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Critical Uncertainties in the Fish and Wildlife Program

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Report to Policy Review Group

by

Scientific Review Group

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SUMMARY

We present and discuss critical ecological uncertainties that identify important gaps in our knowledge of the resources and functional relationships that determine fish and wildlife productivity in the Columbia River ecosystem. These uncertainties compromise progress toward achieving the goals of the Northwest Power Planning Council's Fish and Wildlife Program (FWP).

The FWP assumes that a) the number of adult salmonids recruited is primarily a simple, positive response to the number of smolts or juveniles produced, b) salmonid production can be increased by focusing management primarily on in-river components of the Columbia River ecosystem and c) massive management actions, especially mainstem flow augmentation from headwater reservoirs intended to promote anadromous fish productivity, will not compromise other components of the ecosystem, such as headwater rivers. These assumptions may not be valid and constitute an uncertainty that subsumes others we identified. This uncertainty arises because the FWP lacks a solid conceptual foundation that couples salmonid life histories and production with appropriate ecosystem (headwater, mainstem, estuary and ocean) components.

Other critical uncertainties relate to questions about the long-term sustainability of anadromous salmonid productivity and stock diversity, given the massive extent of environmental change in the ecosystem. We emphasize the need to clearly identify and rank factors that limit natural and artificial production, including possible impacts that hatchery operations may have on wild salmonid stocks. With regard to wildlife actions, we question the implicit assumption of the FWP that increased numbers of target wildlife species will result simply by producing or improving site-specific habitats.

Few of the current FWP projects in the annual implementation work plan are explicitly responsive to our critical uncertainties. However, these projects were not developed from the broad-based uncertainties perspective we present herein.

We recommend development of an explicit, conceptual foundation for the FWP that is based upon thorough review and synthesis of existing scientific information. This will clarify and elaborate critical uncertainties and responses to them. We reiterate a previous recommendation to implement a peer-review process that is responsive to critical uncertainties in the FWP and insures that key gaps in the knowledge base are filled. Finally, we again call for immediate development and implementation of a system-wide monitoring and evaluation program that also is responsive to critical uncertainties.

ASSIGNMENT

The Policy Review Group (PRG) asked the Scientific Review Group (SRG) to identify critical uncertainties in the Northwest Power Planning Council's (NWPPC) Fish and Wildlife Program (FWP) and to assess the extent to which these uncertainties are addressed by projects in the 1992 Annual Implementation Work Plan (AIWP) (see November 19, 1991 memo from Wally Steucke to the SRG).

PROCEDURE

During the 13 month period we worked on this assignment, we had many discussions and several briefings. First, Wally Steucke (CBFWA) briefed us on Phases 1 and 2 of the FWP (NWPPC 1987). We then reviewed and discussed the uncertainties that were apparent to us in each of the program elements of the FWP (NWPPC 1987), including fish disease, habitat, supplementation, mainstem passage, natural production, hatchery effectiveness, resident fish, wildlife and system planning. Some of these uncertainties were discussed in previous reports (SRG 1990a,b, 1991). Chip McConnaha (NWPPC) provided information and analysis of the Phase 3 document (NWPPC 1992) as amendments were drafted and finalized during 1992. Peter Paquet (NWPPC) and Joe DeHerrera (BPA) briefed us on wildlife programs in the FWP and the rationale that guides these activities. We studied background information in the Technical Working Group (TWG) work plans and the Regional Assessment of Supplementation Report (RASP), and we discussed uncertainties identified by the System Planning Group. Lastly, we examined work plans for selected projects in the 1992 AIWP and attended a very useful and informative projects review organized by the Bonneville Power Administration on September 1-3, 1992.

In our initial discussions we noted that uncertainties are a part of any endeavor to alter the course of environmental change. Uncertainties in management actions can be manifested at different scales. For example, we identified uncertainties with regard to the effectiveness of site-specific habitat improvement projects (local scale) and uncertainties associated with flow augmentation to accelerate emigration of smolts (regional scale). Moreover, uncertainties can be ecologically and economically interactive, such as reservoir drawdown in response to an anadromous fish objective which produces uncertainties regarding operations at other reservoirs and associated ecological effects (e.g., resident fish below headwater dams, where anadromous fish do not occur, may be adversely affected by operational changes that result from mandates pertaining only to anadromous fishes).

Therefore, we debated at length how specific we should be, because we or any other knowledgeable group clearly could generate a long list of uncertainties related to management actions in each of the program elements of the FWP. Indeed, uncertainties were identified by the Technical Working Groups. This work should be continued by current scoping groups in the Implementation and Planning Process that develops the AIWP. We also wished to make the product of this exercise constructive. Many millions of dollars have already been spent in an attempt to foster FWP goals and objectives. The 1992 AIWP lists over 200 projects, many of which span several years with multi-million dollar annual budgets. We recognized at the outset that our identification of uncertainties might be used to discredit the FWP or certain projects in the AIWP; whereas, the purpose of our inquiry was primarily to review the scientific rationale for the FWP objective. Therefore, we focused on ecological uncertainties that encompass the FWP as a whole, as opposed to a long list of uncertainties associated with each of the various program elements. In the end we identified five ecological uncertainties, listed in hierarchical order of importance, that critically relate to the main goal of the

FWP, i.e., to achieve a sustainable increase in production of salmonid stocks in the Columbia River Basin. We also identified a critical uncertainty in the wildlife portion of the FWP.

Because of the large number of scientific references pertinent to these topics, we omitted them from this report for the sake of brevity. They were, however, important to us in reaching many of our decisions and conclusions.

DEFINITION

For the purpose of this report, we define critical uncertainties as questions concerning the validity of key assumptions implied or stated in the FWP. Critical uncertainties identify important gaps in our knowledge about the resources and functional relationships that determine fish and wildlife productivity. Resolution of uncertainties will greatly improve chances of attaining recovery goals in the FWP.

CRITICAL UNCERTAINTIES

1. What are the key assumptions in the FWP and are they scientifically valid?

A fundamental, albeit unstated, assumption of the FWP is that the number of adults recruited is primarily a simple, positive response to the number of smolts produced. In other words, it is assumed that human-induced losses of natural production can be mitigated by actions to increase the number of smolts. Evidence in support of this assumption is not conclusive. Much evidence suggests that the long history of hatchery development, coupled with continual harvest in mixed-stock fisheries, has been detrimental to production of wild stocks in the Columbia River system. Moreover, for many stocks for which productivity data do exist, there seems to be no simple relationship between numbers of smolts produced and adults returned. The relationship between smolts and adults is complicated by the interactive effects of biological and physical factors in the ecosystem that influence production. Thus, the efficacy of efforts to increase the number of adults may be obscured by factors not presently considered in the FWP. These unknowns do not discount the importance of management actions to increase survival at any life stage, because most stocks have declined precipitously and actions to enhance survival of all life stages clearly are warranted.

Another assumption, again not specifically stated in the FWP, is that salmon and steelhead production can be increased by focusing management primarily on in-river components of the Columbia River ecosystem. However, estuary and ocean conditions may exert significant influences on anadromous salmonid production. Productivity of the ocean food web varies over the long term (decades) in response to natural events. For example, El Niños and other meteorologic and oceanic cycles vary the location and timing of upwelling on the Pacific coast and thereby control fish production through complicated and poorly understood reactions within the oceanic food web. Harvest in ocean fisheries since the 1880s, heavily impacting first nearshore then offshore species, very likely introduced additional variation. Potential consequences of these natural and human-mediated events range from conditions of chronic food web instability, in which salmonid life stages in the ocean may be severely compromised, to subtle variations in biophysical conditions that produce long- and short-term oscillations in oceanic salmonid production. If major changes in the oceanic food web structure have occurred, as many scientists firmly believe, then oceanic effects may significantly influence salmonid production and obscure the effects of in-river management actions. Lack of clear understanding of the ocean component of the ecosystem and its relationship to marine survival of salmonids presents a serious hurdle to identifying and resolving uncertainties related to salmonid production in the Columbia River Basin.

Finally, it is generally assumed in the FWP that massive management actions, especially mainstem flow augmentation from headwater reservoirs to promote anadromous fish survival and productivity, will not compromise environmental attributes of headwater rivers. Many of these streams are relatively pristine and valuable resources in their own right. The spring freshet in the Columbia River has been considerably reduced by storage in large headwater reservoirs. Therefore, flow augmentation to promote mainstem passage of smolts below Grand Coulee Dam and on the Snake River must involve operations at the headwater dams. In several documented cases (e.g., Flathead River, Montana) changing operational mandates have apparently accelerated the negative effects that hydropower and flood-control manipulations are already exerting on local, non-salmon environments.

Our message from this basic and encompassing uncertainty is that the FWP is not founded upon a clear articulation of the interrelations between major biological and physical components of the Columbia River ecosystem (headwater reaches, mainstem, estuary, ocean). Therefore, management actions likely are occurring that have little or no chance of contributing to the program goal. This uncertainty identifies a weakness in the foundation of the FWP that subsumes other critical uncertainties discussed below.

2. Can salmonid populations in the Columbia River be increased and sustained over the long term, given the multitude of biological, physical and cultural constraints?

This uncertainty is essentially a restatement of the FWP goal itself. We could not determine if program actions are adequate to sustain and enhance stocks. System-wide monitoring of fish stocks is not being done to the extent that program measures can be evaluated (see SRG 1990b). Adequate data do not exist to assess the productivity of stocks, quality of available spawning and rearing habitats, minimum viable population size for different stocks and the role of hatchery fish relative to wild fish in terms of the long-term sustainability of the anadromous salmonid fishery. Identification of sources and extent of mortality by life stage (eggs, juveniles, smolts, adults) is needed to clearly identify factors that limit natural production for each management unit in the basin. Factors that contribute to mortality within ecosystem components (river, estuary, ocean) and at each life history stage include: hydroelectric facilities and reservoirs; in-river bypass and transportation mechanisms; quantity, quality and temporal availability of critical habitat (as characterized by water quality and quantity, temperature regimes, substratum and cover characteristics, flow velocity changes, predation and other food web interactions); disease and harvest.

3. Can the diversity of anadromous salmonid stocks be sustained over the long term?

Life history diversity is an important, natural feature of Columbia River salmonid fishes, resulting from the adaptation of local populations to natural variation inherent in the ecosystem (river, estuary and ocean). Many natural, ecological factors limit or constrain the life history energy balance of each species in a manner that has produced a diversity of salmonid stocks, each with unique life cycles.

Life history diversity, which has long-term adaptive value to fish, has decreased dramatically in recent years due largely to human-induced changes in riverine and oceanic components of the Columbia River ecosystem. At a minimum, maintenance of remaining natural stock diversity is essential to the long-term integrity of the ecosystem. While actions under the Endangered Species Act should respond to this uncertainty, these actions so far are responsive to only a few critically damaged stocks, most of which may be non-viable.

We believe that current actions to sustain and enhance biodiversity of salmonid stocks run a high risk of failure, unless guided by a robust conceptual foundation developed in the context of life histories of fish stocks targeted in various mitigation actions. Empirical data that relate to this uncertainty are sparse. Detailed information is needed to accurately describe the range of biological (life history and genetic) diversity that currently remains in the ecosystem and specifically how salmonid stock diversity and production are influenced by environmental change.

4. What are the relative contributions of habitat loss, harvest, predation and mainstem passage to reduced riverine survival and production of anadromous salmonids and other fishes targeted in the FWP?

Mainstem dams, loss of critical spawning and rearing habitats and overharvest clearly have compromised stock productivity and diversity of anadromous salmonids. Mitigative actions fostered by the FWP are largely focused on these problems. However, the relative importance of these sources of mortality to the recovery goal is far from clear.

A number of analyses and modeling exercises have led to a general consensus by managers that smolt mortality at the dams, coupled with in-river predation of smolts by squawfish, is so extreme that harvest of adults does not significantly contribute to observed decline of some stocks. Data obtained in the riverine portion of the ecosystem suggest that habitat loss, predation and passage mortality may indeed be of greater concern than in-river harvest, but measures to reduce harvest in the estuary and ocean have not been pursued in a proactive manner as stocks declined. Few would argue that predation is not a source of smolt mortality. Predators, including but not limited to squawfish, are abundant in the highly flow-regulated mainstem. Smolts are easy prey as a consequence of stress associated with bypass problems and maladaptation to the riverine-reservoir environments that characterize much of the migration corridor. However, a definite relationship between salmonid productivity and mortality of smolts due to riverine predators has yet to be substantiated. Some studies have suggested that egg-smolt survival problems related to habitat availability limit population expansion, more so than other sources of mortality. Again, such conclusions have not been clearly substantiated on the basis of empirical information describing cause and effect relations in Columbia River salmonid populations.

The uncertainty of the relative influence of major sources of in-river mortality clearly is an interactive problem. Indeed, tributaries that appear to be relatively pristine show little resilience with respect to recovery of anadromous salmonids. One example is the Middle Fork of the Salmon River, most of which has been protected for many years by wilderness status, with copious high quality habitat. Research has demonstrated that the physical nature of this tributary river is largely unaltered relative to other sub-basins where habitat clearly has been damaged by poor land use practices. Yet, few anadromous salmon of any stock are produced in this river. Historically intense harvest of spawning adults at key spawning sites (e.g., in the Stanley Basin) probably decimated natural production. Dams and other mainstem problems, coupled with harvest in the mixed stock fishery, also contributed to the decline in adult returns. Perhaps so few adults spawn and die that the nutritive capacity of the river may now be very limited; fry and juveniles cannot survive, owing to lack of food that would normally result from decomposition of adult carcasses. Moreover, questions remain about the effects on adult returns of the smolt capture and transportation program for all Snake River chinook stocks. Current conditions in many other river segments of the Columbia River system likewise underscore the need to quantify the relative impact of different sources of in-river mortality. This uncertainty confounds current management actions because amelioration of one problem may be offset by an increase in one of the other major sources of mortality. On the other hand, efforts to reduce all suspected sources of in-river mortality may be unjustified, if these changes do not occur or if only one or a few sources actually cause most of the mortality.

5. To what extent are hatchery production and supplementation programs detrimental to wild salmonid productivity and stock diversity?

Even though this statement is implicit in the more encompassing uncertainties given above, this problem deserves emphasis because of its pervasive influence on scientific interpretation of the salmonid recovery program. Eighty-four salmon and steelhead hatcheries currently produce ca. 200 million smolts annually which are released into the Columbia River ecosystem. Sophisticated supplementation facilities (e.g., Yakima, Wenatchee and Methow projects) are now being implemented, and the thought that supplementation can mitigate losses from hydropower development pervades recovery programs for resident fishes as well (e.g., Flathead River bull trout supplementation plan).

At least two major problems are inherent in this uncertainty. First, the massive propagation of hatchery fish encourages increased harvest in mixed stock fisheries and can produce an increasingly greater impact on wild fish as the level of hatchery production increases. Second, the likelihood of genetic introgressions and behavioral interactions that are detrimental to wild fish probably increases as hatchery stocks dominate the river and ocean fisheries derived from Columbia River stocks. These questions have been raised repeatedly. Yet, limited scientific experimentation has been done to clarify these problems empirically, while investment in hatcheries and rearing systems has continued with too little evaluation of hatchery effectiveness (SRG 1990a) and impacts on wild stocks (SRG 1991).

We recognize that domination of Columbia River and other salmon fisheries by hatchery stocks resulted from a management policy specifically aimed at replacing wild stocks eliminated or reduced by river development. Conventional hatcheries were not intended to support, or reconstruct, the original diversity of the historical species composition in the river systems of the Columbia Basin. However, the hatchery "tool" clearly has evolved over the years, and our statement of uncertainty does not necessarily fault the natural production objectives of the supplementation projects in the FWP. Nonetheless, the uncertainty of impacts of fish culture operations of all types on wild fish is a critical one and can only be resolved through a management approach that is responsive to scientific experimentation coupled with an effective monitoring and evaluation program.

6. To what extent are assumptions in the wildlife part of the FWP ecologically sound?

Implementation of the wildlife portion of the program relies primarily on trust agreements, land acquisitions or conservation easements to secure or enhance habitat for wildlife. This approach assumes mitigation actions will yield increased numbers of target wildlife species simply by producing habitat. In some cases, habitat may not be easy to define, particularly if all aspects of the life history of the target species are considered. Great winter habitat for elk may not be very useful as calving grounds, and few, if any, new animal units may result.

Moreover, there is some likelihood that new habitats appropriate for specific populations may have a negative impact on other populations. In other words, the proposed mitigation action may cause problems for other wildlife or ecosystem attributes. In addition, questions arise from difficulties associated with measuring and evaluating the success of habitat acquisition projects. A standardized and coordinated approach to monitoring and evaluating wildlife projects clearly would be beneficial. This should include quantification of species-specific responses of target <u>and</u> non-target wildlife in addition to changes in habitat characteristics.

RESPONSIVENESS OF 1992 AIWP PROJECTS TO CRITICAL UNCERTAINTIES

Detailed study design and rationale were not given in project work plans we reviewed, which made it impossible for us to confidently evaluate projects in terms of the critical uncertainties we identified. Moreover, uncertainties are not explicitly given in the FWP, and few, if any, of the projects were rationalized from the broad-based uncertainties perspective we present. In the future, projects should be designed in accordance with our previous recommendations for proposal preparation (SRG 1990c) to be amenable to such evaluation. Oral presentations at the BPA projects review workshop allowed us to better understand many of the projects. But, we concluded that few of the projects in the 1992 AIWP were fully responsive to our critical uncertainties. Nevertheless, we offer some general impressions that should make the projects responsive to uncertainties.

a) Modeling efforts have proceeded beyond the validity of available data, such as stock-specific mortalities by life history stage or river reach, reach survival of smolts as influenced by reach conditions (e.g., water velocity, temperature, predation), stock-specific ocean survival rates and production trends of hatchery and wild stocks.

b) Progress in many areas is long on mechanics (e.g., field data gathering or modeling elegance) and short on data evaluation or sound conclusions. Indeed, in too many cases we could not determine how particular projects would be evaluated in any context.

c) The several smolt monitoring projects on the Snake River are not integrated and do not contribute new understanding about reach survival that is critically needed.

d) Resident fish program actions should be an integrated part of the AIWP and review process. Actions to enhance salmon may compromise resident fish actions in upstream areas not inhabited by salmon.

PERSPECTIVE AND CONCLUSIONS

The FWP is ambitious on an unprecedented scale, given the dimensions of the ecosystem, the amount of environmental change and bioeconomic interrelations of fish and wildlife, hydropower, navigation, irrigation, recreation and flood control. Uncertainties at many levels are to be expected and are not entirely unknown to managers or scientists working in the FWP.

Our identification of critical uncertainties in the FWP is handicapped by the lack of an explicit theory to explain ecosystem changes, such as declining fish stocks. In other words, management actions intended to increase salmonid production have proceeded without the benefit of guidance from a conceptual foundation that couples life histories and production with appropriate ecosystem components. Such a foundation would integrate many management actions and projects, allowing uncertainties to be more clearly specified, articulated, tested and measured where appropriate. Uncertainties could then be resolved either through methods of rigorous experimentation or adaptive implementation.

Progress toward FWP goals continues to suffer from a lack of empirical evaluation and peer review. Data, projects, biological objectives and program measures need coordination and integration. Wildlife mitigation efforts could be cooperative and complementary with fisheries objectives. For example, off-site efforts to mitigate wildlife habitat lost by reservoir inundation (e.g., by land acquisition, special habitat management) could be coupled with fisheries production goals, such as the restoration of stream segments where damage to riparian zones has impacted both fish and wildlife habitat values (e.g., Vey Ranch, Upper Grande Ronde River in eastern Oregon).

Numerous data bases and models exist throughout the Columbia River Basin. However, meaningful application of existing data and subsequent adaptive learning is severely handicapped by a lack of accessibility and coordination. The FWP would benefit from thorough collection, review and scientific analysis of existing information. This review and synthesis would provide guidance for adaptive modification of program structure, responses to uncertainties and creation and implementation of an integrated and coordinated monitoring and evaluation program. The FWP would benefit if those actions to be evaluated through adaptive implementation were identified along with the expected results, specific monitoring procedures and methods of evaluation to be used.

RECOMMENDATIONS

1. Develop a conceptual framework for the FWP through review and synthesis of existing information in order to clarify and elaborate critical uncertainties and responses.

We recommend that the PRG request development of an explicit conceptual foundation that couples productivity and salmonid life history characteristics with appropriate features of the ecosystem. Such a foundation would assist in the identification, clarification and resolution of critical uncertainties that presently limit effectiveness of the FWP. Resolution of uncertainties also involves quantification of the dynamic structure and function of the Columbia River ecosystem, including interconnected river and ocean components. Thus, development of the conceptual foundation should occur in conjunction with a detailed scientific review of the FWP.

We believe data exist that would, if coordinated and analyzed, give a better understanding of the ecosystem with regard to FWP goals. We also recommend that the PRG request a review of the current FWP (including Phases 1-3) that includes a critical evaluation of data, models and assumptions. The review should be an ecosystem-level analysis and include a synthesis of the stock-specific productive potential of each sub-basin and current limitations on productivity (e.g., passage, harvest, habitat degradation, disease, competitive interactions, genetic introgression). It would cover existing sub-basin plans and the System Planning Model. It should also consider variation in ocean conditions (short-term and long-term trends) and marine harvest. The reviewers would have to be cognizant of the influence of cultural, economic and legal aspects of the Columbia River fisheries, but the review fundamentally should relate existing data to ecosystem structure and function. This would provide a defensible foundation for the identification of critical uncertainties and the derivation of a monitoring and evaluation program as a part of the AIWP.

The review we are recommending should produce a peer-reviewed paper that uses appropriate data to demonstrate the utility and prognosis of salmonid enhancement in the Columbia River Ecosystem. The paper should be published in an appropriate scientific journal. No such document currently exists, nor does it appear that the available data have ever been thoroughly examined from an ecosystem perspective and related to the FWP goals.

2. Implement peer review within the AIWP to insure responsiveness to critical uncertainties.

We have noted previously (SRG 1990c) that expenditures made without peer accountability are less likely to provide progress toward the FWP goals than those made on the basis of competitive proposals and constructive peer criticism of proposals. The present exercise to identify program-level uncertainties, coupled with evaluation of the current AIWP, yielded a clear mandate for peer review, including peer evaluation of progress after the project is funded and some mechanism for communicating results at the conclusion of projects, perhaps in professional journals or volumes that are peer reviewed.

3. Implement a system monitoring and evaluation program that is responsive to critical uncertainties.

Development and implementation of a system monitoring and evaluation program was mandated under Phase 3 of the FWP (NWPPC 1992). We wish to reiterate (see SRG 1990b) the critical importance of this mandate, especially in light of critical uncertainties articulated above. We stress that presence of a monitoring and evaluation program will be effective only within the context of a responsive adaptive management structure.

LITERATURE CITED

Northwest Power Planning Council. 1987. 1987 Columbia River Basin Fish and Wildlife Program. Northwest Power Planning Council, Portland, Oregon. 246 pp.

Northwest Power Planning Council. 1992. Strategy for salmon. Volume II. Columbia River Basin Fish and Wildlife Program, Report No. 92-21A. Portland, Oregon. 98 pp.

Scientific Review Group. 1990a. Comments on hatchery effectiveness work plan and projects. Memorandum to Policy Review Group, March 9, 1990. Portland, Oregon.

Scientific Review Group. 1990b. Annual Report. Memorandum to John Palensky, August 15, 1990. Portland, Oregon.

Scientific Review Group. 1990c. Recommended guidelines for research proposals. Memorandum to Policy Review Group, July 25, 1990. Portland, Oregon.

Scientific Review Group. 1991. Review of fisheries supplementation in the context of activities related to the Columbia River Basin Fish and Wildlife Plan. Memorandum to Wally Steucke, January 21, 1991. Portland, Oregon.