agencies have changed the name of this study framework to "Willamette Configuration /Operation Planning" (COP). The Willamette System Review Study lacked certainty and commitment that fish passage, temperature control, and other improvements would be funded and completed during the term of this Opinion. As a result, the COP is significantly different than the Willamette System Review Study in that it adds certainty to the Action Agencies' proposed study by requiring firm dates for completion of specific measures.

The COP process, and NEPA when appropriate, will outline the costs of the projects, their biological benefits, technical feasibility, potential alternatives, and compliance with all applicable statutes and regulations. The analysis tool of cost effectiveness and incremental cost analysis will be used to assess the range of alternatives. An alternative plan is considered cost effective if it provides a given level of biological benefit for the least cost. Cost effectiveness analysis will be used to identify the least cost solution for each alternative that provides necessary environmental benefit. Incremental cost analysis compares the additional costs to the additional biological benefits of an alternative.

> The effect of this RPA will be that the Action Agencies will complete evaluations that they state are needed to move forward on various fish passage, temperature control and other improvement projects and will then move forward with implementation of these measures. This will minimize time lost before fish protective measures are implemented and become effective at improving fish survival and habitat affected by Project facilities. With respect to critical habitat, this RPA will address the Habitat Access pathway by minimizing time lost before access is improved past physical barriers, and thereby will improve the status of PCEs for spawning, rearing, and migration of UWR Chinook salmon and UWR steelhead.

9.5 WATER QUALITY

The RPA measures in this section are based on sections 3.6 and 3.7 of the Supplemental BA (USACE 2007a). In section 3.6, the Action Agencies propose to evaluate the need and opportunities to achieve water temperature control at Project dams as part of the Willamette System Review Study. In section 3.7, the Action Agencies propose to do the following: 1) continue to operate the Cougar WTC to meet downstream water temperature targets; 2) conduct extended RM&E for Cougar WTC; and 3) carry out ongoing and new RM&E for water quality in Project-affected tributaries and the mainstem Willamette River.

NMFS agrees (in McKenzie Effects section 5.3) that continued operation of the Cougar WTC will provide more normative water temperatures in the South Fork McKenzie and mainstem McKenzie rivers, and will continue to support adult spawning, egg incubation, and fry and juvenile rearing for UWR Chinook salmon. While NMFS agrees that extensive RM&E studies are needed at Cougar to evaluate the effectiveness of the WTC and throughout the basin (General Effects, section 5.1) to monitor water quality and determine appropriate courses of action to achieve water quality standards, the Proposed Action does not provide sufficient certainty that these RM&E studies will be sufficient to provide necessary data and guide decision-making. Additionally, while NMFS agrees that further alternatives analysis is needed to identify priorities for implementing temperature control measures at Project dams (General Effects, section 5.1), the Proposed Action does not require any interim temperature control measures nor does it provide certainty that any permanent facilities will be constructed or operations will be carried out. RPA measure 5 is intended to address these issues.

The adverse effects of the Proposed Action on listed fish and critical habitat include unacceptable water temperature and TDG downstream of the Project dams where listed fish are forced to spawn because they have inadequate access to upstream habitat. The Proposed Action also causes adverse effects on critical habitat conditions downstream of the dam for the same reasons listed above. The water quality measures in the RPA will minimize these project-related adverse effects because they will make water temperatures and TDG more similar to natural conditions. The RPA measures will also provide for fish protection when there are emergencies causing the facilities to operate outside their normal procedures.

Some of the measures in this section of the RPA provide interim protection for listed fish and critical habitat by requiring the Action Agencies to implement certain temperature control measures in the next few years. These measures will address immediate needs of listed fish by providing more suitable habitat downstream of certain dams in areas used for spawning. In addition, the emergency protocols and actions will prevent further harm to listed fish and critical habitat by providing measures for listed fish protection the USACE can take immediately when emergencies arise.

RPA 5 Water Quality

5.1 **Interim Water Quality Measures: Until permanent temperature control facilities and water quality improvements are constructed or operations are established, the Action Agencies will evaluate and carry out, where feasible, interim operational measures and use existing conduits such as spillways, regulating outlets, and turbine outlets to achieve some measure of temperature control and reduced TDG exceedances below Project dams, including Detroit/Big Cliff, Green Peter/Foster, Hills Creek, Lookout Point/Dexter, Fall Creek, and Blue River.**

Rationale/Effect of RPA 5.1: Currently, listed fish are generally limited to inadequate habitat below the Project dams. Water quality problems are one of the major limiting factors in this habitat and prevent proper functioning of critical habitat directly below all of the Project dams listed above except Blue River. Therefore, until long term solutions for effective passage above the dams to properly functioning habitat are available, it is very important to make the habitat below the dams usable for listed fish.

This measure is necessary to ensure that short term actions are taken during the first 5 to 10 years of this Opinion until permanent facilities and operations are constructed and operational. Because permanent temperature control facilities such as the Cougar WTC are complex, large, and very expensive construction projects, the Action Agencies cannot build one or more in the initial years of this Opinion. However, because some of the UWR Chinook salmon populations are presently at such low abundance levels and at high risk of extinction, interim measures are needed as soon as possible to avoid further declines in abundance.

The effect of this measure will be that temperatures below one or more Project dams will more closely resemble normative conditions and TDG exceedances will be reduced, resulting in increased survival of juveniles, eggs, and adults over baseline conditions. This increased survival will help to maintain existing low populations of UWR Chinook salmon and UWR steelhead and will lead to increased productivity and abundance of those populations in affected tributaries. These interim measures will also minimize adverse project effects on critical habitat by increasing the value of critical habitat downstream of the dams by modifying temperature.

5.1.1 **<u>Temperature Control at Detroit/Big Cliff Dams</u>: By March 2009, the Action Agencies will complete an evaluation of the feasibility of modifying operations at Detroit/Big Cliff Dams to improve downstream temperature and TDG conditions, with the objective of achieving similar benefits to water temperature below the dams as was attained in 2007. This analysis will build on information developed during the summer 2007 emergency operation at Detroit Dam in which spill volumes were balanced with releases from the regulating outlets to achieve more desirable downstream temperatures during turbine outages.**

The Action Agencies will establish a Major Milestone (MM) to occur by March 2009, when the evaluation of feasibility is completed. If determined feasible, the Action Agencies will begin to implement the proposed operation beginning in Water Year 2009. If implemented, the Action Agencies will conduct monitoring and evaluation studies to determine the effectiveness of the operation and determine whether the operation should continue in future years. This operational alternative is considered a critical component of Configuration/Operation Planning (COP); effectiveness of using operations of existing facilities to achieve desired downstream water quality conditions will be important in future milestone decisions regarding whether or not to pursue structural water quality improvements.

Rationale/Effect of RPA 5.1.1: This measure identifies the initial location for carrying out interim temperature control measures that will address project-related adverse temperature effects on listed anadromous fish and critical habitat in the North Santiam River. Detroit Dam is a high priority for this action because interim temperature control was shown to be possible and effective in 2007, as described in North Santiam Effects section 5.6.

The effect of this measure is as described above in measure 5.1. Improved water temperatures will result in increased egg survival, as well as likely increased survival of adult and juvenile life stages, causing increases in abundance and productivity for both UWR Chinook salmon and steelhead in the North Santiam River. Another effect of this measure is to improve the value of critical habitat by improving temperature in spawning and rearing areas.

5.1.2 **<u>Additional Interim Water Quality Measures</u>: By March 2010, the Action Agencies will identify measures, in addition to those described in RPA measure 5.1.1 above, that they can start implementing in April 2010, if feasible. By April 2010, the Action Agencies will carry out those operational changes that will result in immediate downstream temperature and TDG benefits; and that do not require congressional authorization, detailed environmental review, extensive permitting, and that are within existing physical or structural limitations. Specific interim operational measures will be determined by the Action Agencies, with the advice of and review by the Services.**

Rationale/Effect of RPA 5.1.2: This measure provides for development of interim measures that can be easily identified and carried out at Project dams other than Detroit Dam without detailed analysis, structural modification, or additional authorization. The Action Agencies have not been able to identify such opportunities at other Project dams, but NMFS includes this measure to require the Action Agencies to assess existing gates, outlets, and operations at Project dams to determine if it is possible to mix outflow from turbines, regulating outlets or other valves with spillway flow to achieve improved downstream water temperatures while minimizing TDG exceedances. Lookout Point Dam is a priority for evaluation because monitoring shows extremely high egg mortality for UWR Chinook salmon in the very limited spawning habitat below Dexter Dam (see Middle Fork Willamette Effects section 5.2). Hills Creek Dam is another location that would likely provide immediate improvements in fish spawning and rearing habitat in the Middle Fork Willamette River below the dam downstream to the upper limit of Lookout Point reservoir.

The effect of this measure is that it may result in interim water quality improvements at more than the one or two dams listed in measure 5.1.1 above. This is an initial assessment that may or may not provide interim options, and thus, the effect on abundance and productivity of listed fish, as well as on critical habitat, is uncertain. However, it is included in this RPA because it has potential benefits to listed fish and critical habitat.

5.1.3 **<u>Complex Interim Water Quality Measures</u>: The Action Agencies will evaluate measures that require detailed environmental review, permits, and/or congressional authorization as part of the COP (see RPA measure 4.13 above). The Action Agencies will complete this component of the COP by April 2011, including seeking authorization and completing design or operational implementation plans for those operations that are determined feasible. The Action Agencies will carry out operations that are feasible by May 2011, contingent on funding, issuance of necessary permits and authorization. The Services will comment on the measures and inform the Action Agencies whether they agree[38] with the interim water quality measures.**

Rationale/Effect of RPA 5.1.3: This measure recognizes that some interim water quality improvement alternatives may include facility or operational changes that would require detailed environmental review, permits, or congressional authorization, and therefore, should be evaluated as part of the COP study (measure 4.13). NMFS distinguishes this interim measure from that in measure 5.2 below, which involves more extensive design and cost, and would be considered a more permanent solution. NMFS expects the kinds of measures that would be included here would be proposals to replace valves on regulating outlets or to install automatic controls on spillway gates. These changes are neither

[38] See RPA 1.3 & 1.4 for elaboration of decision making process.

structurally complex nor expensive, though they would likely require more detailed review than the measures contemplated in measure 5.1.2.

The effect of this measure is that interim water quality improvements may be carried out at more Project dams than contemplated in measure 5.1.2, resulting in more populations of UWR Chinook salmon and steelhead that could benefit from improved downstream temperatures and reduced TDG exceedances. However, NMFS cannot consider the effects of this measure on abundance and productivity of listed fish and critical habitat because there is no certainty that any complex interim alternatives will be carried out. However, it is included in this RPA because it has potential benefits to listed fish and critical habitat.

5.1.4 **Monitoring and reporting of interim water quality improvement measures*:* Each year from 2009 through the term of this Opinion, the USACE will monitor and evaluate the effectiveness of interim and permanent water quality improvement measures, and will produce an annual report, by March 1 of the following year, for review and comment by the Water Quality/Temperature committee. The report will include recommendations, if any, to modify project operations to further improve water quality. The Services will comment on the draft report and inform the Action Agencies if they agree[39] with the recommendations.**

5.1.5 **Modifying interim water quality improvement measures: Each year from 2010 through the term of this Opinion, the USACE will carry out modified project operations proposed in the annual reports described above in RPA measure 5.1.4 unless such modifications require detailed analysis and authorization. If such additional analysis is needed, then the Action Agencies will analyze those proposed modifications as part of the COP (see RPA measure 4.13).**

Rationale/Effect of RPAs 5.1.4 & 5.1.5: Measure 5.1.4 ensures that the Action Agencies will monitor the effectiveness of interim water quality improvement measures carried out as a result of measures 5.1.1, 5.1.2, and 5.1.3, and that they will produce an annual report of their findings. Measure 5.1.5 requires the Action Agencies to use results of monitoring studies and annual report conclusions to modify interim water quality improvement measures, if indicated. NMFS recognizes in these measures that changes requiring detailed analysis, funding, or authorization will not be immediately implemented, but instead, must be considered through the COP study process.

The effect of these measures is that monitoring and reporting will give NMFS and the Action Agencies necessary information to modify water quality improvement measures to improve operations that will better protect UWR Chinook salmon and steelhead below Project dams. NMFS cannot consider effects on abundance and

[39] See RPA 1.3 & 1.4 for elaboration of decision making process.

productivity of listed fish and critical habitat because NMFS cannot predict the results of monitoring and subsequent changes that might be determined beneficial for future interim water quality improvement measures. However, it is included in this RPA because it has potential benefits to listed fish and critical habitat.

5.2 **<u>Water Temperature Control Facilities and Operations:</u> During the term of this Opinion, the Action Agencies will make structural modifications or major operational changes for improved water quality to at least one of the Project dams. Based on the best available information at the time of development of the RPA, NMFS identifies Detroit as the highest priority dam for construction of a temperature control structure or operational changes to achieve temperature control.**

The Action Agencies will investigate the feasibility of improving downstream temperatures and reducing TDG exceedances in the North Santiam River for ESA-listed fish species. The Action Agencies will take necessary interim steps beginning no later than 2010, which may include feasibility studies, a design report, authorization and appropriation, and plans and specifications, if appropriate. As part of this effort, the Action Agencies will evaluate alternatives to achieve both temperature control and downstream fish passage. If feasible and more efficient to achieve both purposes through one construction project, the Action Agencies will include downstream fish passage in this effort, rather than delaying it until 2023, as stated in RPA measure 4.12.3, Detroit Dam downstream passage. The Action Agencies will complete construction of any structural temperature control facilities by December 2018. By March 2019, the Action Agencies will begin operation of permanent downstream temperature control at Detroit Dam.

The Action Agencies will establish a Major Milestone (MM4) near the end of 2011 in conjunction with completion of the Detroit Feasibility Study. The major decision associated with that milestone will be "go/no go" on the feasibility of temperature control facilities. Because temperature control was not included as part of the original project authorization, NMFS assumes that construction of temperature control facilities at Detroit Dam may require Congressional action. Another Major Milestone (MM5) may be needed near the end of 2012 pending congressional action on authorization and appropriation of proposed facilities.

Rationale/Effect of RPA 5.2: This measure builds on the Proposed Action (section 3.6 of the Supplemental BA [USACE 2007a]), in which the Action Agencies propose to evaluate water temperature control at Project dams as part of the Willamette System Review Study. However, the Proposed Action lacks certainty that any temperature control facilities or operations would be provided during the term of this Opinion. This measure provides needed specificity and certainty by identifying a location and date certain when construction will be complete and when improved downstream temperature conditions and reduced TDG exceedances will be achieved.

NMFS chose Detroit Dam as a highest priority for water quality improvements for several reasons. First, past studies by USACE indicate that temperature control is achievable with existing storage capacity at Detroit Dam (see North Santiam Effects section 5.6.3). Second, water quality improvements in the North Santiam would benefit both UWR Chinook salmon and steelhead. Third, UWR steelhead in the North Santiam River are especially dependent on spawning habitat just below Big Cliff Dam and are more likely to be harmed by adverse water temperature conditions and TDG exceedances than steelhead in the South Santiam, which are not as confined to spawning habitat below Foster Dam. Finally, interim operations at Detroit in 2007 confirmed that restoring a more normative water temperature regime caused beneficial effects on downstream fish populations.

The effect of this measure will be that temperatures below Detroit Dam will more closely resemble normative conditions and TDG exceedances will be reduced, resulting in increased survival of juveniles, eggs, and adults over baseline conditions. This increased survival will help to increase productivity and abundance of North Santiam populations of UWR Chinook salmon and UWR steelhead. These more normative temperatures and TDG will also benefit critical habitat because they will make it more useful for listed fish.

5.3 **<u>Protecting Water Quality during Emergency and Unusual Events or Conditions</u>: The Action Agencies will apply protocols developed under RPA measure 4.3 and take actions within existing operational and structural capabilities at all project dams and reservoirs to protect water quality during unusual events and conditions.**

5.3.1 Where the protocols described in RPA measure 4.3 above cannot ensure adequate protection of water quality and other impacts to ESA-listed fish during unusual events/conditions, the USACE will identify structural or mechanical changes that could be made at project facilities for this purpose. The USACE will produce a draft report by September 1, 2009, proposing to make structural or mechanical changes to protect water quality during anomalous events.

5.3.2 With review and comment by the WATER Water Quality/Temperature committee, the USACE will produce a final report by January 1, 2010. NMFS and FWS will inform the USACE if the report's recommendations are inconsistent with this RPA.

5.3.3 The Action Agencies will begin to carry out structural and mechanical changes that will protect water quality during anomalous events and that do not require congressional authorization, detailed environmental review, or extensive permitting by March 1, 2010. These minor changes include only those that meet all of the following criteria: no need to prepare an EIS pursuant to NEPA; no need to obtain additional congressional authorization; no need to submit to extensive permitting procedures; and within reasonable cost.

5.3.4 The Action Agencies will evaluate those measures that require detailed environmental review, permits, and congressional authorization as part of the COP (see measure 4.13). The Action Agencies will complete this component of the COP by April 2011, including seeking authorization and completing design for those structural measures that are determined feasible. The Action Agencies will begin to construct and operate those measures determined feasible by May 2011, contingent on funding and issuance of necessary permits. The Services will inform the Action Agencies whether they agree[40] with the structural measures.

5.3.5 As structural and mechanical changes are completed, the USACE will update the protocols described in measure 4.3 above to include any new instructions for operating the modified facilities.

5.3.6 Any structural or mechanical improvements that are carried out will be continued through the term of this Opinion unless the Action Agencies and the Services determine, as more information is obtained, that there is a better way (that is obviously feasible) to operate for water quality.

***Rationale/Effect of RPA 5.3*:** This measure requires the Action Agencies to prepare for emergency and unscheduled events that may alter water quality and cause harm to listed fish in Project reservoirs and downstream habitat. As described in North Santiam Baseline section 4.6 (and Effects section 5.6), a powerhouse fire at Detroit and Big Cliff in 2007 caused rapid increases in TDG below Big Cliff, potentially killing young steelhead alevins (the stage between hatching and leaving the gravel) as they prepared to emerge from redds below that dam. Had protocols been in place that described ways to avoid and minimize harmful effects of emergency conditions on water quality and fish, these actions could have been carried out immediately by Project staff, thereby reducing the number of steelhead alevins that would have been killed.

The effect of this measure will be that actions to minimize fish harm from emergency events will be identified in advance, and will then be carried out as soon as possible after such events occur, resulting in less injury and mortality to listed fish above and below Project dams. Additionally, because this measure requires the Action Agencies to investigate and carry out structural or mechanical changes determined feasible to protect water quality during emergency events, fish losses will be further reduced.

5.4 **<u>Cougar Dam RM&E</u>: The Action Agencies will fund and carry out an extended biological RM&E program associated with the Cougar Dam WTC. The RM&E program will begin in 2011, after completion of the RM&E program included in the previously authorized Cougar Trap project. The RM&E program will evaluate effects of the WTC operation on the downstream ecosystem (including TDG), fish passage through the reservoir, dam, and regulating outlet, and effectiveness of the trap-and-haul program. It will also quantitatively assess biological benefits realized**

[40] See RPA 1.3 & 1.4 for elaboration of decision making process.

from these protective and restorative measures. By September 2010, the Action Agencies will prepare a revised Cougar Dam WTC Monitoring and Evaluation Plan, based on the original plan developed as part of a previous consultation, subject to review and comment by the Services, and consistent with the RM&E process described below in RPA measure 9 (RM&E). The Action Agencies must obtain NMFS' review of the plan prior to initiating any research-related activities anticipated in this RPA. The proposals must identify anticipated take levels of each species and life stage for each year. The Services will inform the Action Agencies whether they agree[41] with the revised plan, proposed studies, draft reports, and NEPA alternatives. The Action Agencies will begin to carry out the extended RM&E program by March 1, 2011.

Rationale/Effect of RPA 5.4: This measure modifies a similar action described in section 3.7.1.2 of the Supplemental BA (USACE 2007a). The Proposed Action does not specify when this RM&E program would begin, or how it would mesh with ongoing monitoring at Cougar Dam. Monitoring the Cougar WTC and associated fish passage at that facility is already required thru at least 2010 as part of the Cougar Trap project, and NMFS completed consultation on that proposed action in 2007 (NMFS 2007a). In this measure, NMFS requires the Action Agencies to continue RM&E at Cougar Dam beginning in 2011 to ensure that studies include a sufficient number of years of data to represent a variety of water year conditions and to include adult return data.

The effect of this measure will be to ensure that decisions regarding temperature control and downstream passage at Cougar Dam and other Project dams are based on reliable biological information. As a result, existing structures will be operated to improve fish survival and new structures will be more likely to provide safe fish passage and favorable water quality conditions for listed fish below Project dams.

9.6 HATCHERIES

The following actions are included in the RPA for Hatcheries. These actions are necessary for reducing short- and long-term risks faced by the Chinook ESU and steelhead DPS, thereby increasing the viability of the affected populations.

RPA 6 Hatcheries

6.1 **The Action Agencies will work cooperatively with the State of Oregon to ensure that Willamette Project hatchery programs are not reducing the viability of listed ESUs/DPSs.**

6.1.1 **Implementation of Hatchery and Genetic Management Plans (Willamette Basin-wide): The Action Agencies will implement the actions described in the Willamette Hatchery and Genetic Management Plans (ODFW 2003, 2004a, 2005a, 2007a, 2008a, 2008b) for spring Chinook, summer steelhead,**

[41] See RPA 1.3 & 1.4 for elaboration of decision making process.

and rainbow trout, after NMFS approval of these plans. Implementation of these actions requires cooperation with the State of Oregon, who partially funds and operates many of the facilities associated with the Hatchery Mitigation Program.

***Rationale/Effect of RPA 6.1.1*:** The HGMPs provide the detailed management plan for each hatchery program throughout the entire life cycle of the fish. Adherence to the HGMP is necessary since the fine details of the hatchery programs are not (and should not be) included in the Supplemental BA.

The effect of this measure will be to reduce and minimize adverse effects of hatchery programs on UWR Chinook and steelhead. There are many specific protocols and guidelines for spawning, raising, and releasing hatchery fish that need to be implemented to be in accordance with best management practices for reducing impacts to ESA-listed stocks.

6.1.2 **<u>Hatchery Facility Improvements (Willamette Basin-wide)</u>: The Action Agencies will improve fish collection facilities associated with the hatchery mitigation program; including salmonid ladders, traps, holding, and acclimation facilities associated with hatchery broodstock collection and the outplanting program. Facilities will be rebuilt according to the schedule described in RPA measures 4.6 and 4.7 above.**

Rationale/Effect of RPA 6.1.2: Improving the collection facilities associated with hatchery broodstock collection and the outplanting program of fish above the dams is necessary in order to reduce the handling impacts to listed fish associated with using the existing facilities. The existing facilities were not designed (nor originally intended) to capture and handle listed fish.

The effect of this measure will be to reduce handling stress and mortality to listed salmon and steelhead associated with the collection of fish associated with the outplanting program above the dams and hatchery broodstock collection.

6.1.3 **<u>Mass-marking of Hatchery Releases (Willamette Basin-wide)</u>:- The Action Agencies will continue to mark all hatchery fish releases in the Willamette Basin with an adipose fin clip and otolith mark. The Action Agencies will ensure that coded wire tags (or blank tags if appropriate) will be inserted into all hatchery spring Chinook released into the McKenzie Basin, beginning with the 2008-09 smolt releases. The Action Agencies, with the cooperation of the ODFW, will phase in the tagging of all other Chinook releases according to the schedule described in RPA measure 4.13 above, so that the first year of the age-4 return can be detected at the rebuilt facilities. There is no need to wire tag Chinook releases unless infrastructure is in place to detect adult returns.**

Rationale/Effect of RPA 6.1.3**:** It is necessary to continue to externally mark all hatchery fish releases so that (1) the status of natural-origin and hatchery-origin returns can be determined, (2) the percentage of hatchery fish spawning naturally in the wild can be determined, and (3) so that managers can incorporate natural-origin fish into hatchery broodstocks as appropriate.

The effect of this measure will be to ascertain effects of the hatchery program on the natural-origin population in terms of the percentage of natural-origin fish collected for broodstock and percentage of hatchery fish on the natural spawning grounds.

6.1.4 **Improvements at Leaburg Dam (McKenzie): The Action Agencies will fund the design, construction, and operation[42] of a sorting facility at Leaburg Dam on the McKenzie River to reduce hatchery fish straying into core spring Chinook natural production areas upstream. Modification of the existing facilities, or construction of new ones, is contingent on agreement by the facility owner, Eugene Water & Electric Board (EWEB), and collaboration with EWEB and ODFW. The Action Agencies will establish a Working Group, comprised of representatives from BPA, USACE, NMFS, ODFW, and EWEB, to scope the design and implementation of the sorting facility. The design philosophy for this facility will be that it automatically separates hatchery-origin adults from other fish.[43] If it is not feasible to design the facility with automatic sorting capability, the Action Agencies will seek NMFS' agreement[44] to use an alternative facility design that minimizes harm to UWR Chinook salmon. The Action Agencies will complete construction of the sorting facilities by December 2013, and begin operation in time for the spring Chinook upstream migration beginning in 2014. If an acceptable sorting facility at this site is deemed infeasible by the Working Group and agreed to by NMFS, then the Action Agencies will take alternative actions to reduce hatchery fish straying to less than 10% of the total population spawning in the wild.**

Rationale/Effect of RPA 6.1.4**:** The McKenzie run of Chinook is a stronghold population and currently produces the highest number of natural-origin fish in the ESU. Significant spawning by hatchery-origin fish (13-36%) in the wild presently occurs and represents substantial risks to population productivity and diversity. It is necessary to reduce the effects of hatchery fish on this population to the lowest extent possible (0-10%) in order to restore this population and to be able to evaluate its sustainability without the continual infusion of hatchery spawners.

[42] Operation could be partially or completely funded by another entity.
[43] Hatchery-origin fish have had small metal tags implanted in them. These tags may be electronically sensed and the resulting signal used to operate sorting devices. Non-hatchery origin fish do not have these tags and could theoretically be allowed to pass upstream without human intervention, reducing the injury and stress that they experience.
[44] See RPA 1.3 & 1.4 for elaboration of decision making process.

The effect of this measure will be to reduce the natural spawning of hatchery fish in the wild, thereby reducing risks of genetic introgression.

6.1.5 <u>Management of Hatchery-origin Spring Chinook Upstream of Cougar Dam (McKenzie)</u>**: The Action Agencies will discontinue releases of all hatchery spring Chinook salmon above Cougar Dam on the South Fork McKenzie River once sufficient numbers of wild fish can be safely collected at the rebuilt Cougar Dam trap and outplanted above the dam. The minimum number of wild fish needed for the outplanting program will be determined by the Fish Passage and Hatchery Management Committee. If insufficient numbers of wild fish (e.g., less than 100 wild fish) are collected at Cougar Dam, then hatchery fish may be used to supplement natural spawning above Cougar Dam, up to a maximum of 50% of the outplanted fish. The FPHM committee will annually update the Willamette Fish Operations Plan with the appropriate number of hatchery-origin fish to be released upstream of Cougar Dam.**

***Rationale/Effect of RPA 6.1.5*:** The continual outplanting of adult hatchery fish above Cougar Dam represents significant productivity and diversity risks to the McKenzie population because offspring from these outplanted fish (i.e. F1 hatchery fish) would be indistinguishable from natural-origin fish in the population. These fish would then spawn naturally in the population, thereby infusing hatchery genes into the wild population. The continual release of hatchery fish upstream of Cougar Dam is inconsistent with RPA measure 6.1.4 and continues to allow hatchery fish to influence the natural-origin population. This measure includes cooperation with the State of Oregon, who partially funds and operates many of the facilities associated with the Hatchery Mitigation Program.

The effect of this measure will be to manage genetic introgression of hatchery fish in the McKenzie population and facilitate local adaptation of a self-sustaining run of spring Chinook upstream of Cougar Dam in the South Fork of the McKenzie.

6.1.6 <u>Improve Summer Steelhead Release</u>**: The Action Agencies, in cooperation with ODFW, will improve the release of hatchery summer steelhead smolts by allowing volitional emigration from the point of release over an extended period of time (e.g., 2-4 weeks) with any non-migrants being removed and not released into free flowing waters below the Projects, to extent possible given constraints on the current infrastructure. When the facilities are reconstructed, the Action Agencies will ensure that any new acclimation facilities allow for this operation.**

***Rationale/Effect of RPA 6.1.6*:** Improving the release protocols for hatchery summer steelhead smolts should reduce the percentage of hatchery fish that residualize and thus interact with listed fish below the dams. Previously management practices released all of the fish into the river and did not remove fish that were not ready to actively emigrate to the ocean.

The effect of this measure will be to reduce competition and predation of hatchery fish on natural-origin Chinook and steelhead downstream of the dams.

6.1.7 **<u>Reduce Summer Steelhead Recycling in the Santiam Basin</u>: The Action Agencies, in cooperation with ODFW, will stop recycling adult summer steelhead for fishery harvest purposes by September 1st of each year in the North Santiam and South Santiam rivers. The Action Agencies will continue to operate fish collection traps on a weekly basis through October 15th in order to maximize the collection of summer steelhead, to the extent possible with the current facilities. These fish will then be held at the hatchery for spawning, unless determined otherwise by the FPHM committee.**

Rationale/Effect of RPA 6.1.7**:** Previously, summer steelhead were periodically recycled through the end of October for sport fisheries downstream of the dams. The practice of recycling fish later in the season (i.e. September through October) when fishery effort is low and the fish are nearing spawning time likely increases the number of summer steelhead that spawn in the wild during the fall and winter. Eliminating the recycling program later in the season and removing the summer steelhead that are captured in the traps will decrease the number of naturally-spawning summer steelhead.

The effect of this measure will be to reduce straying and spawning by summer steelhead in listed winter steelhead habitat and reduce competitive interactions between juvenile summer and winter steelhead.

6.1.8 **<u>Adjust Releases of Summer Steelhead in the Santiam Basin</u>: The Action Agencies, in cooperation with ODFW, will reduce the hatchery summer steelhead release in the North Santiam River to 125,000 smolts. To offset this reduction, summer steelhead releases may be increased in one or more of the following subbasins: South Santiam, McKenzie, and Middle Fork Willamette (up to a total of 36,000 fish) to maintain the existing hatchery mitigation in the Willamette Basin. The revised HGMP for summer steelhead will identify how these production changes will be allocated among the different rivers.**

Rationale/Effect of RPA 6.1.8**:** Recent creel survey data shows the sport fishery in the South Santiam catches more summer steelhead than in the North Santiam (Schroeder et al. 2006). However, more hatchery fish are released in the North Santiam than the South Santiam. The combination of greater hatchery fish released and lower fishery harvest in the North Santiam is leading to widespread spawning by hatchery summer steelhead in the listed winter steelhead habitats. Adjusting the release numbers in the North and South Santiam to be more aligned with current fishery needs, and will allow greater harvest and reduce impacts to winter steelhead.

The effect of this measure will be to reduce spawning of summer steelhead in listed winter steelhead habitat of the North Santiam, thus reducing adverse effects of the hatchery program. More fish released in the South Santiam will provide more harvest in the sport fishery, where fishing effort is greater. Harvest of summer steelhead will likely increase, and thus straying and spawning by summer steelhead should not increase appreciably.

6.1.9 **<u>Future Summer Steelhead Management Actions</u>: The Action Agencies, in cooperation with ODFW, will implement future management actions aimed at reducing the impacts of the summer steelhead hatchery program on ESA-listed species. These actions will be developed according to the process described in section 3.4.10.2 of the Supplemental BA (USACE 2007a), which will incorporate the results of research, monitoring, and evaluation.**

Rationale/Effect of RPA 6.1.9: If RM&E in the near future continues to show unacceptable straying and spawning by summer steelhead in the DPS after recent management changes have been implemented, then further actions to reduce impacts will be developed and implemented as necessary.

The effect of this measure will be to adaptively manage the summer steelhead hatchery program and thus guide future management decisions that could reduce impacts on listed winter steelhead.

6.2 **The Action Agencies will preserve and rebuild genetic resources through conservation and supplementation objectives to reduce extinction risk and promote recovery. These actions rely in part on cooperation with the State of Oregon, which partially funds and operates many of the facilities associated with the Hatchery Mitigation Program.**

6.2.1 **<u>Implementation of Hatchery and Genetic Management Plans (Willamette Basin-wide)</u>: When approved by NMFS, the Action Agencies, in cooperation with ODFW, will implement the actions described in the NMFS-approved Willamette HGMPs for spring Chinook, summer steelhead, and rainbow trout.**

***Rationale/Effect of RPA 6.2.1*:** This measure is identical to that described as RPA measure 6.1.1, but is included here because of the importance of HGMPs to practices that rebuild genetic resources.

6.2.2 **<u>Genetically Integrated Management of Spring Chinook Programs (Willamette Basin-wide)</u>: For all Willamette spring Chinook hatchery mitigation programs, in each population area (Middle Fork, McKenzie, South Santiam, North Santiam), the Action Agencies, in cooperation with ODFW, will fund and implement conservation and supplementation programs that build genetic diversity using local broodstocks and manage the composition of natural spawners according to the sliding-scale matrices,**

as described in Section 3.4 of the Proposed Action, Supplemental BA (USACE 2007a, and ODFW 2003,2004a, 2005a, 2007a, 2008a, 2008b). The Action Agencies will monitor and evaluate implementation of actions through the end of the ESA take coverage period (term of this Opinion is 15 years).

Rationale/Effect of RPA 6.2.2: Since the hatchery Chinook programs are being used for reintroduction efforts above some of the impassable dams, based upon the best available science, it is necessary for the hatchery stock to be integrated with the natural-origin population to the extent possible at this time. Therefore natural origin fish must be incorporated into the hatchery broodstocks. In addition, hatchery fish will be managed on the spawning grounds to manage genetic risks to the wild population over the long-term.

The effect of this action will be to make the Chinook hatchery stocks as similar as possible to their respective natural-origin counterparts to the extent possible. This will reduce domestication and genetic risks of hatchery fish to the natural-origin population above and below the dams.

6.2.3 **Continue Adult Chinook Outplanting Program (Willamette Basin-wide):- The Action Agencies will continue the existing Adult Chinook Salmon Outplanting program, capturing spring Chinook salmon below USACE projects and transporting them into habitat that is currently inaccessible above the following dams: in the North Santiam, above Detroit Dam; in the South Santiam, above Foster Dam; in the South Fork McKenzie, above Cougar Dam; and in the Middle Fork Willamette, above Lookout Point and Hills Creek dams; and carry out the operational and handling protocols described in the HGMP for each subbasin hatchery. The Action Agencies will use hatchery fish in each population area as described in the HGMP sliding scale matrices. See RPA measures 4.1 through 4.4 of this RPA for additional details.**

Rationale/Effects of RPA 6.2.3**:** For several Chinook populations (North Santiam, South Santiam, Middle Fork Willamette), it is necessary to use existing hatchery stocks for outplanting efforts above the impassable dams because of the lack of natural-origin fish available. Since the dams blocked most of the historical holding and spawning habitat in these populations and there are problems with water temperature below the Projects, it is necessary to regain production from the areas upstream of the dams, even though hatchery stock will be used for reestablishing the fish above the dams. This measure relies on the Action Agencies working in cooperation with ODFW.

The effect of this measure will be to re-establish natural production in historical habitat above impassable dams. Since the outplanting program has significant impediments at this time with the trapping facilities, prespawning mortality, downstream passage of juvenile fish through the reservoirs and dams, the use of hatchery fish is more appropriate in many cases than using natural-origin fish.

6.2.4 **<u>Adjust Spring Chinook Release Strategy (Willamette Basin-wide)</u>: The Action Agencies will use more natural (i.e. "wild-type") growth rates and size at release for all juvenile spring Chinook reared and released at hatcheries, as feasible. Actions shall be taken to release hatchery fish that are more similar to their natural-origin counterparts to the extent feasible. As proposed in the Supplemental BA, the Action Agencies will work with ODFW to develop a plan for an experimental release in 2009, with an associated RM&E program. The FPHM Committee will evaluate RM&E results, current science on release strategies, and additional information resulting from analysis of previous releases, to develop a plan for modifying future releases. These Chinook hatchery programs serve a dual purpose (fishery augmentation and population conservation), thus consideration shall be given to the survival effects of this hatchery reform action. Unacceptably low survival rates would prevent attainment of both conservation and fishery objectives.**

***Rationale/Effects of RPA 6.2.4*:** Since hatchery Chinook are being used for conservation purposes, it is necessary to align hatchery fish to the extent possible with the natural-origin population. The hatchery fish, when released as smolts, are larger than wild smolts, which has implications for survival, age at return, and reproductive potential. This RPA action will experiment with different release strategies to align hatchery smolts more with wild smolts with the intent of reducing hatchery effects on population viability.

The effect of this measure will be to make the hatchery Chinook more similar to their natural-origin counterparts, thus making them more appropriate for supplementation and reintroduction purposes.

6.2.5 **<u>Molalla River Chinook Recovery:</u> The Action Agencies will support ODFW efforts to eliminate the use of the non-local hatchery Chinook stock (South Santiam) released into the Molalla River. The Action Agencies will work with ODFW to identify potential funding and implementation mechanisms to develop a locally-adapted broodstock, using the conceptual approach described in the hatchery management strategy for the Molalla River Basin.**

***Rationale/Effects of RPA 6.2.5*:** The best available science suggests a locally-derived hatchery stock is better for supplementation purposes than an out-of-population and/or domesticated hatchery stock. The proposed action is to continue to release South Santiam hatchery stock into the Molalla River. Development of a locally derived Chinook broodstock would contribute to recovery efforts in the Molalla River by addressing the effects of the Project.

The effect of this measure will be to reduce impacts of the existing hatchery stock on the population. A locally-derived stock is likely to be more fit to local environmental conditions and more productive.

9.7 HABITAT

This section of the RPA is intended to build upon the measures described in Section 3.5, Habitat Restoration and Management Actions, of the Supplemental BA (USACE 2007a). For the most part, the Proposed Action measures involve assessment of habitat needs and studies to identify and prioritize possible restoration projects, if funding is available. In this Opinion, Section 5, Effects, NMFS describes adverse effects of continued operation of Project dams and maintenance of Project revetments on downstream physical habitat (See Middle Fork Willamette Section 5.2.4; McKenzie Section 5.3.4, etc). The Proposed Action would continue to degrade existing rearing, holding, and spawning habitat below Project dams, reducing abundance and productivity of UWR Chinook salmon and UWR steelhead. Additionally, as described in the Habitat Access and Fish Passage subsections within key tributary sections of Effects (Middle Fork Willamette Section 5.2.1, McKenzie Section 5.3.1, South Santiam Section 5.5.1, and North Santiam Section 5.6.1), the Proposed Action would continue to prevent safe access to historical habitat above the dams, restricting most of the fish to existing habitat below the dams. Thus, during the term of this Opinion, while fish passage solutions are being researched and installed at the highest priority Project dams, the Action Agencies must actively restore habitat downstream of the dams to offset continued degradation in this remaining habitat. Further, as described in Section 3, Rangewide Status, juvenile rearing habitat in the lower reaches of most tributaries is one of the key factors limiting productivity of most populations of UWR Chinook salmon. Even after other limiting factors are addressed that increase productivity (e.g., water temperature and/or fish passage), restoration of juvenile rearing habitat in reaches downstream of the dams will still be necessary to ensure adequate habitat is available for this life stage. Habitat restoration work will prevent further declines in abundance and productivity of UWR Chinook salmon and UWR steelhead associated with Project effects on downstream habitat, and will be necessary to ensure success of other actions required in this RPA by addressing limiting factors associated with other life stages.

7.1 **Willamette River Basin Mitigation and Habitat Restoration: The Action Agencies will plan and carry out habitat restoration programs on off-site lands. Existing programs will continue (7.1.1); a comprehensive program will be established (7.1.2); and additional projects will be done (7.1.3). The purpose of the program will be to protect and restore aquatic habitat to address limiting habitat factors for ESA-listed fish.**

7.1.1 The Action Agencies will continue to carry out the projects listed in Table 9.7-1 (below).

Table 9.7-1 Ongoing Habitat Restoration Projects in the Willamette Basin

Project/Program	Water Body	Description
Willamette Basin Mitigation (BPA 199206800)	Mainstem Willamette	Integrative mitigation program that protects, conserves, and restores areas containing diverse habitats that assist the life history needs and resources for multiple terrestrial and aquatic species in the Willamette Basin.
Delta Ponds (Section 206, USACE)	Mainstem Willamette near Eugene	Construction initiated in 2005 with the City of Eugene, and will continue. The project is providing floodplain and hydraulic connectivity to the Willamette River through a series of old gravel pits.
Springfield Millrace (Section 206, USACE)	Middle Fork Willamette near Springfield	Construction initiated 2008 with the City of Springfield. The project will restore historic millrace and mill pond and creation of wetlands, fish passage and water quality improvements.
North Santiam Gravel Study (Planning Assistance to States, USACE)	North Santiam River	This study was initiated in 2008 and will assess the need and potential locations for gravel placement in the North Santiam River.

7.1.2 The Action Agencies will develop and carry out a comprehensive habitat restoration program, in collaboration with the Services, which will include funding for carrying out habitat restoration projects during the term of this Opinion. The Action Agencies will work with the Services to pursue authorization, if necessary, and appropriations to carry out the habitat restoration program.

The Action Agencies will work closely with the Services to accomplish the following:

1. **Develop project selection criteria aimed specifically at addressing factors limiting the recovery of Willamette basin ESA-listed fish populations, focusing on, but not limited to, those factors caused at least partially by the Willamette Project. These criteria should be informed by regional plans including Willamette Basin Recovery Plans for anadromous salmonids (ODFW 2007b), Willamette Aquatic Habitat Assessment (unpublished, see RPA measure 7.5), Willamette Subbasin Plan (WRI 2004), Willamette River Basin Planning Atlas (Hulse et al. 2002), and the COP evaluation (measure 4.13).**
2. **Identify proposals for habitat restoration projects.**
3. **Forward those proposals that meet project selection criteria to NMFS for review and determination if they are consistent with improving survival and recovery.**
4. **Fund priority projects, through applicable programs and processes (see Table 9.7-2), that NMFS and FWS determine to be consistent with recovery plans for their respective ESA-listed species.**

Table 9.7-2 Authorities/Programs to Facilitate Implementation of Habitat Restoration Projects in the Willamette Basin

Program	Water Body	Description
Columbia River Basin Fish and Wildlife Program	Columbia Basin (including Willamette)	The Northwest Power Act of 1980 directs the Council to develop a program to protect, mitigate and enhance fish and wildlife of the Columbia River Basin that have been impacted by hydropower dams, and make annual funding recommendations to the Bonneville Power Administration for projects to implement the program. The Bonneville Power Administration then decides which projects to fund and implements the selected projects.
Continuing Authorities Program (CAP); (USACE Sections 206 & 1135 Programs)	Oregon	Continuing Authorities Program funds small restoration projects that address a variety of water resource and land related problems. A description of the CAP program is provided in section 3.5.2.3 of the Supplemental BA (USACE 2007a)
General Investigation Program (GI); USACE)	Oregon	Authority to conduct complex, large-scale, multiple purpose water resource projects. Applicable existing GI studies are described in Section 3.5.2.2 of the Supplemental BA and include: the Willamette River Floodplain Restoration Study; Eugene-Springfield Metro Area Watershed Feasibility Study, Lower Willamette Ecosystem Restoration Feasibility Study
Planning Assistance to States (PAS); USACE)		Authority to work with non-Federal sponsor to study and evaluate water and related land resource problems. Current study of North Santiam Gravel under this authority
Upper Willamette Watershed Ecosystem Restoration Authority (USACE Sec 3138 program)	Willamette watershed upstream of Albany	New authority from WRDA 2007 to conduct ecosystem restoration studies for the upper Willamette basin to protect, monitor, and restore fish and wildlife habitat.
Ecosystem Restoration and Fish Passage Improvement Authority (USACE Sec 4073)	Oregon	New authority in WRDA 2007 to conduct studies for ecosystem restoration and fish passage improvement on rivers throughout Oregon. Emphasis on fish passage and restoration to benefit species that are ESA listed. In conjunction with study, pilot project to demonstrate effectiveness of actions is authorized.
Sustainable Rivers Partnership with The Nature Conservancy	Willamette Basin	Cooperative agreement between USACE and The Nature Conservancy to assess and implement dam operational changes to better mimic natural river flows in the Willamette basin

7.1.3 By 2010, the Action Agencies will complete at least two of the highest priority projects that should result in significant habitat improvement for listed fish species. The Action Agencies will complete additional habitat projects each year from 2011 through the term of this Opinion. Alternatively, larger projects that might require several years to complete could be funded over a multi-year period instead of funding individual, smaller projects each year. NMFS will inform the Action Agencies whether they agree with the decision to fund and carry out these projects.

Rationale/Effect of RPA 7.1: This measure builds on the multiple studies and authorities the Action Agencies describe in the Proposed Action, section 3.5.2 through 3.5.4, of the Supplemental BA (USACE 2007a). It requires the Action Agencies to develop, fund, and carry out a comprehensive habitat restoration program for listed fish species in the Willamette basin.

Measure 7.1.1 acknowledges continued funding of existing projects in the Willamette watershed that provides some habitat improvements for UWR Chinook salmon and UWR steelhead. Although NMFS proposes to redirect project priorities to benefit these listed species, most of the funds for these projects have already been committed for other purposes, so only a small number of projects might be funded through this process. The Willamette Basin Mitigation project has some benefit, although limited, because it is directed primarily at terrestrial species. The Willamette Basin Mitigation projects will primarily benefit UWR Chinook salmon and UWR steelhead, and to a lesser degree, LCR Chinook salmon, LCR steelhead, and LCR coho salmon.

The priority for the new program and restoration projects described in RPA measures 7.1.2 and 7.1.3 is to maximize benefits for listed fish populations for which habitat degradation due to the Project is a major limiting factor. NMFS expects that most funded projects will have ecological benefits beyond helping listed fish species. Although specific projects are not identified, this measure provides enough certainty that the Action Agencies will establish a program, identify priority projects, acquire funding, and complete at least 2 projects by 2010, with additional projects funded and completed each year from 2011 through 2023, the term of this Opinion. This measure on its own would not be sufficient to offset continued population declines associated with degraded downstream habitat, but it does ensure an incremental improvement in downstream habitat, and would help to maintain populations at existing levels below the dams.

The effect of this measure is to offset adverse impacts of the Willamette Project on elements of critical habitat, such as degraded rearing and migration habitat in the mainstem Willamette and lower reaches of its tributaries caused by reduction in channel-forming flows and continued existence and maintenance of revetments. This measure will offset the effects by creating complex rearing habitat, adult holding habitat, and access to off-channel habitat, resulting in increased abundance and productivity of UWR Chinook salmon and UWR steelhead, and will improve the functioning of the PCEs for safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. If any projects are funded in the Willamette River below the falls, LCR Chinook salmon, LCR steelhead, and LCR coho salmon would also see small increases in abundance and productivity.

Some restoration projects will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks). Examples include sediment plumes, localized and brief chemical contamination from machinery, and the destruction or disturbance of some existing riparian vegetation. These impacts will be limited by the use of the practices described in NMFS (2008e). The positive effects of these projects on population viability and PCEs will be long term.

7.2 **Habitat Restoration and Enhancement on USACE Lands at Project Dams and Reservoirs: The USACE will continue to use existing authorities and programs for land and water resource stewardship on the lands it administers at the 13 Willamette projects to carry out aquatic and riparian habitat projects to benefit**

terrestrial organisms and resident fish species, in ways that do not harm ESA-listed species. Additionally, the USACE may design projects on USACE lands to benefit ESA-listed anadromous species. These actions will be carried out consistent with the best management practices identified in the "SLOPES IV Restoration" (NMFS 2008f) or other applicable biological opinions.

Rationale/Effect of RPA 7.2: In section 3.5.1 of the Proposed Action in the Supplemental BA (USACE 2007a), the Action Agencies propose to continue on-site habitat management activities aimed primarily at resident fish and wildlife species that use the reservoirs and adjacent lands. NMFS includes this measure to ensure that continued on-site activities are reviewed and modified, if necessary, to avoid adverse effects on listed UWR Chinook salmon and UWR steelhead. Further, on-site habitat projects that benefit UWR Chinook salmon and UWR steelhead should be funded through this program.

NMFS cannot quantify the effect of this measure on listed fish or critical habitat because the measure does not specify the number of projects or magnitude of benefit that should be directed at listed anadromous species. Insufficient information is available to assess the value of these reservoirs for rearing juvenile salmon and steelhead, and thus NMFS cannot determine how much, if any, habitat restoration work is needed in the reservoirs and adjacent aquatic habitat. However, this measure will provide benefit to listed anadromous fish because it will ensure that there are adequate protections for listed salmonids when the Action Agencies are conducting projects that benefit other species.

7.3 <u>Large Wood Collected at Project Dams</u>: **During annual maintenance operations, the Action Agencies will collect large wood that accumulates at Project dams and make it available for habitat restoration projects above and below Project dams.**

Rationale/Effect of RPA 7.3: This new measure that is not addressed in the Proposed Action is aimed at restoring large wood transport past Project dams. The continuing effects of Project dams on interruption of large wood transport were discussed in detail in each of the major tributary Effects sections (Middle Fork Willamette Section 5.2.4, McKenzie Section 5.3.4, South Santiam Section 5.5.4, and North Santiam Section 5.6.4). Lack of large wood in downstream fish habitat continues to reduce available rearing and holding habitat for juvenile and adult UWR Chinook salmon and steelhead. This measure ensures that large wood that collects in the reservoirs will be made available for such projects.

The effect of this measure is generally positive for listed anadromous fish because it is a first step in the process of habitat restoration that provides large woody debris that is a benefit to the fish and habitat elements.

7.4 <u>Restoration of Habitat at Revetments</u>: **In coordination with the Services, the Action Agencies will undertake a comprehensive assessment of revetments placed or funded by the USACE Willamette River Bank Protection Program. The revetment assessment will be completed, including identifying sites with potential for**

modification, by December 31, 2010. The USACE will use applicable existing authorities and programs for funding habitat restoration identified in Table 9.7-2, as well as new programs that are applicable, to fund priority projects identified in this assessment.

Rationale/Effect of RPA 7.4: This measure provides additional certainty to the Willamette River Bank Protection Program study described in section 3.5.4 of the Proposed Action (USACE 2007a). The Action Agencies indicated in that section that they had not identified funding sources or a timeline for conducting the study or follow-up actions. This RPA measure requires the USACE to secure funds for the study and complete it by December 31, 2010. Once completed, the Action Agencies would be required to seek funds to carry out projects at high priority sites.

The effect of this measure is that high priority sites for restoration or removal will be identified in the near term, and will be considered for funding through applicable authorities and programs. When projects are funded and carried out, the effect will be improved rearing and holding habitat, by opening access to off-channel rearing habitat and allowing establishment of complex habitat used for rearing and holding.

7.5 <u>Aquatic Habitat Assessment:</u> **By June 2008, the Action Agencies will complete surveys of spawning and holding habitat availability and condition in the major spawning tributaries with USACE dams (N. Santiam, S. Santiam, South Fork McKenzie, and Middle Fork Willamette rivers). The Action Agencies will distribute copies of the final report to the Services and will make the report available on the USACE's Portland District's website. Habitat survey data will also be available to the public in a GIS format. The Action Agencies will use the assessment to inform habitat restoration priorities for RPA measure 7.1.**

Rationale/Effect for RPA 7.5: The Action Agencies propose to complete this assessment by the end of FY 2008 (i.e., end of September 2008). These surveys will provide essential information for decision-makers regarding the availability of suitable habitat above and below Project dams for UWR Chinook salmon and steelhead.

9.8 ESA Compliance & Coordination

These measures are based on similar Proposed Action measures in section 3.6.5 of the Supplemental BA (USACE 2007a). Additionally, the coordination process described in these measures is encompassed within RPA measure 1, Coordination, of this Chapter 9. However, the following measures add specificity to those measures with regard to design review and construction implementation. Specificity is necessary to ensure that needed reviews will happen and that construction will be accomplished in a way that minimizes impacts on listed fish.

RPA 8 ESA Compliance, Maintenance, and Construction Projects Environmental Coordination and Management

8.1 **Review of Design and Construction Reports: The Action Agencies will collaborate with the Services on the design, construction and operation of all potential structural modifications to the dams and associated facilities, including fish collection and handling facilities, fish passage improvements, and water temperature control facilities. The Action Agencies will obtain the Services' review[45] of design reports and will address their recommendations in subsequent design reports. The Action Agencies will provide final design reports and drawings to the Services at least 30 days in advance of making the final design decision to allow time for their review and comment.**

Rationale/Effect of RPA 8.1: This measure is needed to ensure constructive collaboration between the Services and the Action Agencies to ensure facilities will be designed and constructed to be as benign to fish as possible. This review will take place as part of one of the technical subcommittee of the WATER group, as described in measure 1.2, and that decisions will be made according to the processes described in measures 1.3 and 1.4.

The effect of this measure is that facilities will be designed and constructed to minimize injury, mortality, and delay of listed fish, resulting in improved abundance and productivity, and in certain cases such as for fish passage facilities, increased spatial distribution of UWR Chinook salmon and steelhead.

8.2 **Construction Practices: Construction and operation will be carried out according to Best Management Practices (BMPs) and design specifications agreed[46] to by the Services. The Action Agencies will follow BMPs provided in Section 12, Incidental Take Statement. If these are updated, the Services will provide the updates to the Action Agencies, and the Action Agencies should follow the updated BMPs.**

Rationale/Effect of RPA 8.2: This measure builds on the Action Agencies' Proposed Action in section 3.6.5 of the Supplemental BA (USACE 2007a), in which the Action Agencies agreed to adopt and follow BMPs for construction of all potential structural modifications to the dams and associated facilities. In their Proposed Action, the Action Agencies agreed to use the BMPs outlined in NMFS' Biological Opinion concerning construction of the Cougar adult fish collection facilities (NMFS 2007a) as a starting point, and proposed to use a technical subcommittee of the WATER group to further refine BMPs. NMFS provides this modified measure to require BMPs consistent with those identified in the Incidental Take Statement for this Opinion, included as chapter 11. Additionally, NMFS broadens the action to apply to all construction activities that may include in-water work or affect fish or fish habitat, rather than only for fish facility construction.

The effect of this measure is that construction projects carried out as part of the Proposed Action, including continued Project operation and maintenance, revetment maintenance,

[45] See RPA 1.3 and 1.4 for elaboration of the decision making process.
[46] See RPA 1.3 and 1.4 for elaboration of the decision making process.

and fish and wildlife mitigation measures, will be done in a manner that minimizes harm to listed fish and avoid negative effects to critical habitat.

9.9 RESEARCH, MONITORING & EVALUATION (RM&E)

In their Proposed Action, the Action Agencies identify the need for developing a comprehensive research, monitoring, and evaluation (RM&E) program that will provide information necessary for making informed adaptive management decisions, in addition to tracking and documenting progress toward achievement of these RPA measures. They further identify the practicality of developing and managing this RM&E program under the auspices of the cooperative WATER subcommittee structure.

The Action Agencies provide certain guiding principles and strategic questions for consideration in developing a sound RM&E program. They also provide areas of concern where RM&E studies are needed. However, they generally do not make specific study recommendations.

The following RPA measures combine with portions of the PA and RPA measures described above to identify the broad outlines of an adaptive RM&E program. A comprehensive RM&E program is essential to guiding Action Agencies' decisions in carrying out PA and RPA measures and that will affect productivity, abundance, spatial distribution, and genetic diversity of listed fish species. Additional and specific details of the RM&E program, study objectives, and methodologies will be developed and refined through the WATER process.

RPA 9 Research, Monitoring & Evaluation (RM&E)

9.1 <u>**Comprehensive Program:**</u> **The Action Agencies will, in consultation with the WATER RM&E subcommittee, established as a technical subcommittee as described in RPA measure 1.2, develop and manage the comprehensive Willamette Project RM&E program. In developing and conducting the RM&E studies, the Action Agencies will work closely with the Services to ensure that the studies will provide information useful to the Services and the Action Agencies in making decisions regarding the effectiveness of mitigation measures in the Proposed Action and the RPA, including alternatives for downstream flows and ramping, fish passage, water quality, hatchery program operations, habitat restoration and other measures. The Action Agencies will seek NMFS' review of draft study proposals and draft reports. Comments submitted by NMFS on draft evaluation proposals must be reconciled by the Action Agencies in writing to NMFS' satisfaction prior to initiating any research-related activities anticipated in this RPA.[47] The proposals must identify annual anticipated incidental take levels by species, life stage, and origin[48] for each year. The Services will inform the Action Agencies whether they agree[49] with the proposed studies, reports, and NEPA alternatives. The Action**

[47] See RPA 1.3 & 1.4 for elaboration of decision making process.
[48] That is, hatchery-origin or non-hatchery origin fish.
[49] See RPA 1.3 & 1.4 for elaboration of decision making process.

Agencies will make modifications to operations and facilities based on the results of the RM&E information.

Rationale/Effect of RPA 9.1: Research, monitoring, and evaluation studies comprise an essential and important component of the protective measures identified within the RPA. Often lacking within the basin is detailed information regarding geographically-specific environmental conditions (e.g., quantity and distribution of functional spawning and rearing habitat) and the extent to which ongoing Willamette Project operations are continuing to affect those conditions (e.g., flow variation and duration in relation to sediment transport dynamics, channel and habitat complexity, and related juvenile fish behavior and survival). In other instances, problems attributable to Willamette Project dams and operations (e.g., migration barriers and water temperature alteration) require additional information to assess the most prudent and effective means of overcoming these important limiting factors. Consequently, the functional effectiveness of RPA measures often depends upon the ability to make informed and timely decisions regarding the most effective and practical means of achieving protection and restoration objectives associated with each of the listed species. In studies aimed at obtaining this information, and in documenting tangible progress toward achieving protection and restoration objectives, the Services must discern whether the proposed studies are designed and conducted in a manner that is in keeping with the original intent of the RPA measures. They must also assure that the results of these studies are effectively applied.

Other kinds of RM&E include monitoring the existing and new mitigation measures. This is necessary to ensure that the measures are functioning properly and continue to do so. Also, the RM&E information can be the basis for making modifications to make them function effectively.

The effect of this measure is that the Action Agencies will have a basis for informed decisions about new mitigation measures, and will be able to ensure that current and new measures will be effective, and can modify them as needed.

9.2 **<u>Mainstem Flow, Tributary Flow, and Ramping RM&E:</u> The Action Agencies will develop and carry out RM&E to determine compliance with, and effectiveness of, flow and ramping measures and to better discern and evaluate the relationships between flow management operations and the resulting dynamics of ecosystem function and environmental conditions downstream of Willamette Project dams. Because flow releases and ramping rates are measures that can be implemented immediately, the Action Agencies should give high priority to studies to evaluate their effectiveness. The Action Agencies will begin flow and ramping rate studies by 2009. The Action Agencies will make modifications to Project operations and facilities that affect mainstem and tributary flows, ramping, and Reclamation water contract implementation, including RPA measures 2 and 3 listed above, no later than January 2011, as indicated by results of the monitoring and evaluation, and with NMFS' agreement.**

Rationale/Effect of RPA 9.2: The studies and monitoring of mainstem and tributary flow rates and of project ramping rate restrictions, as identified above in RPA2.10 (Flow-Related RM&E) of Section 9.2 (Flow Management), are necessary to acquire specific information about the functional relationship between rates of flow (e.g., flow stage), or change in flow, and resulting habitat conditions, fish behavior, and survival (e.g., winter steelhead spawning in the North and South Santiam rivers during spring; juvenile fish stranding during flow level changes). Information from physical habitat surveys and from hydrologic modeling will provide the data needed to make informed decisions regarding the adequacy and effectiveness of the mainstem and tributary flow measures.

The effect of this measure is that it will provide the basis for decisions on important mitigation measures, mainstem flow, tributary flows, and ramping rates that are adequate for listed fish protection. The measure includes interim measures for these flows and ramping, so it will help listed fish in the short term by improving their habitat downstream of the dams.

9.3 **<u>Fish Passage RM&E</u>: The Action Agencies will develop and carry out RM&E to determine the most effective and efficient means to accomplish safe fish passage at applicable Project dams. The studies will be used to determine 1) locations where it is feasible to re-establish self sustaining populations; 2) potential population size for each subbasin; 3) effectiveness of rebuilt trap-and-haul facilities; 4) downstream fish passage timing and survival through Project reservoirs; 5) downstream fish passage timing and survival through Project dams; 6) operational methods for higher juvenile and adult survival at Project facilities; 7) infrastructure needs to ensure long term viability of populations; and 8) selection of hatchery or natural-origin broodstock, as well as life stage, for release into habitat above Project dams.**

These facilities must meet performance standards consistent with NMFS' Fish Passage Criteria and Guidelines (NMFS 2008e) or as determined through the FPHM committee of WATER and agreed to by the Services. The Action Agencies will monitor the effectiveness of the fish passage facilities. The Action Agencies will make modifications to Project operations and facilities that affect fish passage, including RPA 4 measures listed above, as indicated by results of the monitoring and evaluation, and with NMFS' agreement.

Rationale/Effect of RPA 9.3: Most historical production areas for UWR Chinook salmon and for UWR steelhead lie above federal dams in the Willamette River Basin. In general, the quality of the remaining habitat in these areas (e.g., on U.S. Forest Service lands) is also superior to that of the available habitat remaining below the dams. Re-accessing this habitat is a fundamentally important component of the strategy for protecting and restoring these listed species. Downstream fish passage through reservoirs and dams is influenced by unique characteristics at each site, such as dam configuration, reservoir length and depth, and life stage and physiological state of fish as they move downstream. In other words, what works at one project may not work at another, and thus, a study regarding the most effective and feasible means of re-accessing this habitat is essential.

This measure is needed to ensure that once passage facilities or operations are implemented at a Project dam, monitoring will take place to determine if facilities are performing as intended. If the facilities are not providing safe and effective passage, then they need to be modified accordingly. Performance standards are necessary to provide a quantitative measure of effectiveness.

The effect of this measure is to provide information to make decisions on passage measures that are one of the most important kinds of mitigation for project effects. It will also ensure that passage is working effectively.

9.4 **Water Quality RM&E: The Action Agencies will develop and carry out RM&E to monitor the effectiveness of measures in the RPA and Proposed Action to improve water quality, including but not limited to: 1) monitor operational performance and associated biological response of water temperature control in the McKenzie River Subbasin at Cougar Dam; 1a) quantify effects of USACE dams on water temperature; 2) evaluate biological effects of water temperature alteration caused by USACE dams on ESA listed fish species in the Santiam and Middle Fork Willamette rivers; 2a) quantify the effects of USACE dissolved gas and turbidity; 3) evaluate the effects of dissolved gas supersaturation and of turbidity alterations caused by USACE dams on ESA listed fish species in the Santiam, McKenzie, and Middle Fork Willamette rivers; and 4) conduct an aquatic macroinvertebrate species abundance and community structure study at USACE projects on the Santiam, McKenzie, and Middle Fork Willamette rivers to discern the extent to which project operations affect macroinvertebrate community composition, structure, and function. The Action Agencies will make modifications to Project operations and facilities that affect water quality, including RPA measure 5 (and its sub-measures) listed above as indicated by results of the monitoring and evaluation, and with NMFS' agreement.**

Rationale/Effect of RPA 9.4: It is well documented that Willamette Basin projects have dramatically affected water temperatures below federal dams, and also affect other important water quality parameters, to the detriment of listed species. These studies are necessary to document geographically-specific effects, their relevance to protection and the water quality RPA measures 5, and the tangible options for addressing these concerns.

9.5 **Hatchery Programs RM&E: The Action Agencies will develop and carry out RM&E to monitor the effectiveness of hatchery measures in the RPA and Proposed Action to improve hatchery effectiveness and reduce adverse effects to listed fish species, including but not limited to the following:**

9.5.1 **Spring Chinook**

1. **Broodstock Management- Determine collection and spawning timing of broodstock, composition of hatchery and wild fish.**

2. **Composition of Hatchery Fish on the Spawning Grounds- Determine the abundance, distribution, and percent hatchery-origin Chinook on the spawning grounds of each population annually.**
3. **Survival of Adult Hatchery Fish Outplanted above Federal Dams- Determine the survival rate of outplanted fish and abundance of spawners above the dams.**
4. **Reproductive Success of Hatchery Fish in the Wild- Determine juvenile production by hatchery and wild spawners above the dams.**
5. **Use of Hatchery Fish to Evaluate Migration and Survival through Reservoirs and Dams- As hatchery program reforms are implemented to make hatchery fish more similar to wild fish, use hatchery fish as a surrogate for wild fish in the testing and evaluation of migration, behavior, and survival of fish through the reservoirs and dams. Wild fish may be used in the future if risks are deemed acceptable.**

9.5.2 <u>Summer Steelhead</u>

1. **Fund, design, and implement a study plan, in collaboration with ODFW, to determine the extent of summer steelhead reproduction in the wild. Collect tissue samples from juvenile steelhead for genetic analysis to determine if offspring are of winter- or summer-run origin. Sampling shall begin in 2009. Details to be worked out by the Research, Monitoring, and Evaluation Committee.**
2. **Fund and conduct a spawning survey for three years (i.e. 2010-2012) to determine the extent of summer steelhead spawning in the North Santiam River Basin. Survey shall be initiated after the reduction of the North Santiam hatchery summer steelhead release is implemented.**

Rationale/Effect of RPA 9.5: The RM&E tasks identified above for the hatchery programs are essential in order to evaluate the effects of hatchery fish spawning in the wild and to determine how many natural-origin fish are being taken for broodstock. Information on both of these attributes helps inform and guide future management decisions on these hatchery programs and helps determine the status of listed populations. In addition, the Chinook hatchery programs are being used in many cases to reintroduce Chinook back into historical habitats above Project dams, thus it is necessary to evaluate the success of these outplanting programs.

9.6 <u>Habitat Restoration RM&E:</u> **The Action Agencies will develop and carry out RM&E for habitat restoration projects identified in the Proposed Action and this RPA to document changes in ecosystem function and biological response. The Action Agencies will make modifications to Project-related habitat restoration activities and structures, including RPA 7 measures listed above, as indicated by the results of the monitoring and evaluation and with NMFS' agreement.**

Rationale/Effect of RPA 9.6: The functional relationship between the characteristics and dynamics of habitat and related biological responses is poorly understood, in general. This is due, in part, to the complexity of those relationships and, in part, to the failure of restoration efforts to document their resulting biological effects. Careful planning of projects, with stated assumptions and objectives, in combination with post-construction physical and biological monitoring is required to document that intended benefits are realized. The information gained from this endeavor will provide the documentation required to make informed and adaptive management and planning decisions.

9.10 MAINTENANCE

These maintenance RPA measures are based on similar measures[50] described in the Proposed Action and apply to any constructed or fabricated features whose failure or improper function might affect ESA-listed fish and fish habitat such as, but not limited to, dams, gates, valves, pumps, access roads, fish hauling trucks, electrical power transmission grids, signal, control devices, and fish facilities.

These measures do not apply to the following:

- riverine components of the Willamette Project such as revetments, riprap, or riparian habitat improvements,
- re-configuration or rebuilding[51] of existing facilities (until they are placed in service.),
- items that are not likely to affect fish, such as building renovations, campground maintenance, recreational facilities, and
- preventative or routine maintenance.

The following measures add specificity to those maintenance measures in the Proposed Action:

RPA 10 Maintenance

10.1 **<u>Identify fish protection maintenance needs</u>. The USACE will develop and maintain a list of scheduled and unscheduled maintenance needs of existing infrastructure that could potentially negatively impact listed fish and will place high priority on maintaining performance of all such facilities. The scope of maintenance activities included encompasses all USACE dams, facilities, and appurtenances that *may significantly and adversely affect listed fish*, and includes not only "fisheries" facilities such as fish traps but all facilities required to meet the operations described in this Opinion (e.g. because forced spill can adversely affect downstream water quality, items such as turbines and generators may fall within this purview). This measure also affects those hatcheries raising listed fish, and all related hatchery facilities, including fish hauling trucks and related equipment used in fish transfers.**

The timeline for database modification and data entry:

[50] USACE 2007a including, but not limited to, pages 3-5, 6, 17, 18, 40, 41, 53, 54, 55, 56, 59, 68, 69, 71, 79-81, 91,136,137.

[51] Defined as measures costing more than 25% of the replacement cost of the existing structure.

1) All <u>new</u> items entered after 2008 shall include information noting whether they *may significantly and adversely affect listed fish,*[52]

2) All items, both new and pre-existing, shall be so notated by and after 2015[53].

Rationale/Effect of RPA 10.1: This RPA measure clarifies and makes uniform the maintenance reporting requirements for fish protection at all Project elements. USACE has a comprehensive maintenance program, including an associated database of maintenance needs. This RPA measure will enhance the USACE's database by associating with each discrepancy or defect noted in the maintenance database whether the needed maintenance *may significantly and adversely affect listed fish.* This measure is needed to ensure that all facilities that might affect listed fish—not merely fish facilities—will be maintained to minimize adverse effects to listed fish and fish habitat caused by equipment malfunctions.

The effect of this measure is to clarify that <u>all</u> facilities will be maintained to minimize injury, mortality, and delay of listed fish and destruction of fish habitat, resulting in improved abundance and productivity, and in certain cases such as for fish passage facilities, increased spatial distribution of UWR Chinook salmon and steelhead.

10.2 **<u>Inventory of Needed Maintenance</u>: The USACE will provide the maintenance report described in the Proposed Action (USACE 2007a, p. 3-18 Item 2 in Section 3.2.2[54]) in electronic[55] database format to NMFS by February 1, 2009, and thereafter whenever requested in writing by NMFS. This report will include an inventory of current major deficiencies, (i.e., where facilities are in need of maintenance or replacement) and the anticipated date of correction, and for those previously identified maintenance items that have been corrected, the report will identify the date the deficiencies were corrected. To aid in the identification of repeated problems, all corrected deficiencies will be retained in the database.**

Rationale/Effect of RPA10.2: This measure builds on the Action Agencies' commitment to maintain project facilities included in the Proposed Action. The Action Agencies commit "to describe scheduled and unscheduled" maintenance, but do not commit to reporting or inventorying discovered discrepancies, or their correction. The effect of this measure will be to ensure that the Action Agencies will maintain an orderly and systematic record of maintenance deficiencies and problems that might affect listed fish and a record of when these deficiencies are corrected. Ultimately, in conjunction with the measure below, this will assist in minimizing harm to listed fish and avoiding degradation of designated critical habitat.

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[52] That is, this is not an immediate requirement to go through the existing database—at least for five years-- to determine whether the items in the existing backlog *may significantly and adversely affect listed fish.*

[53] The intent here is to avoid an immediate requirement to research each of reportedly 30,000 items in the existing maintenance database for their impact on fish. During this five-year period any new deficiencies entered into the database will be annotated with respect to their possibility to affect fish. Presumably, many of the currently existing deficiencies will have been corrected within 5 years, so at the end of this period the task of assessing remaining deficiencies will not be great.

[54] Now within the Willamette Fish Operations and Management Plan--WFOP

[55] MS Access format or other mutually agreed upon format.

10.3 **<u>Perform Timely Maintenance</u>: The Action Agencies will correct the items noted in the inventories identified in RPA measures 10.1 and 10.2 above in a timely manner. All identified maintenance needs will be corrected, subject to congressional appropriation, or unless otherwise concurred with by NMFS. Notwithstanding, the USACE will correct deficiencies likely to cause substantial fish injury, mortality, or habitat degradation as soon as reasonably possible after discovery. The determination of whether injury, mortality, or loss of habitat function will occur in any particular instance will be collaboratively determined by NMFS and the Action Agencies.**

Rationale/Effect of RPA 10.3**:** The Action Agencies have committed "to describe scheduled and unscheduled" maintenance (USACE 2007a), but have not actually committed to a timeline for correcting maintenance discrepancies.

The effect of this measure will be to minimize the likelihood of mortality and injury of adult and juvenile UWR Chinook and steelhead associated with malfunctioning equipment, unscheduled shutdowns, toxic substances, and other consequences of maintenance discrepancies. Additionally, this measure will reduce the likelihood of degradation of designated critical habitat for UWR Chinook and steelhead caused by malfunctioning equipment and other consequences of maintenance discrepancies.

9.11 CONCLUSION: EFFECTS OF THE REASONABLE & PRUDENT ALTERNATIVE

This section presents NMFS' rationale for concluding that with the adoption of this RPA, the Action Agencies would avoid jeopardizing listed species and adversely modifying their critical habitats while operating and maintaining Project facilities and revetments, funding the hatchery mitigation program, and administering the water service program. This rationale is presented for the species that NMFS concluded would be jeopardized by the proposed action (UWR Chinook salmon and UWR steelhead) and for the other species that would be affected by the RPA.

The Proposed Action would jeopardize the continued existence of UWR Chinook salmon and UWR steelhead, and would destroy or adversely modify critical habitat because it did not adequately address adverse effects of the dams, revetments and hatcheries on listed fish, factors that are suppressing the viability of both species and are contributing to the high risk of extinction for UWR Chinook.[56] NMFS' RPA provides a package of measures that will allow for the survival with an adequate potential for recovery for these two species. The main negative effects of the Proposed Action are lack of effective passage to important habitat, degradation of remaining habitat, adverse flows and temperature, and hatchery actions that have the potential to reduce the viability of the natural-origin populations. The RPA provides specific measures that will address project effects by improving the status of natural-origin UWR Chinook salmon and UWR steelhead. The RPA measures will improve spatial distribution (habitat access; geographic range), diversity (hatchery broodstock management), productivity (improved conditions below the dams), and abundance (reduced mortality rates), which are the four VSP parameters.

[56] The WLCTRT (McElhany et al. 2007) estimated the risk of extinction over 100 years for UWR Chinook ("high;" see Figure 3-5 in Section 3.2.1.3). The TRT did not estimate the species' short-term extinction risk.

Improvements in these four VSP parameters will increase viability and reduce the risk of extinction to the affected populations and to the UWR Chinook salmon ESU and UWR steelhead DPS as at the species level. The RPA provides increased certainty that Proposed Action measures intended to benefit listed species will be accomplished within reasonable time periods to prevent extinction in the short term and to support improvements in UWR Chinook salmon and UWR steelhead abundance. RPA measures also improve habitat PCEs, ensuring that critical habitat will be able to serve its conservation role.

9.11.1 UWR Chinook Salmon

9.11.1.1 Effects of the RPA

The RPA specifies many significant measures that will reduce the adverse effects of the Willamette Project on the UWR Chinook ESU and bring about the proper functioning of primary constituent elements (PCEs) of its critical habitat. Many of the RPA measures specifically address key limiting factors/threats facing each population and caused by the Willamette Project: lack of passage, the degraded quality of the remaining habitat downstream of the dams; and the risks of genetic introgression, competition, and predation from hatchery fish. Four core populations have been identified for this ESU (Middle Fork Willamette, McKenzie, South Santiam, and North Santiam; see Chapter 3), and each of these populations will benefit from major RPA measures in the form of access to historical habitat, and/or temperature control and flow measures within the first few years of implementation (Section 9.11.1.3.1). With full implementation of the RPA, NMFS expects that the status of the ESU, including the four VSP parameters, will improve significantly compared to their potential status under the Proposed Action.

As shown in Table 9.11-1, several major RPA measures will be completed between 2015 through 2024, including passage at dams in the Middle Fork and South Santiam, which will provide safe passage to and from historical upstream habitat, and temperature control to improve downstream habitat in the North Santiam. Most of these measures are major construction projects that take a significant amount of time to plan, fund, and execute. For a full description of the authorization and funding processes needed for these types of measures, see the Supplemental Biological Assessment (USACE 2007a). It is not economically and technically feasible to move the timelines for many of these measures forward significantly due to their magnitude and the time needed for studies, design, authorization and construction.

Given these constraints, the anticipated population status improvements will begin in the next 15 years and continue to increase over the 15-year term of this Opinion. It will take several generations of the Chinook life cycle to respond to the positive improvements in the operation of the Willamette Project and associated measures. Therefore, significant improvements in the status of the ESU will continue to accrue in the next 30 years (approximately six generations). While implementation of these RPA measures will occur during the term of this Opinion, their full effects on population metrics (e.g., abundance, productivity) will occur over a considerable period of time after implementation. Therefore, NMFS expects that substantial improvements to the ESU will result from the implementation of the Proposed Action and the RPA.

In addition to the major measures specified in Table 9.11-1, numerous other near-term measures such as changes to flow, screening irrigation diversions, hatchery program modifications, and habitat mitigation projects are included in the RPA. The "near-term" measures in Table 9.11-1 directly address project effects on listed fish and critical habitat without requiring as many years to plan and implement as the measures discussed above. A third group of measures, such as conducting RM&E studies, developing fish operations manuals, project planning, and implementing the WATER collaborative process, will begin in the near term. Although this third group of activities also has not been included in the summary table, these are essential tasks that will facilitate construction of the large structures as well as guide annual operations, all of which will benefit UWR Chinook.

Difference between the Proposed Action and RPA

The effect of the RPA measures on UWR Chinook is significantly different than the effect of the Proposed Action. The Proposed Action mainly provided for further studies to consider options such as passage facilities to historical upstream habitat, as well as a major downstream habitat improvement measure of temperature control. In addition, the RPA includes measures to improve degraded downstream habitat through changes to flows, screens at irrigation diversions, hatchery improvements, and other habitat improvement projects. These RPA measures are significant because UWR Chinook are currently limited to degraded downstream habitat in three important subbasins. The RPA measures both provide access to higher quality habitat and improve downstream habitat conditions, which together will provide significant enough improvements to allow the UWR Chinook ESU to increase in numbers, productivity, spatial structure, and diversity.

Table 9.11-1 Date of implementation of the RPA measures that will directly benefit UWR Chinook salmon and steelhead and their habitat.

Timeline: pre-2008, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024

End of Biological Opinion ESA Coverage

Geographic Area	RPA #
Middle Fork Willamette	
Adult outplant site(s)	4.7
Dexter collection facility rebuild	4.6.3
Fall Creek collection facility rebuild	4.6.4
Juvenile prototype (here or Green Peter (SS))	4.9
Lookout Point downstream facility	4.12.2
Interim temperature control (actions unspecified)	5.1.2
Water contract program	9.3
BOR compliance with fish protection criteria	3.2
Chinook outplanting above dams	4.1
Project-specific ramping rates	2.6
Project-specific min & max flows	2.4, 2.5
Fall Creek reservoir drawdown	4.8.1
Hatchery and Genetic Mgmt Plans (HGMPs)	6.1.1
McKenzie	
Cougar collection facility	
Adult outplant site(s)	4.7
Leaburg hatchery sorting	6.1.4
Cougar downstream facility	4.12.1
Water contract program	9.3
BOR compliance with fish protection criteria	3.2
Chinook outplanting above dams	4.1, 6.1.5
Project-specific ramping rates	2.6
Project-specific min & max flows	2.4, 2.5
Hatchery and Genetic Mgmt Plans (HGMPs)	6.1.1
South Santiam	
Adult outplant site(s)	4.7
Foster collection facility rebuild	4.6.2
Juvenile prototype (here or Lookout Pt (MFW))	4.9
Water contract program	9.3
BOR compliance with fish protection criteria	3.2
Reduce hatchery steelhead residualism	6.1.6
Reduce hatchery steelhead recycling	6.1.7
Chinook outplanting above Foster Dam	4.1
Winter steelhead outplanting above Foster Dam	4.2
Project-specific ramping rates	2.6
Project-specific min & max flows	2.4, 2.5
Foster reservoir spring spill operations	2.7
Hatchery and Genetic Mgmt Plans (HGMPs)	6.1.1

ongoing, continuing measures that have been in effect prior to the completion of this Biological Opinion

new measures that will be taken in the future (after this Biological Opinion is completed)

* This chart summarizes only a portion of the measures analyzed in this Opinion. Numerous other planning processes other planning processes, operational protocols and guidelines, research monitoring and evaluation, emergency operation plans are not included here.

Table continued on next page.

Table 9.11-1. *(Continued)*

Geographic Area	RPA #	Timeline (pre-2008, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024)
Calapooia		
No RPA actions identified in this geographic area.		
North Santiam		
Adult outplant site(s)	4.7	
Minto collection facility rebuild	4.6.1	
Detroit Water Temperature Facility	5.2	
Interim temperature control	5.1.1	
Detroit downstream facility	4.12.3	
Water contract program	9.3	
BOR compliance with fish protection criteria	3.2	
Reduce hatchery steelhead production	6.1.8	
Reduce hatchery steelhead residualism	6.1.6	
Reduce hatchery steelhead recycling	6.1.7	
Chinook outplanting above dams	4.1	
Project-specific ramping rates	2.6	
Project-specific min & max flows	2.4, 2.5	
Hatchery and Genetic Mgmt Plans (HGMPs)	6.1.1	
Molalla		
Hatchery Chinook reform	6.2.5	No date specified.
Hatchery and Genetic Mgmt Plan (HGMP)	6.1.1	
Clackamas		
No RPA actions identified in this geographic area.		
Mainstem Willamette River		
Mainstem flow targets	2.3	
Habitat restoration projects		Two projects will be funded in 2010. Others unspecified.
Water contract program	9.3	
BOR compliance with fish protection criteria	3.2	

End of Biological Opinion ESA Coverage

ongoing, continuing measures that have been in effect prior to the completion of this Biological Opinion

new measures that will be taken in the future (after this Biological Opinion is completed)

* This chart summarizes only a portion of the measures analyzed in this Opinion. Numerous other planning processes other planning processes, operational protocols and guidelines, research monitoring and evaluation, emergency operation plans are not included here.

9.11.1.2 UWR Chinook Populations—Summary of Effects of the RPA

The following is a population-by-population summary of the effects of the RPA. The RPA and the analysis in this section specifically address short-falls in the effects of the Proposed Action, which are identified in earlier sections of this Opinion (see especially Chapter 7, "Summary of Effects of the Proposed Action on UWR Chinook and Steelhead.")

Middle Fork Willamette Chinook

The primary reason for the poor status of the Middle Fork Willamette Chinook population (very high risk of extinction) is the loss of access to historical habitat due to the four Willamette Project dams and elevated temperatures in the reach below Dexter Dam and in lower Fall Creek. The risk of genetic introgression from hatchery-origin fish interbreeding with those of natural origin is also a key limiting factor.

- The RPA will improve upstream passage survival by rebuilding the collection facilities at Dexter and Fall Creek dams to reduce stress, injury, and mortality during capture and handling of Chinook salmon for outplanting (safe passage) above Project dams.
- *RPA 4.6: complete construction at Dexter by December 2014 and begin operations by March 2015; complete construction at Fall Creek by December 2015 and begin operations by March 2016*
- Construction and operation of new adult release sites above Lookout Point, Hills Creek, and Fall Creek dams will increase upstream passage survival and reduce pre-spawn mortality by minimizing stress and injury of adult Chinook salmon outplanted above the dams.
- *RPA 4.7: complete site/concept study by February 2009, establish priorities, and complete construction of all selected sites by June 2012*
- A downstream passage facility at Lookout Point reservoir/dam will allow higher survival of juvenile Chinook emigrants resulting from the adult outplanting program.
- *RPA 4.9: build prototype for head-of-reservoir juvenile collection facility at Lookout Point or Foster by 2014*
- *RPA 4.12.2: develop permanent downstream passage facility at Lookout Point—begin feasibility studies by 2012, construct by December 2021, and operate by March 2022 (if not feasible, make "no go" decision by end of 2014)*
- Drawdown to at least elevation 714.0 by the end of November each year will optimize downstream passage conditions at Fall Creek Dam during the juvenile outmigration.
- *RPA 4.8.1: reduce head by implementing Fall Creek drawdown beginning in Water Year 2008 (Nov-Jan, except during flood control operations), reducing injury and mortality of Chinook smolts*
- Interim operational measures at Lookout Point, Hills Creek, and Fall Creek dams will restore normative seasonal water temperatures.
- *RPA 5.1.2: Identify interim measures by March 2010*

- *RPA 5.1.3: Evaluate more complex measures (requiring detailed environmental review, permits, and/or congressional authorization) by April 2011*

- Address effects of the Willamette Project (specifically, reduced frequency of channel-forming flows, altered seasonal flow patterns below dams, and the maintenance of revetments) on downstream habitat

- *RPA 2.4.4: enabled by implementation of RPA measures 2.4.1-2.4.3, modify operations to optimize system's ability to meet improved flow objectives to the degree feasible, by January 2012.*

- *RPA 2.7: test pilot "environmental" or "pulse" flows below Project dams to achieve channel-forming and channel-maintenance flows; implement where feasible without compromising authorized Project purposes.*

- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

- Screening diversions will remove impediments or barriers to juvenile Chinook migrants

- *RPAs 3.2 and 3.3: Reclamation will require that existing, new, and renewed contracts for stored water include conditions that protect fish from entrainment into diversions.*

- Adverse effects of the Chinook hatchery program will be minimized.

- *RPAs 6.1.2 and 6.2.2: cooperate with ODFW in the implementation of HGMPs, which include management plans for building genetic diversity using local broodstocks.*

- *RPA 4.6: improve fish collection facility at Dexter Ponds (begin construction by December 2014 and begin operations by March 2015) and at Fall Creek Dam (begin construction by December 2015 and begin operations by March 2016).*

- *RPA 6.1.3: continue to mark all hatchery Chinook released in the Willamette Basin with adipose fin clip and otolith mark, and insert coded wire tags into all hatchery Chinook prior to release*

- *RPA 6.2.4: cooperate with ODFW to release juvenile hatchery-origin Chinook that are more similar to natural-origin fish.*

The combined effect of these measures (especially the mechanisms for efficient sorting of hatchery fish for broodstock and to augment spawning above Dexter and Fall Creek dams, improvements in downstream passage survival in the Middle Fork Willamette and Fall Creek and in water temperatures in the Middle Fork) are expected to significantly improve the status of the Middle Fork Willamette population. Chinook will have access to high quality historical spawning and rearing habitat above the dams and the opportunity for successful spawning, incubation, and rearing in the lower reaches. Resulting juvenile production will emigrate downstream with reduced rates of injury and mortality. NMFS expects increases in the abundance, productivity, spatial structure, and diversity of natural-origin Chinook as these

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[57] Habitat restoration projects may be distributed in the lower reaches of the tributaries with spawning populations and in the mainstem Willamette.

measures become operational. These actions will improve the function of PCEs in designated critical habitat including:

- Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development (specifically RPA measures 2.4.4; 2.7; 5.1.2; 5.1.3; and 7.1.3).
- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development (RPA 2.4.4; 2.7; 5.1.2; 5.1.3; and 7.1.3).
- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival (RPA 2.7; 3.2; 3.3; 4.6; 4.7; 4.8.1; 4.9; 4.12.2; and 7.1.3).

McKenzie Chinook

The McKenzie Chinook population is at moderate risk of extinction. The risk of genetic introgression by hatchery fish and the loss of historical habitat due to blockage by Cougar Dam on the South Fork McKenzie River are two of the key limiting factors identified for this population. Under the Proposed Action, a new adult collection facility, to be completed by 2010, will allow fish to be collected and transported above Cougar Dam, restoring access to this high quality habitat with reduced rates of stress, injury, and mortality. In addition:

- The RPA will significantly reduce the risk of genetic introgression and competition by hatchery fish in the natural population by limiting hatchery fish straying above Leaburg Dam in the lower McKenzie River.

- *RPA 6.1.4: complete construction of the adult trap and sorting facility at Leaburg Dam by December 2013 and begin operations by spring 2014.*

- Construction and operation of an adult release site above Cougar Dam will increase upstream passage survival and reduce pre-spawning mortality by minimizing the stress and injury of adult Chinook salmon outplanted above the dam.

- *RPA 4.7: complete site/concept study by February 2009, establish priorities, and complete construction of all selected sites by June 2012*

- A downstream fish passage facility will be constructed at Cougar Dam to improve juvenile Chinook outmigrant survival

- *RPA 4.12.1: Initiate planning and make "go/no go" decision by end of 2010; complete construction by 2014, begin operations by 2015*

- The RPA will address the effects of the Willamette Project (specifically, reduced frequency of channel-forming flows, altered seasonal flows, and the maintenance of revetments) on downstream habitat

- *RPA 2.4.4: enabled by implementation of RPA measures 2.4.1-2.4.3, modify operations to optimize system's ability to meet improved flow objectives to the degree feasible, by January 2012.*

- *RPA 2.7: test pilot "environmental" or "pulse" flows below Project dams to achieve channel-forming and channel-maintenance flows; implement where feasible without compromising authorized Project purposes.*
- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.[57] Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

• Screening diversions will remove impediments or barriers to juvenile Chinook migrants

- *RPAs 3.2 and 3.3: Reclamation will require that existing, new, and renewed contracts for stored water include conditions that protect fish from entrainment into diversions.*

• Adverse effects of the Chinook hatchery program will be minimized.

- *RPAs 6.1.2 and 6.2.2: cooperate with ODFW in the implementation of HGMPs, which include management plans for building genetic diversity using local broodstocks.*
- *RPA 6.1.3: continue to mark all hatchery Chinook released in the Willamette Basin with adipose fin clip and otolith mark and insert coded wire tags into all hatchery Chinook prior to release.*
- *RPA 6.2.4: cooperate with ODFW to release juvenile hatchery-origin Chinook that are more similar to natural-origin fish.*

These measures (especially the mechanism for efficient removal of hatchery fish from the spawning population above Leaburg Dam, implementation of hatchery reforms per HGMPs, flow management, and improvements in upstream and downstream passage survival at Cougar Dam), are expected to significantly improve the status of the McKenzie River population. Natural-origin Chinook will have access to high quality historical spawning and rearing habitat above Cougar and the opportunity for successful spawning, incubation, and rearing. Juveniles produced above Cougar will emigrate downstream with reduced rates of injury and mortality. NMFS expects increases in the abundance, productivity, spatial structure, and diversity of natural-origin Chinook as these measures become operational. These actions will also improve the functioning of PCEs in designated critical habitat including:

• Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development (specifically RPA measures 2.4.4; 2.7; and 7.1.3).

• Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development (RPA 2.4.4; 2.7; and 7.1.3).

• Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival (RPA 2.7; 3.2; 3.3; 4.12.1; 6.1.4; and 7.1.3).

Calapooia Chinook

The risk of genetic introgression by hatchery fish interbreeding with those of natural origin and impaired physical habitat from past and/or present land uses are key limiting factors for the Calapooia population, which is at very high risk of extinction.

- Address effects of the Willamette Project (specifically, maintenance of revetments) on habitat in the mainstem and Willamette tributaries

- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

- Adverse effects of the Chinook hatchery program will be minimized.

- *RPAs 6.1.1 and 6.2.2: cooperate with ODFW in the implementation of HGMPs, which include management plans for building genetic diversity using local broodstocks.*

- *RPA 6.1.3: continue to mark all hatchery Chinook released in the Willamette Basin with adipose fin clip and otolith mark and insert coded wire tags into all hatchery Chinook prior to release.*

Implementation of the hatchery measures will increase the genetic diversity of Chinook spawning in the Calapooia River and will lead to increased abundance and productivity over time. Because the RPA does not require that habitat projects be located within the Calapooia subbasin, NMFS does not assume that this RPA measure will improve the status of this Chinook population or the functioning of PCEs in the Calapooia subbasin.

South Santiam Chinook

The loss of access to historical habitat above Foster and Green Peter dams and the risk of genetic introgression by hatchery fish interbreeding with those of natural origin, especially in the lower South Santiam below Foster Dam, are key limiting factors for this population, which is at very high risk of extinction.

- The RPA requires rebuilding of the collection facility at the base of Foster Dam to allow better capture and handling of Chinook for outplanting into historically accessible habitat above the dam.

- *RPA 4.6: complete construction of the new adult collection and handling facilities at Foster Dam by December 2013 and begin operations by March 2014.*

- Construction and operation of new adult release sites above Foster Dam will increase upstream passage survival and reduce pre-spawn mortality by minimizing stress and injury of adult Chinook salmon outplanted above the dams.

- *RPA 4.7: complete site/concept study by February 2009, establish priorities, and complete construction of all selected sites by June 2012*

- The RPA addresses the long-term need to improve reservoir and dam passage survival at Foster Dam for juvenile Chinook throughout the juvenile migration period.

- *RPA 4.13: The Action Agencies will evaluate a range of potentially beneficial actions for listed fish species at Project dams and reservoirs, including Foster, in their development of the Willamette Configuration and Operation Plan (COP). This will include facilities and operations that require detailed study including feasibility studies and environmental permitting such as long-term fish passage solutions at Foster Dam.*

- Interim operational measures at Green Peter and Foster dams will help to restore more normative seasonal water temperatures

- *RPA 5.1: Identify interim measures by March 2010*

- *RPA 5.1.3: Evaluate more complex measures (required detailed environmental review, permits, and/or congressional authorization) by April 2011*

- The RPA will address effects of the Willamette Project (specifically, reduced frequency of channel-forming flows, altered seasonal flow patterns, and the maintenance of revetments) on downstream habitat

- *RPA 2.4.4: enabled by implementation of RPA measures 2.4.1-2.4.3, modify operations to optimize system's ability to meet improved flow objectives to the degree feasible, by January 2012.*

- *RPA 2.7: test pilot "environmental" or "pulse" flows below Project dams to achieve channel-forming and channel-maintenance flows; implement where feasible without compromising authorized Project purposes.*

- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

- Screening diversions will remove impediments or barriers to juvenile Chinook migrants

- *RPAs 3.2 and 3.3: Reclamation will require that existing, new, and renewed contracts for stored water include conditions that protect fish from entrainment into diversions.*

- Adverse effects of the Chinook hatchery program will be minimized.

- *RPAs 6.1.2 and 6.2.2: cooperate with ODFW in the implementation of HGMPs, which include management plans for building genetic diversity using local broodstocks.*

- *RPA 4.6: improve fish collection facility at Foster Dam (begin construction by December 2013 and begin operations by March 2014).*

- *RPA 6.1.3: continue to mark all hatchery Chinook released in the Willamette Basin with adipose fin clip and otolith mark, and insert coded wire tags into all hatchery Chinook prior to release*

- *RPA 6.2.4: cooperate with ODFW to release juvenile hatchery-origin Chinook that are more similar to natural-origin fish.*

These measures (especially the mechanism for efficient removal of hatchery fish from the spawning population above Foster Dam, implementation of hatchery reforms per HGMPs, flow management, and improvements in downstream passage survival at Foster Dam) are expected to significantly improve the status of the South Santiam population. Natural-origin Chinook will have the opportunity for successful spawning, incubation, and rearing in the reach above Foster and juveniles will emigrate downstream with reduced rates of injury and mortality. NMFS expects increases in the abundance, productivity, spatial structure, and diversity of natural-origin Chinook as these measures become operational. These actions will also improve the functioning of PCEs in designated critical habitat including:

- Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development (specifically RPA measures 2.4.4; 2.7; 5.1.2; 5.1.3; and 7.1.3).
- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development (RPA 2.4.4; 2.7; 5.1.2; 5.1.3; and 7.1.3).
- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival (RPA 2.7; 3.2; 3.3; 4.6; 4.7; 4.13; and 7.1.3).

North Santiam Chinook

The loss of access to historical habitat above Big Cliff and Detroit dams, poor natural production below the dams, and the risk of genetic introgression by hatchery fish interbreeding with those of natural origin are key limiting factors for this population, which is at very high risk of extinction.

- The RPA provides measures that will improve upstream passage survival by building a new adult collection facility to replace the trap at the Minto barrier dam, allowing the capture and handling of Chinook for outplanting above Big Cliff/Detroit dams with reduced levels of stress, injury, and mortality.

- *RPA 4.6: complete construction of the new adult collection and handling facilities in North Santiam by December 2012 and begin operations by March 2013.*

- Construction and operation of new adult release sites above Detroit Dam will increase upstream passage survival and reduce pre-spawn mortality by minimizing stress and injury of adult Chinook salmon outplanted above the dams.

- *RPA 4.7: complete site/concept study by February 2009, establish priorities, and complete construction of all selected sites by June 2012*

- Downstream passage improvements at Detroit Dam and Reservoir will increase juvenile Chinook survival and increase the number of smolts emigrating from the population. Combined with RPA 4.6, above, this measure is expected to increase the abundance, productivity, and spatial structure of the North Santiam Chinook population.

- *RPA 4.12.3: initiate planning by 2015, make "go/no go" decision by end of 2017; complete construction by end 2023, begin operations by March 2024.*

- The RPA requires implementation of interim temperature control using existing facilities. This action will provide immediate survival benefits, significantly reducing the problem with the altered water temperature regime in natural production areas downstream of Detroit/Big Cliff dams until a Water Temperature Control facility or alternative solution is implemented. Normative water temperatures, particularly during the critical egg incubation period in late fall, will improve the abundance and productivity of the population.

- *RPA 5.1.1: identify and evaluate interim operational measures at Detroit Dam and, if feasible, begin implementation in Water Year 2009.*
- *RPA 5.2: make structural modifications or major operational changes at Detroit Dam for improved water quality, initiating planning by 2010, completing construction by December 2018, and beginning operations by March 2019.*

- The RPA will address effects of the Willamette Project (specifically, reduced frequency of channel-forming flows, altered seasonal flow patterns, and the maintenance of revetments) on downstream habitat

- *RPA 2.4.4: enabled by implementation of RPA measures 2.4.1-2.4.3, modify operations to optimize system's ability to meet improved flow objectives to the degree feasible, by January 2012.*
- *RPA 2.7: test pilot "environmental" or "pulse" flows below Project dams to achieve channel-forming and channel-maintenance flows; implement where feasible without compromising authorized Project purposes.*
- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

- Screening diversions will remove impediments or barriers to juvenile Chinook migrants

- *RPAs 3.2 and 3.3: Reclamation will require that existing, new, and renewed contracts for stored water include conditions that protect fish from entrainment into diversions.*

- Adverse effects of the Chinook hatchery program will be minimized.

- *RPAs 6.1.1 and 6.2.2: cooperate with ODFW in the implementation of HGMPs, which include management plans for building genetic diversity using local broodstocks.*
- *RPA 4.6: build new fish collection facility in the North Santiam (begin construction by December 2012 and begin operations by March 2013).*
- *RPA 6.1.3: continue to mark all hatchery Chinook released in the Willamette Basin with adipose fin clip and otolith mark and insert coded wire tags into all hatchery Chinook prior to release.*
- *RPA 6.2.4: cooperate with ODFW to release juvenile hatchery-origin Chinook that are more similar to natural-origin fish.*

These measures (especially implementation of hatchery reforms per HGMPs, providing safe upstream and downstream passage at Big Cliff/Detroit dams, flow management, and improvements in water temperature below Big Cliff Dam) are expected to significantly improve the status of the North Santiam population. Natural-origin Chinook will have the opportunity for successful spawning, incubation, and rearing in the reach above Detroit and juveniles will emigrate downstream with reduced rates of injury and mortality. NMFS expects increases in the abundance, productivity, spatial structure, and diversity of natural-origin Chinook as these measures become operational. These actions will also improve the functioning of PCEs in designated critical habitat including:

- Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development (specifically RPA measures 2.4.4; 2.7; 5.1.1; 5.2; and 7.1.3).
- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development (RPA 2.4.4; 2.7; 5.2; and 7.1.3).
- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival (RPA 2.7; 3.2; 3.3; 4.7; 4.12.3; and 7.1.3).

Molalla Chinook

Genetic introgression of an out-of-basin hatchery stock and impaired physical habitat for past and/or present land uses are key limiting factors for this population, which is at very high risk of extinction.

- The RPA will address effects of the Willamette Project (specifically, maintenance of revetments) on habitat in the mainstem and Willamette tributaries

\- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

- The RPA will eliminate use of the current out-of-basin hatchery stock and replacement over time with a locally-derived broodstock. This hatchery reform action will promote local adaptation within the population.

\- *RPAs 6.1.1 and 6.2.2: cooperate with ODFW in the implementation of HGMPs, which include management plans for building genetic diversity using local broodstocks.*

\- *RPA 6.1.3: continue to mark all hatchery Chinook released in the Willamette Basin with adipose fin clip and otolith mark and insert coded wire tags into all hatchery Chinook prior to release.*

\- *RPA 6.2.5: support ODFW efforts to eliminate use of non-local Chinook stock and to develop locally-adapted broodstock.*

Implementation of the hatchery RPA measures will increase the genetic diversity of Chinook spawning in the Molalla River and will lead to increased abundance and productivity over time. Because the RPA does not require that habitat projects be located in the Molalla subbasin, NMFS does not assume that this RPA measure will improve the status of this Chinook population or the functioning of PCEs in the Molalla subbasin.

Clackamas Chinook

The risk of genetic introgression by hatchery fish interbreeding with those of natural origin and impaired physical habitat from past and/or present land uses are limiting factors for the Clackamas spring Chinook population, which is at moderate risk of extinction.

- Address effects of the Willamette Project (specifically, maintenance of revetments) on habitat in the mainstem and Willamette tributaries

- *RPA 7.1.3: implement at least tow habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.[57] Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

- Adverse effects of the Chinook hatchery program will be minimized.

- *RPAs 6.1.1 and 6.2.2: cooperate with ODFW in the implementation of HGMPs, which include management plans for building genetic diversity using local broodstocks.*

- *RPA 6.1.3: continue to mark all hatchery Chinook released in the Willamette Basin with adipose fin clip and otolith mark and insert coded wire tags into all hatchery Chinook prior to release.*

Implementation of the hatchery measures will increase the genetic diversity of Chinook spawning in the Clackamas River and will lead to increased abundance and productivity over time. Because the RPA does not require that habitat projects be located within the Clackamas subbasin, NMFS does not assume that this RPA measure will improve the status of this Chinook population or the functioning of PCEs in the Clackamas subbasin.

All UWR Chinook Populations

The following RPA actions, located or affecting conditions within the mainstem Willamette, will affect all populations of UWR Chinook salmon.

- RPA 2.3: obtain NMFS' approval before changing mainstem Willamette (Albany and Salem) flow objectives, to ensure that flow-related habitat needs of UWR Chinook for rearing and juvenile and adult migrations are fully considered.

- Address effects of the Willamette Project (specifically, reduced frequency of channel-forming flows and the maintenance of revetments) on downstream habitat.

- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.[57] Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

- Ensure that the availability of adequate water for fish and habitat protection in the tributaries and in the mainstem Willamette is not precluded by the water contract program

- *RPA 3: Reevaluate the availability of water from conservation storage for the water contract program and reinitiate consultation if future irrigation demands exceed 95,000 acre-feet.*

These actions will improve the functioning of PCEs in designated critical habitat:

- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development (specifically RPA measures 2.3; 7.1.1; and 7.1.3).

- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival (RPA 2.3; 7.1.1, and 7.1.3).

9.11.1.3 Conclusions—UWR Chinook Salmon

9.11.1.3.1 Jeopardy Analysis

The beneficial effects of the RPA (see above), which includes the Proposed Action (Chapters 5 and 7), combined with recent improvements in project facilities and operations (Chapter 4), is expected to address the harm to UWR Chinook caused by the Project. The RPA is designed to increase the abundance, productivity, spatial structure and diversity of the natural-origin Middle Fork Willamette, McKenzie, and South and North Santiam Chinook populations and to increase the genetic diversity of the Calapooia, Molalla, and Clackamas populations. The loss of access to historical habitat will be ameliorated by the rebuilding of fish collection facilities below Fall Creek, Dexter, Foster, and Big Cliff dams to allow significantly safer capture, handling, and transport of Chinook for release above the Project dams. Downstream passage facilities will be constructed for three populations (Middle Fork, McKenzie, and North Santiam) to provide significantly higher survival of emigrating Chinook than under either current operations or the Proposed Action. Interim and long-term water temperature control operations in the North Santiam River will improve altered water temperatures that have depressed natural production in the habitat below the dams. Hatchery reform actions will limit the risk of genetic introgression into the natural-origin populations, promoting life-history diversity and increasing the abundance and productivity of each population. Increases in the viability of these populations will contribute to increases in the status, lowering the risk of extinction, of the ESU as a whole.

Although the RPA measures combined with the Proposed Action will be implemented over the 15-year term of the Opinion and some of the biological benefits will take even longer to accrue, a number of measures will provide benefits in the short-term, reducing the ESU's short-term risk of extinction. Specifically, project operations have had a key role in degrading habitat conditions downstream, which in the North and South Santiam, South Fork McKenzie, and Middle Fork Willamette are the only areas accessible to Chinook for spawning, incubation, and early rearing. The Action Agencies began new reservoir operations in 2000 to meet mainstem and tributary flow objectives for listed fish. These, and operations that began in 2005 at the new Water Temperature Control facility at Cougar Dam, are already able to have a positive influence on adult returns. By spring of 2009, interim temperature control operations at Detroit will improve water temperatures in the North Santiam, increasing the survival of eggs, juveniles, and prespawning adults and thus population productivity. All of these measures will reduce extinction risk in the short-term as well as contributing to long-term viability. The Action Agencies will adapt their operations to new information on physical habitat properties, including those related to climate change, as the information becomes available over the next 15 years (Section 5.1.7).

The hatchery program for UWR Chinook acts as a safety net for most of the affected populations, reducing the short-term risk of extinction. Under the RPA and Proposed Action, the Action Agencies will cooperate with ODFW in continuing the transition from the historical supplementation programs to conservation/supplementation programs that focus on building genetic diversity using local broodstocks. As part of this effort, the Action Agencies will complete construction of a new sorting facility at Leaburg Dam by 2013. ODFW will use the new facility to prevent hatchery-origin Chinook from interbreeding with natural-origin fish above Leaburg. This will preserve the genetic diversity of fish in an important natural production area, another buffer against short-term extinction.

Reclamation will immediately improve its water contracting program. All (existing, new, and renewed) contracts will be subject to the availability of water, and when there is not enough water to meet minimum flow targets and irrigation contracts, instream flows will be preserved. All contracts will require that irrigation intakes and diversion dams be screened to preclude entrainment and all existing water diversions served by existing water contracts will be screened by April 1, 2010. The headgate requirement will ensure that water diversions can be stopped when not needed, or when directed by OWRD. Particularly during deficit water conditions, this reform will preserve instream flows for fish habitat needs.

The Action Agencies will continue to outplant adult UWR Chinook salmon above Detroit (North Santiam); Foster (South Santiam); Cougar (McKenzie); and Lookout Point, Hills Creek, and Fall Creek dams (Middle Fork Willamette population), an operation that enhances spatial structure in the short term while long-term passage facilities are developed. The outplanting program will be managed according to an annual Fish Operations Plan, coordinated with the Services and ODFW, which will address how, where, and when outplanted fish will be collected, held, marked, sampled, transported, and released, and will incorporate changes needed to further protect these fish based on research and monitoring.

The Action Agencies will also begin to upgrade existing adult fish collection and handling facilities in the first half of the term of the Opinion. Dates for beginning operations at the new facilities are March 2013 in the North Santiam, 2014 at Foster Dam (South Santiam), 2015 at Dexter Ponds, and 2016 at Fall Creek Dam (Middle Fork Willamette). Once construction is complete, adult fish will experience reduced levels of stress and injury, which is expected to lessen pre-spawning mortality. Completion of these facilities will also help ensure that broodstock targets are met.

The Action Agencies will design and begin to use new adult release sites above the dams by 2012. These new sites, like the improved adult collection facilities, will reduce stress and injury and thus the risk of prespawning mortality.

In addition to these measures, which will immediately (during the first one-to-seven years of this Opinion) improve population viability and reduce the risk of extinction, the RPA requires that the Action Agencies complete various RM&E efforts, feasibility studies, and where needed, NEPA analysis. NMFS expects that these evaluations will lead to the construction of facilities and adjustments in operations during the second half of the term of this Opinion that will ensure that conditions are optimized for all affected life stages of UWR Chinook. These will include:

- Adjustments to mainstem and tributary flow objectives and ramping rates to meet the needs of the species over all affected life stages
- Operations for water quality (temperature and dissolved gas) and construction of new facilities
- Construction of additional juvenile passage facilities
- Full implementation of the habitat restoration program
- Adaptation of flow management and water quality measures to changing climatic conditions

The near- and longer-term RPA measures described above will address the effects of the Willamette Project that are detrimental to all life stages of UWR Chinook that occur within the

Willamette Basin: adult migration and holding, spawning and incubation, juvenile rearing, and emigration.

Other measures taken by the same Action Agencies under the environmental baseline (as required by the 2008 FCRPS RPA; NMFS 2008a) will improve the survival and condition of juvenile UWR Chinook in the lower Columbia River and estuary. The effects of the Willamette Project on habitat are very small in the lower Columbia and estuary, with slight to negligible adverse effects on viability (Section 5.11). However, the FCRPS RPA includes beneficial measures to reduce smolt predation by Caspian terns and Northern pikeminnows and a significant estuary habitat restoration program to ensure that biological requirements are met. These actions will benefit both yearling and subyearling Chinook from the Willamette Basin during the critical period prior to ocean entry.

After reviewing the effects of the RPA measures combined with the Proposed Action, which address significant adverse impacts of the Willamette Project (lack of effective passage, degraded water quality and physical habitat properties, and adverse effects of hatchery practices on population viability), the rangewide status of the species, the effects of the environmental baseline (UWR Chinook limited to significantly degraded habitat in several important subbasins), and cumulative effects (reasonably certain non-federal activities intended to benefit the status of the species mixed with those likely to have adverse effects), NMFS has determined that the UWR Chinook salmon ESU is expected to survive with an adequate potential for recovery. The actions that will be implemented in the first few years, including reforms to the Hatchery Mitigation Program, will protect the species against the short-term risk of extinction while longer-term measures are designed and constructed. NMFS therefore concludes that the RPA and Proposed Action, combined, are not likely to jeopardize the continued existence of the UWR Chinook salmon ESU.

9.11.1.3.2 Critical Habitat Analysis

The measures described in the RPA combined with the Proposed Action will also improve the functioning of primary constituent elements of habitat needed for the conservation of the species, restoring the ability of designated critical habitat affected by the Project to serve its conservation role. The actions described above will significantly improve the following PCEs over the term of the Opinion:

- Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development
- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development
- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival

In the first one-to-seven years, the Action Agencies will rebuild the adult Chinook collection facilities and will build new release sites above Project dams. These measures will provide safe passage to high quality freshwater spawning sites with water quantity and quality and substrate that support spawning, incubation, and larval development. A new downstream passage facility at Cougar will also become operational during this period, further improving passage conditions for juvenile Chinook. Ongoing operations to meet flow objectives in the Middle Fork

Willamette, McKenzie, and South and North Santiam rivers, and operations that preserve instream flows during deficit water conditions will ensure adequate water quantity in spawning, rearing, and early migration areas. The Action Agencies will implement interim temperature control operations at Detroit Dam in the North Santiam to provide water quality needed for adult migration, spawning and incubation, and juvenile and kelt downstream survival. All existing water diversions will be screened by April 1, 2010, also contributing to safe passage in the juvenile migration corridor.

The actions to be implemented in second half of the term of this Opinion will continue these trends, restoring the functioning of safe passage for juveniles and kelts in the North Santiam and of water quality in the South Santiam. Full implementation of the habitat restoration program will ensure that habitat affected by Project operations can serve its conservation role for the species.

After reviewing the effects of the RPA combined with the Proposed Action, the status of the species, the environmental baseline, and cumulative effects, NMFS has determined that the functioning of critical habitat is likely to improve and to remain functional. NMFS therefore concludes that the Proposed Action and the RPA, combined, are not likely to result in the destruction or adverse modification of designated critical habitat for UWR Chinook salmon.

9.11.2 UWR Winter Steelhead

9.11.2.1 Effects of the RPA

The RPA specifies many significant measures that will reduce the adverse effects of the Willamette Project on the UWR steelhead DPS and will bring about proper functioning of primary constituent elements (PCEs) of its critical habitat. Many of the RPA measures specifically address key limiting factors/threats facing each population and caused by the Willamette Project: lack of passage, the degraded quality of the remaining habitat downstream of the dams, and the risk of genetic introgression from out-of-ESU hatchery fish spawning in the wild. By implementing the RPA, it is very likely the status of the populations in the North and South Santiam rivers, designated core populations (see Chapter 3), will improve significantly. . With implementation of the RPA, NMFS expects that the status of the DPS, including the four VSP parameters, will improve significantly compared to their potential status under the Proposed Action.

As shown in Table 9.11-1, several major RPA measures will be completed between 2015 and 2024 including passage at Detroit Dam, which will provide access to and from historical habitat that is currently blocked and temperature control to improve downstream habitat in a different location. Most of these measures are major construction projects that take a significant amount of time to plan, fund, and execute. For a full description of the authorization and funding processes needed for these types of measures, see the Supplemental Biological Assessment (USACE 2007I). It is not economically and technically feasible to move the timelines for many of these measures forward significantly due to their magnitude and the time needed for studies, design, authorization and construction.

Given these constraints, the anticipated population status improvements will begin in the next 15 years and continue to increase over the 15-year term of this Opinion. It will take several generations of the steelhead life cycle to respond to the positive improvements in the operation of the Willamette Project and associated measures. Therefore, significant improvements in the status of the DPS will continue to accrue in the next 30 years (approximately six generations). While implementation of these RPA measures will occur during the term of this Opinion, their full effects on population metrics (e.g., abundance, productivity) will occur over a considerable period of time after implementation. Therefore, NMFS expects that substantial improvements to the ESU will result from the implementation of the Proposed Action and the RPA.

In addition to the major measures specified in Table 9.11-1, there are numerous other near-term measures such as changes to flow, screening irrigation diversions, hatchery program modifications, and habitat mitigation projects that are included in the RPA. The near-term measures in Table 9.11-1 directly address project effects on listed fish and critical habitat without requiring as many years to implement as the measures discussed above. A third group of measures, such as conducting RM&E studies, developing fish operations manuals, project planning, and implementing the WATER collaborative process, will begin in the near term. Although this third group of activities also has not been included in the summary table, these are essential tasks that will facilitate construction of the large structures as well as guide annual operations, all of which will benefit UWR steelhead.

Difference between the Proposed Action and RPA

The effect of the RPA measures on UWR steelhead is significantly different than the effect of the Proposed Action. The Proposed Action mainly provided for further studies to consider options such as passage facilities to historical upstream habitat, as well as a major downstream habitat improvement measure of temperature control. In addition, the RPA includes measures to improve degraded downstream habitat through changes to flows, screens at irrigation diversions, hatchery improvements, and other habitat improvement projects. These RPA measures are significant because UWR steelhead are currently limited to degraded downstream habitat in one of the important subbasins (North Santiam). The RPA measures both provide access to higher quality habitat and improve downstream habitat conditions, which together will provide significant enough improvements to allow the UWR steelhead DPS to increase in numbers, productivity, spatial structure, and diversity.

9.11.2.2 UWR Steelhead Populations—Summary of Effects of the RPA

The following is a population-by-population summary of the benefits of the RPA on UWR steelhead populations. It is important that this section be read in the context of Chapter 7, "Summary of Effects of the Proposed Action on UWR Chinook and Steelhead."

Calapooia Steelhead

Impaired physical habitat from past and/or present land uses is a key limiting factor for the Calapooia population, which is at a moderate risk of extinction.

- Address effects of the Willamette Project (specifically, maintenance of revetments) on habitat in the mainstem and Willamette tributaries

- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use* *project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

Because the RPA does not require that habitat projects be located within the Calapooia subbasin, NMFS does not assume that this RPA measure will improve the status of this steelhead population or the functioning of PCEs in the Calapooia subbasin.

South Santiam Steelhead

Competition with hatchery-origin summer steelhead smolts, inadequate passage facilities at Foster and Green Peter dams, and degraded habitat downstream of Foster Dam are key limiting factors for this population, which is at moderate risk of extinction.

- The RPA will reduce impacts associated with the summer steelhead hatchery program.
  - *RPA 6.1.6: reduces the risk of residualism by allowing the volitional emigration of hatchery summer steelhead from the point of release over an extended period of time and removing non-migrants from the system.*
  - *RPA 6.1.7: ends the recycling of hatchery-origin summer steelhead for harvest purposes by September 1st of each year to decrease the risk of straying and spawning in the wild.*
  - *RPA 6.1.8: adjusts the releases of summer steelhead in the Santiam basin. More summer steelhead are caught by recreational fishers in the South Santiam, but a disproportionate number of smolts are released in the North Santiam. Aligning releases with fishery needs will reduce the risk of competition with listed winter steelhead for spawning sites.*
  - *RPA 6.1.9: ensures that the Action Agencies will cooperate with ODFW to reduce the risks to winter steelhead of straying and spawning of summer steelhead based on information acquired through research and monitoring.*
- The RPA requires rebuilding of the adult collection facility at the base of Foster Dam to allow better capture and handling of winter steelhead for outplanting into historically accessible habitat above the dam.
  - *RPA 4.6: complete construction of adult fish collection and handling facilities at Foster by December 2013 and begin operations by March 2014.*
- Construction and operation of one or more new adult release sites above Foster Dam will increase upstream passage survival and reduce pre-spawn mortality by minimizing stress and injury of adult steelhead outplanted above the dam.
  - *RPA 4.7: complete site/concept study by February 2009, establish priorities, and complete construction of all selected sites by June 2012*
- The RPA addresses the long-term need to improve reservoir and dam passage survival at Foster Dam for juvenile steelhead and kelts.
  - *RPA 4.13: The Action Agencies will evaluate a range of potentially beneficial actions for listed fish species at Project dams and reservoirs, including Foster, in their development of the Willamette Configuration and Operation Plan (COP). This will include facilities and operations that require detailed study including feasibility studies and environmental permitting such as long-term fish passage solutions at Foster Dam.*

- The RPA requires continuation of the spill program for juvenile steelhead passage at Foster Dam, which provides better passage survival that turbine passage
- *RPA 2.8: continuation of spill for juvenile steelhead passage at Foster from April 15 to May 15 each year*
- Interim operational measures at Green Peter and Foster dams will help to restore more normative seasonal water temperatures
- *RPA 5.1: identify interim measures by March 2010*
- *RPA 5.1.3: evaluate more complex measures (requiring detailed environmental review, permits, and/or congressional authorization) by April 2011.*
- The RPA will address effects of the Willamette Project (specifically, reduced frequency of channel-forming flows, altered seasonal flow patterns, and the maintenance of revetments) on downstream habitat.
- *RPA 2.4.4: enabled by implementation of RPA measures 2.4.1-2.4.3, modify operations to optimize system's ability to meet improved flow objectives to the degree feasible, by January 2012.*
- *RPA 2.7: test pilot "environmental" or "pulse" flows below Project dams to achieve channel-forming and channel-maintenance flows; implement where feasible without compromising authorized Project purposes.*
- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*
- Unscreened diversions create impediments or barriers to juvenile steelhead migrants.
- *RPAs 3.2 and 3.3.: Reclamation will require that existing, new, and renewed contracts for stored water include conditions that protect fish from entrainment into diversions.*

These measures (especially the hatchery program improvements and increases in downstream passage survival at Foster Dam) are expected to significantly improve the status of the South Santiam steelhead population. Natural-origin winter steelhead are already collected at Foster and released upstream, but the RPA will ensure that these operations and juvenile and kelt movements downstream entail less injury, mortality, and stress. NMFS expects increases in the abundance, productivity, spatial structure, and diversity of natural-origin steelhead as these measures become operational. These actions will also improve the functioning of PCEs in designated critical habitat including:

- Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development (specifically RPA measures 2.4.4; 2.7; 5.1.2; 5.1.3; and 7.1.3).
- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development (RPA 2.4.4; 2.7; 5.1.2; 5.1.3; and 7.1.3).
- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival (RPA 2.7; 2.8; 3.2; 3.3; 4.6; 4.7; 4.13; and 7.1.3).

North Santiam Steelhead

Competition with hatchery-origin summer steelhead smolts, loss of access to historical habitat above Detroit Dam, and altered habitat downstream of Big Cliff Dam are key limiting factors for this population, which is at moderate risk of extinction.

- The RPA will reduce impacts associated with the summer steelhead hatchery program.
- *RPA 6.1.6: reduces the risk of residualism by allowing the volitional emigration of hatchery fish from the point of release over an extended period of time and removing non-migrants from the system.*
- *RPA 6.1.7: ends the recycling of hatchery-origin summer steelhead for harvest purposed after September 1st of each year to decrease the risk of straying and spawning in the wild.*
- The RPA will significantly reduce the problem with altered water temperatures released from Detroit/Big Cliff dams in natural production areas downstream by requiring the Action Agencies to construct a Water Temperature Control Facility, or alternative operational measures, at Detroit Dam.
- *RPA 5.1.1: identify and evaluate interim operational measures at Detroit and if feasible, begin implementation in Water Year 2009.*
- *RPA 5.2: make structural modifications or major operational changes at Detroit Dam for improved water quality, initiating planning by 2010, completing construction by December 2018, and beginning operations by March 2019.*
- The RPA addresses the potential need to provide upstream adult passage at Detroit and Big Cliff dams. Replacing Minto Trap will allow for capture and handling of steelhead for outplanting, if determined necessary, with reduced levels of stress, injury, and mortality.
- *RPA 4.2: If determined necessary by NMFS, in coordination with the FPHM (WATER subcommittee), the Action Agencies will collect adult steelhead at the Minto trap and release them above Detroit and/or Big Cliff dams.*
- Construction and operation of new adult release sites above Detroit Dam will increase upstream passage survival and reduce pre-spawn mortality by minimizing stress and injury of adult Chinook salmon outplanted above the dams.
- *RPA 4.7: complete site/concept study by February 2009, establish priorities, and complete construction of all selected sites by June 2012*
- The RPA addresses the potential need to provide downstream juvenile steelhead and kelt passage at Detroit and Big Cliff dams if NMFS determines that steelhead should be outplanted above Detroit Dam.
- *RPA 4.12.3: initiate planning by 2015, make "go/no go" decision by end of 2017; complete construction by end of 2023, begin operations by March 2024.*
- The RPA will address effects of the Willamette Project (specifically, reduced frequency of channel-forming flows, altered seasonal flow patterns, and the maintenance of revetments) on downstream habitat

- *RPA 2.4.4: enabled by implementation of RPA measures 2.4.1-2.4.3, modify operations to optimize system's ability to meet improved flow objectives to the degree feasible, by January 2012.*
- *RPA 2.7: test pilot "environmental" or "pulse" flows below Project dams to achieve channel-forming and channel-maintenance flows; implement where feasible without compromising authorized Project purposes.*
- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.[57] Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

These measures, especially the hatchery program improvements, providing safe upstream/downstream passage at Big Cliff/Detroit dams, and improvements in water temperatures below Big Cliff Dam, are expected the significantly improve the status of the North Santiam population. Natural-origin steelhead will have the opportunity for successful spawning, incubation, and rearing in the reach above Detroit and juveniles will emigrate downstream with reduced rates of injury and mortality. NMFS expects increases in the abundance, productivity, spatial structure, and diversity of natural-origin winter steelhead as these measures become operational. These actions will also improve the functioning of PCEs in critical habitat:

- Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development (specifically RPA measures 2.4.4; 2.7; 5.1.1; 5.2; and 7.1.3).
- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development (RPA 2.4.4; 2.7; 5.1.1; 5.2; and 7.1.3).
- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival (RPA 3.2; 3.3; 4.2; 4.6; 4.7; 4.12.3; and 7.1.3).

Molalla Steelhead

Insufficient streamflows due to land use-related water withdrawals resulting in impaired water quality and reduced habitat availability and impaired physical habitat from past and/or present land use practices are secondary limiting factors for this population, which is at a moderate risk of extinction.

- The RPA will address effects of the Willamette Project (specifically, maintenance of revetments) on habitat in the mainstem Willamette and tributaries.
- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.[57] Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

Because the RPA does not require that habitat projects be located in the Molalla subbasin, NMFS does not assume that this RPA measure will improve the status of this steelhead population or the functioning of PCEs in the Molalla subbasin.

All UWR Steelhead Populations

The following RPA actions, located. or affecting conditions within the mainstem Willamette, will affect all populations of UWR steelhead.

- RPA 2.3: obtain NMFS' approval before changing mainstem Willamette (Albany and Salem) flow objectives, to ensure that flow-related habitat needs of UWR steelhead for rearing and juvenile and adult migration are fully considered.
- Address effects of the Willamette Project (specifically, reduced frequency of channel-forming flows and the maintenance of revetments) on downstream habitat
  - *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*
- Ensure that the availability of adequate water for fish and habitat protection in the tributaries and in the mainstem Willamette is not precluded by the water contract program.
  - *RPA 3: Reevaluate the availability of water from conservation storage for the water contract program and reinitiate consultation if future irrigation demands exceed 95,000 acre-feet.*

These actions will improve the functioning of PCEs in designated critical habitat:

- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development (specifically RPA measures 2.3; 7.1.1; and 7.1.3).
- Freshwater rearing corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival (RPA 2.3; 7.1.1, and 7.1.3).

9.11.2.3 Conclusions—UWR Steelhead

9.11.2.3.1 Jeopardy Analysis

The risk of extinction for the four UWR steelhead populations is moderate and the improvements in conditions that will result from the RPA and Proposed Action, combined with recent improvements in project facilities and operations (Chapter 4), will address limiting factors caused by the Project. The RPA is designed to increase the abundance and productivity of the South and North Santiam populations, to increase the spatial structure (geographic range) of the North Santiam population, and to improve the diversity (locally adapted genotypes) of all four populations (including the Calapooia and Molalla). The relationship between the RPA improvements, population viability, and the risk of extinction is similar to that described in Section 9.11.1.3 for UWR Chinook salmon, with a few differences. The Action Agencies are already passing winter steelhead upstream of Foster Dam, but the RPA requires that the adult collection facility be rebuilt to allow safer capture, handling, and transport to will increase the survival and therefore productivity of the outplanted fish. The downstream passage facilities, used by both juvenile steelheads and kelts, also will be improved to increase survival. Interim and long-term water temperature control operations in the North Santiam River and ongoing reservoir management to meet flow objectives will improve conditions that have depressed natural production below the dams and contributed to the populations' moderate risk of extinction. Hatchery reforms will reduce competitions for spawning sites with out-of-basin summer steelhead and the risk of genetic introgression, promoting life history diversity and increasing the abundance and productivity of each population.

Measures implemented in the first half of the term of this Opinion will further reduce the species' risk of extinction. These include operations to meet mainstem and tributary flow objectives, which were initiated in 2000 and are beginning to positively influence adult returns. These will continue under the RPA and Proposed Action. The Action Agencies will conduct flow studies to ensure that the flow objectives are adequate, based on gauging stations they will establish or improve. By January 2011, the Action Agencies will have determined whether the Opinion's flow levels should be revised to better meet the species needs and will meet any revised flow objectives to the extent possible given all project purposes. Thus, the Action Agencies will improve their operations, reducing negative effects on the listed species and their critical habitat, and will adapt their operations to new information on physical habitat properties, including those related to climate change (Section 5.1.7).

Reclamation will immediately improve its water contracting program. All (existing, new, and renewed) contracts will be subject to the availability of water, and when there is not enough water to meet minimum flow targets and irrigation contracts, instream flows will be preserved. All contracts will require that irrigation intakes and diversion dams be screened to preclude entrainment (fish sucked into irrigation diversions) and the headgate requirement will ensure that water diversions can be stopped when not needed, or when directed by OWRD. These reforms will minimize fish entrainment and, particularly during "deficit" water conditions, preserve instream flows for fish habitat needs. In addition, all existing water diversions served by water contracts will be screened to prevent entrainment by April 1, 2010.

In the short-term, the Action Agencies will continue to pass adult UWR steelhead above Foster on the South Santiam to enhance spatial structure. Fish survival and productivity will be improved by the outplanting program, managed according to an annual Fish Operations Plan that are coordinated with the Services and ODFW and which will address how, where, and when outplanted fish will be collected, held, marked, sampled, transported, and released, and will incorporate changes needed to further protect these fish based on research and monitoring.

By spring of 2009, interim temperature control operations at Detroit will improve water temperatures in the North Santiam, increasing the survival of eggs, juveniles, and prespawning adults and thus population productivity. The Action Agencies will design and begin to use new adult release sites above the dams by 2012. These new sites, like the improved adult collection facilities, will reduce stress and injury and thus the risk of prespawning mortality.

The Action Agencies will also begin to upgrade existing adult fish collection and handling facilities in the first half of the term of the Opinion. Dates for beginning operations at the new facilities are March 2013 in the North Santiam and 2014 at Foster Dam (South Santiam. Once construction is complete, adult fish will experience reduced levels of stress and injury, which is expected to lessen pre-spawning mortality.

In addition to these measures, which will immediately (during the first one-to-seven years of this Opinion) improve population viability and reduce the risk of extinction, the RPA requires that the Action Agencies complete various RM&E efforts, feasibility studies, and where needed, NEPA analysis. NMFS expects that these evaluations will lead to the construction of facilities and adjustments in operations during the second half of the term of this Opinion that will ensure that conditions are optimized for all affected life stages of UWR steelhead. These will include:

- Adjustments to mainstem and tributary flow objectives and ramping rates to meet the needs of the species over all affected life stages
- Operations for water quality (temperature and dissolved gas) and construction of new facilities
- Construction of improved juvenile and kelt passage facilities
- Full implementation of the habitat restoration program
- Adaptation of flow management and water quality measures to changing climatic conditions

The near- and longer-term actions described above will address the effects of the Willamette Project on all life stages of UWR steelhead that occur within the Willamette Basin: adult migration, spawning and incubation, juvenile rearing, and juvenile and kelt downstream migrations.

Other measures taken by the Action Agencies under the environmental baseline (as required by the 2008 FCRPS RPA; NMFS 2008a) will improve the survival and condition of juvenile UWR Chinook in the lower Columbia River and estuary. The effects of the Willamette Project on habitat are very small in the lower Columbia and estuary, with slight to negligible adverse effects on viability (Section 5.11). However, the FCRPS RPA includes beneficial measures to reduce smolt predation by Caspian terns and Northern pikeminnows, and a significant estuary habitat restoration program to ensure that biological requirements are met. These actions will benefit yearling steelhead from the Willamette Basin during the critical period prior to ocean entry.

After reviewing the effects of the RPA measures combined with the Proposed Action, which address significant adverse impacts of the Willamette Project (lack of effective passage, degraded water quality and physical habitat properties, and adverse effects of hatchery practices on population viability), the rangewide status of the species, the effects of the environmental baseline (degraded spawning and rearing habitat in tributaries below Project dams), and cumulative effects (reasonably certain non-federal activities that are intended to benefit these status of the species mixed with those likely to have adverse effects), NMFS has determined that the UWR steelhead DPS is expected to survive with an adequate potential for recovery. The actions implemented in the first few years will protect the species against the short-term risk of extinction while longer-term measures are designed and constructed. NMFS therefore concludes that the RPA and Proposed Action, combined, are not likely to jeopardize the continued existence of the UWR steelhead DPS.

9.11.2.3.2 Critical Habitat Analysis

The measures described in the RPA combined with the Proposed Action will also improve the functioning of PCEs, restoring the ability of primary constituent elements of habitat needed for the conservation of the species. The actions described above will significantly improve the following PCEs over the term of the Opinion:

- Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development
- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development

- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival

In the first one to seven years, the Action Agencies will rebuild the adult steelhead collection facilities and will build new release sites above Project dams. These measures will improve safe passage to high quality freshwater spawning sites that have water quantity and quality and substrate that support spawning, incubation, and larval development. Ongoing operations to meet flow objectives in the South and North Santiam rivers, and operations that preserve instream flows during deficit water conditions will ensure adequate water quantity in spawning, rearing, and early migration areas below the dams. The Action Agencies will implement interim temperature control operations at Detroit Dam in the North Santiam to provide water quality needed for adult migration and holding, spawning and incubation, and juvenile survival. All existing water diversions will be screened by April 1, 2010, also contributing to safe passage in the juvenile migration corridor.

The actions to be implemented in second half of the term of this Opinion will continue these trends, restoring the functioning of safe passage for juveniles in three of the four tributaries with Project dams and of water quality in the Middle Fork and South Santiam. Full implementation of the habitat restoration program will ensure that habitat affected by Project operations can serve its conservation role for the species.

After reviewing the effects of the RPA combined with the Proposed Action, the status of the species, environmental baseline, and cumulative effects, NMFS has determined that the functioning of designated critical habitat is likely to improve and remain functional. NMFS therefore concludes that the Proposed Action and the RPA, combined, are not likely to result in the destruction or adverse modification of designated critical habitat for UWR steelhead.

9.11.3 Snake River, Upper Columbia River, Middle Columbia River, and Lower Columbia River Salmon and Steelhead

As described in Sections 8.3-8.7, NMFS has concluded that, taking into account the current status of 11 species of Interior and Lower Columbia Basin salmon and steelhead and of critical habitat designated for 10 of those species,[58] the condition of the environmental baseline and cumulative effects within the action area, the Proposed Action is not likely to jeopardize the continued existence of any of these species or to destroy or adversely modify critical habitat. Adverse effects of the Proposed Action were limited to a very small decrease in average monthly flows in the lower Columbia River and estuary during February through June and very small reductions in the delivery of turbidity and large wood, trapped behind Project dams. These were expected to result in "slight to negligible" effects on habitat conditions, including the PCEs safe passage in the juvenile migration corridor and water quantity, turbidity, floodplain connectivity, large wood, and natural cover in freshwater/estuarine rearing areas, and on population viability. In addition, NMFS anticipates that habitat conditions in the lower Columbia River and estuary will improve over the term of this Opinion due to relocation of Caspian terns to sites outside Columbia Basin, ongoing control of Northern Pikeminnow predation, and implementation of a 10-year estuary habitat program under the 2008 FCRPS RPA (NMFS 2008a). These future improvements in baseline habitat conditions are expected to exceed the small to negligible

[58] NMFS has not yet designated critical habitat for LCR coho salmon.

adverse effects of the RPA and Proposed Action. Thus, NMFS concludes that the Proposed Action and the RPA are not likely to jeopardize the continued existence of any of these species or to destroy or adversely modify critical habitat.

9.11.4 Southern Resident Killer Whales and Southern DPS of North American Green Sturgeon

After conducting the analyses included as Appendices A and B to this Opinion, NMFS determines that the Proposed Action and the RPA are not likely to adversely affect either species or critical habitat designated for the Southern Resident killer whale.

Chapter 10
Reinitiation of Consultation

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10 REINITIATION OF CONSULTATION

As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action on listed species or designated critical habitat in a manner or to an extent not considered in this Opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, the Action Agencies must consult with NMFS to determine whether specific actions will be taken to address such events including but not limited to ceasing or modifying the causal activity.

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Chapter 11
Incidental Take Statement

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11 INCIDENTAL TAKE STATEMENT

Section 9(a)(1) of the ESA prohibits any taking (to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct) of endangered species without a specific permit or exemption. Protective regulations adopted pursuant to Section 4(d) of the ESA extend the prohibition to threatened species. Harm is defined to include significant habitat modification or degradation that results in death of or injury to listed species by significantly impairing behavioral patterns such as spawning, rearing, feeding, and migrating (50 CFR §222.102; NMFS 1999f). The ESA does not define harassment nor has NMFS defined this term through regulation. However, for this Opinion, NMFS considers an action to be harassment if it is an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity by a Federal agency or applicant (50 CFR §402.02). Under the terms of Section 7(b)(4) and Section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA, provided that such taking is in compliance with the terms and conditions of the incidental take statement.

An incidental take statement specifies the impact of any incidental taking of endangered or threatened species. It also provides reasonable and prudent measures that are necessary to minimize these impacts, and sets forth terms and conditions with which the action agency must comply in order to implement the reasonable and prudent measures. The measures described in this section are nondiscretionary.

If USACE, Reclamation, or BPA fails to comply with the terms and conditions of this incidental take statement, they may no longer be in compliance with the ESA. To monitor the impact of incidental take, USACE, Reclamation, and BPA must report the progress of the action and its effect on each listed species to NMFS, as specified in this incidental take statement (50 CFR §402.14(i)(3)).

11.1 Amount or Extent of Anticipated Take

Incidental take will occur as a result of the continued operation of the Willamette Project dams and reservoirs, maintenance of revetments, administration of Reclamation's water contract program, implementation of on- and off-site habitat mitigation measures, operation of the Willamette Hatchery Mitigation Program, and RM&E activities. Because of the inherent biological characteristics of aquatic species such as listed salmon and steelhead, the dimensions and variability of the river system, and the operational complexities of hatchery actions, it is not possible to determine precise (or even to quantify) levels of mortality for juveniles and adults attributable to many features of the RPA and Proposed Action (e.g., reduced availability of habitat for spawning or rearing if tributary flow objectives are not met; predation by program hatchery-origin fish on listed fish below release locations). The following sections therefore specify an *amount* of take where possible (collection of adults for outplanting or broodstock; juvenile or kelt project passage, Sections 11.1.1 and 11.1.5), but otherwise specify a geographic and temporal *extent* of take (Sections 11.1.2 through 11.1.5).

These are the maximum amounts or extents of take that NMFS anticipates will occur as a result of the RPA and Proposed Action. If actual take exceeds an amount or (geographic and temporal) extent specified here, it is likely that the authorized incidental take allowed under this Opinion has been exceeded by some indeterminate amount. NMFS will evaluate the best science available and determine whether authorized take has, in fact, been exceeded and if reinitiation of consultation is required.

As the RPA and Proposed Action are implemented, incidental take in the forms of adult and juvenile passage mortality and due to adverse water quality and quantity conditions is expected to decline. With respect to fish passage, RPA measure #9.3 includes RM&E measures that will lead to the development of performance objectives for the Project. These standards will be consistent with NMFS (2008e) or as determined through the Fish Passage and Management Committee of WATER and agreed to by NMFS. As these standards are developed, they will replace the permitted amount of take due to fish passage as described in this statement. Similarly, RM&E on mainstem Willamette and tributary flows are expected to lead to amendments to flow objectives (RPA measures #2.3; 2.4.2-2.4.4; 2.6.4; 2.10; and 9.2).

11.1.1 Amount or Extent of Take from Operation of Willamette Project Dams & Reservoirs

NMFS anticipates that the continued operation of the Willamette Project dams and reservoirs under the PA and RPA will result in incidental take of the species considered in this opinion (see Environmental Baseline [specifically Sections 4.2, 4.3, 4.5, 4.6, and 4.11]; Effects of the Proposed Action [Sections 5.2, 5.3, 5.5, 5.6, and 5.11]; and Effects of the RPA [Section 9.10]). For UWR Chinook salmon and UWR steelhead, which spawn and/or rear in several of the subbasins with Project dams, effects will include juvenile and adult passage mortality as well as effects on habitat conditions below the dams (i.e., in the tributaries and mainstem Willamette and in the lower Columbia River). Take of individuals of the other 11 species (LCR steelhead, LCR Chinook Salmon, LCR coho Salmon, CR chum salmon, MCR steelhead, SR steelhead, SR fall Chinook salmon, SR spring/summer Chinook salmon, SR sockeye salmon, UCR steelhead, and UCR spring Chinook salmon) would be limited to those that occurred due to adverse effects on habitat conditions in the lower Columbia River and estuary (e.g., altered flows, interrupted transport of large wood and turbidity), but these were determined to be slight to negligible (i.e., did not rise to the level of take; Section 5.11).

NMFS expects, at most, the (quantifiable) amounts of incidental take of UWR Chinook and steelhead due to project passage, including trapping, transporting, and outplanting adults as well as juvenile passage, in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins shown in Table 11.1-1. The maximum (quantifiable) amounts of incidental take of UWR steelhead adults (including kelts) and juveniles are shown in Table 11.1-2.

The relationships between tributary flows and water quality, the functioning of rearing habitat, and carrying capacity (one of the environmental factors controlling abundance and productivity) are explained in Appendix C and in Sections 5.2-5.10 (see subsections titled “Water Quantity and Hydrograph,” “Water Quality,” and “Physical Habitat Quality”). The major sources of take due to these features of the RPA and Proposed Action are the reduced availability and functioning of spawning, rearing, and juvenile and adult migration habitat. The expected geographic or temporal extent of take are shown for each species in each part of the action area in Tables 11.1-3a through 11.1-6c.

11.1.2 Extent of Take from Maintenance of Revetments

The relationships between maintenance of revetments, the functioning of rearing habitat, and carrying capacity are explained in Sections 5.2-5.10 (see subsections titled "Physical Habitat Quality"). The major source of take due to maintaining revetments under the Proposed Action and RPA is the reduced availability of rearing habitat. The expected geographic or temporal extent of take are shown for each species in each part of the action area in Tables 11.1-3a through 11.1-7.

11.1.3 Extent of Take from Administration of Reclamation's Water Contract Program

The relationships between actions that will occur as a result of administering water contracts, habitat condition, and carrying capacity (a factor in population abundance and productivity) are explained in Chapter 9 (see RPA measure #3). The major sources of take and the expected geographic or temporal extent of take due to effects of water contracting under the Proposed Action and RPA are: 1) reduced availability of rearing habitat between points of diversion and the confluence of each tributary with the Willamette during July and August and 2) mortality due to entrainment at points of diversion during July and August (but only through 2009, after which all existing diversions will be screened) (Tables 11.1-3a through 11.1-6c).

11.1.4 Extent of Take from Implementation of Habitat Measures

Habitat restoration projects could be implemented in the mainstem Willamette and in any of the tributary subbasins with Project dams or revetments. Some habitat restoration projects will have negative effects during construction (e.g., sediment plumes, localized and brief chemical contamination from machinery, or the destruction or disturbance of some existing riparian vegetation). These are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks). However, due to these short-term adverse effects, incidental take is reasonably certain to occur.

Take of listed salmonids resulting from habitat projects developed to implement this RPA and authorized, funded, or carried out by the USACE that are consistent in type, design, and implementation to those covered by the Endangered Species Action Section 7 Formal Programmatic Consultation and Magnuson-Stevens Fishery Conservation and Management Act, Essential Fish Habitat Consultation for the Revised Standard Local Operating Procedures for Endangered Species (SLOPES IV) to Administer Certain Activities Authorized or Carried Out by the Department of the Army in the State of Oregon and on the North Shore of the Columbia River, falls within the take provisions of that Biological Opinion (NMFS 2008f). Take resulting from projects that fall outside the explicit criteria in the SLOPES IV Biological Opinion will require separate and subsequent consultation.

Similarly, take of listed salmonids resulting from habitat projects developed to implement this RPA and authorized, funded, or carried out by BPA that are consistent in type, design, and implementation to those covered by the Endangered Species Action Section 7 Formal Programmatic Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Implementation of the Bonneville Power Administration Habitat Improvement Program in Oregon, Washington, and Idaho, CY 2007-CY2011 (HIP II), falls within the take provisions of that Biological Opinion (NMFS 2008d). Take resulting from projects that fall outside the explicit criteria in the HIP II Biological Opinion will require separate and subsequent consultation.

NMFS authorizes no additional take of ESA-listed species (beyond that previously authorized by the SLOPES IV and HIP II Biological Opinions) for the habitat restoration activities required by the RPA and Proposed Action in this Opinion. NMFS will work with the Action Agencies to develop additional programmatic biological opinions to address off-site mitigation projects and their associated take.

11.1.5 Amount or Extent of Take from Operation of the Willamette Hatchery Mitigation Program

The PA and RPA require programs and processes to ensure that the Willamette Project hatchery mitigation programs do not reduce the viability of the listed species. Incidental take from these hatchery programs is assessed in the effects chapters and is further described in the Supplemental Biological Assessment and relevant HGMPs. For the summer steelhead and rainbow trout hatchery programs that involve solely incidental take of listed species, ESA take for those programs is authorized in this ITS for these hatchery programs. For the Chinook hatchery programs, incidental and direct take of listed natural (unclipped) Chinook and steelhead is proposed. The incidental take of listed steelhead from the Chinook hatchery programs are authorized in this ITS. However, authorization of the incidental and direct take of listed Chinook from the Chinook hatcheries will be processed under limit #5 (the artificial propagation limit) of the 4d Rule (June 28, 2005; 70 FRN 37160).

Levels of incidental mortality for juveniles and adults attributable to hatchery operations per the RPA and Proposed Actions are, in most cases, not quantifiable at the present time (e.g., predation by program hatchery-origin fish on listed fish below release locations; competition and density dependent effects in the Lower Willamette and estuary). Though the levels of mortality to juvenile and adults cannot be measured directly for specific artificial propagation programs, impacts of some of the general effects of artificial propagation can be inferred through other measurements and monitoring and evaluation activities. The general and specific effects of the hatchery programs on listed fish are fully described in Chapter 5. It is possible to estimate take of the listed species for certain hatchery activities (e.g., numbers of fish handled and collected during broodstock collection, see Tables 11.1-1 and 11.1-2). For the other activities where take is currently unquantifiable, NMFS estimates the geographic and temporal extent of each type of take in Tables 11.1-3a through 11.1-7.

11.1.6 Amount or Extent of Take from RM&E activities

This section identifies the authorized incidental take allowed under this Opinion for RM&E actions (see Effects of the Proposed Action [Section 5.1] and Effects of the RPA [Section 9.10]). Under the PA and RPA, the Willamette Project Action Agencies, or their contractors, are required to implement the following RM&E actions:

1. Monitor compliance with the effectiveness of flow and ramping measures (RPA measure #9.2);
2. Support performance monitoring and adaptive management related to fish passage measures (RPA measure #9.3);
3. Support performance monitoring and adaptive management related to water quality actions (RM&E measure #9.4);
4. Support performance monitoring and adaptive management related to hatchery actions (RM&E measure #9.5); and
5. Support performance monitoring and adaptive management related to habitat restoration (RM&E measure #9.6);

Many of these research, monitoring, and evaluation actions will result in short-term adverse impacts on the listed species. The primary adverse effects will be in the form of incidental "take," a major portion of which takes the form of harassment. Harassment generally leads to stress and other sub-lethal effects and is caused by observing, capturing, and handling fish.

11.1.6.1 Amount or Extent of Incidental Take from Flow and Ramping RM&E Actions

Incidental take due to habitat alterations caused by flow and ramping rate RM&E actions would not exceed that described for "Tributary flows" in Tables 11.1-3a through 11.1-6c. In addition, juvenile Chinook and steelhead may be handled or tagged. NMFS has determined that mortalities, based on consideration of similar studies to date, are likely to be less than 3%. Therefore, mortality of up to 3% of juvenile Chinook and steelhead handled is permitted as incidental take.

11.1.6.2 Amount or Extent of Incidental Take from Fish Passage RM&E Actions

Incidental take from fish passage RM&E will include harassment, handling, injury, and mortality of adults at trapping sites; handling and mortality of adults during transport; juvenile injury and mortality during project passage; and juvenile trap mortality at the lower end of the study site. The amount or extent of take expected from each these activities is shown in Tables 11.1-3a through 11.1-6c.

11.1.6.3 Amount or Extent of Incidental Take from Water Quality RM&E Actions

Incidental take from water quality RM&E actions will include harassment of adults and juveniles during construction of monitoring stations and/or during measurement of physical and biological metrics, although the harassment of listed salmon or steelhead during spawning while constructing or using monitoring stations is not permitted.

11.1.6.4 Amount or Extent of Incidental Take from Hatchery RM&E Actions

Incidental take from hatchery RM&E actions will include observation, harassment, carcass sampling, injury, and mortality during broodstock collection activities, spawning surveys, and release of juvenile Chinook above and below Project dams, as shown in Tables 11.1-3a through 11.1-6c. Incidental take of listed winter steelhead will be similar, with the addition observation, harassment, and collection of juveniles during the hatchery summer steelhead genetic study (Tables 11.1-3b and 11.1-4b).

11.1.6.5 Amount or Extent of Incidental Take from Habitat Restoration RM&E Actions

Take resulting from habitat RM&E will occur primarily as harassment or harm caused by handling, increased delivery of contaminants and fine sediments to streams, and human activities in or around streams. Take from these activities will occur more sporadically and within a larger area than take from in- and near-water construction. For these activity categories, the extent of take is best identified by the total number of projects implemented each year. The Action Agencies shall begin initiating individual consultations on research, monitoring, and evaluation projects not involving in-water or near-water construction if over 100 of these projects are implemented in a given calendar year. The first 100 of these projects are covered under this programmatic consultation.

11.1.6.6 Summary of Amount or Extent of Incidental Take from All RM&E Actions

As a result of implementing the RM&E actions required by the PA and the RPA, NMFS' best estimate of the average take that is likely to be experienced by the salmon and steelhead species considered in this Opinion is provided in Tables 11.1-1 through 11.1-7.

11.1.7 Effect of the Take

Earlier in this Opinion (Section 9.11), NMFS determined that the RPA and Proposed Action, combined, are not likely to result in jeopardy to any of the 13 ESA-listed species. Thus, the effect of the amount and extent of take associated with these actions is fully considered in Chapter 9 of the Opinion.

Table 11.1-1 Estimates of the (quantifiable) amount of incidental take of UWR Chinook salmon associated with operation of Willamette Project dams and reservoirs (based on Willis 2008 and ODFW 2004a, 2008a,b).

SUBBASIN	FEATURE	LIFE STAGE(S)	AMOUNT OF TAKE
North Santiam	Minto Trap	Adults	Handled: up to 5,000 fish annually including broodstock collection of up to 800 fish each year Injury: up to 2% of fish handled Mortality: up to 4% of fish handled
	Haul from Minto and release above Detroit Reservoir or below Big Cliff Dam (outplanting of adult Chinook)	Adults	Handled: up to 4,200 fish annually Mortality: up to 1% of fish handled
	Outmigrant passage at Detroit and Big Cliff	Juveniles (primarily produced by hatchery-origin spawners)	Mortality: up to 65%
	Fish passage RM&E (screw traps and nets)	Juveniles	Mortality: up to 1%
South Santiam	Foster Trap	Adults	Handled: up to 7,000 fish annually including broodstock collections of up to 1,400 each year Injury: up to 1% of fish handled Mortality: up to 1% of fish handled
	Haul from Foster trap and release at sites located above Foster Reservoir or below Foster Dam	Adults	Handled: up to 5,600 fish annually Mortality: 1% of fish handled
	Downstream passage at Green Peter and Foster dams	Juveniles (primarily produced by hatchery-origin spawners)	Mortality: up to 83% of run past Green Peter Dam and up to 10% of run past Foster Dam
	Fish passage RM&E (screw traps and nets)	Juveniles	Mortality: up to 1%

SUBBASIN	FEATURE	LIFE STAGE(S)	AMOUNT OF TAKE
McKenzie	Cougar Trap	Adults	(Estimated based on the Fall Creek fish handling facility) Handled: up to 1,300 annually for years 1-7 and up to 2,600 fish annually for years 8-15 Injury: up to 1% of fish handled Mortality: up to 1% of fish handled
	Haul from Cougar trap and release at sites located above Cougar Reservoir or downstream of Cougar Dam	Adults	Handled: up to 1,300 annually for years 1-7 and up to 2,600 fish annually for years 8-15 Mortality: up to 1% of fish handled
	Downstream passage at Cougar Dam	Juveniles (primarily produced by hatchery origin spawners)	Mortality: up to 18.1% of fish passing through the turbines and up to 32% of those passing through the regulating outlet
	Fish passage RM&E (screw traps and nets)	Juveniles	Mortality: up to 1%
Middle Fork Willamette	Fall Creek Trap	Adults	Handled: up to 2,805 fish annually for years 1-7 and up to 5,610 fish annually for years 8-15 Injury: up to 1% Mortality: up to 1%
	Haul from Fall Creek trap and release at sites above Fall Creek Reservoir	Adults	Transported: up to 2,805 fish annually for years 1-7 and up to 5,610 fish annually for years 8-15 Mortality: 1% of fish transported
	Downstream passage at and Fall Creek Dam (Downstream Migrant Facility—horns)	Juveniles	Mortality: up to 68.3 %
	Downstream passage at and Fall Creek Dam (regulating outlet)	Juveniles	Mortality: up to 41% (Downey 1992)

SUBBASIN	FEATURE	LIFE STAGE(S)	AMOUNT OF TAKE
	Dexter Trap	Adults	Handled: up to 11,375 annually for years 1-7 and up to 22,750 annually for years 8-15 including broodstock collection of up to 1,600 each year Injury: up to 1% Mortality: up to 1%
	Haul from Dexter trap and released at sites above Lookout Point or Hills Creek reservoir	Adults	Transport: up to 11,375 annually for years 1-7 and up to 22,750 annually for years 8-15 Mortality: up to 2% of fish transported
	Downstream passage at Lookout Point and Dexter dams	Juveniles	Mortality: up to 21% of run
	Downstream passage at Hills Creek Dam	Juveniles (primarily produced by hatchery origin spawners)	Mortality: up to 60% of run
	Fish passage RM&E (screw traps and nets)	Juveniles	Mortality: up to 1%

Table 11.1-2 Estimates of the (quantifiable) amount of incidental take of UWR steelhead associated with operation of Willamette Project dams and reservoirs (based on Willis 2008 and ODFW 2004a).

SUBBASIN	FEATURE	LIFE STAGE(S)	AMOUNT OF TAKE
North Santiam	Minto Trap	Adults	Handled: up to 400 fish annually for years 1-7 and up to 800 annually for years 8-15 Injury: up to 2% of fish handled Mortality: up to 1% of fish handled
	Haul from Minto and release between Big Cliff Dam and Minto barrier (or potential future release above Detroit Reservoir)	Adults	Handled: up to 1,000 fish annually for years 1-7 and up to 2,000 annually for years 8-15 Mortality: up to 1% of fish handled
	Outmigrant passage at Detroit and Big Cliff (progeny of potential future outplants above Detroit Reservoir)	Juveniles	Mortality: up to 65%
		Adults (kelts)	Mortality: up to 95%
	Fish passage RM&E (screw traps and nets)	Juveniles	Mortality: up to 1%
South Santiam	Foster Trap	Adults	Handled: up to 600 fish annually for years 1-7 and up to 1,200 annually for years 8-15 Injury: up to 2% of fish handled Mortality: up to 1% of fish handled
	Haul from Foster trap and release at sites above Foster Reservoir or below Foster Dam	Adults	Handled: up to 5,000 fish annually Mortality: 1% of fish handled
	Downstream passage at Green Peter and Foster dams	Juveniles	Mortality: up to 83% of run past Green Peter Dam; up to 10% of run past Foster Dam
		Adults (kelts)	Mortality: up to 95%
	Fish passage RM&E (screw traps and nets)	Juveniles	Mortality: up to 1%

Table 11.1-3a Estimates of the type and geographic and temporal extent of incidental take of UWR Chinook salmon associated with effects of the Willamette Project, including Big Cliff and Detroit dams, in the North Santiam subbasin (based on Willis 2008).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Tributary flows (unable to meet minima due to hydrologic conditions; change in peak/base flows for flood damage reduction; flow and ramp rate studies)	Adults	Barrier to spawning habitat below Big Cliff Dam and reduced amount of adult holding habitat	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Jun – 5% Jul-Aug – 5% Sep – 17% Oct – 5%
	Juveniles	Desiccation of eggs when dewatered, barrier to marginal (shallow) juvenile rearing habitat, stranding and entrapment during flow fluctuations	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Nov-Jan – 5% Feb-Mar – 5% Apr-May – 5% Ramping rates not to exceed 1 inch per hour during nighttime and 2 inches per hour during the day except during active flood control damage reduction operations or where physical configuration of a project does not allow this level of precision (RPA 2.6.1).
Water quality (temperature)	Adults	Low temperatures below dams cause pre-spawner straying & mortality	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	May-Aug

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
	Juveniles	Elevated temperatures cause reduced egg viability and increase susceptibility to disease	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	Oct-Dec
Water quality (dissolved gas), including RM&E	Juveniles	Elevated levels of total dissolved gas caused by spilling or by regulating outlet discharge during fall drawdown and high overwinter flows effect survival, especially during incubation and before emergence. Spill over approx. 1,400 cfs generates more than 115% TDG	Within 1 mile downstream of the base of Big Cliff Dam	Percent of days mean daily spill exceeds 1,400 cfs, unless coordinated through the WATER flow management committee process (RPA 2.1): Oct 19% Nov 42% Dec 32% Jan 39%
Substrate (i.e., gravel, cobble, boulder); off-channel habitat; large woody debris; channel condition/dynamics; streambank condition; floodplain connectivity	Adults	Reduced forage and cover/shelter	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	All year
	Juveniles	Reduced forage and cover/shelter	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	All year
Water contract administration	Juveniles	Reduced amount of rearing habitat	Points of diversion to confluence with Willamette River	July and August
	Juveniles	Mortality due to entrainment at diversions	Points of diversion	July and August 2008-2009

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Maintenance of revetments	Juveniles	Reduced amount of rearing	RM 20 (upstream end of reach with USACE revetments) to confluence with the Willamette	All year
Release of hatchery Chinook and steelhead smolts	Juveniles	Competition, predation, and residualism	From Minto Dam acclimation site (RM 42) to confluence with South Santiam River	Feb-May
Hatchery Chinook spawning surveys below Big Cliff Dam	Juveniles and adults	Observed; harassed; carcasses sampled	From Big Cliff Dam tailrace (RM 46.4) to confluence with South Santiam River	June-Oct
Hatchery Chinook spawning surveys above Detroit Dam	Juveniles and adults	Observed; harassed; carcasses sampled	All spawning areas in the North Santiam River and tributaries above Detroit Reservoir	June-Oct
Juvenile Chinook surveys above Detroit Dam to evaluate hatchery fish spawning success	Juveniles and adults	Observed; harassed; carcasses sampled	North Santiam River Basin above Detroit Dam	Feb-Oct

Table 11.1-3b Estimates of the type and geographic and temporal extent of incidental take of UWR steelhead associated with effects of the Willamette Project, including Big Cliff and Detroit dams, in the North Santiam subbasin (based on Willis 2008).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Tributary flows (unable to meet minima due to hydrologic conditions; change in peak/base flows for flood damage reduction; flow and ramp rate studies)	Adults	Barrier to spawning habitat below Big Cliff Dam and reduced amount of adult holding habitat	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Mar – 5% Apr-Jun – 5%
	Juveniles	Desiccation of eggs when dewatered, barrier to marginal (shallow) juvenile rearing habitat, stranding and entrapment during flow fluctuations	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Jun – 5% Jul-Aug – 5% Sep – 17% Oct-Jan – 5% Feb-Mar – 5% Apr-May – 5% Ramping rates not to exceed 1 inch per hour during nighttime and 2 inches per hour during the day except during active flood control damage reduction operations or where physical configuration of a project does not allow this level of precision (RPA 2.6.1).
Water quality (temperature) , including RM&E	Adults	Low temperatures below dams cause delayed spawning and contribute to pre-spawner straying & mortality	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	May-Jun

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
	Juveniles	Low temperatures below dams cause delayed hatching, incubation and emergence. Delayed emergence results in less over-summer growth, which likely results in reduced over-winter survival for subyearlings. Low temperatures also result in less favorable rearing habitat for yearlings and may effect use for otherwise acceptable rearing habitat within the N. Santiam.	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	Jun-Sep (subyearlings) May-Sep (yearlings)
Water quality (dissolved gas)	Adults	Elevated levels of total dissolved gas caused by spilling or by regulating outlet discharge during operational WTC implementation may effect pre-spawner survival. Spill over approx. 1,400 cfs generates more than 115% TDG	Within 1 mile downstream of the base of Big Cliff Dam	Percent of days mean daily spill exceeds 1,400 cfs, unless coordinated through the WATER flow management committee process (RPA 2.1): Apr – 5% May – 5%

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
	Juveniles	Elevated levels of total dissolved gas caused by spilling or by regulating outlet discharge during operational WTC implementation may effect survival, especially during incubation and before emergence. Spill over approx. 1,400 cfs generates more than 115% TDG	Within 1 mile downstream of the base of Big Cliff Dam	Jun-Jul (incubation) Apr-Aug (rearing) Percent of days mean daily spill exceeds 1,400 cfs, unless coordinated through the WATER flow management committee process (RPA 2.1): Apr 5% May 5% Jun 5% Jul 5% Aug 5%
Substrate (i.e., gravel, cobble, boulder); off-channel habitat; large woody debris; channel condition/dynamics; streambank condition; floodplain connectivity	Adults	Reduced forage and cover/shelter	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	All year
	Juveniles	Reduced forage and cover/shelter	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	All year
Water contract administration	Juveniles	Reduced amount of rearing habitat	Points of diversion to confluence with Willamette River	July and August
	Juveniles	Mortality due to entrainment at diversions	Points of diversion	July and August 2008-2009
Maintenance of revetments	Juveniles	Reduced amount of rearing	RM 20 (upstream end of reach with USACE revetments) to confluence with the Willamette	All year

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Release of hatchery Chinook and steelhead smolts	Juveniles	Competition, predation, and residualism.	From Minto Dam acclimation site to confluence with the South Santiam River (approx. 42 miles)	Feb-May
Hatchery summer steelhead spawning surveys below Big Cliff Dam	Juveniles and adults	Observed, harassed, carcasses sampled	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	Dec-May
Hatchery Summer steelhead genetic study	Juveniles	Observed, harassed, and collected. Take levels determined by Research, Monitoring and Evaluation Committee of WATER.	North Santiam River Basin and tributaries below Minto Dam	Feb-Oct

Table 11.1-4a Estimates of the type and geographic and temporal extent of incidental take of UWR Chinook salmon associated with effects of the Willamette Project, including Foster and Green Peter dams, in the South Santiam subbasin (based on Willis 2008).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Tributary flows (unable to meet minima due to hydrologic conditions; change in peak/base flows for flood damage reduction; flow and ramp rate studies)	Adults	Barrier to spawning habitat below Foster Dam and reduced amount of adult holding habitat	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Jun – 5% Jul-Aug – 5% Sep-Oct – 25%
	Juveniles	Desiccation of eggs when dewatered, barrier to marginal (shallow) juvenile rearing habitat, stranding and entrapment during flow fluctuations	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Oct-Jan – 20% Feb-Mar – 5% Apr-May – 20% Ramping rates not to exceed 1 inch per hour during nighttime and 2 inches per hour during the day except during active flood control damage reduction operations or where physical configuration of a project does not allow this level of precision (RPA 2.6.1).
Water quality (temperature), including RM&E	Adults	Low temperatures below dams cause pre-spawner straying & mortality	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	May-Aug
	Juveniles	Elevated temperatures cause reduced egg viability and increase susceptibility to disease	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	Oct-Dec

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Water quality (dissolved gas), including RM&E	Juveniles	Elevated levels of total dissolved gas caused by spilling or by regulating outlet discharge during fall drawdown and high overwinter flows effect survival, especially during incubation and before emergence. Spill over approx. 1,400 cfs at Foster generates more than 115% TDG below Foster Dam.	Within 1 mile downstream of the base of Foster Dam	Oct-Feb (incubation) Mar-Sep (rearing) Percent of days mean daily spill exceeds 1,400 cfs, unless coordinated through the WATER flow management committee process (RPA 2.1): Oct – 5% Nov – 29% Dec – 54% Jan – 65% Feb – 25% Mar – 28% Apr – 13% May – 5% Jun – 5% Jul-Sep – 5%
Substrate (i.e., gravel, cobble, boulder); off-channel habitat; large woody debris; channel condition/dynamics; streambank condition; floodplain connectivity	Adults	Reduced forage and cover/shelter	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	All year
	Juveniles	Reduced forage and cover/shelter	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	All year
Water contract administration	Juveniles	Reduced amount of rearing habitat	Points of diversion to confluence with Willamette River	July and August
	Juveniles	Mortality due to entrainment at diversions	Points of diversion	July and August 2008-2009

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Maintenance of revetments	Juveniles	Reduced amount of rearing	RM 19 (upstream end of reach with USACE revetments) to confluence with the Willamette	All year
Release of hatchery Chinook and steelhead smolts	Juveniles	Competition, predation, and residualism.	From Foster Dam to confluence with the North Santiam River (approx. 37.7 miles)	Feb-May
Hatchery Chinook spawning surveys below Foster Dam	Juveniles and adults	Observed, harassed, carcasses sampled	From Foster Dam to confluence with the North Santiam River (approx. 37.7 miles)	June-Oct
Hatchery Chinook spawning surveys above Foster Dam	Juveniles and adults	Observed, harassed, carcasses sampled	All spawning areas in the South Santiam River and tributaries above Foster reservoir	June-Oct
Juvenile Chinook surveys above Foster Dam to evaluate hatchery fish spawning success	Juveniles and adults	Observed, harassed, collected, sampled	South Santiam River Basin above Foster Dam	Feb-Oct

Table 11.1-4b Estimates of the type and geographic or temporal extent of incidental take of UWR steelhead associated with effects of the Willamette Project, including Foster and Green Peter dams, in the South Santiam subbasin (based on Willis 2008).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Tributary flows (unable to meet minima due to hydrologic conditions; change in peak/base flows for flood damage reduction); flow and ramp rate studies	Adults	Barrier to spawning habitat below Foster Dam and reduced amount of adult holding habitat	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Mar-May – 20%
	Juveniles	Desiccation of eggs when dewatered, barrier to marginal (shallow) juvenile rearing habitat, stranding and entrapment during flow fluctuations	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	May-Jun (incubation) May-Apr (rearing) Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): May-Jun – 5% Apr – 20% Ramping rates not to exceed 1 inch per hour during nighttime and 2 inches per hour during the day except during active flood control damage reduction operations or where physical configuration of a project does not allow this level of precision (RPA 2.6.1).
Water quality (temperature), including RM&E	Adults	Low temperatures below dams cause delayed spawning and contribute to pre-spawner straying & mortality	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	Apr-May

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
	Juveniles	Low temperatures below dams cause delayed hatching, incubation and emergence. Delayed emergence results in less over-summer growth, which likely results in reduced over-winter survival for subyearlings. Low temperatures also result in less favorable rearing habitat for yearlings and may affect use for otherwise acceptable rearing habitat within the S. Santiam.	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	Jun-Sep (subyearlings) Apr-Sep (yearlings)
Water quality (dissolved gas), including RM&E	Adults	Elevated levels of total dissolved gas caused by spilling or by regulating outlet discharge during operational WTC implementation may effect pre-spawner survival. Spill over approx. 1,400 cfs generates more than 115% TDG	Within 1 mile downstream of the base of Foster Dam	Percent of days mean daily spill exceeds 1,400 cfs, unless coordinated through the WATER flow management committee process (RPA 2.1): Apr – 5% May – 5%

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
	Juveniles	Elevated levels of total dissolved gas caused by spilling or by regulating outlet discharge during operational WTC implementation may effect survival, especially during incubation and before emergence. Spill over approx. 1,400 cfs generates more than 115% TDG	Within 1 mile downstream of the base of Foster Dam	May-Jun (incubation) May-Apr (rearing) Percent of days mean daily spill exceeds 1,400 cfs: May – 5% Jun – 5% Jul-Oct – 5% Nov – 29% Dec – 54% Jan – 65% Feb – 25% Mar – 28% Apr – 13%
Substrate (i.e., gravel, cobble, boulder); off-channel habitat; large woody debris; channel condition/dynamics; streambank condition; floodplain connectivity	Adults	Reduced forage and cover/shelter	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	All year
	Juveniles	Reduced forage and cover/shelter	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	All year
Water contract administration	Juveniles	Reduced amount of rearing habitat	Points of diversion to confluence with Willamette River	July and August
	Juveniles	Mortality due to entrainment at diversions	Points of diversion	July and August 2008-2009

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Maintenance of revetments	Juveniles	Reduced amount of rearing	RM 19 (upstream end of reach with USACE revetments) to confluence with the Willamette	All year
Release of hatchery Chinook and steelhead smolts	Juveniles	Competition, predation, and residualism.	From Foster Dam to confluence with the North Santiam River (approx. 37.7 miles)	Feb-May
Hatchery summer steelhead genetic study	Juveniles	Observed, harassed, and collected. Take levels determined by Research, Monitoring and Evaluation Committee of WATER.	South Santiam River Basin and tributaries below Foster Dam	Feb-Oct

Table 11.1-5 Estimates of the type and geographic and temporal extent of incidental take of UWR Chinook salmon associated with effects of the Willamette Project, including Cougar Dam, in the McKenzie River subbasin (based on Willis 2008).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT	TEMPORAL EXTENT
Tributary flows (unable to meet minima due to hydrologic conditions; change in peak/base flows for flood damage reduction; flow and ramp rate studies)	Adults	Barrier to spawning habitat below Cougar Dam and reduced amount of adult holding habitat	From Cougar Dam tailrace to confluence with the McKenzie River (approx. 4 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1) Jun-Oct – 5%.
	Juveniles	Desiccation of eggs when dewatered, barrier to marginal (shallow) juvenile rearing habitat, stranding and entrapment during flow fluctuations	From Cougar Dam tailrace to confluence with the McKenzie River (approx. 4.5 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1) Nov- May – 5% Ramping rates not to exceed 1 inch per hour during nighttime and 2 inches per hour during the day except during active flood control damage reduction operations or where physical configuration of a project does not allow this level of precision (RPA 2.6.1).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT	TEMPORAL EXTENT
Water quality (dissolved gas), including RM&E	Juveniles	Elevated levels of total dissolved gas caused by spilling or by regulating outlet (RO) discharge during fall drawdown and high overwinter flows effect survival, especially during incubation and before emergence. Under full powerhouse generation, spill over approx. 2,000 cfs at Cougar Dam's RO generates about 115% TDG at the USGS gage located 0.6 mile below the confluence of the RO channel and the powerhouse channel.	Within 1 mile downstream of the base of Cougar Dam	Oct-Mar (incubation) Oct-Sep (rearing) Percent of days mean daily spill exceeds 2,000 cfs, unless coordinated through the WATER flow management committee process (RPA 2.1): Oct – 5% Nov – 5% Dec – 14% Jan – 20% Feb – 7% Mar – 6% Apr – 6% May – 5% Jun – 5% Jul-Sep – 5%
Substrate (i.e., gravel, cobble, boulder); off-channel habitat; large woody debris; channel condition/dynamics; streambank condition; floodplain connectivity	Adults	Reduced forage and cover/shelter	From Cougar Dam tailrace to confluence with the McKenzie River (approx. 4.5 miles)	All year
	Juveniles	Reduced forage and cover/shelter	From Cougar Dam tailrace to confluence with the McKenzie River (approx. 4.5 miles)	All year
Water contract administration	Juveniles	Reduced amount of rearing habitat	Point of diversion to confluence with Willamette River	July and August
		Mortality due to entrainment at diversions	Points of diversion	July and August 2008-2009

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT	TEMPORAL EXTENT
Maintenance of revetments	Juveniles	Reduced amount of rearing	RM 40 (upstream end of reach with USACE revetments) to confluence with the Willamette	All year
Release of hatchery Chinook, steelhead, and rainbow trout	Juveniles	Competition, predation, and residualism.	Chinook and steelhead Smolts- McKenzie River below Leaburg Dam Rainbow Trout- McKenzie River above and below Leaburg Dam	All year
Hatchery Chinook broodstock collection at Leaburg Dam	Adults	Observed, harassed, handled, removed. Limits specified in McKenzie Chinook HGMP.	Fish ladder on Leaburg Dam	May-Oct
Hatchery fish sorting at Leaburg Dam	Adults	Observed, harassed, handled, removed	Fish ladders on Leaburg Dam	May-Oct
Hatchery Chinook spawning surveys	Juveniles and adults	Observed, harassed, carcasses sampled	McKenzie River and tributaries where spring Chinook spawn	June-Oct
Hatchery Chinook spawning surveys above Cougar Dam	Juveniles and adults	Observed, harassed, carcasses sampled	All spawning areas in the South Fork McKenzie River and tributaries above Cougar reservoir	June-Oct
Juvenile Chinook surveys above Cougar Dam to evaluate hatchery fish spawning success	Juveniles and adults	Observed, harassed, collected, sampled	South Fork McKenzie River above Cougar Dam	Feb-Oct

Table 11.1-6a Estimates of the type and geographic and temporal extent of incidental take of UWR Chinook salmon associated with effects of the Willamette Project, including Fall Creek Dam, in the Middle Fork Willamette subbasin. (based on Willis 2008).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT	TEMPORAL EXTENT
Tributary flows (unable to meet minima due to hydrologic conditions; change in peak/base flows for flood damage reduction; flow and ramp rate studies)	Adults	Barrier to spawning habitat below Fall Creek Dam and reduced amount of adult holding habitat	From Fall Creek Dam tailrace to confluence with the Middle Fork Willamette River (approx. 7 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): May-Oct – 5%
	Juveniles	Desiccation of eggs when dewatered, barrier to marginal (shallow) juvenile rearing habitat, stranding and entrapment during flow fluctuations	From Fall Creek Dam tailrace to confluence with the Middle Fork Willamette River (approx. 7 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Nov-May – 5% Ramping rates not to exceed 1 inch per hour during nighttime and 2 inches per hour during the day except during active flood control damage reduction operations or where physical configuration of a project does not allow this level of precision (RPA 2.6.1).
Water quality (temperature), including RM&E	Adults	Low temperatures below dams cause pre-spawner straying & mortality	From Fall Creek Dam tailrace to confluence with the Middle Fork Willamette River (approx. 7 miles)	May-Aug
	Juveniles	Elevated temperatures cause reduced egg viability and increase susceptibility to disease	From Fall Creek Dam tailrace to confluence with the Middle Fork Willamette River (approx. 7 miles)	Oct-Dec

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT	TEMPORAL EXTENT
Water quality (dissolved gas), including RM&E	Juveniles	Elevated levels of total dissolved gas caused by regulating outlet discharge during fall drawdown and high overwinter flows affect survival, especially during incubation and before emergence. Spill over approx. 1,500 cfs generates more than 110% TDG below Fall Creek Dam (NMFS 1972).	Within 1 mile downstream of the base of Fall Creek Dam	Percent of days mean daily spill from Fall Creek Dam exceeds 1,500 cfs, unless coordinated through the WATER flow management committee process (RPA 2.1):: Jan – 68% Feb – 22% Mar – 20% April – 20% May – 23% June–Oct – 5% Nov – 42% Dec – 36%
Substrate (i.e., gravel, cobble, boulder); off-channel habitat; large woody debris; channel condition/dynamics; streambank condition; floodplain connectivity	Adults	Reduced forage and cover/shelter	From Fall Creek Dam tailrace to confluence with the Middle Fork Willamette River (approx. 7 miles)	All year
	Juveniles	Reduced forage and cover/shelter	From Fall Creek Dam tailrace to confluence with the Middle Fork Willamette River (approx. 7 miles)	All year
Water contract administration	Juveniles	Reduced amount of rearing habitat	Points of diversion to confluence with Willamette River	July and August
		Mortality due to entrainment at diversions	Points of diversion	July and August 2008-2009
Hatchery RM&E *(see Table 11.1-4b)*				

Table 11.1-6b Estimates of the type and geographic and temporal extent of incidental take of UWR Chinook salmon associated with effects of the Willamette Project, including Dexter and Lookout Point Dams, in the Middle Fork Willamette subbasin (based on Willis 2008).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Tributary flows (unable to meet minima due to hydrologic conditions; change in peak/base flows for flood damage reduction; flow and ramp rate studies)	Adults	Barrier to spawning habitat below Dexter Dam and reduced amount of adult holding habitat	From Dexter Dam tailrace to confluence with the Coast Fork Willamette River (approx. 17 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): May-Oct – 5%
	Juveniles	Desiccation of eggs when dewatered, barrier to marginal (shallow) juvenile rearing habitat, stranding and entrapment during flow fluctuations	From Dexter Dam tailrace to confluence with the Coast Fork Willamette River (approx. 17 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Nov-May – 5% Ramping rates not to exceed 1 inch per hour during nighttime and 2 inches per hour during the day except during active flood control damage reduction operations or where physical configuration of a project does not allow this level of precision (RPA 2.6.1).
Water quality (temperature), including RM&E	Adults	Low temperatures below dams cause pre-spawner straying & mortality	From Dexter Dam tailrace to below the confluence of the mainstem Willamette and McKenzie rivers (approx. 17 miles)	May-Aug

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
	Juveniles	Elevated temperatures cause reduced egg viability and increase susceptibility to disease	From Dexter Dam tailrace to below the confluence of the mainstem Willamette and McKenzie rivers (approx. 17 miles)	Oct-Dec
Water quality (dissolved gas), including RM&E	Juveniles	Elevated levels of total dissolved gas caused by spilling discharge during fall drawdown and high overwinter flows affect survival, especially during incubation and before emergence. Spill over approx.1,000 cfs through 1 spillway bay at Dexter Dam generates more than 115% TDG below Dexter Dam.	Within 1 mile downstream of the base of Dexter Dam	Percent of days mean daily spill from all 7 spill bays at Dexter Dam exceeds 7,000 cfs, unless coordinated through the WATER flow management committee process (RPA 2.1): Jan – 30% Feb – 30%
Substrate (i.e., gravel, cobble, boulder); off-channel habitat; large woody debris; channel condition/dynamics; streambank condition; floodplain connectivity	Adults	Reduced forage and cover/shelter	From Dexter Dam tailrace to confluence with the Coast Fork Willamette River (approx. 17 miles)	All year
	Juveniles	Reduced forage and cover/shelter	From Dexter Dam tailrace to confluence with the Coast Fork Willamette River (approx. 17 miles)	All year
Water contract administration	Juveniles	Reduced amount of rearing habitat	Points of diversion to confluence with Willamette River	July and August

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
		Mortality due to entrainment at diversions	Points of diversion	July and August 2008-2009
Maintenance of revetments	Juveniles	Reduced amount of rearing	RM 8 (upstream end of reach with USACE revetments) to confluence with the Willamette	All year
Release of hatchery Chinook and steelhead smolts	Juveniles	Competition, predation, and residualism.	From Dexter Dam to confluence with the Coast Fork Willamette River	Feb-May
Hatchery Chinook spawning surveys above and below Fall Creek, Dexter/Lookout Point, and Hills Creek dams	Juveniles and adults	Observed, harassed, carcasses sampled	Throughout the Middle Fork Willamette subbasin in the areas where Chinook spawn	June-Oct
Juvenile Chinook surveys above Fall Creek, Dexter/Lookout Point, and Hills Creek dams to evaluate hatchery fish spawning success	Juveniles and adults	Observed, harassed, collected, sampled	Middle Fork Willamette Subbasin	Feb-Oct

Table 11.1-6c Estimates of the type and geographic or temporal extent of incidental take of UWR Chinook salmon associated with effects of the Willamette Project, including Hills Creek Dam, in the Middle Fork Willamette subbasin (based on Willis 2008).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Tributary flows (unable to meet minima due to hydrologic conditions; change in peak/base flows for flood damage reduction; flow and ramp rate studies)	Adults	Barrier to spawning habitat below Hills Creek Dam and reduced amount of adult holding habitat	From Hills Creek Dam tailrace to the upstream end of Lookout Point Reservoir (approx. 9 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): May–Oct – 5%
	Juveniles	Desiccation of eggs when dewatered, barrier to marginal (shallow) juvenile rearing habitat, stranding and entrapment during flow fluctuations	From Hills Creek Dam tailrace to the upstream end of Lookout Point Reservoir (approx. 9 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Sep-May – 5% Ramping rates not to exceed 1 inch per hour during nighttime and 2 inches per hour during the day except during active flood control damage reduction operations or where physical configuration of a project does not allow this level of precision (RPA 2.6.1).
Water quality (temperature), including RM&E	Adults	Low temperatures below dams cause pre-spawner straying & mortality	From Hills Creek Dam tailrace to the upstream end of Lookout Point Reservoir (approx. 9 miles)	May-Aug
	Juveniles	Elevated temperatures cause reduced egg viability and increase susceptibility to disease	From Hills Creek Dam tailrace to the upstream end of Lookout Point Reservoir (approx. 9 miles)	Oct-Dec

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Water quality (dissolved gas), including RM&E	Juveniles	Elevated levels of total dissolved gas caused by spilling or by regulating outlet discharge during fall drawdown and high overwinter flows affect survival, especially during incubation and before emergence. Spill over approx. 1,500 cfs generates more than 110% TDG below Hills Creek Dam.	Within 1 mile downstream of the base of Hills Creek Dam	Percent of days with mean daily spill from the regulating outlet at Hills Creek Dam exceeds 1,500 cfs: Jan – 17% Feb – 5% Mar–Oct – 5% Nov – 5% Dec – 17%
Substrate (i.e., gravel, cobble, boulder); off-channel habitat; large woody debris; channel condition/dynamics; streambank condition; floodplain connectivity	Adults	Reduced forage and cover/shelter	From Hills Creek Dam tailrace to the upstream end of Lookout Point Reservoir (approx. 9 miles)	All year
	Juveniles	Reduced forage and cover/shelter	From Hills Creek Dam tailrace to the upstream end of Lookout Point Reservoir (approx. 9 miles)	All year
Water contract administration	Juveniles	Reduced amount of rearing habitat	Points of diversion to confluence with Willamette River	July and August
		Mortality due to entrainment at diversions	Points of diversion	July and August 2008-2009
Hatchery RM&E *(see Table 11.1-4b)*				

Table 11.1-7 Estimates of the type and geographic and temporal extent of incidental take of UWR Chinook salmon associated with effects of the Willamette Project in the Calapooia, Molalla, and Clackamas subbasins.

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT	TEMPORAL EXTENT
Maintenance of revetments	Juveniles	Reduced amount of rearing	Molalla RM (upstream end of reach with USACE revetments) to confluence with the Willamette	All year

11.2 Reasonable & Prudent Measures

The following reasonable and prudent measures (RPM) and their related terms and conditions (T&C) are necessary and appropriate to minimize incidental take to the extent practicable and to monitor the incidental take of the ESA-listed species resulting from implementation of the PA and RPA. This includes continued operation and maintenance of the Willamette Project, maintenance of Project revetments, administration of Reclamation's water contract program, implementation of on-site and off-site mitigation measures, and operation of the Willamette Hatchery Mitigation Program. The RPMs and T&Cs are intended to avoid or minimize adverse effects of Project operations on listed fish species and on designated critical habitat.

USACE, Reclamation, and BPA must comply with all of the following reasonable and prudent measures and related terms and conditions, which are non-discretionary.

1) Minimize incidental take from general construction activities associated with implementation of the Proposed Action and RPA by applying best management practices to avoid or minimize adverse effects to listed species or to water quality, riparian habitat, or other aquatic system components of critical habitat.
2) Minimize incidental take from continued maintenance of revetments and from habitat restoration or mitigation activities by complying with the in-water work period and applying best management practices.
3) Minimize incidental take from general Research, Monitoring and Evaluation activities.
4) Ensure completion of a monitoring and reporting program to demonstrate compliance with the requirements of this ITS.
5) Minimize incidental take from operation of the Hatchery Mitigation Program

11.2.1 Terms and Conditions

In order to be exempt from the take prohibitions of Section 9 of the ESA and regulations issued pursuant to Section 4(d) of the ESA, the USACE, Reclamation, and BPA must carry out the following terms and conditions, which implement the RPMs listed above. These terms and conditions constitute no more than minor changes because they only provide further elaboration on the more general measures in the PA and RPA. These terms and conditions are non-discretionary. NMFS may amend the provisions of this ITS consistent with its statutory and regulatory authorities. Timely reporting of the results from Monitoring and Evaluation activities will help to identify the potential need to take such corrective action.

1) <u>Reasonable and prudent measure #1 implementation</u>: In all proposed actions involving construction in or near waterways, USACE, Reclamation, and BPA must ensure that best management practices for construction activities to control sediment, disturbance, and other potential detrimental effects to listed salmonids and critical habitat, described below, are followed.

a. Minimize areas impacted by construction. Construction impacts will be confined to the minimum area necessary to complete the project. Boundaries of clearing limits associated with site access and construction will be marked to avoid or minimize disturbance of riparian vegetation, wetlands and other sensitive sites.

b. Alteration or disturbance of the streambanks and existing riparian vegetation will be minimized to the greatest extent possible.

c. Mechanical removal of undesired vegetation and root nodes is permitted, but not herbicide use.

d. All existing vegetation within 150 ft of the edge of bank should be retained, to the greatest extent possible.

e. Timing of inwater work. Work below the bankfull elevation will be completed during the State of Oregon's preferred inwater work period as appropriate for the project area, unless otherwise approved in writing by NMFS. Other project specific requirements may apply (e.g., notification of NMFS prior to, or at the end of, inwater work) as identified during review of proposed project plans by NMFS.

f. Cessation of work. Construction project activities will cease under high flow conditions that may result in inundation of the project area, except for efforts to avoid or minimize resource damage. All materials, equipment, and fuel must be removed if flooding of the area is expected to occur within 24 hours.

g. Fish screens. All water intakes used for a construction project, including pumps used to isolate an inwater work area, will have a fish screen installed, operated, and maintained according to NMFS' fish screen criteria. This clause does not authorize screens for any permanent use.

h. Fish passage. Passage must be provided for any adult or juvenile salmonid species present in the Project area during construction, unless otherwise approved in writing by NMFS, and maintained after construction for the life of the Project. Passage will be designed in accordance with NMFS' "Anadromous Salmonid Passage Facility Design" (NMFS 2008e). Upstream passage is required during construction if it previously existed.

i. Construction activities associated with habitat enhancement and erosion control measures must meet or exceed best management practices and other performance standards contained in the applicable state and Federal permits.

j. Pollution and Erosion Control Plan. Prepare, in consultation with NMFS, and carry out a Pollution and Erosion Control Plan to prevent pollution caused by survey, construction, operation, and maintenance activities. The Plan will be available for inspection upon request by NMFS.

i. Plan Contents. The Pollution and Erosion Control Plan will contain the pertinent elements listed below, and meet requirements of all applicable laws and regulations.

   1. The name and address of the party(s) responsible for accomplishment of the Pollution and Erosion Control Plan.
   2. Practices to prevent erosion and sedimentation associated with access roads, decommissioned roads, stream crossings, drilling sites, construction sites, borrow pit operations, haul roads, equipment and material storage sites, fueling operations, and staging areas.
   3. Practices to confine, remove, and dispose of excess concrete, cement, and other mortars or bonding agents, including measures for washout facilities.
   4. A description of any regulated or hazardous products or materials that will be used for the Project, including procedures for inventory, storage, handling, and monitoring.
   5. A spill containment and control plan with notification procedures, specific cleanup and disposal instructions for different products, quick response containment and cleanup measures that will be available on the site, proposed methods for disposal of spilled materials, and employee training for spill containment.
   6. Practices to prevent construction debris from dropping into any stream or water body, and to remove any material that does drop with a minimum disturbance to the streambed and water quality.
   7. Erosion control materials (e.g., silt fence, straw bales, aggregate) in excess of those installed must be available on site for immediate use during emergency erosion control needs.
   8. Temporary erosion and sediment controls will be used on all exposed slopes during any hiatus in work exceeding 7 days.

ii. Inspection of erosion controls. During construction, the operator must monitor instream turbidity and inspect all erosion controls daily during the rainy season (October through May) and weekly during the dry season (June through September), or more often as necessary, to ensure the erosion controls are working adequately.[1]

   1. If monitoring or inspection shows that the erosion controls are ineffective, mobilize work crews immediately to make repairs, install replacements, or install additional controls as necessary.

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[1] "Working adequately" means that project activities do not increase ambient stream turbidity by more than 10% above background 100 feet below the discharge, when measured relative to a control point immediately upstream of the turbidity-causing activity.

2. Remove sediment from erosion controls once it has reached one-third of the exposed height or capacity of the control.

k. Construction discharge water. Treat all discharge water created by construction (e.g., concrete washout, pumping for work area isolation, vehicle wash water, drilling fluids) as follows:

   i. Water quality. Design, build, and maintain facilities to collect and treat all construction discharge water, including any contaminated water produced by drilling, using the best available technology applicable to site conditions. Provide treatment to remove debris, nutrients, sediment, petroleum hydrocarbons, metals, and other pollutants likely to be present.

   ii. Discharge velocity. If construction discharge water is released using an outfall or diffuser port, velocities will not exceed 4 fps, and the maximum size of any aperture will not exceed one inch.

   iii. Spawning areas, submerged estuarine vegetation. Do not release construction discharge water within 300 ft upstream of spawning areas or areas with submerged estuarine vegetation. Clean construction discharge may be released.

   iv. Pollutants. Do not allow pollutants, including green concrete, contaminated water, silt, welding slag, sandblasting abrasive, or grout cured less than 24 hours to contact any wetland or the 2-year floodplain, except cement or grout when abandoning a drill boring or installing instrumentation in the boring.

   v. Drilling discharge. All drilling equipment, drill recovery and recycling pits, and any waste or spoil produced, will be completely isolated to prevent drilling fluids or other wastes from entering the stream.

      (1) All drilling fluids and waste will be completely recovered then recycled or disposed to prevent entry into flowing water.

      (2) Drilling fluids will be recycled using a tank instead of drill recovery/recycling pits, whenever feasible.

      (3) When drilling is completed, attempts will be made to remove the remaining drilling fluid from the sleeve (e.g., by pumping) to reduce turbidity when the sleeve is removed.

l. <u>Piling installation</u>: Install temporary and permanent pilings as depicted on NMFS-approved design drawings. Sound attenuation measures, including vibration dampeners, and unconfined or confined bubble curtains, will be used when impact driving steel pilings. Approval by NMFS of the measures is required before construction.

m. Piling removal: If a temporary or permanent piling will be removed from water containing fish, the following conditions apply.

   i. Dislodge the piling with a vibratory hammer.

   ii. Once loose, place the piling onto the construction barge or other appropriate dry storage site.

   iii. If a treated wood piling breaks during removal, either remove the stump by breaking or cutting 3 feet below the sediment surface or push the stump in to that depth, then cover it with a cap of clean substrate appropriate for the site.

n. During completion of habitat enhancement activities, no pollutants of any kind (sewage, waste spoils, petroleum products, etc.) should come in contact with the water body or wetlands nor their substrate below the mean high-high water elevation or 10-year flood elevation, whichever is greater.

o. Treated wood.

   i. Projects using treated wood that may contact flowing water or that will be placed over water where it will be exposed to mechanical abrasion or where leachate may enter flowing water will not be used, except for pilings installed following NMFS' guidelines.

   ii. Visually inspect treated wood before final placement to detect and replace wood with surface residues and/or bleeding of preservative.

   iii. Projects that require removal of treated wood will use the following precautions:

      1. Treated wood debris. Take care to insure that no treated wood debris falls into the water. If treated wood debris does fall into the water, remove it immediately.

      2. Disposal of treated wood debris. Dispose of all treated wood debris removed during a project, including treated wood pilings, at an upland facility approved for hazardous materials of this classification. Do not leave treated wood pilings in the water or stacked on the streambank.

p. Preconstruction activity. Complete the following actions before significant alteration of the Project area:

   i. Marking. Flag the boundaries of clearing limits associated with site access and construction to prevent ground disturbance of critical riparian vegetation, wetlands, and other sensitive sites beyond the flagged boundary. Construction activity or movement of equipment into existing vegetated areas must not begin until clearing limits are marked.

   ii. Emergency erosion controls. Ensure that the following materials for emergency erosion control are on site:

1. A supply of sediment control materials (e.g., silt fence, straw bales).

2. An oil-absorbing, floating boom whenever surface water is present.

iii. Temporary erosion controls. All temporary erosion controls will be in place and appropriately installed downslope of project activity within the riparian buffer area until site rehabilitation is complete.

q. Temporary access roads.

i. Steep slopes. Do not build temporary roads mid-slope or on slopes steeper than 30 percent.

ii. Minimizing soil disturbance and compaction. Low-impact, tracked drills will be walked to a survey site without the need for an access road. Minimize soil disturbance and compaction for other types of access whenever a new temporary road is necessary within 150 ft of a stream, water body, or wetland by clearing vegetation to ground level and placing clean gravel over geotextile fabric, unless otherwise approved in writing by NMFS.

iii. Temporary stream crossings.

1. Do not allow equipment in the flowing water portion of the stream channel where equipment activity could release sediment downstream, except at designated stream crossings.

2. Minimize the number of temporary stream crossings.

3. Design new temporary stream crossings as follows:

    a) Survey and map any potential spawning habitat within 300 ft downstream of a proposed crossing.

    b) Do not place stream crossings at known or suspected spawning areas, or within 300 ft upstream of such areas if spawning areas may be affected.

    c) Design the crossing to provide for foreseeable risks (e.g., flooding and associated bedload and debris) to prevent the diversion of stream flow out of the channel and down the road if the crossing fails.

    d) Vehicles and machinery will cross riparian buffer areas and streams at right angles to the main channel wherever possible.

4. Obliteration. When the project is completed, obliterate all temporary access roads, stabilize the soil, and revegetate the site. Abandon and restore temporary roads in wet or flooded areas by the end of the inwater work period.

r. Vehicles and heavy equipment. Restrict use of heavy equipment as follows:

i. Choice of equipment. When heavy equipment will be used, the equipment selected will have the least adverse effects on the environment (e.g., minimally sized, low ground pressure equipment).

ii. Vehicle and material staging. Store construction materials and fuel, operate, maintain, and store vehicles as follows:

1. To reduce the staging area and potential for contamination, ensure that only enough supplies and equipment to complete a specific job will be stored on-site.

2. Complete vehicle staging, cleaning, maintenance, refueling, and fuel storage, except for that needed to service boats, in a vehicle staging area placed 150 ft or more from any stream, water body, or wetland, unless otherwise approved in writing by NMFS.

3. Inspect all vehicles operated within 150 ft of any stream, water body, or wetland daily for fluid leaks before leaving the vehicle staging area. Repair any leaks detected in the vehicle staging area before the vehicle resumes operation. Document inspections in a record that is available for review on request by NMFS.

4. Before activities begin and as often as necessary during construction activities, steam clean all equipment that will be used below the bankfull elevation until all visible external oil, grease, mud, and other visible contaminates are removed. Any washing of equipment must be conducted in a location that will not contribute untreated wastewater to any flowing stream or drainage area.

5. Diaper all stationary power equipment (e.g., generators, cranes, stationary drilling equipment) operated within 150 ft of any stream, waterbody, or wetland to prevent leaks, unless suitable containment is provided to prevent potential spills from entering any stream, water body, or wetland to prevent leaks, unless suitable containment is provided to prevent potential spills from entering any stream or water body.

6. At the end of each work shift, vehicles must not be stored within or over the waterway.

s. Site preparation. Conserve native materials for site rehabilitation.

i. If possible, leave native materials where they are found.

ii. If materials are moved, damaged, or destroyed, replace them with a functional equivalent during site rehabilitation.

iii. Stockpile any large wood, native vegetation, weed-free topsoil, and native channel material displaced by construction for use during site rehabilitation.

t. Isolation of inwater work area. If adult or juvenile fish are reasonably certain to be present, or if the work area is less than 300 ft upstream of spawning habitats, completely isolate the work area from the active flowing stream using inflatable bags, sandbags, sheet pilings, or similar materials, unless otherwise approved in writing by NMFS.

u. Capture and release of fish in construction salvage operations. Before and intermittently during pumping to isolate an inwater work area, attempt to capture fish from the isolated area using trapping, seining, electrofishing, or other methods as are prudent to minimize risk of injury, then release them at a safe and suitable release site.

   i. The entire capture and release operation will be conducted or supervised by a fishery biologist experienced with work area isolation and competent to ensure the safe handling of all ESA-listed fish.

   ii. If backpack electrofishing methods are used, workers must comply with NMFS' Guidelines for Electrofishing (NMFS 2000c) and summarized below.

      1. Do not electrofish near adult salmon in spawning condition or near redds containing eggs.

      2. Keep equipment in good working condition. Complete manufacturers' preseason checks, follow all provisions, and record major maintenance work in a log.

      3. Train the crew by a crew leader with at least 100 hours of electrofishing experience in the field using similar equipment. Document the crew leader's experience in a logbook. Complete training in waters that do not contain listed fish before an inexperienced crew begins any electrofishing.

      4. Measure conductivity and set voltage as follows:

Conductivity (µS/cm)	Voltage
Less than 100	900 to 1100
100 to 300	500 to 800
Greater than 300	150 to 400

      5. Use direct current (DC) at all times.

      6. Begin each session with pulse width and rate set to the minimum needed to capture fish. These settings should be gradually increased only to the point where fish are immobilized and captured. Start with a pulse width of 500µs and do not exceed 5 milliseconds. Pulse rate should start at 30Hz and work carefully upward. In general, pulse rate should not exceed 40 Hz, to avoid unnecessary injury to the fish.

7. The zone of potential fish injury is 0.5 meters from the anode. Care should be taken in shallow waters, undercut banks, or where fish can be concentrated, because in such areas the fish are more likely to come into close contact with the anode.

8. Work the monitoring area systematically, moving the anode continuously in a herringbone pattern through the water. Do not electrofish one area for an extended period.

9. Have crew members carefully observe the condition of the sampled fish. Dark bands on the body and longer recovery times are signs of injury or handling stress. When such signs are noted, the settings for the electrofishing unit may need adjusting. End sampling if injuries occur or abnormally long recovery times persist.

10. Whenever possible, place a block net below the area being sampled to capture stunned fish that may drift downstream.

11. Record the electrofishing settings in a logbook along with conductivity, temperature, and other variables affecting efficiency. These notes, with observations on fish condition, will improve technique and form the basis for training new operators.

iii. Do not use seining or electrofishing if water temperatures exceed 18°C unless no other more suitable and effective method of capture is available.

iv. Handle ESA-listed fish with extreme care, keeping fish in water to the maximum extent possible during seining and transfer procedures, to prevent the added stress of out-of-water handling.

v. Transport fish by providing circulation of clean cold water in aerated buckets, tanks, or in sanctuary nets that hold water during transfer. Minimize holding times.

vi. Release fish into a safe and appropriate release site as quickly as possible, and as near as possible to the original capture sites.

vii. Do not transfer ESA-listed fish to anyone except NMFS personnel, unless otherwise approved in writing in advance of the transfer.

viii. Obtain all other Federal, state, and local permits necessary to conduct the capture and release activity.

ix. Allow NMFS or its designated representative to accompany the capture team during the capture and release activity, and to inspect the team's capture and release records and facilities.

x. An electronic copy of the Salvage Report Form is submitted to NMFS within 10 calendar days of completion of the salvage operations, noting the quantities and species of fish salvaged.

xi. Fish salvage operations must be re-conducted should the isolated construction areas be temporarily hydraulically re-connected to the adjacent waterway, such as after a high-water event or cofferdam failure.

v. Earthwork. Complete earthwork (including drilling, excavation, dredging, filling, and compacting) as quickly as possible.

i. Excavation. Material removed during excavation will only be placed in locations where it cannot enter sensitive aquatic resources. Whenever topsoil is removed, it must be stored and reused on site to the greatest extent possible. If riprap is used for protecting a culvert inlet or outlet, it will be class 350 metric or larger, and topsoil will be placed over the rock and planted with native woody vegetation.

ii. Drilling and sampling. If drilling, boring, or jacking is used, the following conditions apply.

1. Isolate drilling operations from stream channels using a steel pile, sleeve, or other appropriate isolation method to prevent drilling fluids from contacting water.

2. If it is necessary to drill through a bridge deck, use containment measures to prevent drilling debris from entering the stream channel.

3. If directional drilling is used, the drill, bore, or jack hole will span the channel migration zone and any associated wetland or wetted stream channel.

4. Sampling and directional drill recovery/recycling pits, and any associated waste or spoils, will be completely isolated from surface waters, off-channel habitats, and wetlands. All drilling fluids and waste will be recovered and recycled or disposed of to prevent future entry into flowing water.

5. If a drill boring conductor breaks and drilling fluid or waste is visible in water or a wetland, all drilling activity will cease, pending written approval from NMFS to resume drilling.

iii. Site stabilization. Stabilize all disturbed areas, including obliteration of temporary roads, following any break in work, unless construction will resume within 4 days.

iv. Source of materials. Obtain boulders, rock, woody materials, and other natural construction materials used for the project outside the riparian buffer area. Spawning gravel for augmentation of spawning habitats must be washed (i.e. cleaned, rinsed rock) river rock, of suitable size for UWR spring Chinook spawning or for UWR winter steelhead spawning (as appropriate by location), and if possible, from a source within the local watershed.

w. Stormwater management: Prepare and carry out a stormwater management plan for any project that will produce a new impervious surface or a land cover conversion that slows the entry of water into the soil. The plan must be available for inspection on request by NMFS.

   i. Plan contents. The goal is to avoid and minimize adverse effects due to the quantity and quality of stormwater runoff for initial construction, and throughout the life of the project by maintaining or restoring natural runoff conditions. The plan will meet the following criteria and contain the pertinent elements listed below, and meet requirements of all applicable laws and regulations.

      1. A system of management practices and, if necessary, structural facilities, designed to complete the following functions:

         a. Minimize, disperse and infiltrate stormwater runoff onsite using sheet flow across permeable vegetated areas to the maximum extent possible without causing flooding, erosion impacts, or long-term adverse effects to groundwater.

         b. Pretreat stormwater from pollution generating surfaces, including bridge decks, before infiltration or discharge into a freshwater system, as necessary to minimize any nonpoint source pollutant (e.g., debris, sediment, nutrients, petroleum hydrocarbons, metals) likely to be present in the volume of runoff predicted from a 6-month, 24-hour storm.

      2. Document completion of the following storm water management activities according to a regular schedule for the operation, inspection and maintenance of all structural facilities and conveyance systems, in a log available for inspection on request by NMFS.

         a. Inspect and clean each facility as necessary to ensure that the design capacity is not exceeded, heavy sediment discharges are prevented, and whether improvements in operation and maintenance are needed.

         b. Promptly repair any deterioration threatening the effectiveness of any facility.

         c. Post and maintain a warning sign on or next to any storm drain inlet that says, as appropriate for the receiving water, 'Dump No Waste - Drains to Ground Water, Streams, or Lakes.'

d. Only dispose of sediment and liquid from any catch basin in an approved facility.

ii. Runoffs/discharge into a freshwater system. When stormwater runoff will be discharged directly into fresh surface water or a wetland, or indirectly through a conveyance system, the following requirements apply.

1. Maintain natural drainage patterns and, whenever possible, ensure that discharges from the project site occur at the natural location.

2. Use a conveyance system comprised entirely of manufactured elements (e.g., pipes, ditches, outfall protection) that extends to the ordinary high water line of the receiving water.

3. Stabilize any erodible elements of this system as necessary to prevent erosion.

4. Do not divert surface water from, or increase discharge to, an existing wetland if that will cause a significant adverse effect to wetland hydrology, soils or vegetation.

5. The velocity of discharge water released from an outfall or diffuser port may not exceed 4 feet per second.

6. Waste anesthetic-laden water must be disposed of in accordance with applicable laws.

x. Implementation monitoring. For projects undertaken by or funded by USACE, Reclamation, or BPA, the USACE, Reclamation, or BPA will include the status of a project or a description of the completed project in the annual report. This annual report will be submitted to NMFS describing the status of projects and, if completed, the success in meeting the RPMs and associated terms and conditions of the Opinion. It will include the following:

i. Project identification.

1. Project implementer name, project name, detailed description of the project.

2. Project location by 5th or 6th field HUC and by latitude and longitude as determined from the appropriate U.S. Geological Survey 7-minute quadrangle map.

3. Starting and ending dates for the work completed, or expected completion date for ongoing projects.

ii. Photo documentation. Photo documentation of habitat conditions at the project site before, during, and after project completion.

1. Include general views and close-ups showing details of the project and project area, including pre- and post-construction.

2. Label each photo with date, time, project name, photographer's name, and documentation of the subject activity.

iii. Other data. Additional project-specific data, as appropriate, for individual projects:

1. Work cessation. Dates work ceased because of high flows, if any.

2. Fish screen. Compliance with NMFS' fish screen criteria.

3. Pollution and Erosion Control Plan. A summary of pollution and erosion control inspections, including any erosion control failures, contaminant releases, and correction efforts.

4. Description of site preparation.

5. Isolation of inwater work area, capture, and release.

   a) Supervisory fish biologist's name and address.

   b) Methods of work area isolation and take minimization.

   c) Stream conditions before, during, and within 1 week after completion of work area isolation.

   d) Means of fish capture.

   e) Number of fish captured by species.

   f) Location and condition of all fish released.

   g) Any incidence of observed injury or mortality of listed species.

6. Streambank protection.

   a) Type and amount of materials used.

   b) Project size - one bank or two, width, and linear feet.

7. Site rehabilitation. Photo or other documentation that site rehabilitation performance standards were met.

NMFS will be reviewing the detailed construction plans submitted to advise USACE, Reclamation, or BPA regarding whether or not those plans are likely to meet the "best management practices" articulated in this incidental take statement's terms and conditions, or such additional best management practices that NMFS deem appropriate.

2) Reasonable and prudent measure #2 implementation: The Action Agencies will comply with the following conditions related to the maintenance of revetments and to habitat restoration or mitigation activities in the Willamette River Basin.

   a. In water work period. All work within the wetted channel will be completed during periods of time listed in the Oregon Guidelines (ODFW 2000b)except that the winter work window is not approved for projects in the Willamette River below Willamette Falls. Also, hydraulic and topographic measurements may be completed at any time, provided that the affected area is not occupied by adult fish congregating for spawning or an area where redds are occupied by eggs or preemergent alevins. The guidelines are available from the ODFW, Wildlife Division, Salem, Oregon.

   b. Work Area Isolation. Any activity resulting in work within the wetted channel will be completely isolated from the active stream whenever a fish is reasonably certain to be present, or if the work area is 300 feet or less upstream from spawning habitats.

   c. Work Area Isolation Plan. When work area isolation is required, a work area isolation plan will be prepared and carried out, commensurate with the scope of the project, that includes: (a) The name, phone number, and address of the person responsible for accomplishing each component of the plan; (b) an estimate of stream flows likely to occur during isolation; (c) a plan view of all isolation elements and fish release areas; (d) a list of equipment and materials necessary to complete the plan, including a fish screen for any pump used to dewater the isolation area; (e) and the sequence and schedule of dewatering and rewatering activities. Pile driving may occur without isolation during the in-water work period, provided that hydro-acoustic sound pressure attenuation requirements and all other relevant conservation measures are met.

   d. Work from top of bank. To the extent feasible, heavy equipment will work from the top of the bank, unless work from another location would result in less habitat disturbance.

   e. Site restoration. Any large wood, native vegetation, topsoil, and native channel material displaced by construction will be stockpiled for use during site restoration. When construction is finished, all streambanks, soils, and vegetation will be cleaned up and restored as necessary to renew ecosystem processes that form and maintain productive fish habitats. Fencing will be installed as necessary to prevent access to revegetated sites by livestock or unauthorized persons.

   f. Plant willows or other trees on 3’ centers in rock interstices on all revetments whenever maintenance activities occur. These plantings will be maintained and allowed to freely grow. No mowing of vegetation and no new revetments are allowed under this consultation. If the Corps opts to not vegetate revetments, they shall enhance adjacent riparian areas at a 5:1 linear ratio (i.e. for a 100’ of revetment, 500’ of riparian area will be enhanced from one site potential tree height measured outward from top of bank, and extending down the bank to the line of no plant growth) or remove riprap from the stream at a 2:1 ratio (i.e. for every 100' of rock replaced, 200' will be removed.)

g. For habitat enhancement actions, the Corps shall follow the terms and conditions set forth in the incidental take statement of the SLOPES IV Restoration Biological Opinion (NMFS 2008f).

3) Reasonable and prudent measure #3 implementation: The Action Agencies will comply with the following conditions that relate to the implementation of research, monitoring, and evaluation studies identified in the PA and RPA.

a. All Monitoring and Evaluation plans associated with anadromous fish developed under the PA and RPA must meet NMFS' satisfaction and must be agreed to by NMFS. Work will be conducted by USACE, Reclamation, BPA, or their contractors. To ensure that the monitoring and evaluation plan will provide a benefit to listed species, and provide useful information on the effectiveness of various aquatic measures as well as achievement of fish passage goals, USACE, Reclamation, and BPA will develop plan(s) and methods to monitor aspects of the various aquatic measures, including:

- Flow management
- Fish passage
- Adult anadromous salmonid migration, spawning, distribution & abundance
- Water quality
- Hatchery mitigation programs
- Habitat restoration
- Resident fish species

The USACE, Reclamation, and BPA's plan(s), among other items, will thoroughly describe all methods that will be used to capture fish and how fish will be handled; details such as sampling locations and dates; and any use of invasive procedures such as tagging, taking tissue samples, or sacrifice of fish explaining the necessity and purpose of each procedure. Each plan will include estimates of the number of each species and life stage that will be handled and/or killed for that study. In addition, the plans will include methods by which they will be modified if empirical evidence indicates that negative effects on a species/life stage are greater than expected. USACE, Reclamation, and BPA will provide NMFS with annual reports, which they will use to determine whether or not to authorize the next year's work under a multiyear plan. NMFS must approve all plans in writing before they are implemented.

The USACE, Reclamation, and BPA will make the following terms and conditions a conditional part of any contractual arrangement or other agreement made with other parties regarding the conduct of research, monitoring, and evaluation studies approved for implementation by NMFS under the auspices of this ITS.

b. Workers[2] must ensure that listed species are taken only at the levels, by the means, in the areas, and for the purposes stated in each specific monitoring and evaluation proposal, and according to the conditions in this permit.

c. Workers must not intentionally kill or cause to be killed any listed species unless a specific monitoring or evaluation proposal, reviewed and agreed to by NMFS, specifically allows intentional lethal take.

d. Workers must handle listed fish with extreme care and keep them in appropriately cold water to the maximum extent possible during sampling and processing procedures. When fish are transferred or held, a healthy environment must be provided; e.g., the holding units must contain adequate amounts of well-circulated water. When using gear that captures a mix of species, the researcher must process listed fish first to minimize handling stress.

e. Workers must stop handling listed juvenile fish if the water temperature exceeds 70° F at the capture site. Under these conditions, listed fish may only be visually identified and counted.

f. If workers anesthetize listed fish to avoid injuring or killing them during handling, the fish must be allowed to recover before being released. Fish that are only counted must remain in water and not be anesthetized.

g. Workers must use a sterilized needle for each individual injection when PIT-tags are inserted into listed fish.

h. If workers incidentally capture any listed adult fish while sampling for juveniles, the adult fish must be released without further handling and such take must be reported.

i. If backpack electrofishing methods are used, workers must comply with NMFS' Guidelines for Electrofishing (NMFS 2000c), and as described in Condition #2.u above (electrofishing conditions for salvage).

j. Except for escapement (redd) surveys, no in-water work will occur within 300 feet of spawning areas during anadromous fish spawning and incubation times.

k. Persons conducting redd surveys will be trained in redd identification, likely redd locations, and methods to minimize the likelihood of stepping on redds or delivering fine sediment to redds.

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[2] "Workers" in this context refers to researchers, technicians, consultants, volunteers, and employees of the Action Agencies, Services, or other organization authorized to conduct RM&E as part of this Opinion.

l. Workers will avoid redds and listed spawning fish while walking within or near stream channels to the extent possible. Avoidance will be accomplished by examining pool tail outs and low gradient riffles for clean gravel and characteristic shapes and flows prior to walking or snorkeling through these areas.

m. If redds or listed spawning fish are observed at any time, workers will step out of the channel and walk around the habitat unit on the bank at a distance from the active channel.

n. Snorkel surveys will follow a statistically valid sampling design or rely on a single pass approach.

o. Surveyors will coordinate with other local agencies to prevent redundant surveys.

p. Excavated material from cultural resource test pits will be placed away from stream channels. All material will be replaced back into test pits when testing is completed.

q. Multiple stream sites will be used for field trips to minimize effects on any given stream or riparian buffer area.

r. The Action Agencies must obtain approval from NMFS before changing sampling locations or research protocols.

s. The Action Agencies must notify NMFS as soon as possible but no later than 2 days after any authorized level of take is exceeded or if such an event is likely. The Action Agencies must submit a written report detailing why the authorized take level was exceeded or is likely to be exceeded.

t. The Action Agencies are responsible for any biological samples collected from listed species as long as they are used for research purposes. The Action Agencies may not transfer biological samples to anyone not listed in the application without prior written approval from NMFS.

u. Workers actually doing the evaluation must carry a copy of this ITS and the applicable plan while conducting the authorized activities.

v. Workers must allow any NMFS employee or representative to accompany field personnel while they conduct the evaluation activities.

w. Workers must allow any NMFS employee or representative to inspect any records or facilities related to the permit activities.

x. Workers must obtain all other Federal, state, and local permits/authorizations needed for the evaluation activities.

y. Every year, the Action Agencies must submit to NMFS a post-season report describing the evaluation activities, the number of listed fish taken and the location, the type of take, the number of fish intentionally killed and unintentionally killed, the take dates, and a brief summary of the monitoring results. This report may be included in the annual report identified in the RPA and required by this ITS. Falsifying annual reports or permit records is a violation of this ITS.

z. If workers violate any permit condition they will be subject to any and all penalties provided by the ESA. NMFS may revoke this permit if the authorized activities are not conducted in compliance with the permit and the requirements of the ESA or if NMFS determines that its ESA findings are no longer valid.

4) To implement reasonable and prudent measure #4, USACE, Reclamation, and BPA must complete all monitoring and reporting requirements in the RPA and Proposed Action. They must also report all observations of dead or injured salmon or steelhead adults or juveniles coincident with carrying out the terms and conditions of the above measures (noting whenever possible the species of these individuals) to NMFS within 2 days of their observance, and include a concise description of the causative event (if known), and a description of any resultant corrective actions taken (if any) to reduce the likelihood of future mortalities or injuries. Reports of dead or injured salmon or steelhead should be sent to:

Willamette Project Staff Lead
Hydropower Division
National Marine Fisheries Service
1201 NE Lloyd Blvd., Suite 1100
Portland, Oregon 97232
(503) 736-4720

5) Reasonable and prudent measure #5 implementation: The Action Agencies will comply with the following conditions that relate to the continued operation of the Hatchery Mitigation Program as described in the PA, HGMPs, and the RPA.

a. The Action Agencies (in cooperation with ODFW) shall manage all of the artificial propagation programs as described in the Biological Assessment and the submitted Hatchery and Genetic Management Plans. NMFS (Salmon Recovery Division) must be notified prior to any change in the proposed management or operation of the programs.

b. The Action Agencies (in cooperation with ODFW) must ensure that listed species are taken only at the levels, by the means, in the areas, and for the purposes stated in the Biological Assessment, HGMPs, and the RPA. However, hatchery program management objectives can be adaptively managed based upon the latest scientific and monitoring information as long as authorized take levels of natural-origin fish are not exceeded. Hatchery program management changes that result in lower take levels of listed, natural-origin fish are acceptable, if future information shows the management change is warranted.

c. In the event that circumstances, such as unanticipated, higher-than-expected fecundity, or high egg-to-fry survival rates, lead to the inadvertent possession of salmon or steelhead substantially in excess (>110 percent) of program production levels specified above, then NMFS (Salmon Recovery Division) must be notified immediately to determine future actions, unless specific actions for addressing excess production are provided in the HGMP

d. All hatchery management and monitoring and evaluation reports shall be submitted to NMFS at:

Willamette Hatchery Staff Lead
Salmon Recovery Division
National Marine Fisheries Service
1201 N.E. Lloyd Blvd, Suite 1100
Portland, Oregon 97232
Phone: (503) 736-4737

e. The Action Agencies (in cooperation with ODFW) must notify the Salmon Recovery Division of NMFS as soon as possible, but no later than two days, after any authorized level of take is exceeded or if such an event is likely. The Action Agencies (in cooperation with ODFW) must submit a written report detailing why the authorized take level was exceed or is likely to be exceeded.

f. The Action Agencies (in cooperation with ODFW) shall update and provide to the Salmon Recovery Division of NMFS by December 15th of each year the projected hatchery releases by age class and location for the coming year.

Chapter 12
Conservation Recommendations

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12 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of threatened and endangered species. Conservation recommendations are discretionary measures that NMFS believes are consistent with an Action Agencies' obligation.

NMFS recommends that the Action Agencies carry out the following conservation measures:

12.1 LAMPREY & RESIDENT FISH SPECIES

Consider the needs of Pacific lamprey and native resident fish species in the design and construction of upstream and downstream fish passage and fish sampling facilities associated with the Willamette Project. Passage investigations at each project should consider lamprey passage as well as salmonid passage.

All flow and water quality related operations and structural modifications, whether experimental or standard, should fully take into account potential negative and positive effects on lamprey. The Action Agencies should use latest scientific information to consider how the operations or modifications are neutral or positive for meeting lamprey requirements at all life-history stages and should include measures to evaluate the effects of these operations and structural modifications on lamprey. The Action Agencies should identify existing or develop and implement new lamprey specific research and monitoring activities in consultation with appropriate Tribes and in potential partnerships with others in the basin.

Water withdrawal facilities operated with Reclamation water storage contracts as well as those associated with Willamette Project hatcheries and other Willamette Project facilities should employ structures and operations that avoid negative impacts on lamprey.

12.2 SYSTEM OPERATIONS ANALYSIS

Review existing Project operating criteria and the information used to develop them. If the Action Agencies, with review by WATER and the Services, determine that currently available data and techniques might improve the Corps' ability to meet the flow objectives specified in this Opinion while meeting current flood control objectives, then the Action Agencies should undertake a detailed systems operations analysis, identify operating criteria that meet these objectives, and implement such changes as soon as possible.

Willamette system water management objectives for listed salmonids should be analyzed in a Basin-wide assessment, which considers alternatives to improve the percentage of time that such objectives are attained. Such analysis should consider the effects of alternative flood control operations, improved forecasting procedures, climate change scenarios, improved water quality and other water management strategies that specifically benefit anadromous fish. Beneficial changes from the review should be incorporated into modified management of the Willamette River projects.

Willamette Project seasonal drafting and refilling operations designed to provide storage space to control floods and to refill project reservoirs for summer recreation may at times limit the potential to operate the projects in a manner beneficial to salmon and steelhead. These operating criteria were developed several decades ago, before information on the flow needs for fish were developed and prior to recent improvements in weather and streamflow predictive capacity and climate change. It is likely that project operations could be modified in ways that would have negligible effects on flood risks while providing substantial benefits to fish. In order to identify such changes in project operations, it may be necessary to conduct a detailed systems operations analysis that would use up-to-date predictive modeling, climate change information, and fish flow needs.

12.3 LEABURG SORTING FACILITIES

Construct sorting facilities at Leaburg Dam on the McKenzie River as soon as possible.

This recommendation would supplement RPA measure #6.1.4, in section 9.6 of this Opinion. The RPA measure requires the Action Agencies to complete construction of a sorting facility to reduce hatchery fish straying into core Chinook salmon natural production habitat upstream by December 2013. NMFS recommends that the Action Agencies make every effort to complete this high priority facility by 2011. Efforts are already underway to secure permission from the dam owner, Eugene Water & Electric Board, to install a sorting facility for one or both of the ladders at the dam.

12.4 INTERIM TEMPERATURE CONTROL

Carry out interim temperature management at Foster/Green Peter, Dexter/Lookout Point, Hills Creek, and Blue River beginning in spring 2009, or as soon as possible, as determined by feasibility analyses.

As noted in Section 9.5, interim measures might be feasible at Project dams to provide some level of temperature control similar to that provided by the Cougar Water Temperature Control facilities in the McKenzie River subbasin. Experience at Detroit/Big Cliff in the North Santiam River following a powerhouse fire in 2007 showed that by mixing discharge from spill and the regulating outlet, flows below Big Cliff dam could more closely approximate normative water temperatures than under typical Project operations. RPA measure 5.1.1 requires the Action Agencies to carry out interim temperature control at Detroit/Big Cliff, if feasible. In addition, RPA measure 5.1.2 requires the Action Agencies to carry out temperature control at other Project dams by April, 2010, if feasible. The purpose of this conservation measure is to achieve interim temperature management earlier than April, 2010, carrying out these actions sooner than required in RPA 5.1.1.

Lookout Point Dam is a priority for evaluation for both temperature control and downstream passage because monitoring shows extremely high egg mortality for UWR Chinook salmon in the very limited spawning habitat below Dexter Dam (see Middle Fork Willamette Effects section 5.2). Hills Creek Dam is another location that would likely provide immediate improvements in fish spawning and rearing habitat in the Middle Fork Willamette River below the dam downstream to the upper limit of Lookout Point reservoir.

12.5 Habitat Restoration Projects

Identify and carry out extensive habitat restoration projects, including protection of high value aquatic habitats through land purchase or conservation easements, in the mainstem Willamette and tributaries to address habitat-related limiting factors for UWR Chinook salmon and steelhead. Use the programs and authorities described in Tables 9.7.1 and 9.7.2 (or any other applicable authorities, programs, or funding sources) to seek partnerships to maximize benefits with other Federal, State, and Tribal programs and through watershed councils and other partners.

In section 9.7 of the Opinion, RPA measures 7.1 and 7.2 require the Action Agencies to develop habitat restoration programs and begin to carry out projects by 2010. NMFS recommends that these programs begin as soon as possible, rather than waiting until 2010, and that sufficient funds be allocated to this effort to achieve measurable habitat improvements. NMFS describes in the baseline and effects chapters 4 and 5, respectively, how much of the complex rearing habitat in the mainstem Willamette and lower reaches of the tributaries has been lost due to revetments, flood control, and other land use development. Until UWR Chinook salmon and steelhead can pass safely upstream and downstream past Project dams, productivity and abundance of these species must rely on protecting and restoring downstream habitat.

Much work has already been completed on identifying and prioritizing key aquatic habitat restoration objectives in the “Willamette River Basin Planning Atlas” (Hulse et al. 2002). In particular, Chapter 8 of this Planning Atlas entitled “River Restoration” describes restoration priorities of 1) restoring channel complexity, and 2) protecting and restoring floodplain forests. The habitat restoration program described in this Biological Opinion should incorporate the work of Hulse et al. (2002) in considering the prioritization and funding of projects. The candidate reaches identified as “high ecological potential and low demographic and social constraints” by Hulse et al. (2002) should be the highest priority areas for potentially implementing restoration projects.

12.6 Tribal participation in implementation activities

The Action Agencies should invite appropriate Tribes to seek contracts to assist in performing activities related to investigating the feasibility of fish passage at Project dams. The Action Agencies, as well as other Federal agencies who will manage contracts for this work, should initiate a discussion with each appropriate Tribe to determine their desire to participate in the work and to identify mechanisms to provide funding for Tribal involvement where desired and appropriate.

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Chapter 13
Essential Fish Habitat Consultation

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13 ESSENTIAL FISH HABITAT CONSULTATION

13.1 BACKGROUND

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), 16 U.S.C. §§ 1801-1884, includes requirements to identify, conserve, and enhance essential fish habitat (EFH) for those species regulated under a Federal fisheries management plan. EFH is defined in the MSA as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. NMFS further elaborates on this definition in its EFH regulations and states that: waters include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; substrate includes sediment, hard bottom, structures underlying the waters, and associated biological communities; necessary means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle (50 CFR 600.10). "Adverse effect" means any impact which reduces quality and/or quantity of EFH, and may include direct (e.g., contamination or physical disruption), indirect (e.g., loss of prey or reduction in species fecundity), site-specific, or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810).

Federal agencies must consult with NMFS on agency actions, or proposed actions that may adversely affect EFH, including actions that occur outside EFH, such as certain upstream and upslope activities. NMFS provides EFH conservation recommendations for any Federal or State action that would adversely affect EFH (§305(b)(4)(A)). The EFH conservation recommendations are measures to avoid, minimize or otherwise offset adverse impacts to EFH. Federal agencies must provide a detailed response in writing to NMFS within 30 days after receiving EFH conservation recommendations. The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with NMFS' EFH conservation recommendations, the Federal agency must explain its reasons for not following the recommendations (§305(b)(4)(B)).

13.2 IDENTIFICATION OF EFH

Pursuant to the MSA, the Pacific Fisheries Management Council has designated EFH for three species of federally managed Pacific salmon: Chinook salmon (Oncorhynchus tshawytscha); coho (*O. kisutch*); and Puget Sound pink salmon (O. gorbuscha) (PFMC 1999). Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable manmade barriers (as identified by the PFMC 1999) and longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for several hundred years). [1] In estuarine and marine areas, Pacific salmon EFH extends from the nearshore

[1] The PMFC has determined that the following Willamette Project dams define the upstream limit of EFH: Big Cliff, Cougar, Dexter, and Dorena.

and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone offshore of Washington, Oregon, and California north of Point Conception to the Canadian border. Detailed descriptions and identifications of EFH for salmon are found in Appendix A to Amendment 14 to the Pacific Coast Salmon Plan (PFMC 1999). NMFS' assessment of potential adverse effects to these species' EFH from the proposed action is based, in part, on this information. This consultation addresses adverse effects on EFH for Chinook and coho salmon.

EFH for groundfish and coastal pelagic species encompasses all waters from the mean high water line, and upriver extent of saltwater intrusion in river mouths, along the coasts of Washington, Oregon, and California, and seaward to the boundary of the U.S. exclusive economic zone (PFMC 1998a, 1998b). Detailed descriptions and identifications of these EFH designations are contained in the fishery management plans for groundfish (PFMC 1998a) and coastal pelagic species (PFMC 1998c). Casillas et al. (1998b) provide additional detail on the groundfish EFH habitat complexes. NMFS has identified seven groundfish habitat complexes (estuarine, rocky shelf, non-rocky shelf, neritic zone, oceanic zone, continental slope/break and canyon) and identified species that may occur in each of those areas. The estuarine complex, which (with the neritic zone) is pertinent to this consultation, includes those waters, substrates and associated biological communities within bays and estuaries of the Exclusive Economic Zone[2], from mean higher high water level (MHHW) or extent of upriver saltwater intrusion to the respective outer boundaries for each bay or estuary, as defined in 33 CFR 80.1 (Coast Guard lines of demarcation). The neritic zone is the relatively shallow ocean that extends from the outer edge of the intertidal zone to the edge of the continental shelf. It therefore contains the Columbia River plume. Two groundfish and two coastal pelagic species occur within the action area for the proposed action (Table 13-1).

Table 13-1 Non-salmonid fish species with EFH in the action area for operations & maintenance of the Willamette Project. Sources: Casillas 1998b and Emmett et al 1991

Species	Habitat Preferences
Starry Flounder *Platichthys stellatus*	Mud, sand; often found in estuaries and upstream in freshwater
English sole *Pleuronectes vetulus*	Sand, Mud
Northern Anchovy *Engraulis mordax*	Pelagic
Pacific Sardine *Sardinops sagax*	Pelagic

[2] The Exclusive Economic Zone extends 200 miles off the U.S. coastline.

13.3 Proposed Action

The proposed action under consideration in this EFH consultation includes the Reasonable and Prudent Action (RPA) measures (Chapter 9) combined with PA described in Chapter 2 of the accompanying Biological Opinion (RPA/PA). The RPA/PA affects EFH in portions of the states of Oregon and Washington, and the Columbia River estuary and plume.

Affected portions of the Willamette and Columbia rivers and several affected Willamette basin tributaries serve as migratory corridors for anadromous salmonids, including Chinook and coho salmon. Portions of affected Willamette basin tributaries also serve as spawning and rearing habitats for Chinook and coho salmon.[3] The RPA/PA affects flow in areas of the Columbia River estuary and plume used by the two species of groundfish (starry flounder and English sole) and two coastal pelagic species (northern anchovy and Pacific sardine) for which EFH is also designated.

13.4 Effects of Proposed Action on EFH

As described in Chapter 4, Environmental Baseline and Chapter 5, Effects of the Proposed Action of the Biological Opinion, the proposed operations and maintenance of the Willamette Project may result in short- and long-term impacts, both positive and negative, to a variety of habitat parameters. The adverse impacts to EFH for the unlisted Chinook and coho salmon species are the same as those described for the ESA-listed salmonids. Therefore, the ESA effects analysis in the Biological Opinion (Chapter 5) addresses impacts of the PA to salmon EFH. As described in the following sections, the RPA/PA is likely to adversely affect salmon EFH.

Effects on groundfish and coastal pelagic species EFH are described below.

13.4.1 Effects on Mainstem Habitat Conditions, Including the Estuary & Plume

13.4.1.1 Habitat Blockage Effects

Several of the high-head water storage facilities included in the RPA/PA were developed without fish passage facilities, and where fish passage was provided, it functions poorly. Roughly 70 to 80 percent of the spawning and rearing habitats historically available to Chinook salmon in the North and South Santiam rivers, the McKenzie River, and the Middle Fork Willamette River have been blocked by dams (see Chapter 4 of the Biological Opinion). This reduction in accessible habitats is considered a primary contributing factor in the decline of Willamette basin Chinook salmon (NMFS 1998). Conversely, coho salmon were not known to use the Willamette River, or its tributaries, upstream from Willamette Falls and were introduced into watersheds upstream of the falls in the 1950s following installation of adult fish passage facilities at

[3] Historically, few if any coho salmon ascended Willamette Falls. Currently, the Tualatin River population is the only coho population upstream from Willamette Falls. Coho are thus only affected by the PA/RPA from the confluence of the Willamette and Tualatin rivers downstream to the mouth of the Columbia River and the Columbia River plume.

hydroelectric projects located at the Falls. Of these introductions, only the Tualatin River population remains viable.

The PFMC (1999) determined that several Willamette Project dams are the upstream termini of EFH on their respective tributary streams. Historically accessible habitats upstream from Big Cliff, Cougar, Dexter, and Dorena dams are therefore not EFH. Historically accessible habitats on the South Santiam upstream from Foster and Green Peter dams, and historically accessible habitats on Fall Creek upstream from Fall Creek are EFH. Fish passage conditions at these dams remains poor to non-existent, adversely affecting the utility of this EFH.

13.4.1.2 Water Management Effects

Coho & Chinook Salmon

As described in Chapter 5 of the Biological Opinion, the RPA/PA would cause a net reduction in spring flows (April-June) in the mainstem Willamette River through which both Chinook and coho salmon migrate, and in several of its tributaries occupied by Chinook salmon. In the lower Columbia River, the RPA/PA would reduce spring flows by about 2% (Opinion Table 4.11-2). These flow reductions likely reduce the survival of UWR Chinook[4] and may slightly affect survival of other Chinook and coho populations that migrate through the Columbia River migratory corridor during the spring (e.g. SR spring/summer Chinook salmon, UCR spring Chinook salmon, some populations of LCR Chinook salmon, and MCR spring Chinook salmon).

The RPA/PA also increases flows during the summer and fall as the reservoirs are drafted. Available data suggests that summer flow increases would improve the survival of ocean-type Chinook juveniles migrating through the lower Columbia River during the summer. This would benefit the unlisted UCR summer/fall Chinook and SR fall Chinook. Improved fall flows in the occupied sections of the Willamette basin tributaries downstream from project dams, and the control of flow fluctuations, would improve spawning habitat conditions for UWR Chinook and may benefit non-native fall Chinook that spawn or rear in the Willamette basin.

Two sets of authors recently evaluated the sensitivity of the amount and distribution of shallow-water rearing habitat in the lower Columbia River (i.e., Hyde et al. 2004 for conditions in RMs 0-35; Jay et al. 2004 for RMs 35-55) to changes in discharge at Bonneville Dam during summer (i.e., July through September). Snake River fall Chinook, UCR summer/fall Chinook, and Deschutes River summer/fall Chinook salmon produce subyearling smolts that migrate through and rear within the mainstem during summer, as do migrants from fall-run populations of LCR Chinook salmon. Hyde et al. (2004) focused on the sensitivity to changes in discharge in the 150 to 190 kcfs range, well beyond the effects anticipated under the RPA/PA and found that in the lower 35 miles of the Columbia River, such flow changes appear to have only slight impacts on the total area of shallow-water habitat available and the hours during which it would fit specific depth criteria. Due to extensive diking and the effects of tides, Jay et al. (2004) found that the amount of shallow-water habitat in the lower Columbia River varies very little over a much wider range of flow changes than those identified in the RPA/PA.

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[4] While insufficient data are available to clearly demonstrate a UWR Chinook survival response to changes in Willamette River flows, other Chinook ESUs and UWR steelhead have demonstrated reductions in survival with reductions in flow during their juvenile outmigration.

Thus, because the anticipated flow effects are well below 150 kcfs (maximum effect < 10 kcfs on a monthly average basis), we conclude that the effects on rearing habitats in the lower Columbia River and estuary would be negligible.

The reduction of the spring freshet associated with the RPA/PA would also influence habitat conditions in the Columbia River plume. Assuming that effects on the habitat value of the plume roughly equal the relative change in spring discharge, the RPA/PA would reduce the plume's habitat value by less than 2%. The plume's role as salmon and steelhead habitat is poorly understood. However, a 2% reduction in the size of the plume would appear to be a relatively small effect.

Groundfish

Two groundfish species, starry flounder and English sole, have EFH in areas affected by the RPA/PA. Starry flounder spawn in the ocean, and juveniles enter the estuary at a young age where they are associated with the bottom, feeding on amphipods and copepods (Fox et al. 1984). They are distributed throughout the estuary, but younger fish (less than 2 years) are more concentrated in the freshwater or low salinity areas. Fish older than 2 years are more concentrated in areas of higher salinity. During spring, abundance is generally low and flounder are restricted to part of Youngs Bay and an area between Tongue Point and Woody Island (approximately RM 29). During summer and fall, they are more widely distributed but are most abundant in areas of low velocity currents such as Grays Bay, Youngs Bay, Baker Bay, Cathlamet Bay, and intertidal habitats, where their principal prey, amphipods, concentrate.

The English sole is a marine species that is associated with the bottom for most of its life cycle. It prefers high salinities and therefore is found only in the downriver portions of the estuary where the population, primarily juveniles, feed and rear (Fox et al. 1984). English sole eat mainly copepods, amphipods, and mysids, but also incorporate the clam Macoma balthica, polychaetes, and oligochaetes into their diet. Sole less than 1 year old are localized in low-velocity, shallow areas such as the Ilwaco and Chinook Channels during spring, but are distributed further upriver in relatively saline water during summer and fall. Both their relative abundance and distribution in the estuary decrease in winter. Relatively few of the individuals in the estuary are 1 year old or older, and these are found downriver from the Astoria-Megler Bridge year round.

Both species are associated with low-velocity, shallow-water habitat in the estuary, where their prey species are abundant. Thus, effects on estuarine EFH for these species are likely to be similar to those described above for subyearling salmon. That is, the RPA/PA only slightly affects the total area of shallow-water rearing habitat available in the lower Columbia River and the hours during which it fits specific depth criteria, with the difference greatest during summer and in the upstream tidally-influenced reach closest to Bonneville Dam.

Coastal Pelagic Species

Northern anchovy are distributed from the Queen Charlotte Islands, British Columbia, to Magdalena Bay, Baja California, and anchovy have recently colonized the Gulf of California (PFMC 1998c). The population is divided into northern, central, and southern subpopulations, or stocks. The southern subpopulation is entirely within Mexican waters. The central subpopulation, which supports significant commercial fisheries in the U.S. and Mexico, ranges from approximately San Francisco, California, to Punta Baja, Baja California. The bulk of the central subpopulation is located in the Southern California Bight, a 20,000-square-nautical-mile area bounded by Point Conception, California, in the north and Point Descanso, Mexico (about 40 miles south of the U.S.-Mexico border) in the south. The geographic distribution of northern anchovy has been more consistent over time and is more nearshore than the geographic distribution of Pacific sardine.

The northern anchovy is commonly found both within the Columbia River estuary and offshore in large schools during all seasons. Adults spawn in the ocean, but all life stages can be found in the estuary where they feed mostly on copepods (and some phytoplankton) in the water column (Fox et al. 1984). Fish older than one year prefer higher salinity areas and are found further upriver when outflow is lower.

It is generally accepted that sardines off the west coast of North America form three subpopulations or stocks: a northern subpopulation (northern Baja California to Alaska), a southern subpopulation (off Baja California), and a Gulf of California subpopulation. A fourth, far northern subpopulation has also been postulated (PFMC 1998c). Although the ranges of the northern and southern subpopulations overlap, the stocks may move north and south at similar times and not overlap significantly.

Pacific sardines are pelagic at all life history stages. They occur in estuaries, but are most common in the nearshore and offshore domains along the coast. They have been captured in both purse and beach seines in the Columbia River estuary, often with anchovies. Like the northern anchovy, sardines are planktivorous, consuming both phytoplankton and zooplankton.

The RPA/PA has a small effect on flows in the Columbia River plume. For pelagic species, the increase in summer flows that would be provided by the RPA/PA means that the aerial extent of the low salinity environment in the plume would also be slightly enlarged. There is no information available on how habitat use by coastal pelagic species is affected by changes in flow on the order of the RPA/PA.

13.4.1.3 Water Quality Effects

The RPA/PA would have three primary effects on water quality: modified water temperatures, reduced turbidity (or increased clarity), and during spill operations, increased concentrations of dissolved gasses. These effects are strongest immediately downstream from the dams and diminishes in a downstream direction. Of these, water temperature is likely the most limiting water quality effect on Chinook and coho survival in the affected tributaries. However, total dissolved gas may have acute effects during spill operations. Because spill is an uncommon event at these projects, these adverse effects are uncommon.

Given that the influence of the Willamette Project on water quality diminishes with distance downstream from the dams and that total Willamette flows are a fraction of total Columbia River flows, the reduction of water quality related EFH quality exists only in the Willamette basin, primarily in the affected tributaries (e.g. North and South Santiams, McKenzie, and Middle Fork Willamette rivers) and affects only the EFH for Willamette basin Chinook and coho salmon. Both of these species would be adversely affected by the RPA/PA’s effects on water quality.

13.5 Conclusion

NMFS concludes that the RPA/PA would adversely affect EFH for Columbia Basin Chinook and coho salmon by: continuing to block habitat for Willamette basin populations, degrading Willamette basin water quality, and modifying flows in the Willamette River and several of its salmon-bearing tributaries, and by contributing to diminished habitat quality in the lower Columbia River, its estuary and plume.

Effects on groundfish and coastal pelagic species EFH would be slight to negligible.

13.6 EFH Conservation Recommendations

Pursuant to §305(b)(4)(A) of the MSA, NMFS provides EFH conservation recommendations to the USACE, BPA, and Reclamation (the Action Agencies) to conserve EFH that would be adversely affected by the Willamette Project.

This MSA consultation and the EFH conservation recommendations are predicated on the assumption that the Action Agencies would adopt the RPA provided by NMFS in the Biological Opinion accompanying this MSA consultation. Failure by the Action Agencies to adopt any of the measures included in that RPA would render this MSA consultation null and void. Because lost access to historical spawning and rearing habitat upstream of Foster and Fall Creek dams is a primary adverse effect on designated EFH, NMFS recommends that the Action Agencies place high priority on achieving successful upstream and downstream fish passage at these dams. NMFS also recommends that the Action Agencies adopt and implement the terms and conditions in the Incidental Take Statement (ITS) in Chapter 11 of the Biological Opinion as EFH conservation measures. These terms and conditions in the ITS are necessary to minimize adverse impacts to EFH because they will address remaining project effects by minimizing harm to anadromous fish and EFH from construction and maintenance activities.

With improvements to passage, adherence to operating criteria described in the PA/RPA, and the adoption of the ITS measures, the RPA/PA's adverse effects on salmon EFH would be minimized.

13.7 Statutory Response Requirement

Pursuant to the MSA (§305(b)(4)(B)) and 50 CFR 600.920(j), Federal agencies are required to provide a detailed written response to NMFS' EFH conservation recommendations within 30 days of receipt of these recommendations. In case of a response that is inconsistent with the EFH conservation recommendations, the response must explain the reasons for not following the recommendations, including the scientific justification for any disagreements over the anticipated effects of the RPA/PA and the measures needed to avoid, minimize, mitigate, or offset such effects.

13.8 Reinitiation of Consultation

The Action Agencies must reinitiate EFH consultation with NMFS if the RPA/PA is substantially revised in a manner that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations (50 CFR 600.920(k)).

Literature Cited

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Literature Cited

Abbe, T.B. and D.R. Montgomery. 1996. Large woody debris jams, channel hydraulics and habitat formation in large rivers. Regulated Rivers: Research & Management 12:201-221.

Abernethy, A. S. 1886. Salmon in the Clackamas River. Bulletin of the U.S. Fisheries Commission 8:332.

Adams, P.B., C.B. Grimes, S.T. Lindley, and M.L. Moser. 2002. Status review for the North American green sturgeon. National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, California.

Ainslie, B.J., J.R. Post, and A.J. Paul. 1998. Effects of pulsed and continuous DC electrofishing on juvenile rainbow trout. North American Journal of Fisheries Management 18(4):905-918.

Alabaster, J. S. 1988. The dissolved oxygen requirements of upstream migrant Chinook salmon, *Oncorhynchus tshawytscha*, in the lower Willamette River, Oregon. Journal of Fish Biology 32:635-636.

Allee, B.J. 1974. Spatial requirements and behavioral interactions of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Doctoral dissertation, University of Washington, Seattle.

Allendorf, F.W. and N. Ryman. 1987. Genetic management of hatchery stocks. Pages 141-159 *in* N. Ryman and F. Utter, editors. Population Genetics and Fishery Management. University of Washington Press, Seattle,

Alsea Geospatial, Hardin-Davis, Pacific Wildlife Research, and WaterWork Consulting. 2000. McKenzie River subbasin assessment: technical report. Prepared for the McKenzie Watershed Council, Oregon.

Anderson, C. 2003. Draft text for the biological opinion. Communication to L. Krasnow from C. Anderson, U.S. Geological Survey, Portland, Oregon. May 30.

Anderson, C. 2007. Influence of Cougar Reservoir drawdown on sediment and DDT transport and deposition in the McKenzie River basin, Oregon, water years 2002–04: U.S. Geological Survey Scientific Investigations Report 2007–5164.

Anderson, C.W., F.A. Rinella, and S.A. Rounds. 1996. Occurrence of selected trace elements and organic compounds and their relation to land use in the Willamette River Basin, Oregon, 1992–94. U.S. Geological Survey, Water-Resources Investigations Report 96–4234.

Andrus, C.W. and J. Walsh. 2002. Aquatic and riparian assessment for the Eugene-Springfield area. Prepared for the Eugene-Springfield Metropolitan Endangered Species Act Coordinating Team (MECT) by WaterWork Consulting and Upstream Connection.

Annear, R., and S. Wells. 2006. Lower Clackamas River model: model development, calibration, and scenarios. Water Quality Research Group, Portland State University, Portland, Oregon.

Araki, H. and M. Blouin. 2005. Unbiased estimation of relative reproductive success of different groups: evaluation and correction of bias caused by parentage assignment errors. Molecular Ecology 14: 4097–4109.

Araki, H., W.R. Arden, E. Olsen, B. Cooper, and M.S. Blouin. 2007a. Reproductive success of captive-bred steelhead trout in the wild: evaluation of three hatchery programs in the Hood River. Conservation Biology 21(1):181-190.

Arendt, K., S.P. Cramer, and N.K. Ackerman. 2008. Population life-cycle model for lower Clackamas River salmonids: technical memorandum 3. Final report from Cramer Fish Sciences, Gresham, Oregon, to Portland General Electric Company, Portland, Oregon.

Arkoosh, M.R., E. Casillas, E. Clemons, B. McCain, and U. Varanasi. 1991. Suppression of immunological memory in juvenile Chinook salmon (*Oncorhynchus tshawytscha*) from an urban estuary. Fish and Shellfish Immunology 1:261-277.

Arkoosh, M.R., E. Casillas, E. Clemons, J. Evered, J.E. Stein, and U. Varanasi. 1998. Increased susceptibility of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) from a contaminated estuary to the pathogen *Vibrio anguillarum*. Transactions of the American Fisheries Society 127:360-374.

Arkoosh, M.R., E. Clemons, M. Myers, and E. Casillas. 1994. Suppression of B-cell mediated immunity in juvenile Chinook salmon (*Oncorhynchus tshawytscha*) after exposure to either a polycyclic aromatic hydrocarbon or to a polychlorinated biphenyls. Immunopharmocology and Immunotoxicology 16(2):293-314.

Bachman, R.A. 1984. Foraging behavior of free-ranging wild and hatchery brown trout in a stream. Transactions of the American Fisheries Society 113:1-32.

Bain, D. 1990. Examining the validity of inferences drawn from photo-identification data, with special reference to studies of the killer whale (*Orincus orca*) in British Columbia. Report of the International Whaling Commission, Special Issue 12:93-100.

Bain, D.E., J.C. Smith, R. Williams, and D. Lusseau. 2006. Effects of vessels on behavior of Southern Resident killer whales (*Orcinus spp.*). Contract Report for the National Marine Fisheries Service, Seattle, Washington.

Baird, R.W. 2001. The killer whale: foraging specialization and group hunting. Pages 127-153 in J. Mann, R.C. Connor, P.L. Tyack, and H. Whitehead, editors. Cetacean societies: field studies of dolphins and whales. The University of Chicago Press, Chicago, Illinois.

Bakkala, RG. 1970. Synopsis of biological data on the chum salmon, *Oncorhynchus keta* (Walbaum) 1792. FAO Species Synopsis No. 41. Circular 315. U.S. Department of the Interior, Washington, D.C.

Barin, L.T. 1886. Salmon in the Clackamas River. Bulletin of the U.S. Fisheries Commission 8:111–112.

Barre, L. 2008. Stock identity of Chinook salmon taken by Southern Resident killer whales. Memorandum to the file from L. Barre, National Marine Fisheries Service, Seattle, Washington. June 24.

Bax, N.J. 1983. The early marine migration of juvenile chum salmon (*Oncorhynchus keta*) through Hood Canal - its variability and consequences. Doctoral dissertation, University of Washington.

Bayley, P. B., and C. F. Baker. 2000. Floodplain restoration in off-channel habitats used for gravel mining in the Willamette River Basin: fish population observations in Endicott and Truax ponds. 1998/00 Report to Willamette River Gravel Removal Restoration Fund Program. Oregon State University, Corvallis.

Bayley, P.B., P.C. Klingeman, P.J. Pabst, and C.F. Baker. 2001. Restoration of aggregate gravel mining areas in the Willamette River floodplain, with emphasis on Harrisburg site. Final report to Oregon Watershed Enhancement Board.

Beacham, T.D., and C.B. Murray. 1990. Temperature, egg size, and development of embryos and alevins of five species of pacific salmon: a comparative analysis. Transactions of the American Fisheries Society 119:927-941.

Beamesderfer, R.C., D.L. Ward, and A.A. Nigro. 1996. Evaluation of the biological basis for a predator control program on northern squawfish (*Ptychocheilus oregonensis*) in the Columbia and Snake Rivers. Canadian Journal of Fisheries and Aquatic Sciences 53:2898-2908.

Beamesderfer, R.C., M.L. Simpson, and G.J. Kopp. 2007. Use of life history information in a population model for Sacramento green sturgeon. Environmental Biology of Fishes 79:315-337

Beamis, W.E. and B. Kynard. 1997. Sturgeon rivers: An introduction to acipensiform geography and life history. Environmental Biology of Fishes 48:167-183.

Beauchamp, D.A. 1990. Seasonal and diet food habits of rainbow trout stocked as juveniles in Lake, Washington. Transactions of the American Fisheries Society 119: 475-485.

Behnke, R.J. 1992. Native trout of western North America. American Fisheries Society Monogram 6. American Fisheries Society, Bethesda, Maryland.

Beidler, W. and S. Knapp. 2005. A synopsis of information relating to the success of adult hatchery Chinook salmon releases above migration barriers in the Willamette River System. Oregon Department of Fish and Wildlife, Corvallis.

Bell, M.C. 1991. Fisheries handbook of engineering requirements and biological criteria. Fish Passage Development and Evaluation Program. North Pacific Division, U.S. Army Corps of Engineers, Portland, Oregon.

Bell, M.C. 1986. Fisheries handbook of engineering requirements and biological criteria. U.S. Army Corps of Engineers, Portland, Oregon.

Bendock, T. and M. Alexandersdottir. 1993. Hooking mortality of Chinook salmon released in the Kenai River, Alaska. North American Journal of Fisheries Management 13:540-549.

Benner, P. A. and J. R. Sedell. 1997. Upper Willamette River landscape: A historic perspective. Pages 23-47 *in* Laenen, A. and D. Dunnette, editors. River quality: dynamics and restoration. CRC Lewis Publishers, Boca Raton, Florida.

Berejikian, B.A., S.B. Mathews, T.P. Quinn. 1996. Effects of hatchery and wild ancestry and rearing environments on the development of agonistic behavior in steelhead trout (*Oncorhynchus mykiss*) fry. Canadian Journal of Fisheries and Aquatic Sciences 53: 2004-2014.

Berejikian, B.A., E.P. Tezek, S.L. Schroder, C.M. Knudson, and J.J. Hard. 1997. Reproductive behavioral interactions between spawning and wild and captivity reared coho salmon *Oncorhynchus kisutch*). ICES Journal of Marine Science 54:1040-1049.

Berg, L. and T.G. Northcote. 1985. Changes in territorial, gill-flaring, and feeding behavior in juvenile coho salmon (*Oncorhynchus kisutch*) following short-term pulses of suspended sediment. Canadian Journal of Fisheries and Aquatic Sciences 42:1410-1417.

Bergman, P.K., K.B. Jefferts, H.F. Fiscus, and R.C. Hager. 1968. A preliminary evaluation of an implanted, coded wire fish tag. Washington Department of Fisheries, Fisheries Research Papers 3(1): 63-84.

BIA (Bureau of Indian Affairs). 1998. Biological assessment of 1998 coho salmon releases proposed by the Nez Perce Tribe. Submitted to NMFS by BIA, Portland, Oregon.

Bigelow, P.E. 1997. Emigration of Dworshak National Fish Hatchery steelhead. U.S. Fish and Wildlife Service Idaho Fishery Resource Office, Ahsahka, Idaho.

Bigg, M. 1982. An assessment of killer whale (*Orcinus orca*) stocks off Vancouver Island, British Columbia. Report of the International Whaling Commission 32:655-666.

Bigg, M.A., P.F. Olesiuk, G.M. Ellis, J.K.B. Ford, and K.C. Balcomb. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Report of the International Whaling Commission, Special Issue 12:383-398.

Bigler, B.S., D.W. Wilch, and J.H. Helle. 1996. A review of size trends among North Pacific salmon (*Oncorynchus spp.*). Canadian Journal of Fisheries and Aquatic Sciences. 53: 455-465.

Bilby, R. E. and G. E. Likens. 1980. Importance of organic debris dams in the structure and function of stream ecosystems. Ecology 61: 1107-1113.

Bilby, R. E. and L. J. Wasserman. 1989. Forest practices and riparian management in Washington State: Data based regulation development, p. 87-94. *In* R. E. Gresswell, B.A. Barton, and J. L. Kershner, [Eds.], Practical approaches to riparian resource management. U.S. Bureau of Land Management, Billings, Montana.

Bilby, R. E. and P. A. Bisson. 1998. Function and distribution of large woody debris. Pp. 324-346. In R. J. Naiman and R. E. Bilby [Eds.], River ecology and management: lessons from the Pacific Coastal Eco Region, Springer Verlag New York, Inc. New York, New York.

Bilby, R. E., and J. W. Ward. 1989. Changes in characteristics and function of woody debris with increasing size of streams in western Washington. Transactions of the American Fisheries Society 118: 368-378.

Bilby, R. E., B.R. Fransen, and P. A. Bisson. 1996. Incorporation of nitrogen and carbon from spawning coho salmon into the trophic system of small streams: evidence from stable isotopes. Canadian Journal of Fisheries and Aquatic Sciences 53:164-173.

Bilby, R.E., B.R. Fransen, P.A. Bission, and J.K. Walter. 1998. Response of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead (*Onchorhynchus mykiss*) to the addition of salmon carcasses to two streams in southwestern Washington, U.S.A. Canadian Journal of Fisheries and Aquatic Sciences 55:1909-1918.

Birtwell, I. K., G. F. Hartman, B. Anderson, D. J. McLeay, and J. G. Malick. 1984. A brief investigation of arctic grayling (*Thymallus arcticus*) and aquatic invertebrates in the Minto Creek drainage, Mayo, Yukon Territory: an area subjected to placer mining. Canadian Technical Report of Fisheries and Aquatic Sciences 1287.

Bjornn, T.C. and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-138 *in* W.R. Meehan (editor). Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19.

Black, N., R. Ternullo, A. Schulman-Jangier, A.M. Hammers, and P. Stap. 2001. Occurrence, behavior, and photo-identification of killer whales in Monterey Bay, California. Proceedings of the Biennial Conference on the Biology of Marine Mammals 14:26.

BLME (Bureau of Land Management, Eugene District). 1995a. Mohawk/McGowan watershed analysis. Bureau of Land Management, Eugene, Oregon.

BLME (Bureau of Land Management, Eugene District). 1995b. Row River watershed analysis. Bureau of Land Management, Eugene District, Oregon.

BLME (Bureau of Land Management, Eugene District). 1997. Cottage Grove Lake/Big River watershed analysis. Bureau of Land Management, Eugene District, Oregon.

BLME (Bureau of Land Management, Eugene District). 1999. Sharps Creek watershed analysis. Bureau of Land Management, Eugene District, Oregon. February.

BLMS (Bureau of Land Management, Salem District) and WNF SHRD (Willamette National Forest, Sweet Home Ranger District). 2002. Quartzville watershed analysis. Quartzville Creek Wild and Scenic River. Bureau of Land Management, Salem, Oregon.

BLMS (Bureau of Land Management, Salem District). 1997. Thomas Creek watershed analysis, riparian reserve assessment. Bureau of Land Management, Salem, Oregon.

BLMS (Bureau of Land Management, Salem District). 1998. Little North Santiam River watershed analysis. Bureau of Land Management, Salem District, Oregon.

Bluoin, M. 2004. Relative reproductive success of hatchery and wild steelhead in the Hood River. Final report on work conducted under BPA contract 9245, Project #1988-053-12 and ODFW interagency agreement No. 001-2007s. Oregon Department of Fish and Wildlife, Corvallis, Oregon.

Bordner, C.E., S.I. Doroshov, D.E. Hinton, R.E. Pipkin, R.B. Fridley, and F. Haw. 1990. Evaluation of marking techniques for juvenile and adult white sturgeons reared in captivity. Pages 293-303 *in* N. C. Parker, A.E. Giorgi, R.C. Heidinger, D.B. Jester, Jr., E.D. Prince, and G.A. Winans, editors. Fish-marking techniques. American Fisheries Society, Symposium 7, Bethesda, Maryland.

Bottom, D.L., C.A. Simenstad, and A.M. Baptista. 2000. Salmon at river's end: the role of the estuary in the decline and recovery of Columbia River salmon. National Marine Fisheries Service, Seattle, Washington.

Bottom, D.L., K.K. Jones, and M.J. Herring. 1984. Fishes of the Columbia River estuary. Columbia River Estuary Data Development Program. Columbia River Estuary Study Taskforce, Astoria, Oregon.

Bradley, C. E. and D. G. Smith. 1985. Plains cottonwood recruitment and survival on a prairie meandering river floodplain, Milk River, southern Alberta and northern Montana. Canadian Journal of Botany 64: 1433-1442.

Brannon, E., M. Powell, T. Quinn, and A. Talbot. 2002. Population structure of Columbia River basin Chinook salmon and steelhead trout. National Science Foundation and Bonneville Power Administration. Center for Salmonid and Freshwater Species at Risk, University of Idaho, Moscow.

Britton, J. 2006. Cougar Dam total dissolved gas investigation, April 19-20, 2006. PowerPoint presentation. U.S. Army Corps of Engineers, Portland, Oregon.

Brodeur, R.D. 1991. Ontogenetic variations in the type and size of prey consumed by juvenile coho, *Oncorhynchus kisutch*, and Chinook, *O. tshawytscha,* salmon. Environmental Biology of Fishes 30:303-315.

Bruesewitz, S.L. 1995. Hook placement in steelhead. Technical Report No. AF95-01. Washington Department of Fish and Wildlife, Olympia.

Brynildson, O.M. and C.L. Brynildson. 1967. The effect of pectoral and ventral fin removal on survival and growth of wild brown trout in a Wisconsin stream. Transactions of the American Fisheries Society 96:353-355.

Buchanan, D. V., M. G. Wade, and D. L. Higley. 1993. Restoration of the native winter steelhead runs on the South Santiam River above Foster Dam. Completion Report. Fish Research Project, OR. Oregon Department of Fish and Wildlife, Portland.

Buchanan, D.V., R.M. Hooton, M.G. Wade, and J.E. McCrae. 1979. Willamette River steelhead. Annual report Columbia River fishery development. Period covered: October 1, 1978 to September 30, 1979.

Buckley, R.M. 1999. Incidence of cannibalism and intra-generic predation by Chinook salmon (*Oncorhynchus tshawytscha*) in Puget Sound, Washington. Technical Report # RAD 99-04. Washington Department of Fish and Wildlife, Fish Program, Olympia.

Bugert, R., K. Petersen, G. Mendel, L. Ross, D. Milks, J. Dedloff, and M. Alexandersdottir. 1992. Lower Snake River compensation plan, Tucannon River spring Chinook salmon hatchery evaluation plan. U.S. Fish and Wildlife Service, Boise, Idaho.

Busack, C.A. and K.P. Currens. 1995. Genetic risks and hazards in hatchery operations: fundamental concepts and issues. American Fisheries Society Symposium 15:71-80.

Campton, D.E. 1995. Genetic effects of hatchery fish on wild populations of Pacific salmon and steelhead: What do we really know? American Fisheries Society Symposium 15:337-353.

Cannamela, D.A. 1992. Potential impacts of releases of hatchery steelhead trout smolts on wild and natural juvenile Chinook and sockeye salmon. A White Paper, Idaho Department of Fish and Game, Boise.

Cannamela, D.A. 1993. Hatchery Steelhead Smolt Predation of Wild and Natural Juvenile Chinook Salmon Fry in the Upper Salmon River, Idaho. Copies available from Idaho Department of Fish and Game, Boise, Idaho. 23p.

Cardwell, R.D. and K.L. Fresh. 1979. Predation upon juvenile salmon. Draft technical paper. Washington Department of Fish and Wildlife. Olympia.

Cascadia Research Collective. 2008. Sighting of thin Southern Resident killer whale off Washington coast. Communication to Lynn Barre, National Marine Fisheries Service from Erin Falcone, Cascadia Research Collective, Olympia, Washington. March 4.

Casillas E., M.R. Arkoosh, E. Clemons, T. Hom, D. Misitano, T.K. Collier, J.E. Stein, and U. Varanasi. 1995a. Chemical contaminant exposure and physiological effects in out-migrant juvenile Chinook salmon from urban estuaries of Puget Sound, Washington. Proceedings of Puget Sound Research 95. Puget Sound Water Quality Authority, Olympia, Washington.

Casillas E., M.R. Arkoosh, E. Clemons, T. Hom, D. Misitano, T.K. Collier, J.E. Stein, and U. Varanasi. 1995b. Estuaries chemical contaminant exposure and physiological effects in out-migrant juvenile Chinook salmon from selected urban estuaries of Puget Sound, Washington. Proceedings of the 1994 Northwest Pacific Chinook and Coho Salmon Workshop: Salmon Ecosystem Restoration: Myth and Reality edited by M. Keefe. American Fisheries Society, Oregon Chapter, Corvallis, Oregon.

Casillas, E. 2002. Survival and growth of Juvenile Salmonids in the Columbia River Plume. Proposal. BPA Project No. 199801400. Submitted to the Northwest Power Planning Council's Fish and Wildlife Program for FY 2003. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Casillas, E. B-T. L. Eberhard, T.K. Collier, M.M. Krahn, and J.E. Stein. 1998a. Hylebos fish injury study: round 2. Part 3: exposure of juvenile Chinook salmon to chemical contaminants specific to the Hylebos Waterway: Tissue concentrations and biochemical responses. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Casillas, E., L. Crockett, Y. deReynier, J. Glock, M. Helvey, B. Meyer, C. Schmitt, M. Yoklavich, A. Bailey, B. Chao, B. Johnson, and T. Pepperell. 1998b. Essential fish habitat, west coast groundfish appendix. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

CBFWA (Columbia Basin Fish and Wildlife Authority). 1990. Review of the history, development, and management of anadromous fish production facilities in the Columbia River Basin. CBFWA, Portland, Oregon.

CBFWA (Columbia Basin Fish and Wildlife Authority). 1996. Draft programmatic environmental impact statement impacts of artificial salmon and steelhead production strategies in the Columbia River basin. CBFWA, Portland, Oregon.

Cederholm, C. J., D. B. Houston, D. L. Cole, and W. J. Scarlett. 1989. Fate of coho salmon (*Oncorhynchus kisutch*) carcasses in spawning streams. Canadian Journal of Fish and Aquatic Science 46:1347-1355.

Cederholm, C. J., M. D. Kunze, T. Murota, and A. Sibatani. 1999. Pacific salmon carcasses: Essential contributions of nutrients and energy for aquatic and terrestrial ecosystems. Fisheries 24(10):6-15.

Center for Whale Research. Unpublished data. The historical status of the Southern Resident killer whales. Southern Resident population 1976-2006. Center for Whale Research, Friday Harbor, Washington.

Chapman, D.W. 1986. Salmon and Steelhead Abundance in the Columbia River in the Nineteenth Century. Transactions of the American Fisheries Society 115:662-670.

Chapman, D.W., and T.C. Bjornn. 1969. Distribution of salmonids in streams, with special reference to food and feeding, p. 153-176. In: T.G. Northcote (ed.). Symposium on salmon and trout in streams. H.R. MacMillan Lectures in Fisheries. Institute of Fisheries, University of British Columbia, Vancouver, B.C. In Healy, M.C. 1991. Life history of chinook salmon (*Oncorhynchus tshawytscha*), pp. 311-393. In: C. Groot and L. Margolis. Pacific salmon life histories. UBC Press, Vancouver, British Columbia.

Chilcote, M. 2007. Viability status of Oregon salmon and steelhead populations in the Willamette and Lower Columbia Basins. Appendix B: Oregon abundance time series. Prepared for Oregon Department of Fish and Wildlife and National Marine Fisheries Service, Portland, Oregon.

Chilcote, M.W., S.A. Leider, and J.J. Loch. 1986. Differential reproductive success of hatchery and wild summer-run steelhead under natural conditions. Transactions of the American Fisheries Society 115:726-735.

Chisholm, I.M. and W.A. Hubert. 1985. Expulsion of dummy transmitters by rainbow trout. Transactions of the American Fisheries Society 114:766-767.

Coble, D.W. 1967. Effects of fin-clipping on mortality and growth of yellow perch with a review of similar investigations. Journal of Wildlife Management 31(1):173-180.

Congleton, J.L. 1995. Evaluation procedures for collection, bypass, and downstream passage of outmigrating salmonids. Draft annual report for 1995, MPE-96-10.

Connor, W.P., H. Burge, and R. Bugert. 1992. Migration timing of natural and hatchery fall Chinook in the Snake River Basin. In Passage and Survival of Juvenile Chinook Salmon Migrating from the Snake River Basin, Proceedings of a Technical Workshop, University of Idaho.

Connor, W.P., H.L. Burge, and R. Waitt. 2001. Snake River fall Chinook salmon early life history, condition, and growth as affected by dams. Unpublished report. U.S. Fish and Wildlife Service and University of Idaho, Moscow.

Cooney, R.T., D. Urqhart, R. Neve, J. Hilsinger, R. Clasby, and D. Barnard. 1978. Some aspects of the carry capacity of Prince William Sound, Alaska for hatchery released pink and chum salmon fry. Sea Grant Report 78-4. IMS Report R78-3.

Craig, J.A. and L.D. Townsend. 1946. An investigation of fish-maintenance problems in relation to the Willamette Valley Project. U.S. Fish and Wildlife Service. Special Scientific Report No. 33.

Cramer, D. P., and S. P. Cramer. 1994. Status and population dynamics of coho salmon in the Clackamas River. Portland General Electric, Portland, Oregon.

Cramer, S., C. Willis, S. Vigg, J. Hawksworth, R. Montagne, D. Cramer, F. Shrier, C. Phillips, J. Welty, and K. Reininga. 1997. Synthesis and analysis of the lower Columbia River steelhead initiative. Special Report. Prepared for private sector and local government stakeholders, and submitted to the National Marine Fisheries Service in Portland, Oregon by S.P. Cramer & Associates, Gresham, Oregon.

Cramer, S.P., J. Norris, P. Mundy, G. Grette, K. O'Neal, J. Hogle, C. Steward, and P. Bahls. 1999. Status of Chinook salmon and their habitat in Puget Sound, volume 2. Final report. S.P. Cramer and Associates, Gresham, Oregon.

Crozier, L., R. Zabel, and A. Hamlet. 2008. Predicting differential effects of climate change at the population level with life-cycle models of spring Chinook salmon. Global Change Biology 14:236-249.

Cude, C. 1996a. Oregon water quality index report for Upper Willamette Basin, Water Years 1986-1995. Oregon Department of Environmental Quality, Laboratory Division, Salem.

Cude, C. 1996b. Oregon water quality index report for Middle Willamette Basin, Water Years 1986-1995. Oregon Department of Environmental Quality, Laboratory Division, Salem.

Cude, C. 1996c. Oregon water quality index report for Lower Willamette, Sandy, and Lower Columbia Basins, Water Years 1986-1995. Oregon Department of Environmental Quality, Laboratory Division, Salem.

Cuenco, M.L., T.W.H. Backman, and P.R. Mundy. 1993. The use of supplementation to aid in natural stock restoration. In J.G. Cloud and G.H. Thorgaard, editors. Genetic Conservation of Salmonid Fishes. Plenum Press, New York.

CWC (Calapooia Watershed Council). 2004. Calapooia River watershed assessment. Prepared by Biosystems, Water Work Consulting, Alsea Geospatial for the Calapooia Watershed Council, Brownsville, Oregon.

Dalbey, S.R., T.E. McMahon, and W. Fredenberg. 1996. Effect of electrofishing pulse shape and electrofishing-induced spinal injury to long-term growth and survival of wild rainbow trout. North American Journal of Fisheries Management 16:560-569.

Dawley, E.M., R.D. Ledgerwood, T.H. Blahm, C.W. Sims, J.T. Durkin, R.A. Kirn, A.E. Rankis, G.E. Monan, and F.J. Ossiander. 1986. Migrational characteristics, biological observations, and relative survival of juvenile salmonids entering the Columbia River estuary, 1966-1983. 1985 Final Report. Bonneville Power Administration and National Marine Fisheries Service, Portland, Oregon.

DeVore, P. W., L. T. Brooke, and W. A. Swenson. 1980. The effects of red clay turbidity and sedimentation on aquatic life in the Nemadji River system. Impact of nonpoint pollution control on western Lake Superior. EPA Report 905/9-79-002-B. U.S. Environmental Protection Agency, Washington, D.C.

Dimmick, R. E., and F. Merryfield. 1945. The fishes of the Willamette River system in relation to pollution. Oregon State College, Engineering Experiment Station, Corvallis.

Donner, A. 2008. Willamette Project operations modeling. Communication to R. Domingue, National Marine Fisheries Service, from A. Donnor, U.S. Army Corps of Engineers, Portland, Oregon. May 15.

Doughty, K. 2004. Final report instream flow assessment, Clackamas River: Reach 2B. Final report on Clackamas River Hydroelectric Project, FERC No. 2195. Consultant report to Portland General Electric Company from EES Consulting, Bellingham, Washington.

Downey, T. W. and E. M. Smith. 1992. Evaluation of spring Chinook salmon passage at Fall Creek Dam, 1991. Draft report. Fish Research and Development Section, Oregon Department of Fish and Wildlife.

Dunnigan, J.L. 1999. Feasibility and risks of coho reintroduction in Mid-Columbia monitoring and evaluation. 1999 annual report. Yakama Nation Department of Fisheries. Project # 9604000. Bonneville Power Administration. Portland, Oregon.

Dwyer, W.P. and R.G. White. 1997. Effect of electroshock on juvenile Arctic grayling and Yellowstone cutthroat trout growth 100 days after treatment. North American Journal of Fisheries Management 17:174-177.

Dykaar, B.B. 2005. Status and trends of Middle and Coast Forks Willamette River and their floodplain habitat using geomorphic indicators. Prepared for Willamette Partnership and the U.S. Army Corps of Engineers. Ecohydrology West, Santa Cruz, California.

Dykaar, B.B. and R.J. Wigington, Jr. 2000. Floodplain formation and cottonwood colonization patterns on the Willamette River, Oregon, USA. Environmental Management 25(1): 87-104.

E&S (E&S Environmental Chemistry, Inc.). 2000. South Santiam watershed assessment. Final report. South Santiam Watershed Council and E&S Environmental Chemistry, Corvallis, Oregon.

E&S (E&S Environmental Chemistry, Inc.). 2002. North Santiam watershed assessment. E&S, Corvallis, Oregon. .

EA Engineering (EA Engineering, Science, and Technology). 1994. The fluvial geomorphology of the lower McKenzie River. Prepared for Eugene Water and Electric Board. August.

Ecotrust. 2000. Rock and Richardson Creek watershed assessment. Report to the Clackamas Basin Watershed Council. Ecotrust, Portland, Oregon.

EES (EES Consulting). 2004. Regional water providers consortium – RWSP source options update. Final report. EES Consulting, Bellingham, Washington.

Eggers, R. 2002. USBR Willamette Basin Project water marketing program summary, updated. Letter to Colonel R. Butler, U.S. Army Corps of Engineers, from R. Eggers, U.S. Bureau of Reclamation.

Elliot, D.G., R.J. Pascho. 1994. Juvenile fish transportation: impact of bacterial kidney disease on survival of spring/summer Chinook salmon stocks, 1992. Prepared for the U.S. Army Corps of Engineers by the Northwest Biological Science Center, National Biological Survey, Seattle, Washington.

Elliott D.G., R.J. Pascho, L.M. Jackson, G.M. Mathews, and J.R. Harmon. 1997. *Renibacterium salmoninarum* in spring-summer Chinook salmon smolts at dams on the Columbia and Snake River. Aquatic Animal Health 9:114-126.

Ely, C. 1981. Wild trout inventory, 1979 Northwest Region. Oregon Department of Fish and Wildlife, Portland.

Embody, G. C. 1934. Relation of temperature to the incubation period of eggs of four species of trout. Trans. Am. Fish. Soc. 64:281-292.

Emmett, R. L., S. L. Stone, S.A. Hinton, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries, volume II: species life history summaries. National Oceanic and Atmospheric Administration, National Ocean Service ELMR Report No. 8, Rockville, Maryland.

Enhancement Planning Team. 1986. Salmon and steelhead enhancement plan for the Washington and Columbia River conservation area, volume 1. Preliminary review draft.

Enright, C, M. Aoki, D. Oetter, D. Hulse, and W. Cohen. 2002. Land use/land cover ca. 1990. pp. 78- 82. In Willamette River basin planning atlas. Hulse, D., S. V. Gregory, and J. Baker [Eds.] for the Pacific Northwest Ecosystem Research Consortium. Oregon State University Press, Corvallis.

EPA (Environmental Protection Agency). 1999. A review of synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids with special reference to Chinook salmon. EPA, Region 10, Seattle, Washington.

EPA (Environmental Protection Agency). 2003a. Guidance for Pacific Northwest state and tribal water quality standards. EPA, Region 10, Seattle, Washington.

EPA (Environmental Protection Agency). 2003b. Managing Nonpoint Source Pollution from Agriculture. Nonpoint Source Control Branch. Washington D.C.

EPA (Environmental Protection Agency). 2003c. Types of Pesticides. May 27. Washington D.C.

EPA (Environmental Protection Agency). 2008. EPA's Report on the Environment (Final Report). ROE Indicators. EPA, Region 10, Seattle, Washington.

Erickson, A. W. 1978. Population studies of killer whales (*Orcinus orca*) in the Pacific Northwest: a radio-marking and tracking study of killer whales. U.S. Marine Mammal Commission, Washington, D.C.

Everest, F.H., G.H. Reeves, J.R. Sedell, D.B. Hohler, and T. Cain. 1987. The effects of habitat enhancement on steelhead trout and coho salmon smolt production, habitat utilization, and habitat availability in Fish Creek, Oregon, 1983-86. Annual report to the Bonneville Power Administration, Portland, Oregon.

Fausch, K.D. 1984. Profitable stream position for salmonids: relating specific growth rate to net energy gain. Canadian Journal of Zoology 62: 441-451.

Federal Security Agency. 1951. Public Health Service, Division of Water Pollution Control, Pacific Northwest Drainage Basins. Federal Security Agency, Public Health Service. Water Pollution Series, No. 6.

FERC (Federal Energy Regulatory Commission). 2006. Final Environmental Impact Statement for the Clackamas River Hydroelectric Project Clackamas County, Oregon (FERC Project No. 2195). FERC, Washington, D.C.

FERC (Federal Energy Regulatory Commission). 1996. Final Environmental Impact Statement of the Leaburg-Walterville Hydroelectric Project (FERC Project No. 2496), Oregon. FERC, Washington, D.C.

Fernauld, A.G., P.J. Wigington, and D.H. Landers. 2001. Transient storage and hyporheic flow along the Willamette River, Oregon: Field measurements and model estimates. Water Resources Research 37: 1681-1694.

Fierke, M.K. 2002. Composition, structure, and biomass of cottonwood-dominated gallery forests along a successional gradient, Willamette River, Oregon. Master's thesis, Oregon State University, Corvallis, Oregon.

Firman, J., M. Buckman, R. Schroeder, and K. Kenaston. 2005. Work completed for compliance with the Biological Opinion for hatchery programs in the Willamette Basin, USACE funding: 2004. Task Order: NWP-OP-FH-02-01. Oregon Department of Fish and Wildlife, Corvallis.

Firman, J., R. Schroeder, R. Lindsay, K. Kenaston, and M. Hoganson. 2004. Work completed for compliance with the Biological Opinion for Hatchery Programs in the Willamette Basin, USACE funding: 2003. Task Order: NWP-OP-FH-02-01. Oregon Department of Fish and Wildlife, Corvallis.

Fish, F.F. and R.A. Wagner. 1950. Oxygen block in the mainstem Willamette River. Special Scientific Report: Fisheries No. 41. U.S. Fish and Wildlife Service, Washington, D.C.

Flagg, T.A. and C.E. Nash (editors). 1999. A Conceptual Framework for Conservation Hatchery Strategies for Pacific Salmonids. U.S. Dept. of Commerce. NOAA Tech. Memo. NMFS-NWFSC-38, pp. 54.

Flagg, T.A., F.W. Waknitz, D.J. Maynard, G.B Milner, and C.V.W. Mahnken. 1995. The effect of hatcheries on native coho salmon populations in the lower Columbia River. Proceedings of the of the American Fisheries Society Symposium 15:366-375.

Fleming, I.A. and M.R. Gross. 1993. Breeding success of hatchery and wild *coho salmon*. Ecological Applications 3(2):230-245.

Fletcher, D.H., F. Haw, and P.K. Bergman. 1987. Retention of coded-wire tags implanted into cheek musculature of largemouth bass. North American Journal of Fisheries Management 7:436-469.

Fodrea, K.A. 2007. Question on Willamette Power. Communication to S. Burchfield, National Marine Fisheries Service, from K. Fodrea, Bonneville Power Administration, Portland, Oregon. June 7.

Fonda, R. W. 1974. Forest succession in relation to river terrace development in Olympic National Park, Washington. Ecology 55(5): 927-942.

Foote, A.D., R.W. Osborne, and A.R. Hoelzel. 2004. Whale-call response to masking boat noise. Nature 428:910.

Ford, J.K.B, G.M. Ellis. 2005. Prey selection and food sharing by fish-eating 'resident' killer whales (*Orcinus orca*) in British Columbia. Fisheries and Oceans Canada, Nanaimo, British Columbia.

Ford, J.K.B. and G.M. Ellis. 2006. Selective foraging by fish-eating killer whales Orcinus orca in British Columbia. Marine Ecology Progress Series 316:185-199.

Ford, J.K.B., and G.M. Ellis. 1999. Transients: mammal-hunting killer whales of British Columbia, Washington, and southeastern Alaska. UBC Press, Vancouver, British Columbia

Ford, J.K.B., G.M. Ellis, and K.C. Balcomb. 2000. Killer whales: the natural history and genealogy of Orcinus orca in British Columbia and Washington State, 2nd edition. UBC Press, Vancouver, British Columbia.

Ford, J.K.B., G.M. Ellis, and P.F. Olesiuk. 2005. Linking prey and population dynamics: did food limitation cause recent declines of 'resident' killer whales *(Orcinus orca)* in British Columbia? Fisheries and Oceans Canada, Nanaimo, British Columbia.

Ford, J.K.B., G.M. Ellis, L.G. Barrett-Lennard, A.B. Morton, R.S. Palm, and K.C. Balcomb. 1998. Dietary specialization in two sympatric populations of killer whales (*Orcinus orca*) in coastal British Columbia and adjacent waters. Canadian Journal of Zoology 76:1456-1471

Fox, D.S., S. Bell, W. Nehlsen, J. Damron, and E. Krebill. 1984. The Columbia River estuary atlas of physical and biological characteristics. Columbia River Estuary Data Development Program, Portland, Oregon.

FPC (Fish Passage Center). 1992. Fish Passage Center 1991 annual report. FPC, Portland, Oregon.

Franklin, J.F. and C.T. Dyrness. 1973. Natural vegetation of Oregon and Washington. USDA Forest Service General Technical Report PNW-8. U.S. Department of Agriculture, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. 417 p.

Fresh, K.L., E. Casillas, L.L. Johnson, and D.L. Bottom. 2005. Role of the estuary in the recovery of Columbia River Basin salmon and steelhead: an evaluation of the effects of selected factors on salmonid population viability. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-69, 105p.

Friedman, J. M., W. R. Osterkamp, M. L. Scott, and G. T. Auble. 1998. Downstream effect of dams on channel geometry and bottomland vegetation: regional patterns in the Great Plains. Wetlands 18(4): 619-633.

Friesen, T.A. 2005. Biology, behavior, and resources of resident and anadromous fish in the lower Willamette River. Final Report of Research, 2000-2004. Report to City of Portland, Bureau of Environmental Services by Oregon Department of Fish and Wildlife, Clackamas.

Friesen, T.A., and D.L. Ward. 1999. Management of northern pikeminnow and implications for juvenile salmonid survival in the lower Columbia and Snake Rivers. North American Journal of Fisheries Management 19:406-420.

Friesen, T.A., J. S. Vile, and A. L. Pribyl. 2007. Outmigration of juvenile Chinook salmon in the Lower Willamette River, Oregon. Northwest Science 81:3

Fujii, B. 2003. Re: water availability in the Santiam River system. Communication to R. Domingue, National Marine Fisheries Service, from B. Fuji, Oregon Water Resources Department, Salem.

Fulton, L. A. 1970. Spawning areas and abundance of Steelhead Trout and Cohp, Sockeye and Chum Salmon in the Columbia River Basin– past and present. U.S. Fish and Wildlife Service. Spec. Sci. Rep. Fish. 618. Washington D.C. December.

Fulton, L.A. 1968. Spawning areas and abundance of Chinook salmon, *Oncorhynchus tshawytscha*, in the Columbia River basin – past and present. U.S. Fish and Wildlife Service, Special Science Report on Fisheries 571:26.

Gall, G.A.E. 1993. Genetic change in hatchery populations. Pages 81-92 in J.G. Cloud and G.H. Thorogaard, editors. Genetic Conservation of Salmonid Fishes. Plenum Press, New York.

Geraci, J.R. 1990. Physiologic and toxic effects on cetaceans. Pages 167-198 *in* J.R. Geraci and D.J. St. Aubin, editors. Sea mammals and oil: confronting the risks. Academic Press, New York.

Gharrett, A.J. and S.M. Shirley. 1985. A genetic examination of spawning methods in a salmon hatchery. Aquaculture 47:245-256.

Giorgi, A.E., T. W. Hillman, J. R. Stevenson, S. G. Hays and C. M. Peven. 1997. Factors that influence the downstream migration rates of juvenile salmon and steelhead through the hydroelectric system in the Mid-Columbia River Basin. North American Journal of Fisheries Management 17:268-282.

Gomez and Sullivan. 2001. Supplemental analysis for hydrologic study, supplemental report No. 2. Technical memorandum prepared for Portland General Electric and the Clackamas Fish and Aquatic Workgroup.

Good, T.P. and J.C. Fabbri. 2002. Catastrophic risk assessment of Lower Columbia River and Willamette River ESUs for endangered and threatened Pacific salmon. Appendix L. in McElhany et al. (Eds.) Willamette/Lower Columbia Pacific salmonid viability criteria. Interim report on viability criteria for Willamette and Lower Columbia basin Pacific salmonids. Willamette/Lower Columbia Technical Recovery Team (W/LC TRT). Northwest Fisheries Science Center, Seattle, WA.

Good, T.P., R.S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Dept. Commerce, NOAA Tech. Memo., NMFS-NWFSC-66.

Grant, G. E., S. L. Lewis, and P. Kast. 2002. Sediment mass balance for Cougar Reservoir sediment releases. Prepared for the U.S. Army Corps of Engineers by U.S. Department of Agriculture, Pacific Northwest Research Station, and Oregon State University, Corvallis.

Grant, G.E., A. Jefferson, and S. Lewis. 2004. Discharge, source areas, and water ages of spring-fed streams and implications for water management in the McKenzie River Basin. Report to Eugene Water and Electric Board, Eugene, Oregon.

Grant, S.W. (editor). 1997. Genetic effects of straying of non-native hatchery fish into natural populations: Proceedings of the workshop. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-30, 130p.

Gregory, R. S. 1993. Effect of turbidity on the predator avoidance behavior of juvenile chinook salmon (*Oncorhynchus tshawytcha*). Canadian Journal of Fisheries and Aquatic Sciences 50:241-246.

Gregory, R. S., and C. D. Levings. 1998. Turbidity reduces predation on migrating juvenile Pacific salmon. Transactions of the American Fisheries Society 127: 275-285.

Gregory, S. V., F. J. Swanson, W. A. McKee, and K. W. Cummins. 1991. An ecosystem perspective of riparian zones. BioScience 41(8): 540-551.

Gregory, S., L. Ashkenas, and C. Nygaard. 2007. Environmental flows workshop for the Middle Fork and Coast Fork of the Willamette River, Oregon. Summary report. Institute for Water Resources and Watersheds, Oregon State University, Corvallis.

Gregory, S., L. Ashkenas, D. Oetter, P. Minear, K. Wildman, J. Christy, S. Kolar, E. Alverson. 2002. Pre-settlement vegetation ca. 1851 Pages 38-39 *In* Hulse, D., S. V. Gregory, and J. Baker [Eds.], Willamette River basin planning atlas. Prepared for the Pacific Northwest Ecosystem Research Consortium. Oregon State University Press, Corvallis, Oregon.

Gresh, T., J. Lichatowich, and P. Schoonmaker. 2000. An estimation of historic and current levels of salmon production in the northeast Pacific ecosystem: Evidence of a nutrient deficit in the freshwater ecosystems of the Pacific Northwest. Fisheries 25(1):15-21.

Grette, G. B. 1985. The abundance and role of large organic debris in juvenile salmonid habitat in streams in second growth and unlogged forests. Master's Thesis. University of Washington, Seattle.

Grimaldo, L. and S. Zeug. 2001. IEP Resident Fish Project Work Team hosts meeting on green sturgeon. IEP Newsletter 14(4):19-32

Hansen, R.P. and M.D. Crumrine. 1991. The effects of multipurpose reservoirs on the water temperature of the North and South Santiam Rivers, Oregon. U.S. Geological Survey, Water-Resources Investigations Report 91-4007.

Hanson, M.B. 2008. Southern Resident killer whales data requests for biological opinion. Communication to A. Agness, National Marine Fisheries Service, from M.B. Hanson, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. February 26.

Hanson, M.B., R.W. Baird, C. Emmons, J. Hempelmann, G.S. Schorr, and D.Van Doornik. 2007. Stock identification of prey selected by "southern resident" killer whales in their summer range. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, and Cascadia Research Collective, Olympia, Washington.

Hard, J.J., R.P. Jones, Jr., M.R. Delarm, and R.S. Waples. 1992. Pacific salmon and artificial propagation under the Endangered Species Act. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-2, 56p.

Hare, S.R., N.J. Mantua, and R.C. Francis. 1999. Inverse production regimes: Alaska and West Coast pacific salmon. Fisheries 24(1):6-14.

Hargreaves, N.B. and R.J. LaBrasseur. 1986. Size selectivity of coho (*Oncorhynchus kisutch*) preying on juvenile chum salmon (*O. keta*). Canadian Journal of Fisheries and Aquatic Sciences 43:581-586.

Hartl, D.L. and A.G. Clark. 1989. Principles of population genetics, second edition. Sinauer Associates, Sutherland, Massachusetts.

Hastein, T. and T. Lindstad. 1991. Diseases in wild and cultured salmon: possible interaction. Aquaculture 98:277-288.

Hawkins, S. 1998. Residual hatchery smolt impact study: wild fall Chinook mortality 1995-97. Columbia River Progress Report #98-8. Washington Department of Fish and Wildlife, Olympia.

Hawkins, S. and J.M. Tipping. 1998. Predation by juvenile hatchery salmonids on wild fall Chinook salmon fry in the Lewis River, Washington. Washington Department of Fish and Wildlife, Olympia.

Healey, M. C. 1991. The life history of Chinook salmon (*Oncorhynchus tshawytscha).* Pages 311-393 *In* C. Groot and L. Margolis, editors. Life history of Pacific salmon. University of British Columbia Press, Vancouver, B.C.

Healey, M.C. 1982. Juvenile Pacific salmon in estuaries: the life support system. Pages 343-364 *in* V. S. Kennedy, editor. Estuarine Comparisons, Academic Press, New York.

Hevlin, W. and S. Rainey. 1993. Considerations in the use of adult fish barriers and traps in tributaries to achieve management objectives. Pages 33-40 *in* K. Bates, editor. Fish passage policy and technology, proceedings of a symposium. American Fisheries Society, Bioengineering Section, Portland, Oregon.

Hilderbrand, G. V., T. A. Hanley, C. T. Robbins, and C. C. Schwartz. 1999. Role of brown bears (*Ursus arctos*) in the flow of marine nitrogen into a terrestrial ecosystem. Oecologia 121:546-550.

Hillman, T.W. and J.W. Mullan. 1989. Effect of hatchery releases on the abundance of wild juvenile salmonids. *In* Summer and winter ecology of juvenile Chinook salmon and steelhead trout in the Wenatchee River, Washington. Report to Chelan County PUD by D.W. Chapman Consultants, Boise, Idaho.

Hindar, K., N. Ryman, and F. Utter. 1991. Genetic effects of cultured fish on natural fish populations. Canadian Journal of Fisheries and Aquatic Sciences 48:945-957.

Hockersmith, E.E., W.D. Muir, S.G. Smith, B.P. Sandford, N.S. Adams, J.M. Plumb, R.W. Perry, D.W. Rondorf. 2000. Comparative performance of sham radio tagged and PIT-tagged juvenile salmon. Prepared for the U.S. Army Corps of Engineers, by the National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Hollender, B.A. and R.F. Carline. 1994. Injury to wild brook trout by backpack electrofishing. North American Journal of Fisheries Management 14:643-649.

Homolka, K. and T.W. Downey. 1995. Assessment of thermal effects on salmon spawning and fry emergence, Upper McKenzie River, 1992. Information Reports Number 95-4. Oregon Department of Fish and Wildlife, Portland.

Hooton, R.S. 1987. Catch and release as a management strategy for steelhead in British Columbia. *In* R. Barnhart and T. Roelofs, editors. Proceedings of Catch and Release Fishing: a Decade of Experience, a National Sport Fishing Symposium. Humboldt State University, Arcata, California.

Horner, N.J. 1978. Survival, densities and behavior of salmonid fry in stream in relation to fish predation. Master’s Thesis, University of Idaho, Moscow.

Howe, N.R. and P.R. Hoyt. 1982. Mortality of juvenile brown shrimp *Penaeus aztecus* associated with streamer tags. Transactions of the American Fisheries Society 111:317-325.

Howell, P., K. Jones, D. Scarnecchia, and L. LaVoy. 1985. Stock assessment of Columbia River anadromous salmonids, Volume I: Chinook, coho, chum, and sockeye salmon summaries. Final report. Bonneville Power Administration, Portland, Oregon.

HSRG (Hatchery Scientific Review Group). 2004. Hatchery reform: principles and recommendations of the Hatchery Scientific Review Group. HSRG, Seattle, Washington.

HSRG (Hatchery Scientific Review Group). 2008. Columbia River Chinook Salmon hatchery analysis. Draft report. HSRG, Seattle, Washington.

Hubbard, L.E., T.A. Herrett, J.E. Poole, and G.P. Ruppert. 1997. Water resources data; Oregon; water year 1996. U.S. Geological Survey. Water Data Report OR-96-1.

Hubbard, L.E., T.A. Herrett, J.E. Poole, G.P. Ruppert, and M.L. Courts. 1996. Water resources data: Oregon, water year 1995. U.S. Geological Survey. Water Data Report OR-95-1.

Hughes, R.M. and J.R. Gammon. 1987. Longitudinal changes in fish assemblages and water quality in the Willamette River, Oregon. Transactions of the American Fisheries Society 116:196-209.

Hulett, P.L., C.W. Wagemann, and S.A. Leider. 1996. Studies of hatchery and wild steelhead in the lower Columbia region. Progress report for fiscal year 1995. Fish Management Program Report RAD 96-01, Washington Department of Fish and Wildlife, Olympia.

Hulse D. (editor). 1998. Willamette River Basin: a planning atlas. Version 1.0. The Institute for a Sustainable Environment, University of Oregon, Eugene.

Hulse, D., S.V. Gregory, and J. Baker, editors. 2002. Willamette River Basin: a planning atlas. Prepared for the Pacific Northwest Ecosystem Research Consortium by Oregon State University Press, Corvallis.

Hunter, M.A. 1992. Hydropower Flow Fluctuations and Salmonids: A Review of the Biological Effects, Mechanical Causes, and Options for Mitigation. Washington Department of Fisheries.

Huntington, C.W. 2000. A supplemental assessment of the Mohawk watershed. Consultant report to the Mohawk Watershed Partnership by Clearwater BioStudies, Canby, Oregon.

Hutchison, J.M., K.E. Thompson, and G.J. Hattan. 1966b. Number and distribution of steelhead trout spawning in the Willamette Basin. Oregon State Game Commission, Portland,

Hutchison, J.M., K.E. Thompson, and J.D. Fortune, Jr. 1966a. Basin investigations: Upper Willamette Basin. The fish and wildlife resources of the Upper Willamette Basin, Oregon, and their requirements. Oregon State Game Commission, Portland, Oregon.

Hyde, N. A., A. Chawla, A. Baptista, and J. Zhang. 2004. Columbia River habitat opportunity: sensitivity to river discharge. Draft. Center for Coastal and Land-Margin Research, Oregon Health Sciences University, Portland.

ICTRT (Interior Columbia Basin Technical Recovery Team). 2003. Independent populations of Chinook, steelhead, and sockeye for listed Evolutionarily Significant Units within the Interior Columbia River Domain. Working draft. National Marine Fisheries Service, Northwest Fisheries Science Center, ICTRT, Seattle, Washington.

ICTRT (Interior Columbia Technical Recovery Team). 2007. Viability criteria for application to interior Columbia Basin salmonid ESUs. Review draft.

IHOT (Integrated Hatchery Operations Team). 1995. Policy and procedures for Columbia Basin anadromous salmonid hatcheries. Annual report 1994 to the Bonneville Power Administration, Portland, Oregon.

IMST (Independent Multidisciplinary Science Team). 1998. Pinniped and seabird predation: implications for recovery of threatened stocks of salmonids in Oregon under the Oregon Plan for Salmon and Watersheds. Technical Report 1998-2 to the Oregon Plan for Salmon and Watersheds. Governor's Natural Resources Office, Salem, Oregon.

Ingram, P. and L. Korn. 1969. Evaluation of fish passage facilities at Cougar Dam on the South Fork McKenzie River in Oregon. Fish Commission of Oregon, Research Division, Portland.

ISAB (Independent Scientific Advisory Board). 2007. Climate change impacts on Columbia River basin fish and wildlife. ISAB, Report 2007-2, Portland, Oregon.

ISG (The Independent Scientific Group). 1996. Return to the river: restoration of salmonid fishes in the Columbia River ecosystem. Development of an alternative conceptual foundation and review and synthesis of science underlying the Fish and Wildlife Program of the Northwest Power Planning Council. Northwest Power Planning Council, Portland, Oregon.

Israel, J.A. and B. May. 2007. Mixed stock analysis of green sturgeon from Washington State coastal aggregations. Final report. Genomic Variation Laboratory, Department of Animal Science, University of California, Davis

Jay, D. A. 2002. Optimization of FCRPS impacts on juvenile salmonids: Restoration of lower-estuary and plume habitats. Proposal. BPA Project No. 30002. Submitted to the Northwest Power Planning Council's Fish and Wildlife Program for FY 2003 by Oregon Health & Science University, Portland.

Jay, D. A., K. Leffler and T. Kukulka. 2004. Summer shallow-water habitat in the Skamokawa-Beaver Reach under the reference vs. proposed flow regimes. Prepared for the National Marine Fisheries Service by the Department of Environmental and Biomolecular Systems, OGI School of Science and Engineering, Oregon Health and Science University.

Jenkins, W.E. and T.I.J. Smith. 1990. Use of PIT tags to individually identify striped bass and red drum brood stocks. Pages 341-345 *in* N. C. Parker, A.E. Giorgi, R.C. Heidinger, D.B. Jester, Jr., E.D. Prince, and G.A. Winans, editors. Fish-marking techniques. American Fisheries Society, Symposium 7, Bethesda, Maryland.

JISAO (Joint Institute for the Study of Atmosphere and Ocean). 2008. The Pacific Decadal Oscillation (PDO). Website maintained by University of Washington, Seattle, Washington.

Johannessen, C. L., W. A. Davenport, A. Millet, and S. McWilliams. 1970. The vegetation of the Willamette Valley. Annals of the American Society of Geographers 61:286-302.

Johnson, D.B. and S. Sprague. 1996. Preliminary monitoring and evaluation results for coho salmon outplanted in the Clearwater River subbasin, Idaho, 1995. Nez Perce Tribe Department of Fisheries Resources Management, Lapwai, Idaho.

Johnson, O. W., et al. 1999. Status review of cutthroat trout from Washington, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-37.

Johnston, J.M. 1967. Food and feeding habits of juvenile coho salmon and steelhead trout in Worthy Creek, Washington. Master's thesis, University of Washington, Seattle.

Jonasson, B.C., R.C. Carmichael, and T.A Whitesel. 1994. Lower Snake River Compensation Plan -- Residual steelhead characteristics and potential interactions with spring Chinook salmon in northeast Oregon. 1994 annual progress report. Oregon Department of Fish and Wildlife, Fish Research Project, Portland.

Jonasson, B.C., R.C. Carmichael, and T.A Whitesel. 1995. Lower Snake River compensation plan -- residual steelhead characteristics and potential interactions with spring Chinook salmon in northeast Oregon. 1995 annual progress report. Oregon Department of Fish and Wildlife, Portland.

Jonasson, B.C., R.C. Carmichael, and T.A. Whitesel. 1996. Lower Snake River compensation plan -- residual hatchery steelhead: characteristics and potential interactions with spring Chinook salmon in northeast Oregon. 1996 annual progress report. Oregon Department of Fish and Wildlife, Portland.

Joyce, J., A.C. Wertheimer, and J.F. Thedinga. 1998. Effects of four generations of domestication on predator avoidance, growth in captivity and predation success in a stock of SE Alaska salmon. Page 112 *in* Ecosystem considerations in fisheries management. American Fisheries Society symposium, Anchorage, Alaska.

Juanes, F. 1994. What determines prey size selectivity in piscivorous fishes? Pages 79-100 *in* D.J. Stouder, K.L. Fresh, and R.J. Feller, editors. Theory and application in fish feeding ecology. University of South Carolina Press, Columbia.

Junk, W. J., P. B. Bayley, and R. E. Sparks. 1989. The flood pulse concept in river-floodplain systems, p. 110-127. In: D. P. Dodge [Ed.], Proceedings of the International Large River Symposium (LARS), Toronto, Ontario, September 14-21, 1986. Canadian Special Publication of Fisheries and Aquatic Sciences.

Kamler, J.F., and K.L. Pope. 2001. Non-lethal methods of examining fish stomach contents. Reviews in Fisheries Science 9(1):1-11.

Kapuscinski, A.R. 1997. Rehabilitation of Pacific salmon in their ecosystems: what can artificial propagation contribute? *In* D.J. Stouder, D.A. Bisson, and R.J. Naiman, editors. Pacific salmon and their ecosystems, status and future options. Chapman and Hall, New York.

Kapuscinski, A.R., and L.M. Miller. 1993. Genetic hatchery guidelines for the Yakima/Klickitat Fisheries Project. Co-Aqua, St. Paul, Minnesota.

Keller, E. A. and F. J. Swanson. 1979. Effects of large organic material on channel form and fluvial processes. Earth Surface Processes 4: 361-380.

Keller, K. 2006. Evaluate spawning of fall Chinook and chum salmon below the four lowermost Columbia River mainstem dams: 2005 Columbia River chum salmon return. 2005-2006 annual report. Prepared for Bonneville Power Administration, Portland, Oregon.

Kenaston, K. 2003. Talk from AFS on rearing and migration of McKenzie spring chinook Communication to L. Krasnow, National Marine Fisheries Service, from K. Kenaston, Oregon Department of Fish and Wildlife, Corvallis. February 28.

Kenaston, K.R., R.B. Linsay, and R.K. Schroeder. 2001. Effect of acclimation on the homing and survival of hatchery winter steelhead. North American Journal of Fisheries Management 21:765-773.

Kendra, W. 1991. Quality of salmonid hatchery effluents during a summer low-flow season. Transactions of the American Fisheries Society. 120:43-51.

Kern, C. 2006. Fisheries Management and Evaluation Plan for 2006 Willamette River Spring Chinook. Oregon Department of Fish and Wildlife, Ocean Salmon and Columbia River Program, Columbia River Management, Clackamas.

Klingeman, P. C. 1979. Willamette River sediment management possibilities: Phase I – problem clarification. Project Completion Report OWRT- Oregon Cooperative Program. Water Resources Research Institute, Oregon State University, Corvallis.

Klingeman, P. C. 1973. Indications of streambed degradation in the Willamette Valley. Water Resources Research Institute, Oregon State University, Corvallis.

Knutsen, C.J. and D. L. Ward. 1991. Behavior of juvenile salmonids migrating through the Willamette River near Portland, Oregon. Oregon Department of Fish and Wildlife, Fish Division Information, Portland.

Kohlhorst, D.W. 1979. Effect of first pectoral fin ray removal on survival and estimated harvest rate of white sturgeon in the Sacramento-San Joaquin estuary. California Fish and Game 65:173-177.

Kondolf, G.M. and P.R. Wilcock. 1996. The flushing flow problem: defining and evaluating objectives. Water Resources Research 32(8):2589-2599.

Kostow, K. (Ed.) 1995. Biennial report on the status of wild fish in Oregon. Oregon Department of Fish and Wildlife, Portland, Oregon. 217 p.

Kostow, K.E., A.R. Marshall, and S.R. Phelps. 2003. Naturally spawning hatchery steelhead contribute to smolt production but experience low reproductive success. Transactions of the American Fisheries Society 132:780-790.

Krahn, M.M., M.B. Hanson, R.W. Baird, R.H. Boyer, D.G. Burrows, C.K. Emmons, J.K.B. Ford, L.L. Jones, D.P. Noren, P.S. Ross, G.S. Schorr, and T.K. Collier. 2007. Persistent organic pollutants and stable isotopes in biopsy samples (2004/2006) from Southern Resident killer whales. Marine Pollution Bulletin 54:1903-1911.

Krahn, M.M., M.J. Ford, W.F. Perrin, P.R. Wade, R.B. Angliss, M.B. Hanson, B.L. Taylor, G.M. Ylitalo, M.E. Dahlheim, J.E. Stein, and R.S. Waples. 2004. 2004 status review of Southern Resident killer whales (*Orincus orca*) under the Endangered Species Act, U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-62, 73 pp.

Krahn, M.M., P.R. Wade, S.T. Kalinowski, M.E. Dahlheim, B.L. Taylor, M.B. Hanson, G.M. Ylitalo, R.B. Angliss, J.E. Stein, and R.S. Waples. 2002. Status review of Southern Resident killer whales (*Orcinus orca*) under the Endangered Species Act, U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-54, 133p.

Krasnow, L. 2001. Adult winter steelhead at Foster Dam. Communication B. Hooten from L. Krasnow, National Marine Fisheries Service, Portland, Oregon. July 27.

Kruse, S. 1991. The interactions between killer whales and boats in Johnstone Strait, B.C. Pages 149-159 *in* K. Pryor and K.S. Norris, editors. Dolphin societies: discoveries and puzzles. University of California Press, Berkley.

Kruzic, L. 2008. Spreadsheet for killer whale analysis. Attachment: Spreadsheet "Killer whale assessment." Communication to L. Krasnow, National Marine Fisheries Service, from L. Kruzic, National Marine Fisheries Service. Portland, Oregon. June 20.

Landers, D., A. Fernald, and C. Andrus. Off-channel Habitats, p. 26 and 27 *In* Hulse, D., S. V. Gregory, and J. Baker [Eds.] 2002. Willamette River basin planning atlas. Prepared for the Pacific Northwest Ecosystem Research Consortium. Oregon State University Press, Corvallis, Oregon.

Larson, D. 2000. Spawning migration movements and emigration through Hills Creek Dam of spring Chinook salmon (*Oncorhynchus tshawytscha*) in the Upper Middle Fork Willamette River, Lane County, Oregon. U.S. Forest Service, Middle Fork Ranger District, Oakridge, Oregon.

LCFRB (Lower Columbia Fish Recovery Board). 2004. Lower Columbia salmon recovery and fish and wildlife subbasin plan. Volume 1. LCFRB, Longview, Washington.

Leider, S.A., P.L. Hulett, J.J. Loch, and M.W. Chilcote. 1990. Electrophoretic comparison of the reproductive success of naturally spawning transplanted and wild steelhead trout through the returning adult stage. Aquaculture 88: 239-252.

Leinkaemper, G. W. and F. J. Swanson. 1987. Dynamics of large woody debris in old-growth Douglas-fir forests. Canadian Journal of Forest Research 17: 150-156.

Leopold, L. B., M. G. Wolman, and J. P. Miller. 1964. Fluvial processes in Geomorphology. Dover Publications, Mineola, New York. 522 pp.

Levings, C. D., C. D. McAllister, and B. D. Chang. 1986. Differential use of the Campbell River estuary, British Columbia, by wild and hatchery-reared juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences. 43: 1386-1397.

Levy, D. A. and T. G. Northcote. 1982. Juvenile salmon residency in a marsh area of the Fraser River estuary. Canadian Journal of Fisheries and Aquatic Sciences 39:270-276.

LGMSC (Lower Granite Migration Study Steering Committee). 1993. Research plan to determine timing, location, magnitude and cause of mortality for wild and hatchery spring/summer Chinook salmon smolts above Lower Granite Dam. Report prepared for Bonneville Power Administration, Portland, Oregon. .

Light, R.W., P.H. Adler, and D.E. Arnold. 1983. Evaluation of gastric lavage for stomach analyses. North American Journal of Fisheries Management 3:81-85.

Ligon, F. K., W. E. Dietrich, and W. J. Trush. 1995. Downstream ecological effects of dams: a geomorphic perspective. Bioscience 45:183-192.

Lindsay, R. B., R. K. Schroeder, and K. R. Kenaston. 1999. Annual progress report. Spring Chinook salmon in the Willamette and Sandy Rivers. October 1997 through September 1998. Oregon Department of Fish and Wildlife, Portland.

Lindsay, R.B., K.R. Kenaston, and R.K. Schroeder. 2001. Reducing Impacts of Hatchery Steelhead Programs. January 2001. Oregon Department of Fish and Wildlife. Final Report of Project F-120-R. Portland, Oregon

Lindsay, R.B., R.K. Schroeder, and K.R. Kenaston. 2000. Spring Chinook salmon in the Willamette and Sandy Rivers. October 1999 through September 2000. Annual progress report. Oregon Department of Fish and Wildlife, Portland.

Lindsay, R.B., R.K. Schroeder, and K.R. Kenaston. 2004. Hooking mortality by anatomical location and its use in estimating mortality of spring Chinook salmon caught and released in a river sport fishery. North American Journal of Fisheries Management 24:367-378.

Lister, D.B. and H.S. Genoe. 1970. Stream habitat utilization by cohabiting underyearlings of Chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon in the Big Qualicum River, British Columbia. Journal of the Fisheries Research Board of Canada 27:1215-1224.

Lloyd, D. S. 1987. Turbidity as a water quality standard for salmonid habitats in Alaska. North American Journal of Fisheries Management 7:34-45.

Lloyd, D. S., J. P. Koenings, and J. D. LaPerriere. 1987. Effects of turbidity in fresh waters of Alaska. North American Journal of Fisheries Management 7:18-33.

Lyons, J. K. and R. L. Beschta. 1983. Land use, floods, and channel changes: Upper Middle Fork Willamette River, Oregon (1936-1980). Water Resources Research 19(2):463-471.

Maher, M. T., M. Sheer, A. Steel, and P. McElhany. 2005. Atlas of salmon and steelhead habitat in the Oregon Lower Columbia and Willamette Basins. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Mahoney, J. M. and S. B. Rood. 1998. Streamflow requirements for cottonwood seedling recruitment- an integrative model. Wetlands 18(4): 634-645.

Mamoyac, S, M. Buckman, and E. Tinus. 2000. Biological and technical justification for the Willamette River flow proposal of the Oregon Department of Fish and Wildlife, Oregon Department of Fish and Wildlife, Portland.

Mamoyac, S. and J. Ziller. 2001. Releasing spring Chinook above USACE dams. Intra-Department memorandum to C. Wheaton ODFW, Salem. October 29.

Mantua, N.J. and S.R. Hare. 2002. The Pacific decadal oscillation. Journal of Oceanography 58:35-44

Massey, J.B. 1967. The downstream migration of juvenile anadromous fish at Willamette Falls, Oregon. Progress report. Oregon State Game Commission, Columbia River Fishery Development Program, Portland, Oregon.

Materna, E. 2001. Environmental Protection Agency. Issue Paper 4. Temperature Interaction. Prepared as Part of EPA Region 10 Temperature Water Quality Criteria Guidance Development Project. May. EPA-910-D-01-004.

Matthews, K.R., and R.H. Reavis. 1990. Underwater tagging and visual recapture as a technique for studying movement patterns of rockfish. Pages 168– 172 *in* N.C. Parker, A.E. Giorgi, R.C. Heidinger, D.B. Jester, Jr., E.D. Prince, and G.A. Winans, editors. Fish-marking techniques. American Fisheries Society, Symposium 7, Bethesda, Maryland.

Mattson, C.R. 1948. Spawning ground studies of Willamette River spring Chinook salmon. Research Briefs of the Oregon Fish Commission 1(2):21-32.

Mattson, C.R. 1962. Early life history of Willamette River spring Chinook salmon. Oregon Fish Commission, Portland, Oregon.

Mattson, C.R. 1963. An investigation of adult spring Chinook salmon for the Willamette River system, 1946-51. Oregon Fish Commission, Portland.

McBain & Trush (McBain and Trush, Inc.). 2004. Synthesis of geomorphic, vegetation, and instream flow studies, Oak Grove Fork Project, Oak Grove Fork and Clackamas River upstream from North Fork Reservoir. Consultant report to Portland General Electric Company by McBain & Trush, Arcata, California.

McBride, J. R. and J. Strahan. 1984. Establishment and survival of woody riparian species on gravel bars of an intermittent stream. The American Midland Naturalist 112(2): 235-245.

McCabe, G.T., Jr., R.L. Emmett, W.D. Muir, and T.H. Blahm. 1986. Utilization of the Columbia River estuary by subyearling Chinook salmon. Northwest Science 60: 113-124.

McClure, M., T. Cooney, and Interior Columbia Technical Recovery Team. 2005. Updated population delineation in the interior Columbia Basin. Memorandum to NMFS NW Regional Office, Co-managers and other interested parties from McClure et al., Interior Columbia Technical Recovery Team.

McCullough, D.A., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Summary of technical literature examining the physiological effects of temperature on salmonids. EPA-910-D-01-005. Environmental Protection Agency, Region 10, Seattle, Washington. May.

McElhany, P., M. Chilcote, J. Myers, and R. Beamesderfer. 2007. Viability status of Oregon salmon and steelhead populations in the Willamette and Lower Columbia Basins. Prepared for Oregon Department of Fish and Wildlife and National Marine Fisheries Service. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-42, 156p.

McIntosh, B.L., S.E. Clarke, and J.R. Sedell. 1995. Summary report for Bureau of Fisheries stream habitat surveys: Willamette River Basin, 1934-1942. Prepared for Bonneville Power Administration, Portland, Oregon.

McLain, J. 2006. The likely distribution of the southern distinct population segment of North American green sturgeon in SWR Waters. Memorandum to the southern distinct population segment of North American green sturgeon consultation guidance from J. McLain, National Marine Fisheries Service, Sacramento, California. December 18.

McLaughlin, L. K. Schroeder, and K. Kenaston. 2008. Interim Activities for Monitoring Impacts Associated with Hatchery Programs in the Willamette Basin, USACE funding: 2007. NWPOD-07-FH-02. January. Oregon Department of Fish and Wildlife, Salem.

McLeay, D. J., G. L. Ennis, I. K. Birtwell, and G. F. Hartman. 1984. Effects on arctic grayling (*Thymallus arcticus*) of prolonged exposure to Yukon placer mining sediment: a laboratory study. Canadian Technical Report of Fisheries and Aquatic Sciences 1241.

McMichael, G.A. 1993. Examination of electrofishing injury and short-term mortality in hatchery rainbow trout. North American Journal of Fisheries Management 13:229-233.

McMichael, G.A., L. Fritts, and T.N. Pearsons. 1998. Electrofishing injury to stream salmonids; injury assessment at the sample, reach, and stream scales. North American Journal of Fisheries Management 18:894-904

McMillen Engineering. 2005. South Willamette Valley fish facilities improvements report. McMillen Engineering, Bellingham, Washington.

McNeil, F.I. and E.J. Crossman. 1979. Fin clips in the evaluation of stocking programs for muskellunge (*Esox masquinongy*). Transactions of the American Fisheries Society 108(4):335-343.

Mears, H.C. and R.W. Hatch. 1976. Overwinter survival of fingerling brook trout with single and multiple fin clips. Transactions of the American Fisheries Society 105(6):669-674.

Meehan, W.R. and T.C. Bjornn. 1991. Salmonid distributions and their life histories. Pages 47-82 in D. R. Meehan (editor). Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19. Bethesda, Maryland.

Meehan, W.R., and R.A. Miller. 1978. Stomach flushing: effectiveness and influence on survival and condition of juvenile salmonids. Journal of the Fisheries Research Board of Canada 35:1359- 1363.

Mellas, E.J. and J.M. Haynes. 1985. Swimming performance and behavior of rainbow trout (*Salmo gairdneri*) and white perch (*Morone americana*): effects of attaching telemetry transmitters. Canadian Journal of Fisheries and Aquatic Sciences 42:488-493.

Merritt, R. W. and K. W. Cummins [Eds.] 1978. An introduction to the aquatic insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa. 862 pp.

Metcalfe, N.B., F.A. Huntington, and J.E. Thorpe. 1986. Seasonal changes in feeding motivation of juvenile Atlantic salmon (*Salmo salar*). Canadian Journal of Zoology 64: 2439-2446.

MFWWC (Middle Fork Willamette Watershed Council). 2002. Lower Middle Fork Willamette River watershed assessment. www.mfwwc.org., Oregon.

Minear, P. J. 1994. Historical change in channel form and riparian vegetation of the McKenzie River, Oregon. Master's thesis. Oregon State University, Corvallis.

Minobe, S. 1997. A 50-70 year climatic oscillation over the North Pacific and North America. Geophysical Research Letters 24(6):683-686.

Mitro, M.G., A.V. Zale, and B.A. Rich. 2003. The relation between age-0 rainbow trout (*Oncorhynchus mykiss*) abundance and winter discharge in a regulated river. Canadian Journal of Fishery and Aquatic Sciences 60: 135-139.

Moberly, E.R. 2008. Mosby Creek summary report, spring chinook salmon enhancement project, 2006 – 2007. Oregon Department of Fish and Wildlife, Springfield.

Mobrand, L.E., J. Barr, L. Blankenship, D.E. Campton, T.T.P. Evelyn, T.A. Flagg, C.V.W. Mahnken, L.W. Seeb, P.R. Seidel, and W.W. Smoker. 2005. Hatchery reform in Washington State: Principles and emerging issues. American Fisheries Society. Fisheries June: 11-23.

Moffatt, R.L., R.E. Wellman, and J M. Gordon. 1990. Statistical summaries of streamflow data in Oregon. Volume 1: monthly and annual streamflow, and flow-duration values. U.S. Geological Survey Open-File Report 90-118.

Mongillo, P.E. 1984. A summary of salmonid hooking mortality. Washington Department of Game, Olympia.

Monk, B.H., E. Dawley, and K. Beiningen. 1975. Concentration of dissolved gases in the Willamette, Cowlitz, and Boise rivers, 1970-72. NMFS Data Report 102. National Marine Fisheries Service, Seattle, Washington.

Montgomery, D. R. and J. M. Buffington. 1998. Channel processes, classification, and response. pp. 13- 41 In River Ecology and Management: Lessons from the Pacific Coastal Ecoregion. Naiman, R. J. and R. E. Bilby [Eds.]. Springer-Verlag, New York, New York.

Montgomery, D. R., J. M. Buffington, R. D. Smith, K. M. Schmidt, and G. R. Pess. 1995. Pool spacing in forest channels. Water Resources Research 31: 1097-1105.

Moring, J.R. 1975. Catchable rainbow trout evaluation. Annual progress report, Project F-94-R. Oregon Department of Fish and Wildlife, Salem.

Moring, J.R. 1990. Marking and tagging intertidal fishes: review of techniques. Pages 109 -116 *in* N.C. Parker, A.E. Giorgi, R.C. Heidinger, D.B. Jester, Jr., E.D. Prince, and G.A. Winans, editors. Fish-marking techniques. American Fisheries Society, Symposium 7, Bethesda, Maryland.

Morrison, J. and D. Zajac. 1987. Histologic effect of coded wire tagging in chum salmon. North American Journal of Fisheries Management 7:439-441.

Moser, M. and S. Lindley. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology of Fishes 79:243-253

Mundi, J.H. 1969. Ecological implications of the diet of juvenile coho in streams, p. 135-152. In: T.G. Northcote (Ed.). Symposium on salmon and trout in streams. H.R. MacMillan Lectures in Fisheries. Institute of Fisheries, University of British Columbia, Vancouver, B.C. In Healy, M.C. 1991. Life history of chinook salmon (*Oncorhynchus tshawytscha*), pp. 311-393. In: C. Groot and L. Margolis. Pacific salmon life histories. UBC Press, Vancouver, British Columbia.

Mundy, P.R. 1997. The role of harvest management in the future of Pacific salmon populations: shaping human behavior to enable the persistence of salmon. *In* D.J. Stouder, P.A. Bisson, and R.J. Naiman, editors. Pacific salmon and their ecosystems: status and future options. Chapman and Hall.

Murray, C.B. and J.D. McPhail. 1988. Effect of incubation temperature on the development of five species of Pacific salmon (*Oncorhynchus*) embryos and alevins. Canadian Journal of Zoology 66:266-273.

Murtaugh, T., R. Rohrer, M. Gray, E. Olsen, T. Rein, and J. Massey. 1992. Clackamas Subbasin fish management plan. Oregon Department of Fish and Wildlife, Portland.

MWC (McKenzie Watershed Council). 1996. Technical plan for water quality and fish and wildlife habitat. Prepared by Lane Council of Governments, Oregon.

Myers, J. M., R. G. Kope, G. Bryant, et al. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. NOAA Tech. Memo., NMFS-NWFSC-35. 443 p.

Myers, J., C. Busack, D. Rawding, A. Marshall, D. Teel, D. M. Van Doornik, and M. T. Maher. 2006. Historical population structure of Pacific salmonids in the Willamette River and lower Columbia River basins. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-73.

Myers, J., C. Busack, D. Rawding, and A. Marshall. 2002. Relationships between historical demographically independent and present day Chinook salmon and steelhead populations in the Lower Columbia River and Upper Willamette River. Appendix C in Identifying historical populations of Chinook and chum salmon and steelhead within the Lower Columbia River and Upper Willamette River Evolutionarily Significant Units. Willamette/Lower Columbia Technical Recovery Team.

Myers, J., C. Busack, D. Rawding, and A. Marshall. 2003. Historical population structure of Willamette and Lower Columbia River Basin Pacific salmonids. Willamette/Lower Columbia Technical Recovery Team Report.

Myers, K.W. and H.F. Horton. 1982. Temporal use of an Oregon estuary by hatchery and juvenile wild salmon. Pages 388-392 *in* V. S. Kennedy, editor. Estuarine Comparisons, Academic Press, New York.

Naiman, R. J. and H. Decamps. 1997. The ecology of interfaces: riparian zones. Annual Review of Ecology and Systematics 28: 621-658.

Naiman, R. J. and J. R Sedell. 1979. Benthic organic matter as a function of stream order in Oregon. Archiv fur Hydrobiologie 87:404-422.

Nakamura, F. and F. J. Swanson. 1993. Effects of coarse woody debris on morphology and sediment storage of a mountain stream in Western Oregon. Earth Surface Processes and Landforms 18: 43-61.

Nanson, G. C. and H. F. Beach. 1977. Forest succession and sedimentation on a meandering-river floodplain, northeast British Columbia, Canada. Journal of Biogeography 4: 229-251.

Narum, S.R., M.S. Powell, R. Everson, B. Sharp, and A.J. Talbot. 2006. Microsatellites reveal population structure of Klickitat River native steelhead and genetic divergence from an introduced stock. North American Journal of Fisheries Management 26:147-155.

Nash, W. 1904. The settler's handbook to Oregon. J. K. Gill Co., Portland, Oregon.

NCSU (North Carolina State University). 2008. NCSU Water Quality Group. Watersheds Glossary.

Nelson, K. and M. Soule. 1987. Genetical conservation of exploited fishes. Pages 345-368 *in* N. Ryman and F. Utter, editors. Population genetics and fishery management. University of Washington Press, Seattle.

NFHRP (National Fish Hatchery Review Panel). 1994. Report of the National Fish Hatchery Review Panel. The Conservation Fund, Arlington, Virginia.

Nicholas, J. 1995. Status of Willamette spring-run Chinook salmon relative to Federal Endangered Species Act. Report to the National Marine Fisheries Service by the Oregon Department of Fish and Wildlife, Salem.

Nickelson, T.A. 2003. The influence of hatchery coho salmon (*Oncorhynchus kisutch*) on the productivity of wild coho salmon populations in Oregon coastal basins. Canadian Journal of Fisheries and Aquatic Sciences 60:1050-1056.

Nickum, M.J., P.M. Mazik, J.G. Nickum, and D.D. MacKinlay, editors. 2004. Propagated fish in resource management. American Fisheries Society, Symposium 44, American Fisheries Society, Bethesda, Maryland.

Nicola, S.J. and A.J. Cordone. 1973. Effects of fin removal on survival and growth of rainbow trout *(Salmon gairdneri*) in a natural environment. Transactions of the American Fisheries Society 102(4):753-759.

Nielsen, L.A. 1992. Methods of marking fish and shellfish. Special Publication 23. American Fisheries Society, Bethesda, Maryland.

Nilsson, C., A. Ekblad, M. Gardfjell, and B. Carlberg. 1991. Long-term effects of river regulation on river margin vegetation. Journal of Applied Ecology 28: 963-987.

Nilsson, N.A. 1967. Interactive segregation in fish species. Pages 295-313 *in* S.D. Gerking, editor. The biological basis of freshwater fish production. Blackwell Scientific, Oxford.

NMFS (National Marine Fisheries Service), USFWS (U.S. Fish and Wildlife Service), ODFW (Oregon Department of Fish and Wildlife). 1984. Letter from NMFS, USFWS, and ODFW to Col. Friedenwald, USACE, regarding temperature and flow guidelines to be used by the Corps of Engineers (Corps) for modeling reservoir operations in the Willamette Basin and their effects on river systems downstream.

NMFS (National Marine Fisheries Service). 1993. Designated critical habitat; Snake River sockeye salmon, Snake River spring/summer Chinook salmon, and Snake River fall Chinook salmon. Final rule. Federal Register 58 (28 December): 68543-68554.

NMFS (National Marine Fisheries Service). 1995a. Proposed recovery plan for Snake River Salmon. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 1995b. Biological Opinion for 1995 to 1998 Hatchery Operations in the Columbia River Basin. April 5, 1995. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 1997. Endangered and threatened species; listing of several Evolutionarily Significant Units (ESUs) of West Coast steelhead. Final rule. Federal Register 62 (18 August):43937-43954.

NMFS (National Marine Fisheries Service). 1998. Factors contributing to the decline of Chinook salmon: An addendum to the 1996 west coast steelhead factors for decline report. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 1999a. Endangered and threatened species; threatened status for three Chinook salmon evolutionarily significant units (ESUs) in Washington and Oregon, and endangered status for one Chinook salmon ESU in Washington. Federal Register 64:56(24 March 1999):14307-14328.

NMFS (National Marine Fisheries Service). 1999b. Endangered and threatened species: threatened status for two ESUs of chum salmon in Washington and Oregon, for two ESUs of steelhead in Washington and Oregon, and for Ozette Lake sockeye salmon in Washington. Rules. Federal Register 64:57(25 March 1999):14508-14517.

NMFS (National Marine Fisheries Service). 1999c. Designated critical habitat; revision of critical habitat for Snake River spring/summer Chinook salmon. Final rule. Federal Register 64:205(25 October 1999):57399-57403.

NMFS (National Marine Fisheries Service). 1999d. Interim standards for the use of captive propagation technology in recovery of anadromous salmonids listed under the Endangered Species Act. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 1999e. Endangered Species Act – Section 7 biological opinion on artificial propagation in the Columbia River Basin. Incidental take of listed salmon and steelhead from federal and non-federal hatchery programs that collect, rear and release unlisted fish species. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 1999f. Endangered and threatened wildlife and plants: Definitions of "harm." Final rule. Federal Register 64(8 November 1999):60727.

NMFS (National Marine Fisheries Service). 1999g. Endangered Species Act -Section 7 consultation biological and conference opinion on approval of Oregon water quality standards for dissolved oxygen, temperature, and pH. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2000a. Endangered Species Act - Section 7 Consultation and Biological Opinion on the impacts from collection, rearing, and release of salmonids associated with artificial propagation programs in the Upper Willamette River spring Chinook and winter steelhead evolutionarily significant units. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2000b. Endangered Species Act - Section 7 Consultation Biological Opinion - reinitiation of consultation on operation of the Federal Columbia River Power System (FCRPS), including the juvenile fish transportation program, and 19 Bureau of Reclamation projects in the Columbia Basin. Issued December 21, 2000. NMFS, Northwest Region. Seattle, Washington.

NMFS (National Marine Fisheries Service). 2000c. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service) and USFWS (U.S. Fish and Wildlife Service). 2000. Endangered Species Act - Section 7 Consultation and Biological Opinion on the effects of Cougar Reservoir Temperature Control Project on the Willamette River Chinook salmon, its critical habitat, bull trout, northern spotted owl, and its critical habitat. NMFS, Northwest Region, and USFWS, Pacific Region, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2001. Potential impacts of toxic contaminants in salmonids and prey from the Columbia River estuary, draft. NMFS, Northwest Fisheries Science Center, Seattle, Washington.

NMFS (National Marine Fisheries Service) and USFWS (U.S. Fish and Wildlife Service). 2001. Endangered Species Act – Section 7 Consultation Biological Opinion on the effects of relicensing EWEB's Leaburg-Walterville Hydroelectric Project in the McKenzie Subbasin, Oregon. NMFS and USFWS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2002. Effects of elevated turbidity from water temperature control construction at Cougar Dam on Upper Willamette River Chinook salmon. Letter to G. Miller, U.S. Army Corps of Engineers, from B. J. Brown, NMFS, Portland.

NMFS (National Marine Fisheries Service). 2003a. Endangered Species Act - Section 7 Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Consultation on Bull Run Hydroelectric Project. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2003b. Endangered Species Act - Section 7 Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for Mill Race Screen and Waller Dam Ladder Project, Mill Creek, North Santiam and Upper Willamette River Basins. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2003c. Endangered Species Act -Section 7 Consultation Biological Opinion on interim operation of the North Fork (FERC No. 2195) and Oak Grove (FERC No. 135) Hydroelectric Projects through 2006. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2003d. Endangered Species Act - Section 7 Consultation Biological Opinion and Magnuson-Stevens Act Essential Fish Habitat Consultation on: 1) Issuance of an incidental take statement (ITS) to the USFWS; 2) Issuance of an ITS to the BPA and the Confederated Tribes and Bands of the Yakama Nation (Yakama Nation); and 3) Issuance of permit 1347 jointly to the Washington Department of Fish and Wildlife (WDFW), the Public Utility District No. 1 of Chelan County (Chelan PUD), and the Public Utility District No. 1 of Douglas County (Douglas PUD). NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2003e. Final programmatic Environmental Impact Statement for Pacific salmon fisheries management off the coasts of Southeast Alaska, Washington, Oregon, and California, and in the Columbia River. NMFS, Northwest Region, Seattle, Washington.

NMFS (National Marine Fisheries Service). 2003f. Regulations governing the taking and importing of marine mammals; Eastern North Pacific Southern Resident killer whales. Federal Register 68:103(29 May 2003):31980-31983.

NMFS (National Marine Fisheries Service). 2004a. Endangered Species Act -Section 7 Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Consultation on operation of the Cowlitz River Hydroelectric Project through 2038. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2004b. Salmon hatchery inventory and effects evaluation report: an evaluation of the effects of artificial propagation on the status and likelihood of extinction of West Coast salmon and steelhead under the Federal Endangered Species Act. U.S. Dept. of Commerce, Tech. Memo., NMFS-NWR/SWR, 557p.

NMFS (National Marine Fisheries Service) 2005a. Policy on the consideration of hatchery-origin fish in Endangered Species Act listing determinations for Pacific salmon and steelhead. Federal Register 70:123(28 June 2005):37204-37216.

NMFS (National Marine Fisheries Service). 2005b. Application of the "destruction or adverse modification" standard under Section 7(a)(2) of the Endangered Species Act. Memorandum to Regional Administrators from W. Hogarth, NMFS, Silver Spring, Maryland. November 7.

NMFS (National Marine Fisheries Service). 2005c. Endangered and threatened species; final listing determinations for 16 evolutionarily significant units of West Coast salmon, and final 4(d) protective regulations for threatened salmonid ESUs. Final rule. Federal Register 70:123(28 June 2005):37160-37204.

NMFS (National Marine Fisheries Service). 2005d. Endangered and threatened species; designation of critical habitat for 12 evolutionarily significant units of West Coast salmon and steelhead in Washington, Oregon, and Idaho. Final rule. Federal Register 70 (2 September): 52630.

NMFS (National Marine Fisheries Service). 2005e. Endangered and threatened wildlife and plants: endangered status for Southern Resident killer whales. Federal Register 70:222(18 November 2005):69903-69912.

NMFS (National Marine Fisheries Service). 2005f. Endangered Species Act – Section 7 Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Consultation on the effects of operating PacifiCorp's Powerdale Hydroelectric Project through 2010 and decommissioning the project in 2012. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2005g. Final assessment of NOAA Fisheries' Critical Habitat Analytical Review Teams for 12 evolutionarily significant units of West Coast salmon and steelhead. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2005h. Endangered Species Act -Section 7 Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the City of Molalla Wastewater Outfall Project on the Molalla River (HUC# 170900090607), Clackamas County, Oregon (Corps No.: 200400864). NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2006a. Columbia River Hatchery Reform Project: progress report. NMFS, Northwest Region, Seattle, Washington.

NMFS (National Marine Fisheries Service). 2006b. Endangered and threatened species: final listing determinations for 10 distinct population segments of West Coast Steelhead. Final rule. Federal Register 71:3(5 January 2006):834-862.

NMFS (National Marine Fisheries Service). 2006c. Endangered and threatened wildlife and plants: threatened status for Southern distinct population segment of North American Green Sturgeon. Federal Register 71:67(7 April 2006):17757-17766.

NMFS (National Marine Fisheries Service). 2006d. Endangered and threatened species; designation of critical habitat for Southern Resident killer whale. Federal Register 71:229(29 November 2006):69054-69070

NMFS (National Marine Fisheries Service). 2006e. Endangered Species Act – Section 7 Biological Opinion on interim operations, decommissioning, and removal of the Condit Dam (FERC No. 2342), White Salmon River, Washington. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2006f. Specification of broodstock and outplanting programs and protocols. Letter to Sue Knapp, Oregon Department of Fish and Wildlife and Randy Bailey, U.S. Army Corps of Engineers, from R. Jones, NMFS, Portland, Oregon. May 15.

NMFS (National Marine Fisheries Service). 2006g. Endangered and threatened species; designation of critical habitat for the Southern Resident killer whale. Federal Register 71:115(15 June 2006):34571-34586.

NMFS (National Marine Fisheries Service). 2006h. Endangered Species Act - Section 7 Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act and Essential Fish Habitat Consultation on the issuance of Section 10(a)(1)(a) ESA Permits to conduct scientific research on the Southern Resident killer whale (*Orcinus orca*) distinct population segment and other endangered and threatened species. NMFS, Northwest Region, Seattle, Washington.

NMFS (National Marine Fisheries Service). 2006i. Endangered Species Act - Section 7 Consultation Biological Opinion on the effects of the 2006 Pacific coast salmon plan on the Southern Resident killer whale (*Orcinus orca*) distinct population segment. NMFS, Northwest Region, Seattle, Washington.

NMFS (National Marine Fisheries Service). 2007a. Endangered Species Act - Section 7 Consultation and Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Consultation on construction and operation of the Army Corps of Engineers fish trap at Cougar Dam. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2007b. Endangered Species Act - Biological Opinion and Magnuson Stevens Fishery Conservation Act Consultation. Operation of PacifiCorp and Cowlitz PUD's Lewis River Hydroelectric Projects for 50 years from the new licenses issued dates. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2007c. Columbia River estuary ESA recovery plan module for salmon and steelhead. Proposed plan. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2008a. Endangered Species Act – Section 7 Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Consultation: consultation on remand for operation of the Federal Columbia River Power System and 19 Bureau of Reclamation Projects in the Columbia Basin. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2008b. Supplemental comprehensive analysis of the Federal Columbia River Power System and mainstem effects of USBR Upper Snake and other tributary actions. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2008c. Endangered Species Act - Section 7 Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation on Treaty Indian Tribes and non-Indian fisheries in the Columbia River Basin subject to the 2008-2017 US v. Oregon Management Agreement. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2008d. Endangered Species Act -Section 7 Formal Programmatic Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the implementation of the Bonneville Power Administration Habitat Improvement Program in Oregon, Washington, and Idaho, CY2007-CY2012 (HIPII). NMFS, Seattle, Washington.

NMFS (National Marine Fisheries Service). 2008e. Anadromous salmonid passage facility design. NMFS, Northwest Region, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2008f. Endangered Species Act - Section 7 Formal and Informal Programmatic Opinion & Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation Revisions to Standard Local Operating Procedures for Endangered Species to Administer Stream Restoration and Fish Passage Improvement Activities Authorized or Carried Out by the U.S. Army Corps of Engineers in the Oregon (SLOPES IV Restoration). NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2008g. Recovery plan for Southern Resident killer whales (*Orcinus orca*). NMFS, Northwest Region, Seattle, Washington.

NMFS (National Marine Fisheries Service). 2008h. Endangered Species Act – Section 7 Consultation Biological Opinion on the effects of the 2008 Pacific Coast Salmon Plan Fisheries on the Southern Resident Killer Whale (*Orcinus orca*) distinct population segment and their critical habitat. NMFS, Seattle, Washington.

NMFS (National Marine Fisheries Service). 2008i. Effects of the Pacific Coast salmon plan during the 2008-2009 annual regulatory cycle on the Southern Resident Killer Whale (*Orcinus orca*) distinct population segment. NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2008j. Chinook prey availability and biological requirements in Coastal Range of Southern Residents, re: Supplemental Comprehensive Analysis of Southern Resident killer whales. Memorandum to D.R. Lohn, NMFS, from D.D. Darm, NMFS, Northwest Region, Seattle, Washington. April 11.

NMFS (National Marine Fisheries Service). 2008k. Endangered and threatened species; recovery plans; final recovery plan for Southern Resident killer whales. Federal Register 73:16(24 January 2008):4176-4177.

NMFS (National Marine Fisheries Service). 2008l. Endangered Species Act - Section 7 Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish habitat Consultation on the re-issuance of regional general permit 3, authorizing 23 maintenance activities in Suisun Marsh, Solano County, California. NMFS, Southwest Region, Long Beach, California.

NOAA (National Oceanic and Atmospheric Administration). 2008. Time-series MEI conditions form 1950 through November 2007. NOAA, Physical Sciences Division, Earth System Research Laboratory, Boulder, Colorado.

Norman, S.A., C.E. Bowlby, M.S. Brancato, J. Calambokidis, D. Duffield, P.J. Gearin, T.A. Gornall, M.E. Gosho, B. Hanson, J. Hodder, S.J. Jeffries, B. Lagerquist, D.M. Lanbourn, B. Mate, B. Norberg, R.W. Osborne, J.A. Rash, S. Riemer, and J. Scordino. 2004. Cetacean strandings in Oregon and Washington between 1930 and 2002. Journal of Cetacean Research and Management 6(1):87-99.

NPPC (Northwest Power Planning Council). 1999. Artificial production review. NPPC, Portland, Oregon.

NRC (National Research Council). 1995. Making ESA decisions in the face of uncertainty. Pages 148-178 *in* Science and the Endangered Species Act. National Academy Press, Washington, D.C.

NRC (National Research Council). 1996. Upstream: salmon and society in the Pacific Northwest. National Academy Press, Washington, D.C.

NRC (National Research Council). 2003. Sources of sound in the ocean and long-term trends in ocean noise. Pages 27-82 *in* Ocean noise and marine mammals. National Academy Press, Washington, D.C.

NRCS (Natural Resources Conservation Service). 2005a. Final 8-digit hydrologic unit profile: South Santiam – 17090006. U.S. Department of Agriculture, NRCS, Washington, D.C.

NRCS (National Resource Conservation Service). 2005b. Molalla/Pudding 17090009 8-Digit Hydrologic Unit Profile. U.S. Department of Agriculture, NRCS, Washington, D.C.

NRCS (Natural Resources Conservation Service). 2005c. Final 8-digit hydrologic unit profile: Clackamas – 17090011. U.S. Department of Agriculture, NRCS, Washington, D.C.

NRCS (National Resource Conservation Service). 2006a. Middle Fork Willamette 17090001 8-Digit Hydrologic Unit Profile. U.S. Department of Agriculture, NRCS, Washington, D.C.

NRCS (National Resource Conservation Service). 2006b. McKenzie River 17090001 8-Digit Hydrologic Unit Profile. U.S. Department of Agriculture, NRCS, Washington, D.C.

NRCS (Natural Resources Conservation Service). 2006c. Final 8-digit hydrologic unit profile: North Santiam – 17090005. U.S. Department of Agriculture, NRCS, Washington, D.C.

ODEQ (Oregon Department of Environmental Quality). 1995. Dissolved Oxygen: 1992-1994 water quality standards review. ODEQ, Portland.

ODEQ (Oregon Department of Environmental Quality). 2002. Oregon's 2002 integrated report and CWA 303(d) List database. ODEQ Laboratory Division, Portland.

ODEQ (Oregon Department of Environmental Quality). 2006a. Willamette Basin TMDL. ODEQ, Portland.

ODEQ (Oregon Department of Environmental Quality). 2006b. 2004/2006 Integrated Water Quality Report. ODEQ, Laboratory Division, Portland.

ODEQ (Oregon Department of Environmental Quality). 2007. Guidance for assessing bioaccumulative chemicals of concern in sediment. ODEQ, Portland.

ODEQ (Oregon Department of Environmental Quality). 2008. Water Quality Standards: Beneficial Uses, Policies, and Criteria for Oregon. ODEQ, Portland.

ODFW (Oregon Department of Fish and Wildlife). 1985. Lost Creek Dam fisheries evaluation phase I completion report, volume II. Anticipated changes in production and harvest of spring Chinook under different water releases and fish management strategies. ODFW, Salem.

ODFW (Oregon Department of Fish and Wildlife). 1986. Steelhead management plan 1986-1992. ODFW, Portland.

ODFW (Oregon Department of Fish and Wildlife). 1987. Rogue Basin fisheries evaluation. Effects of Lost Creek Dam on spring Chinook salmon in the Rogue River, Oregon: an update. ODFW, Salem.

ODFW (Oregon Department of Fish and Wildlife). 1990a. Middle Fork Willamette River, Willamette River subbasin salmon and steelhead production plan. Columbia Basin System Planning. ODFW, Portland.

ODFW (Oregon Department of Fish and Wildlife). 1990b. Santiam and Calapooia Rivers, Willamette River Subbasin salmon and steelhead production plan. ODFW, Portland.

ODFW (Oregon Department of Fish and Wildlife). 1990c. Coast Fork and Long Tom Rivers, Willamette River subbasin salmon and steelhead production plan, Columbia basin system planning. ODFW, Portland.

ODFW (Oregon Department of Fish and Wildlife). 1990d. Willamette River subbasin salmon and steelhead production plan. Columbia Basin System Planning, ODFW, Portland.

ODFW (Oregon Department of Fish and Wildlife) and WDFW (Washington Department of Fish and Wildlife). 1998. Status report: Columbia fish runs and fisheries 1938-1997. ODFW, Portland.

ODFW (Oregon Department of Fish and Wildlife). 2000a. Rogue Basin fisheries evaluation. Effects of Lost Creek Dam on spring Chinook salmon in the Rogue River. Phase II completion report, volume I. ODFW, Portland.

ODFW (Oregon Department of Fish and Wildlife). 2000b. Oregon guidelines for timing of in-water work to protect fish and wildlife resources. ODFW, Portland.

ODFW (Oregon Department of Fish and Wildlife). 2001a. Fisheries management and evaluation plan: Upper Willamette River spring Chinook in freshwater fisheries of the Willamette Basin and Lower Columbia River Mainstem. ODFW, Portland.

ODFW (Oregon Department of Fish and Wildlife). 2001b. Fisheries Management and Evaluation Plan: Willamette River Winter Steelhead in Sport Fisheries of the Upper Willamette Basin and Lower Columbia River Mainstem. ODFW, Portland.

ODFW (Oregon Department of Fish and Wildlife). 2002. Winter Steelhead Forecast 2002, news release. ODFW, Salem, Oregon.

ODFW (Oregon Department of Fish and Wildlife). 2003. Middle Fork Willamette spring Chinook HGMP. Oregon Department of Fish and Wildlife, Salem.

ODFW (Oregon Department of Fish and Wildlife). 2004a. Upper Willamette Steelhead HGMP 2004. Upper Willamette Summer Steelhead (Stock 24). ODFW, Salem.

ODFW (Oregon Department of Fish and Wildlife). 2004b. Thompson's Mill flow and habitat assessment project: final report for OWEB Grant #201-625B. ODFW, Corvallis.

ODFW (Oregon Department of Fish and Wildlife). 2005a. Upper Willamette Trout HGMP 2005. Upper Willamette Hatchery Rainbow Trout Program (Cape Cod Stock 72). ODFW, Salem.

ODFW (Oregon Department of Fish and Wildlife). 2005b. 2005 Oregon native fish status report, volume 1. ODFW, Salem.

ODFW (Oregon Department of Fish and Wildlife). 2007a. Middle Fork Willamette Chinook HGMP 2007. Middle Fork Willamette Spring Chinook (Stock 22). ODFW, Salem.

ODFW (Oregon Department of Fish and Wildlife). 2007b. Upper Willamette Chinook and steelhead recovery plan. Draft. ODFW, Corvallis.

ODFW (Oregon Department of Fish and Wildlife). 2008a. North Santiam Chinook HGMP 2008. North Santiam River spring Chinook (Stock 21). ODFW, Salem.

ODFW (Oregon Department of Fish and Wildlife). 2008b. South Santiam Chinook HGMP 2008. South Santiam River Spring Chinook (Stock 24). ODFW, Salem.

ODFW (Oregon Department of Fish and Wildlife). 2008c. Fisheries management and evaluation for 2007 Willamette River spring Chinook. ODFW, Ocean Salmon and Columbia River Program, Clackamas.

ODFW (Oregon Department of Fish and Wildlife). 2008d. 2008 Oregon sport fishing regulations. ODFW, Salem.

Olesiuk, P.F., G.M. Ellis, and J.K.B. Ford. 2005. Life history and population dynamics of Northern Resident killer whales (*Orcinus orca*) in British Columbia. Fisheries and Oceans Canada, Nanaimo, British Columbia.12:209-244.

Olesiuk, P.F., M.A. Bigg, and G.M. Ellis. 1990. Life history and population dynamics of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Report of the International Whaling Community (special issue).

Olla, B.L., M.W. Davis, and C.H. Ryer. 1998. Understanding how the hatchery environment represses or promotes the development of behavioral survival skills. Bulletin of Marine Science 62:531-550.

Olsen, E., P. Pierce, M. McLean, and K. Hatch. 1992. Stock summary reports for Columbia River anadromous salmonids, volume I: Oregon. Bonneville Power Administration, Portland, Oregon.

O'Neill, S., G. Ylitalo, M. Krahn, J. West, J. Bolton, and D. Brown. 2005. Elevated levels of persistent organic pollutants in Puget Sound salmon: the importance of residency in Puget Sound. PowerPoint presentation.

Osborne, R.W. 1999. A historical ecology of Salish Sea "resident" killer whales *(Orcinus orca)*: with implications for management. Doctoral dissertation. University of Victoria, Victoria, British Columbia.

OWRD (Oregon Water Resources Department). 1999. Willamette Basin reservoir summaries. OWRD, Salem.

OWRD (Oregon Water Resources Department). 2003. Water Right Inventory System data base query. OWRD, Salem, Oregon.

OWRD (Oregon Water Resources Department). 2008. Water availability tables from the Water Availability Report System (WARS). June. OWRD, Salem.

OWRRI (Oregon Water Resources Research Institute). 1995. Gravel disturbance impacts on salmon habitat and stream health: a report for the Oregon Division of State Lands, volumes I and II. Oregon State University, Corvallis.

Park, J.G. And L.R. Curtis. 1997. Mercury distribution in sediments and bioaccumulation by fish in two Oregon reservoirs: point-source and nonpoint-source impacted systems. Archive of Environmental Contaminants and Toxicolology 33:423-429.

Parkhurst, Z.E., F.C. Bryant, and R.S. Nielson. 1950. Survey of the Columbia River and its tributaries. Part 3 (Area 2). U.S. Fish and Wildlife Service Special Scientific Report - Fisheries No. 36.

Partridge, F.E. 1985. Effects of steelhead smolt size on residualism and adult return rates. U.S. Fish and Wildlife Service, Lower Snake River Compensation Plan. Contract No. 14-16-001-83605. Idaho Department of Fish and Game, Boise.

PCSRF (Pacific Coastal Salmon Recovery Fund). 2006. Report to Congress: Pacific Coastal Salmon Recovery Fund FY 2000-2006. National Marine Fisheries Service, Seattle, Washington.

Pearcy, W.G. 1992. Ocean ecology of North Pacific salmonids. Washington Sea Grant Program. University of Washington Press, Seattle.

Pearsons, T. N., and A. L. Fritts. 1999. Maximum size of Chinook salmon consumed by juvenile coho salmon. North American Journal of Fisheries Management 19:165-170.

Pearsons, T.N., G.A. McMichael, S.W. Martin, E.L. Bartrand, M. Fischer, and S.A. Leider. 1994. Yakima River species interaction studies - annual report 1993. Bonneville Power Administration, Portland, Oregon.

Peltz, L. and J. Miller. 1990. Performance of half-length coded wire tags in a pink salmon hatchery marking program. Pages 244-252 *in* N.C. Parker, A.E. Giorgi, R.C. Heidinger, D.B. Jester, Jr., E.D. Prince, and G.A. Winans, editors. Fish-marking techniques. American Fisheries Society, Symposium 7, Bethesda, Maryland.

Perkins, W.A., and M.C. Richmond. 2001. Long-term, one-dimensional simulation of lower Snake River temperatures for current and unimpounded conditions. Prepared for the U.S. Department of Energy by the Pacific Northwest National Laboratory, Richland, Washington.

Peterson, G.R. 1966. The relation of invertebrate drift abundance to the standing crop of benthic organisms in a small stream. Master's thesis, University of British Columbia, Vancouver.

Pettit, S.W. 1977. Comparative reproductive success of caught-and-released and unplayed hatchery female steelhead trout (*Salmo gairdneri*) from the Clearwater River, Idaho. Transactions of American Fisheries Society 106(5):431-435.

PFMC (Pacific Fishery Management Council). 1999. Amendment 14 to the Pacific Coast Salmon Plan. Appendix A: description and identification of essential fish habitat, adverse impacts and recommended conservation measures for salmon. PFMC, Portland, Oregon.

PFMC (Pacific Fishery Management Council). 1998a. Final environmental assessment: regulatory review for Amendment 11 to Pacific Coast groundfish fishery management plan. PFMC, Portland, Oregon.

PFMC (Pacific Fishery Management Council). 1998b. Amendment 8 (to the Northern Anchovy Fishery Management Plan) incorporating a name change to coastal pelagic species fishery management plan. PFMC, Portland, Oregon.

PFMC (Pacific Fishery Management Council). 1998c. Essential fish habitat, coastal pelagic species. PFMC, Portland, Oregon.

PFMC (Pacific Fishery Management Council). 2006. Review of 2005 Ocean Salmon Fisheries. (Document prepared for the Council and its advisory entities.) PFMC, Portland, Oregon.

PGE (Portland General Electric). 2004. Settlement agreement, Willamette Falls Hydroelectric Project, FERC No. 2233. PGE, Portland, Oregon.

Phelps, S.R., B.M. Baker, P.L. Hulett, and S.A. Leider. 1994. Genetic analyses of Washington steelhead: initial electrophoretic analysis of wild and hatchery steelhead and rainbow trout. Fisheries Management Program report 94-9. Washington Department of Fish and Wildlife, Olympia, Washington.

Piegay, H., A. Thevenet, and A. Citterio. 1999. Input, storage, and distribution of large woody debris along a mountain river continuum, the Drome River, France. Catena 35: 19-30.

PNERC (Pacific Northwest Ecosystem Research Consortium). 2002. Willamette Valley planning atlas. Oregon State University Press, Corvallis, Oregon

PNFHPC (Pacific Northwest Fish Health Protection Committee). 1989. Model comprehensive fish health protection program. PNFHPC, Olympia, Washington.

Pogue, T.R. and C.W. Anderson. 1995. Processes controlling dissolved oxygen and pH in the Upper Willamette River Basin, Oregon, 1994. U.S. Geological Survey Water-Resources Investigations Report 95-4205.

Polis, G.A. and S.D. Hurd. 1996. Linking marine and terrestrial food webs: *Allochthonous* input from the ocean supports high productivity in small island and coastal land communities. American Naturalist 173(3):396-423.

Portland (City of Portland). 2007. Combined sewer overflow program progress report, January 2007. Portland, Bureau of Environmental Services, Oregon.

Prentice, E.F. and D.L. Park. 1984. A study to determine the biological feasibility of a new fish tagging system. Annual report of research, 1983-1984.

Prentice, E.F., T.A. Flagg, and C.S. McCutcheon. 1987. A study to determine the biological feasibility of a new fish tagging system, 1986-1987. Annual report of research to the Bonneville Power Administration, Portland, Oregon.

Prentice, E.F., T.A. Flagg, and C.S. McCutcheon. 1990. Feasibility of using implantable passive integrated transponder (PIT) tags in salmonids. Pages 317-322 in N.C. Parker, A.E. Giorgi, R.C. Heidinger, D.B. Jester, Jr., E.D. Prince, and G.A. Winans, editors. Fish-marking techniques. American Fisheries Society, Symposium 7, Bethesda, Maryland.

PSC (Pacific Salmon Commission). 2008. 2007 Annual report of catches and escapements, exploitation rate analysis, and model calibration. Joint Chinook Technical Committee.

Pullium, H.R. 1988. Sources, sinks and population regulation. American Naturalist 132:652-661.

Quinn, T.P. 2005. The behavior and ecology of Pacific salmon and trout. American Fisheries Society, Bethesda, Maryland.

R2 Resource Consultants. 2005. Willamette Valley anadromous fish and bull trout habitat assessment. Prepared for the U.S. Army Corps of Engineers by R2 Resource Consultants, Redmond, Washington.

R2 Resource Consultants. 2007. Willamette River Basin habitat assessment data summary report. Draft. Consultant report to the U.S. Army Corps of Engineers by R2 Resource Consultants, Redmond, Washington.

Redding, J. M., C. B. Schreck, and F. H. Everest. 1987. Physiological effects on coho salmon and steelhead of exposure to suspended solids. Transactions of the American Fisheries Society 116: 737-744.

Reeves, G.H., L.E. Benda, K.M. Burnett, P.A. Bisson, and J.R. Sedell. 1995. A disturbance-based ecosystem approach to maintaining and restoring freshwater habitats of evolutionarily significant units of anadromous salmonids in the Pacific Northwest. American Fisheries Society Symposium 17: 334-349.

Reid, L.M. and T. Dunne. 2003. Sediment Budgets as an Organizing Framework in Fluvial Geomorphology. Pages 463-500 *in* G.M. Kondolf and H. Piegay, editors. Tools in Fluvial Geomorphology. John Wiley and Sons, Hoboken, New Jersey.

Reijnders, P.J.H. and A. Aguilar. 2002. Pollution and marine mammals. Pages 948-957 in W.F. Perrin, B. Wursig, and J.G.M. Thewissen, editors. Encyclopedia of marine mammals. Academic press, San Diego, California.

Reimers, P.E. 1973. The length of residence of juvenile fall Chinook salmon in the Sixes River, Oregon, Research Reports of the Fish Commission of Oregon 4:1-43.

Reingold, M. 1975. Effects of displacing, hooking, and releasing on migrating adult steelhead trout. Transactions of the American Fisheries Society 104(3):458-460.

Reisenbichler, R.R. 1997. Genetic factors contributing to declines of anadromous salmonids in the Pacific Northwest. Pages 223-244 *in* D.J. Stouder, P.A. Bisson, and R.J. Naiman, editors. Pacific salmon and their ecosystems: status and future options. Chapman & Hall, New York.

Reisenbichler, R.R. and J.D. McIntyre. 1986. Requirements for integrating natural and artificial production of anadromous salmonids in the Pacific Northwest. Pages 365-374 *in* R.H. Stoud, editor. Fish culture in fisheries management. American Fisheries Society, Bethesda, Maryland.

Reisenbichler, R.R. and S.P. Rubin. 1999. Genetic changes from artificial propagation of Pacific salmon affect the productivity and viability of supplemented populations. ICES Journal of Marine Science 56:459-466.

Reiser, D.W. and R.G. White. 1983. Effects of complete redd dewatering on salmonid egg-hatching success and development of juveniles. Transactions of the American Fisheries Society 112: 532-540.

Rhine, T.D., J.L. Anderson, R.S. Osborne, and P.F. Hassemer. 1997. Length of hatchery steelhead smolts released in Idaho with implications to residualism. Idaho Dept Fish and Game, Boise.

Rieman, B.E., R.C. Beamesderfer, S. Vigg, and T.P. Poe. 1991. Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:448-458.

Rinella, F., and M. Janet. 1998. Seasonal and spatial variation in nutrients and pesticides in streams of the Willamette Basin, Oregon, 1993-1995. Water Resources Investigation Report 97-4082-C. U.S. Geological Survey, Portland, Oregon.

Roby, D.D., D.P. Craig, K. Colis, and S.L. Adamany. 1998. Avian predation on juvenile salmonids in the lower Columbia River. 1997 Annual report. Oregon State University, Corvallis.

Rondorf, D.W. and W.H. Miller. 1994. Identification of the spawning, rearing and migratory requirements of fall Chinook salmon in the Columbia River Basin. Annual report prepared for the Bonneville Power Administration, Portland, Oregon.

Rood, S. B. and J. M. Mahoney. 1990. Collapse of riparian poplar forests downstream from dams in western prairies: probable causes and prospects for mitigation. Environmental Management 14(4): 451-464.

Rood, S. B. and S. Heinze-Milne. 1989. Abrupt downstream forest decline following river damming in southern Alberta. Canadian Journal of Botany 67:1744-1749.

Rosenfeld, C. L. 1985. The region. Pages 41-47 *in* Kimerling, A. J. and P. L. Jackson, editors. Atlas of the Pacific Northwest. Oregon State University Press, Corvallis.

Ross, P.S., G.M. Ellis, M.G. Ikonomou, L.G. Barrett-Lennard, and R.F. Addison. 2000. High PCB concentrations in free-ranging Pacific killer whales, Orcinus orca: effects of age, sex, and dietary preference. Marine Pollution Bulletin 40(6):504-515.

Rounds, S.A. 2007. Temperature effects of point sources, riparian shading, and dam operations on the Willamette River, Oregon. U.S. Geological Survey Scientific Investigations Report 2007-5185.

Rucker, R. R. and P. H. Kangas. 1974. Effect of nitrogen supersaturated water on coho and Chinook salmon. The Progressive Fish-Culturist 15:24-26.

Ruggerone, G.T. 1989. Coho salmon predation on juvenile sockeye in the Chignik lakes, Alaska. Doctoral dissertation, School of Fisheries, University of Washington, Seattle.

Ruggerone, G.T. 1992. Threespine stickleback aggregations create a potential predation refuge for sockeye salmon fry. Canadian Journal of Zoology 70:1052-1056.

Rutter, L.G. 1997. Salmon fisheries in the Pacific Northwest: How are harvest decisions made? *In* D.J. Stouder, P.A. Bisson, and R.J. Naiman, editors. Pacific salmon and their ecosystems: status and future options. Chapman and Hall.

Ryman, N., P.E. Jorde, and L. Laikre. 1995. Supportive breeding and variance effective population size. Conservation Biology 9:1619-1628.

Salonius, K. and G.K. Iwama. 1993. Effects of early rearing environment on stress response, immune function, and disease resistance in juvenile coho (*Oncorhynchus kisutch*) and Chinook salmon (*O. tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 50: 759-766.

Saulitis, E., C. Matkin, L. Barrett-Lennard, K. Heise, and G. Ellis. 2000. Foraging strategies of sympatric killer whale (*Orcinus orca*) population in Prince William Sounds, Alaska. Marine Mammal Science 16(1):94-109.

Saunders, R.L. 1991. Potential interaction between cultured and wild Atlantic salmon. Aquaculture 98:51-61.

Sauter, S.T., J.M. McMillan, and J. Dunham. 2001. Salmonid behavior and water temperature. EPA-910-D-01-001. Environmental Protection Agency, Region 10, Seattle, Washington.

Scannell, P. O. 1988. Effects of elevated sediment levels from placer mining on survival and behavior of immature Arctic grayling. Alaska Cooperative Fishery Unit, University of Alaska. Unit Contribution 27.

Scheffer, V.B. and J.W. Slipp. 1948. The whales and dolphins of Washington State with a key to the cetaceans of the West Coast of North America. The American Midland Naturalist 39(2):257-337.

Scheuerell, M.D. and J.G. Williams. 2005. Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (*Oncorhynchus tshawytscha*). Fisheries Oceanography 14(6):448-457.

Schill, D.J., and R.L. Scarpella. 1995. Wild trout regulation studies. Annual performance report. Idaho Department of Fish and Game, Boise.

Schisler, G.J. and E.P. Bergersen. 1996. Post release hooking mortality of rainbow trout caught on scented artificial baits. North American Journal of Fisheries Management 16(3):570-578.

Schreck, C.B., A.G. Maule, and S.L. Kaattari. 1993. Stress and disease resistance. Pages 170-175 *in* J.F. Muir and R.J. Roberts, editors. Recent Advances in Aquaculture, Vol. 4. Blackwell Scientific Publications, Oxford.

Schreck, C.B., J.C. Snelling, R.E. Ewing, C.S. Bradford, L.E. Davis, and C.H. Slater. 1994. Migratory characteristics of juvenile spring Chinook salmon in the Willamette River. Completion report. Bonneville Power Administration, Portland, Oregon.

Schroeder, R. K., K. R. Kenaston, and R. B. Lindsay. 2001. Spring Chinook salmon in the Willamette and Sandy Rivers. Annual progress report. Oregon Department of Fish and Wildlife, Portland.

Schroeder, R., M. Wade, J. Firman, M. Buckman, B. Cannon, M. Hogansen, K. Kenaston, and L. Krentz. 2006. Compliance with the biological opinion for hatchery programs in the Willamette Basin. Final Report Task Order: NWP-OP-FH-02-01. Oregon Department of Fish and Wildlife, Corvallis.

Schroeder, R.K., and K.R. Kenaston. 2004. Fish Research Project Oregon: spring Chinook salmon in the Willamette and Sandy Rivers. Annual progress report October 2003 through September 2004. Oregon Department of Fish and Wildlife, Salem.

Schroeder, R.K., K.R. Kenaston, and L.K. Krentz. 2005. Spring Chinook salmon in the Willamette and Sandy Rivers. Annual progress report. Oregon Department of Fish and Wildlife, Fish Research Report F-163-R-10, Portland.

Schroeder, R.K., K.R. Kenaston, and R.B. Lindsay. 2003. Spring Chinook salmon in the Willamette and Sandy Rivers. Oregon Department of Fish and Wildlife, Portland.

Schroeder, R.K., K.R. Kenaston, and R.B. Lindsay. 2000. Spring Chinook salmon in the Willamette and Sandy Rivers. October 1998 through September 1999. Annual progress report, Fish Research Project Oregon. Oregon Department of Fish and Wildlife, Portland.

Schroeder, R.K., K.R. Kenaston, and R.B. Lindsay. 2002. Spring Chinook salmon in the Willamette and Sandy Rivers. Annual progress report. Oregon Department of Fish and Wildlife, Salem.

Schuck, M., A. Viola, J. Bumgarner, and J. Dedloff. 1998. Lyons Ferry Trout Evaluation Study: 1996-97 Annual Report. Washington Department of Fish and Wildlife Report to the USFWS. Report No. H98-10.

Scott, M. L., G. T. Auble and J. M. Friedman. 1997. Flood dependency of cottonwood establishment along the Missouri River, Montana, USA. Ecological Applications 7(2): 677-690.

Scullion, M.K. 2008. Willamette Project – N. Santiam water temperature graphic. Communication to S. Burchfield, National Marine Fisheries Service, from M.K. Scullion, U.S. Army Corps of Engineers, Portland, Oregon. June 30.

Sedell, J. R., J. E. Yuska, and R. W. Speaker. 1984. Habitats and salmonid distribution in pristine, sediment-rich river valley systems: S. Fork Hoh and Queets River, Olympic National Park, p. 33-46. In W. R. Meehan, T. R. Merrell, Jr., and T. A. Hanley, [Eds.], Fish and wildlife relationships in old-growth forests. American Institute of Fishery Research Biologists, Juneau, Alaska.

Sedell, J.R. and J.L. Froggatt. 1984. Importance of streamside forests to large rivers: the isolation of the Willamette River, Oregon, U.S.A., from its floodplain by snagging and streamside forest removal. Verh. Internat. Verein. Limnol. 22:1828-1834.

Sedell, J.R., B.A. McIntosh, and P.J. Minear. 1991. Evaluation of past and present stream habitat conditions. Report for the Army Corps of Engineers McKenzie River Water Temperature Control Feasibility Study by the U.S. Forest Service, Pacific Northwest Research Station, Corvallis, OR.

Servizi, J. A., and D.W. Martens. 1991. Effects of temperature, season, and fish size on acute lethality of suspended sediments to coho salmon. Canadian Journal of Fisheries and Aquatic Sciences 49:1389-1395.

Shaklee, J.B., C. Smith, S. Young, C. Marlowe, C. Johnson, and B.B. Sele. 1995. A captive broodstock approach to rebuilding a depleted Chinook stock. American Fisheries Society Symposium 15:567.

Sharber, N.G. and S.W. Carothers. 1988. Influence of electrofishing pulse shape on spinal injuries in adult rainbow trout. North American Journal of Fisheries Management 8:117-122.

Sharber, N.G., S.W. Carothers, J.P. Sharber, J.C. DeVos, Jr. and D.A. House. 1994. Reducing electrofishing-induced injury of rainbow trout. North American Journal of Fisheries Management 14:340-346.

Shibahara, T., S. Bullock, and D. Cramer. 2001. Upstream migration characteristics of coho salmon above River Mill Dam, Clackamas River, 2000. Final Report. Portland General Electric Company, Portland, Oregon.

Shirvell, C. S. 1990. Role of instream rootwads as juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*O. mykiss*) cover habitat under varying streamflows. Canadian Journal of Fish and Aquatic Science 47: 852-861.

Sigler, J. W., T. C. Bjornn, and F. H. Everest. 1984. Effects of chronic turbidity on density and growth of steelhead and coho salmon. Trans. of the Am. Fisheries Soc.113:142-150.

Simenstad, C.A. and W.J. Kinney. 1978. Trophic relationships of out-migrating chum salmon in Hood Canal, Washington, 1977. University of Washington, Seattle.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: an unappreciated function. Pages 343-364 *in* V. S. Kennedy, editor. Estuarine Comparisons, Academic Press, New York.

Simenstad, C.A., W.J. Kinney, S.S. Parker, E.O. Salo, J.R. Cordell, and H. Buecher. 1980. Prey community structure and trophic ecology of outmigrating juvenile chum and pink salmon in Hood Canal, Washington. University of Washington, Fisheries Research Institute, College of Fisheries, Seattle.

Simmons, D. 2008. Harvest impact distribution tables. Memorandum to P. Dygert, National Marine Fisheries Service, from D. Simmons, National Marine Fisheries Service, Lacey, Washington. April 17.

Simon, R.C., J.D. McIntyre, and A.R. Hemmingsen. 1986. Family size and effective population size in a hatchery stock of coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 43:2434-2442.

SIWG (Species Interaction Work Group). 1984. Evaluation of potential interaction effects in the planning and selection of salmonid enhancement projects. J. Rensel, chairman and K. Fresh editor. Report prepared for the Enhancement Planning Team for implementation of the Salmon and Steelhead Conservation and Enhancement Act of 1980. Washington Department Fish and Wildlife, Olympia.

Small, M.P., A.E. Frye, J.F. Von Bargen, and S.F. Young. 2006. Genetic structure of chum salmon (*Oncorhynchus keta*) populations in the lower Columbia River: are chum salmon in Cascade tributaries remnant populations? Conservation Genetics 7:65-78.

Smith, E. M. and L. Korn. 1970. Evaluation of fish facilities and passage at Fall Creek Dam on Big Fall Creek in Oregon. Final report. Fish Commission of Oregon, Research Division, Portland.

Snelling, J., C.B. Schreck, C.S. Bradford, L.E. Davis, C.H. Slater, M.T. Beck, and S.K. Ewing. 1993. Migratory characteristics of spring Chinook salmon in the Willamette River. Oregon Department of Fish and Wildlife annual report to the Bonneville Power Administration, Portland, Oregon.

Snyder, D.E. 1995. Impacts of electrofishing on fish. Fisheries 20(1):26-27.

Sosiak, A.J., R.G. Randall, and J.A. McKenzie. 1979. Feeding by hatchery-reared and wild Atlantic salmon (*Salmo salar*) parr in a stream. Journal of the Fisheries Research Board of Canada 36:1408-1412.

SPC&A (S.P. Cramer & Associates). 2001. Issue F2, Documentation of existing and historical habitat, and native and introduced fish in the Clackamas Basin. Consultant report to Portland General Electric Company, Portland, Oregon. S.P. Cramer & Associates, Gresham, Oregon.

Spence, B. C., G. A. Lomnicky, R. M. Hughes, and R. P. Novitzki. 1996. An ecosystem approach to salmonid conservation. Mantech Environmental Research Services Corporation, Corvallis, Oregon.

Stein, R.A., P.E. Reimers, and J.F. Hall. 1972. Social interaction between juvenile coho (*Oncorhynchus kisutch*) and fall chinook (*O. tshawytscha*) salmon in Sixes River, Oregon. Journal of the Fisheries Research Board of Canada 29:1737-1748.

Steward, C.R. and T.C. Bjornn. 1990. Supplementation of salmon and steelhead stocks with hatchery fish: a synthesis of published literature. *In* W.H. Miller, editor. Analysis of salmon and steelhead supplementation. Report to Bonneville Power Administration, Portland, Oregon.

Stewart, G., J.R. Glasmann, G.E. Grant, S. Lewis, and J. Ninneman. 2002. Evaluation of fine sediment intrusion into salmon spawning gravels as related to Cougar Reservoir sediment releases. Prepared for the U.S. Army Corps of Engineers by Oregon State University, Corvallis.

Stillwater Sciences. 2006. Carmen-Smith sediment budget for the Carmen-Smith Hydroelectric Project area, Upper McKenzie River Basin, Oregon. Consultant report to the Eugene Water and Electric Board by Stillwater Sciences, Arcata, California.

Stolte, L.W. 1973. Differences in survival and growth of marked and unmarked coho salmon. Progressive Fish-Culturist 35(4):229-230.

Stone, L. 1878. The salmon fisheries of the Columbia River. Pages 801-823 *in* Report of the Commissioner of Fish and Fisheries, Washington, D.C.

Strange, C. D., and G. J. Kennedy. 1981. Stomach flushing of salmonids: a simple and effective technique for the removal of the stomach contents. Fisheries Management 12(1):9–15.

Stroud, R. K., G. R. Bouck, and A. V. Nebeker. 1975. Pathology of acute and chronic exposure of salmonid fishes to supersaturated water. Pages 435-449 *in* W. A. Adams, editors. Chemistry and physics of aqueous gas solutions. The Electrochemical Society, Princeton, New Jersey.

Suring, E.J., E.T. Brown, and K.M.S. Moore. 2006. Lower Columbia River coho status report 2002-2004: population abundance, distribution, run timing, and hatchery influence. Oregon Department of Fish and Wildlife, Corvallis.

Swain, D.P. and B.E. Riddell. 1990. Variation in agonistic behavior between newly emerged juveniles from hatchery and wild populations of coho salmon, *Oncorhynchus kisutch*. Canadian Journal of Fisheries and Aquatic Sciences 47:566-571.

Symbiotics. 2004. Dorena Lake Dam Hydroelectric Project, FERC No. 11945, Final License Application, Stage 3 Consultation Document. Ecosystems Research Institute, Logan, Utah.

Symbiotics. 2005. Dorena Lake Dam Hydroelectric Project, FERC No. 11945, Juvenile Salmonid Study Final Report – Draft. Ecosystems Research Institute, Logan, Utah.

Symbiotics. 2006. Dorena Dam Hydroelectric Project, FERC No. 11945. Letter from V. Lamarra, Symbiotics, to A. Newell, Oregon Department of Environmental Quality. 14 December.

TAC (U.S. v. Oregon Technical Advisory Committee). 2008. Biological assessment of incidental impacts on salmon species listed under the Endangered Species Act in the 2008-2017 non-Indian and treaty Indian fisheries in the Columbia River Basin.

Taylor, B. 1999. Salmon and steelhead runs and related events of the Clackamas River basin – a historical perspective. Consultant report to Portland General Electric Company, Portland, Oregon.

Taylor, E.B. 1991. Behavioral interaction and habitat use in juvenile Chinook, *Oncorhynchus tshawytscha*, and coho, *O. kisutch*, salmon. Animal Behavior 42:729-744.

Taylor, G. and D.F. Garletts. 2007. Effects of water temperature on survival and emergence timing of spring Chinook salmon (*Oncorhynchus tshawytscha)* eggs incubated upstream and downstream of Corps of Engineers dams in the Willamette River Basin, Oregon. U.S. Army Corps of Engineers, Portland, Oregon.

Taylor, G., and R.A. Barnhart. 1999. Mortality of angler caught and released steelhead. California Cooperative Fish and Wildlife Research Unit, Arcata.

Taylor, G., D. Garletts, G. Gauthier, and T. Pierce. 2007. Survival of adult spring Chinook salmon (*Oncorhynchus tshawytscha*) outplanted above U.S. Army Corps of Engineers dams in the Willamette Basin, Oregon. Oregon Chapter American Fisheries Society Annual Meeting, Eugene.

Taylor, G.A. 2000. Monitoring of downstream fish passage at Cougar Dam in the South Fork McKenzie River, Oregon 1998-00. Oregon Department of Fish and Wildlife, Springfield.

Taylor, G.A. 2007. Winter steelhead spawning survey data for 2007 in the North Santiam River below Big Cliff Dam. Communication to L. Kruzic, National Marine Fisheries Service from G.A. Taylor, U.S. Army Corps of Engineers, Portland, Oregon. June 7.

Taylor, G.A. 2008a. Juvenile outmigrant dataset for the Middle Fork Willamette Subbasin. Communication to L. Kruzic, National Marine Fisheries Service from G.A. Taylor, U.S. Army Corps of Engineers, Portland, Oregon. January 24.

Taylor, G.A. 2008b. Data set for the adult Chinook outplanting program above Fall Creek Dam. Communication to L. Kruzic, National Marine Fisheries Service from G.A. Taylor, U.S. Army Corps of Engineers, Portland, Oregon. January 24.

Taylor, M. 2004. Southern Resident orcas: population change, habitat degradation and habitat protection. Report of the International Whaling Commission SC/56/E32.

Taylor, M.J., and K.R. White. 1992. A meta-analysis of hooking mortality of non-anadromous trout. North American Journal of Fisheries Management 12:760-767.

Teensma, P. D. A. 1987. Fire history and fire regimes of the central Western Cascades of Oregon. Doctoral Dissertation, University of Oregon, Eugene, Oregon.

Thieman, C. 2000. Long Tom watershed assessment. Long Tom Watershed Council, Eugene, Oregon.

Thomas, D.W. 1983. Changes in the Columbia River estuary habitat types over the past century. Columbia River Estuary Data Development Program, Astoria, Oregon.

Thompson, K.E., J.M. Hutchison, J.D. Fortune, Jr., and R.W. Phillips. 1966. Fish resources of the Willamette Basin. Willamette Basin Review. A report to the Outline - Schedule Team of the Willamette Basin Task Force. Oregon State Game Commission, Portland, Oregon

Thompson, K.G., E.P. Bergersen, R.B. Nehring, and D.C. Bowden. 1997. Long-term effects of electrofishing on growth and body condition of brown and rainbow trout. North American Journal of Fisheries Management 17:154-159.

Thorpe, J.E. 1994. Salmonid fishes and the estuarine environment. Estuaries 17(1A):76-93.

Titcomb, J.W. 1904. Report on the propagation and distribution of food fishes. Pages 22-110 *in* Report of the Commissioner for the Year Ending June 30, 1902. U.S. Commission of Fish and Fisheries, Government Printing Office, Washington, D.C.

Torgersen, C.E., D.M. Price, H.W. Li and B.A. McIntosh. 1999. Multiscale thermal refugia and stream associations of Chinook salmon. Northeastern Oregon Ecological Applications 9(1):301-319.

Towle, J.C. 1982. Changing geography of Willamette Valley woodlands. Oregon Historical Quarterly 83: 67-87.

Triska, F. J., J. R. Sedell, K. Cromack, Jr., and F. M. McCorison. 1984. Nitrogen budget for a small coniferous forest stream. Ecological Monographs 54:119-140.

U.S. Engineer Office. 1939. Definite project report on Fern Ridge Dam and Reservoir, Long Tom River, Oregon. War Department, U.S. Engineer Office, Portland District, Oregon.

USACE (U.S. Army Corps of Engineers). 1947. Review of survey report: Willamette River and tributaries. Appendix E: levees and overflow channel closures. USACE, Portland District, Portland, Oregon.

USACE (U.S. Army Corps of Engineers). 1980. Environmental Impact Statement on operations and maintenance of the Willamette Reservoir System. USACE, Portland District, Portland, Oregon.

USACE (U.S. Army Corps of Engineers). 1982. Willamette River projects: hydrologic and temperature effects, preliminary literature review and data analysis. USACE, Portland District, Portland, Oregon.

USACE (U.S. Army Corps of Engineers). 1987. Willamette System Temperature Control Study, McKenzie River subbasin, Phase I Report. USACE, Portland District, Portland, Oregon.

USACE (U.S. Army Corps of Engineers). 1988. Willamette System temperature control study, Santiam River Subbasin, phase I report. USACE, Portland District, Portland, Oregon.

USACE (U.S. Army Corps of Engineers). 1989a. Columbia River and tributaries review study: project data and operating limits. CRT 49 (Revised), Book No. 1. USACE, Portland District, Portland, Oregon.

USACE (U.S. Army Corps of Engineers). 1989b. Willamette River bank protection programs summary. USACE, Portland District, Portland, Oregon.

USACE (U.S. Army Corps of Engineers). 1995a. Willamette River temperature control, McKenzie subbasin, Oregon. Volume I, final feasibility report and environmental impact statement. USACE, Portland District, Portland, Oregon.

USACE (U.S. Army Corps of Engineers). 1995b. South Santiam fishery restoration draft reconnaissance study. South Santiam subbasin study. General investigation. USACE, Portland District, Portland, Oregon.

USACE (U.S. Army Corps of Engineers). 1998. 1998 Dissolved gas monitoring, Columbia River Basin. USACE, Reservoir Control Center, Portland District, Portland, Oregon.

USACE (U.S. Army Corps of Engineers). 2000. Biological assessment of the effects of the Willamette River Basin flood control project on species listed under the Endangered Species Act. Submitted to the National Marine Fisheries Service and U.S. Fish and Wildlife Service. Prepared by USACE, Portland, Oregon, and R2 Resource Consultants, Seattle, Washington.

USACE (U.S. Army Corps of Engineers). 2003. Water temperature control, McKenzie River Subbasin, Oregon, Cougar Dam and Reservoir. Draft supplemental information report. USACE, Portland District, Oregon.

USACE (U.S. Army Corps of Engineers). 2006. Green Peter and Foster Dams and Reservoirs. USACE, Portland District, Portland, Oregon.

USACE (U.S. Army Corps of Engineers), Bonneville Power Administration (BPA), and Reclamation (U.S. Bureau of Reclamation). 2007a. Supplemental biological assessment of the effects of the Willamette River Basin Flood Control Project on species listed under the Endangered Species Act. USACE, Portland, Oregon.

USACE (U.S. Army Corps of Engineers), BPA (Bonneville Power Administration), and USBR (U.S. Bureau of Reclamation). 2007b. Comprehensive analysis of the Federal Columbia River Power System and mainstem effects of Upper Snake and other tributary actions. USACE, Portland, Oregon.

USACE (U.S. Army Corps of Engineers). 2008a. Summary of facilitated discussions regarding schedule, certainty and focus of proposed actions and feasibility studies pertaining to structural modifications and related operational alternatives. Exhibit A. USACE, Portland, Oregon.

USACE (U.S. Army Corps of Engineers), BPA (Bonneville Power Administration), and USBR (U.S. Bureau of Reclamation). 2008b. Addendum to "comprehensive analysis of the Federal Columbia River Power System and mainstem effects of Upper Snake and other tributary actions." Analysis of effects on listed Killer Whale and Green Sturgeon distinct population segments. USACE, Portland, Oregon.

USACE (U.S. Army Corps of Engineers). 2008c. Request for consultation on both Orca whales and green sturgeon, with additional information on Orca whales, green sturgeon, and climate change. USACE, Portland, Oregon.

USBR (U.S. Bureau of Reclamation). 1999. Cumulative effects of water use: an estimate of the hydrologic impacts of water resource development in the Columbia River Basin. Final report. USBR, Pacific Northwest Region, Boise, Idaho.

USBR (U.S. Bureau of Reclamation). 2001. Water measurement manual. USBR, Washington, D.C.

USCB (U.S. Census Bureau). 2004. Table 4: annual estimates of the population for incorporated places in Oregon, listed alphabetically: April 1, 2000 to July 1, 2004. USCB, Washington, D.C.

USDA (U.S. Department of Agriculture) and USDI (U.S. Department of Interior). 1994. Record of Decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl.

USFS (U.S. Forest Service). 1988. Draft Environmental Impact Statement and proposed land and resource management plan for Mt. Hood National Forest. USFS, Sandy, Oregon.

USFS (U.S. Forest Service). 1995. Watershed analysis for the Upper Clackamas Watershed. Draft. Mt. Hood National Forest.

USFWS (U.S. Fish and Wildlife Service). 1948. Willamette Valley Project, Oregon. Preliminary evaluation report on fish and wildlife resources. USFWS, Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service). 1959. Cougar Dam and Reservoir Project, Oregon. A detailed report on the fish and wildlife resources. USFWS, Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service). 1961. A detailed report on fish and wildlife resources affected by Green Peter Dam and reservoir project, Oregon. USFWS, Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service). 1962. Fall Creek Dam and Reservoir Project: A detailed report on the fish and wildlife resources. USFWS, Office of the Commissioner, Portland, Oregon.

USFWS (U. S. Fish and Wildlife Service). 1963. Foster Dam and Reservoir Project: A detailed report on the fish and wildlife resources. USFWS, Office of the Commissioner, Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service). 1994. Biological assessments for operation of U.S. Fish and Wildlife Service operated or funded hatcheries in the Columbia River Basin in 1995-1998. Submitted to the National Marine Fisheries Service from the USFWS, Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service). 1995. Fish health policy and implementation. U.S. Fish and Wildlife Service Manual (FWM). USFWS, Washington, D.C.

USFWS (U.S. Fish and Wildlife Service) and NMFS (National Marine Fisheries Service). 1998. Endangered species consultation handbook. Procedures for conducting consultation and conference activities under Section 7 of the Endangered Species Act. USFWS, Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service). 2004. Fish health policy and implementation. U.S. Fish and Wildlife Service Manual (FWM) USFWS, Washington, D.C.

USFWS (U.S. Fish and Wildlife Service). 2007. Eagle Creek National Fish Hatchery assessments and recommendations. Final Report. USFWS, Portland, Oregon.

Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquat. Sci. 37: 130-137.

Varanasi, U., E. Casillas, M.R. Arkoosh, T. Hom, D.A. Misitano, D.W. Brown, S-L Chan, T. L. Collier, B.B. McCain and J.E. Stein. 1993. Contaminant exposure and associated biological effects in juvenile Chinook salmon (*Oncorhynchus tshawytscha*) from urban and nonurban estuaries of Puget Sound. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-8, 112p.

Viola, A.E. and M.L. Schuck. 1991. Estimates of residualism of hatchery reared summer steelhead and catchable size rainbow trout (*Oncorhynchus mykiss*) in the Tucannon River and NF Asotin Creek in SE Washington, 1991. Unpublished report, Washington Department of Wildlife, Olympia.

Vreeland, R.R. 1989. Evaluation of the contribution of fall Chinook salmon reared at Columbia River hatcheries to the Pacific ocean fisheries. Bonneville Power Administration, Portland, Oregon.

Wade, M. 2007. Chinook losses at Cougar Dam. Oregon Department of Fish and Wildlife, Springfield, Oregon.

Wagner, E, and Ingram, P. 1973. Evaluation of fish facilities and passage at Foster and Green Peter Dams on the South Santiam River drainage in Oregon. Fish Commission of Oregon, Portland.

Wahle, R.J. and R.R. Vreeland. 1978. Bioeconomic contribution to Columbia River hatchery fall Chinook salmon, 1961 to 1964 broods, to the Pacific salmon fisheries. Fisheries Bulletin 76:179-208.

Waldman, B. and J.S. McKinnon. 1993. Inbreeding and outbreeding in fishes, amphibians and reptiles. Pages 250-282 *in* N.W. Thornhill, editor. The natural history of inbreeding and outbreeding. University of Chicago Press, Chicago.

Walker, L. R., J. C. Zasada, and F. S. Chapin, III. 1986. The role of life history processes in primary succession on an Alaskan floodplain. Ecology 67(5): 1243-1253.

Wallace, J. B., J. R. Webster, and J. L. Meyer. 1995. Influence of log additions on physical and biotic characteristics of a mountain stream. Canadian Journal of Fish and Aquatic Science 52: 2120-2137.

Wallis, J. 1961. An evaluation of the McKenzie River salmon hatchery. Oregon Fish Commission, Portland.

Wallis, J. 1962. An evaluation of the Willamette River salmon hatchery. Oregon Fish Commission Research Laboratory, Clackamas, Oregon.

Wallis, J. 1963. An evaluation of the North Santiam River salmon hatcheries. Oregon Fish Commission Research Laboratory, Clackamas.

Wallis, J. 1964. An evaluation of the Bonneville salmon hatchery. Oregon Fish Commission Research Laboratory, Clackamas, Oregon.

Wampler, P. and G. Grant. 2003. Geomorphic changes resulting from River Mill Dam operations. Consultant report prepared for Portland General Electric Company, Portland, Oregon.

Waples, R. 1991. Definition of a species under the Endangered Species Act: application to Pacific salmon. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-194, 29p.

Waples, R.S. 1996. Toward a risk/benefit analysis for salmon supplementation. Unpublished paper presented at a workshop on captive breeding in the restoration of endangered species, October 1996, Newport, Oregon.

Waples, R.S., O.W. Johnson, P.B. Aebersold, C.K. Shiflett, D.M. VanDoornik, D.J. Teel, and A.E. Cook. 1993. A genetic monitoring and evaluation program for supplemented populations of salmon and steelhead in the Snake River Basin. Annual report of research to the Bonneville Power Administration, Portland, Oregon.

Ward, D.L., J.H. Petersen, and J.J. Loch. 1995. Index of predation of juvenile salmonids by northern squawfish in the lower and middle Columbia River and the lower Snake River. Transactions of the American Fisheries Society 124:321-334.

WDFW (Washington Department of Fish and Wildlife) and ODFW (Oregon Department of Fish and Wildlife). 2002. Status report Columbia River fish runs and fisheries, 1938-2000. Text only. Joint Columbia River Management Staff, Clackamas, Oregon/Vancouver, Washington

WDFW (Washington Department of Fish and Wildlife) and WWTIT (Western Washington Treaty Indian Tribes). 1998. Co-managers of Washington fish health policy. WDFW, Fish Health Division, Hatcheries Program, Olympia.

WDFW (Washington Department of Fish and Wildlife), Western Washington Treaty Indian Tribes, and Northwest Indian Fisheries Commission. 1995. Dungeness River Chinook salmon rebuilding project progress report 1992-93. *In* C.J. Smith and P. Wampler, editors. Northwest Fishery Resource Bulletin. Project Report Series No. 3. Northwest Indian Fisheries Commission, Olympia, Washington.

WDFW (Washington Department of Fish and Wildlife). 1996. Fish health manual. WDFW, Fish Health Division, Hatcheries Program, Olympia, Washington.

WDFW (Washington Department of Fish and Wildlife). 1998. Section 10 permit application for a permit to enhance the propagation or survival of endangered or threatened species under the Endangered Species Act of 1973. Upper Columbia River spring Chinook adult supplementation and captive broodstock Hatchery Production Activities. WDFW, Olympia.

Weitkamp, D.E. and M. Katz. 1980. A review of dissolved gas supersaturation literature. Trans. Am. Fish. Soc. 109:659-702.

Welch, H.E., and K.H. Mills. 1981. Marking fish by scarring soft fin rays. Canadian Journal of Fisheries and Aquatic Sciences 38:1168-1170.

Welsh, H. H. Jr., G. R. Hodgson, and B. C. Harvey. 2001. Distribution of Juvenile Coho Salmon in Relation to Water Temperatures in Tributaries of the Mattole River, California. North American Journal of Fisheries Management 21: 464-470.

Wevers, M., J. Wetherbee, and W. Hunt. 1992. Santiam and Calapooia Subbasin fish management plan. Oregon Department of Fish and Wildlife, Portland.

Weyerhaeuser. 1994. Lower McKenzie River watershed analysis. Weyerhaeuser, Springfield, Oregon.

Weyerhaeuser. 1998. Calapooia watershed analysis. Weyerhaeuser, Springfield, Oregon.

Whitesel, T.A., B.C. Jonasson, and R.C. Carmichael. 1993. Lower Snake River compensation plan -- residual steelhead characteristics and potential interactions with spring Chinook salmon in northeast Oregon. Oregon Department of Fish and Wildlife, Fish Research Project, Portland, Oregon.

Whitlock, M.C. and N.H. Barton. 1997. The effective size of a subdivided population. Genetics 146:427-441.

Wiles, G.J. 2004. Washington State status report for the killer whale. Washington Department of Fish and Wildlife, Olympia.

Williams, G. P. and M. G. Wolman. 1984. Downstream effects of dams on alluvial rivers. U.S. Geological Survey Professional Paper 1286.

Williams, I.V. and D.F. Amend. 1976. A natural epizootic of Infectious Hematopoietic Necrosis in fry of sockeye salmon (*Oncorhynchus nerka*) at Chilko Lake, British Columbia. Journal of Fisheries Research Board of Canada 33:1564-1567.

Williams, R., A.W. Trites, and D.E. Bain. 2002a. Behavioural responses to killer whales (*Orcinus orca*) to whale-watching boats: opportunistic observations and experimental approaches. Journal of The Zoological Society of London 256:255-270.

Williams, R., D.E. Bain, J.K.B. Ford, and A.W. Trites. 2002b. Behavioral responses of male killer whales to a 'leapfrogging' vessel. Journal of Cetacean Research and Management 4(3):305-310.

Willis, C.F. 1995. Status of Willamette River spring Chinook salmon in regards to the Federal Endangered Species Act. S. P. Cramer & Associates, Gresham, Oregon.

Willis, C.F. 2008. Proposed incidental take tables for N. Santiam, S. Santiam, McKenzie, and Middle Fork Willamette Rivers. Communication to J. Johnson, National Marine Fisheries Service, from C.F. Willis, U.S. Army Corps of Engineers, Portland, Oregon. June 16.

Willis, R.A., M.D. Collins, and R.E. Sams. 1960. Environmental survey report pertaining to salmon and steelhead in certain rivers of Eastern Oregon and the Willamette River and its tributaries. Part II: survey reports of the Willamette River and its tributaries.

Willson, M. F., S. M. Gende, and B. H. Marston. 1998. Fishes and the forest: Expanding perspectives on the fish-wildlife interactions. Bioscience 48:455-462.

Wissmar, R.C., J. E. Smith, B. A. McIntosh, H. Li, G. H. Reeves, and J. R. Sedell. 1994. Ecological health of river basins in forested regions of eastern Washington and Oregon. General Technical Report PNW-GTR-326. USDA Forest Service PNW Research Station, Portland, Oregon.

Witty, K., C. Willis, and S. Cramer. 1995. A review of potential impacts of hatchery fish on naturally produced salmonids in the migration corridor of the Snake and Columbia Rivers. Comprehensive environmental assessment - final report. S.P. Cramer and Associates, Gresham, Oregon.

WLCTRT (Willamette/Lower Columbia Technical Recovery Team). 2003. Interim report on viability criteria for Willamette and Lower Columbia basin Pacific salmonids. National Marine Fisheries Service, Northwest Fisheries Science Center, Willamette/Lower Columbia Technical Recovery Team, Seattle, Washington. March 31.

WLCTRT (Willamette/Lower Columbia Technical Recovery Team). 2004. Status evaluation of salmon and steelhead populations in the Willamette and lower Columbia River basins. National Marine Fisheries Service, Northwest Fisheries Science Center, Willamette/Lower Columbia Technical Recovery Team, Seattle, Washington.

WLCTRT (Willamette/Lower Columbia Technical Recovery Team) and ODFW (Oregon Department of Fish and Wildlife). 2006. Revised Viability Criteria for Salmon and Steelhead in the Willamette and Lower Columbia Basins Review Draft April 1, 2006.

WNF BRRD (Willamette National Forest, Blue River Ranger District). 1994. South Fork McKenzie River watershed analysis. Willamette National Forest Supervisor's Office, Eugene, Oregon.

WNF BRRD (Willamette National Forest, Blue River Ranger District). 1996. Blue River watershed analysis. Willamette National Forest Supervisor's Office, Eugene, Oregon.

WNF DRD (Willamette National Forest, Detroit Ranger District). 1994. Blowout Creek Watershed Analysis. Willamette National Forest Supervisor's Office, Eugene, Oregon.

WNF DRD (Willamette National Forest, Detroit Ranger District). 1995. Upper North Santiam River Watershed Analysis. Willamette National Forest Supervisor's Office, Eugene, Oregon.

WNF DRD (Willamette National Forest, Detroit Ranger District). 1996. Breitenbush River Watershed Analysis. Willamette National Forest Supervisor's Office, Eugene, Oregon.

WNF DRD (Willamette National Forest, Detroit Ranger District). 1997. Detroit Reservoir Tributaries Watershed Analysis. Willamette National Forest Supervisor's Office, Eugene, Oregon.

WNF LRD (Willamette National Forest, Lowell Ranger District). 1997. Lookout Point Reservoir watershed analysis. Willamette National Forest Supervisor's Office, Eugene, Oregon.

WNF MRD (Willamette National Forest, McKenzie Ranger District). 1995. Upper McKenzie watershed analysis. Willamette National Forest Supervisor's Office, Eugene, Oregon.

WNF MRD (Willamette National Forest, McKenzie Ranger District). 1997. Horse Creek watershed analysis. Willamette National Forest Supervisor's Office, Eugene, Oregon.

WNF ORD (Willamette National Forest, Oakridge Ranger District). 1995. North Fork of the Middle Fork Willamette River watershed analysis. Willamette National Forest Supervisor's Office, Eugene, Oregon.

WNF RRD (Willamette National Forest, Rigdon Ranger District). 1996. Upper Middle Fork Willamette watershed analysis. Willamette National Forest Supervisor's Office, Eugene, Oregon.

WNF SHRD (Willamette National Forest, Sweet Home Ranger District). 1995. South Santiam watershed analysis. Willamette National Forest Supervisor's Office, Eugene, Oregon.

WNF SHRD (Willamette National Forest, Sweet Home Ranger District). 1996. Middle Santiam watershed analysis. Willamette National Forest Supervisor's Office, Eugene, Oregon.

Wolman, M. G. and J. P. Miller. 1960. Magnitude and frequency of forces in geomorphic processes. Journal of Geology 68:54-74.

Wood, J. W. 1968. Diseases of Pacific salmon, their prevention and treatment. Washington Department of Fisheries, Olympia.

WPN (Watershed Professionals Network). 2002. Clear and Foster Creek watershed assessment. Consultant report to the Clackamas Basin Watershed Council. Watershed Professionals Network.

WPN (Watershed Professionals Network). 2005. Deep and Goose Creek watershed assessment. Consultant report to the Clackamas Basin Watershed Council. Watershed Professionals Network.

WRI (Willamette Restoration Initiative). 2004. Willamette Subbasin plan. Prepared for the Northwest Power and Conservation Council, Portland, Oregon.

Wursig, B. 1990. Cetaceans and oil: ecological perspectives. Pages 129-166 *in* J.R. Geraci and D.J. St. Aubin, editors. Sea mammals and oil: confronting the risks. Academic Press, New York.

Wydoski, R.S. 1977. Relation of hooking mortality and sublethal hooking stress to quality fishery management. Pages 43-87 *in* R.A. Barnhart and T.D. Roelofs, editors. Proceedings of a national symposium on catch-and-release fishing as a management tool. Humboldt State University, Arcata, California.

Wydoski, R.S. and R.R. Whitney. 1979. Inland fishes of Washington. University of Washington Press, Seattle.

Ylitalo, G.M., C.O. Matikin, J. Buzitis, M.M. Krahn, L.J. Jones, T. Rowles, J.E. Stein. 2001. Influence of life-history parameters on organochlorine concentrations in free-ranging killer whales (*Orcinus orca*) from Prince William Sound, AK. The Science of the Total Environmental 281:183-203.

Young, S. and C. Marlowe. 1995. Techniques of hydraulic redd sampling, seining and electroshocking. Pages 35-57 *in* C.J. Smith and P. Wampler, editors. Dungeness River chinook salmon rebuilding project. Progress Report 1992-1993. Northwest Fishery Resource Bulletin, Project Report Series Number 3. Northwest Indian Fisheries Commission, Olympia, Washington.

Zabel, R. W., M.D. Scheuerell, M.M. McClure, and J.G. Williams. 2006. The interplay between climate variability and density dependence in the population viability of Chinook salmon. Conservation Biology 20 (1):190-200.

Ziller, J. 2002. Adult Chinook releases in the McKenzie and Middle Fork Willamette, 2002 summary. Meeting handout. Oregon Department of Fish and Wildlife, South Willamette Watershed District, Springfield. November 5.

Zirges, M. H. and L. D. Curtis. 1975. An experimental heated water incubation system for salmonid eggs. The Progressive Fish-Culturist 37:217-218.