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Ref.: Hatchery Surplus Review

Dear Dr. Varanasi:

This letter is the ISAB's response to your January 29, 2001 request for our review of several questions pertaining to the disposition of "surplus" hatchery-reared adult salmon. Since salmon are beginning their seasonal migration into the basin, we are aware of the urgency in receiving our answers. The purpose of this letter is to provide our input to your staff and regional stakeholders as they begin working through the decision process on the individual cases where surplus hatchery-reared adults may occur this season. This letter is primarily concerned with a condensed summary answer to your first two questions.

We strongly believe that the scientific evidence indicates that natural spawning by hatchery-reared salmon poses significant risks to wild salmon under most circumstances. Our conclusion is not idiosyncratic, but consistent with evaluations made by other scientific review panels during the past twenty years. We arrived at our conclusions after reviewing recent fisheries and conservation literature and receiving presentations from Columbia River Intertribal Fisheries Commission, National Marine Fisheries Service, and Washington Department of Fisheries and Wildlife representatives and Dr. James Lannan, retired professor Oregon State University. The time allotted to review and respond to all the ideas and concepts we were asked to consider was limited. Consequently, our response presented here is also limited.

The problem: Recently, regional biologists and managers have limited the access of "surplus" adult hatchery-reared salmon to natural spawning grounds. This limitation occurred under two different circumstances. In the first, an ongoing hatchery program is being used to supplement a wild population, and the return of hatchery-reared adults has exceeded the fraction planned to be permitted to reproduce in the wild. It has also occurred when a production hatchery broodstock was being discontinued. In this latter case, adults returning from the final spawning were not needed for producing another generation of hatchery fish, and because they were believed to be inappropriate for restoring wild populations their access to spawning grounds was denied.

To limit the numbers of these hatchery-origin salmon on the spawning grounds, agency personnel have collected and killed them. This is understandably controversial with the public.

Federal and state management agencies are concerned that large numbers of hatchery-reared salmon spawning in the wild could overwhelm extant wild populations. Some regional stakeholders, on the other hand, are supporting the hypothesis that the spawning of the hatchery-reared salmon in the wild would make some positive contribution to the status of the wild population. The technical scientific reasons underlying the concern about the potential negative effects of excessive spawning of hatchery-reared fish in the wild are, unfortunately, very complicated, and have proven difficult for several constituencies to engage constructively. The ISAB was requested to review this issue and specifically to answer six questions.

These questions and our responses to them follow.

1. *For either supplementation or mitigation programs, is it possible to have more adult hatchery fish available to spawn than can be used in a biologically sound manner, for spawning either in the hatchery or in the wild?*

Yes, for both mitigation and supplementation programs it is possible that more adult hatchery-reared salmon return to spawn, particularly in the wild, than can be used in a biologically sound manner. There is substantial scientific literature, both theoretical and empirical, not only suggesting deleterious effects when hatchery-reared salmon in excessive numbers interact with wild salmon, but also suggesting deleterious genetic interactions when hatchery-reared and wild salmon interbreed.

Based on our review of recent literature and presentations at our February ISAB meeting we conclude:

- Demographic "boosts" from allowing excess hatchery fish to spawn with wild populations are unsubstantiated.

- Domestication selection can genetically alter hatchery populations in a relatively few generations.

- Hatchery-reared adults returning from the ocean and spawning in the wild generally produce progeny that do not survive as well as progeny from adults of wild-origin.

and we find a reasonable basis for suspicion that:

- Interbreeding between hatchery-reared adults and wild fish can reduce the fitness of the wild population.

The justifications of these conclusions are as follows:

Demographic Issues

The purpose of providing hatchery-reared adults the opportunity to spawn in the wild is to produce offspring. In supplementation projects, this is part of the program design and the alleged goal is to assist in rebuilding wild stock abundance. Interbreeding between hatchery-reared and wild salmon is an expected result from supplementation. In traditional hatchery programs straying into the wild to spawn is not intended, but progeny from such spawning could perhaps add recruits to the fishery. There is no evidence that reproduction from strays on the spawning grounds of a wild population makes a net positive contribution to tribal, commercial, or sport harvest, or contributes to recovery of the wild population.

Lack of empirical evidence for demographic boosts:
Interannual variation in salmon abundance is quite large and is observed consistently across species as well as geographic regions (Peterman 1987, Cramer 2000). In Oregon, Cramer (2000) observed more than a 50-fold difference in recruits/spawner among years in naturally produced coho salmon in coastal streams. Survival of smolts from the Cowlitz Salmon Hatchery to age 2 varied 10-fold for spring chinook, 20-fold for fall chinook, and 30-fold for coho salmon. Spawner/recruit relationships were asynchronous between species in a river system and between river systems within species. Ricker (1954) and Beverton-Holt (1957) deterministic stock-recruitment relationships account for little of this variation (Peterman 1987, Cramer 2000). Most of the variation appears to be a consequence of density-independent environmental variation, driven largely by survival in the first year after entry into marine waters. Within a stock, there are typically many years with relatively low abundance interspersed with occasional years of enormous abundance. Anticipating substantial harvest or recovery of persistently depressed populations based on egg deposition during years of enormous abundance is inconsistent with our observations and is unlikely. This conclusion is independent of whether the spawning salmon were of hatchery or wild origin.

Further, Nickelson *et al.* (1986) demonstrated that introducing juvenile hatchery-reared coho salmon into coastal Oregon streams did not increase the number of returning adult salmon. In fact, streams where hatchery-reared adults eventually returned and spawned as a result of this juvenile introduction, produced fewer naturally produced fry than locations that were not supplemented.

Although not exhaustive in their assessment of the full complement of demographic interactions, these studies provide convincing evidence that postulated demographic boosts from allowing excess hatchery reared salmon to spawn with wild populations are unsubstantiated.

Genetic Issues

The genetic structure of populations reflects the interaction of mutation, mating systems, migration among populations, natural selection, and random genetic drift. Genes change in form and function through mutation. Transmission of genes from parents to offspring, systems of mating, and migration of individuals among populations combine to create novel genotypes and even new organizational patterns for genes within an individual. These novel genotypes and gene organizational patterns produce the life history variation we observe in salmon, such as the life history differences between the spring-run chinook in the Snake River, and the fall-run chinook in the Hanford reach. By chance, novel genotypes sometimes produce fish that have increased abilities to survive and reproduce. Through natural selection those genotypes are preferentially perpetuated. In other circumstances novel genotypes produce fish incompatible with the environment they are required to live in, and these lineages perish.

The predominant view of scientists is that interbreeding between hatchery-reared and wild salmon could produce offspring with just such incompatible genotypes. As a result, offspring well adapted to the environment could become less abundant than they are now. Consequently, upon termination of supplementation the resulting population would decline to become even less abundant than at present. It is possible that this interbreeding could make it harder to recover wild salmon and could even eliminate the wild populations that are the present objects of our recovery efforts.

These genetic hazards for wild salmon from breeding with hatchery-reared salmon are complex. Some of the hazards are due to gene flow from hatchery salmon breeding with wild salmon that are adapted to different environments and likely to have different genotypes. Incorporating these hatchery genotypes into the wild population may produce salmon poorly adapted to their environment, thereby leading to a loss of fitness in the wild salmon population. Some of the hazards are due to altering the family structure in the salmon population breeding in the wild, and this may occur regardless of whether there are adaptive genetic differences between the hatchery and wild salmon populations. The altered family structure produces a population that has a smaller genetically effective population size. With a reduced effective population size, inbreeding depression can become a problem and allele frequencies will vary from generation to generation in a non-adaptive way owing to random genetic drift.

Interbreeding may lead to loss of fitness (outbreeding depression): When genetically divergent populations interbreed the progeny may be less fit because of a loss of local adaptation (Templeton 1986). Loss of local adaptation can be attributable to two processes. First, gene flow can reduce the frequency of favorable alleles if they are displaced by less favorable alleles in high frequency in a hatchery source population. When there is systematic migration of hatchery-reared adults to wild spawning grounds, locally adaptive alleles will be swamped by hatchery alleles when the migration rate exceeds the selective difference between the genotypes (Felsenstein 1997). As an example, if there is a 10 percent difference in the fitness of the two alleles in a wild population, then migration of more than 10 percent hatchery salmon will overwhelm natural selection.

Second, different ancestral lineages (for example ESU's) that exhibit similar life history patterns are likely to do so using different combinations of genes. These different coadapted gene complexes are generated when alleles become combined into multilocus genotypes through random genetic drift and some are highly advantageous. Disrupting these combinations through interbreeding can change the phenotype of the interbred individuals and reduce the fitness of the population. Through either of the above mechanisms, the loss of fitness incurred by the affected individuals is termed outbreeding depression. Based on empirical evidence from a variety of organisms Templeton (1986) and others predict that when interbreeding divergent populations, as would happen when hatchery salmon of non-local source spawned with wild salmon, there will be outbreeding depression in the offspring. The time it takes for fitness to increase back to original levels would vary, perhaps being as short as tens of generations, or as long as hundreds. Templeton cautions however, that severe outbreeding depression during the early generations following an interbreeding event can increase extinction probability in the near term.

Regarding hatchery broodstock management, Lynch (1997) concluded that hatchery-reared salmon only one or two generations removed from the wild would not likely exhibit much outbreeding depression when interbreeding with the wild salmon population from which they were derived. Outbreeding depression is more likely to occur when interbreeding is between genetically differentiated populations.

Domestication selection as a source of genetic divergence between hatchery and wild salmon: For interbreeding to alter population fitness through the loss of adaptation (outbreeding depression) there needs to be genetic divergence of the populations. Genetic differentiation among populations from different geographic regions (ESU's) for most salmon species is well documented. Consequently, interbreeding between individuals from different ESU's could be deleterious even if both parents were of wild origin. In addition to the divergence among wild populations, domestication selection within hatcheries can lead to genetic divergence of wild and hatchery salmon from the same ESU, because selective pressures in the hatchery are different from the wild. This domestication selection of the hatchery stock represents "natural" selection to the hatchery environment (Campton 1995). Domestication selection is typically inferred from improved survival under culture and alters behavioral characteristics and reproductive performance (Doyle *et al.* 1995). Although domestication selection is unavoidable, there are strategies to minimize the deleterious effects. Because of variation of husbandry in the past, current hatchery stocks likely vary widely in their degree of domestication.

Supportive breeding may reduce effective population size and increase inbreeding: Population size is important in maintaining similar genetic characteristics in parental and progeny populations. Unintentional inbreeding occurs in randomly mating small populations, and random genetic drift increases variance in allele frequencies. The rate of inbreeding and genetic drift is a function of the genetically effective population size (Ne), which is not equal to, but less than, the absolute number of reproducing adults in the population. The sex ratio, the distribution of progeny per family, and the relative proportions of progeny from wild and captively bred individuals are very important (Lande and Barrowclough 1987, Ryman and Laikre 1991, Ryman 1994, Ryman *et al*. 1995). When progeny from a limited number of parents make up a substantial proportion of a wild spawning population, the genetically effective population size is substantially less than the census numbers. This circumstance is most likely to arise when a hatchery is used to provide a survival advantage to a portion of a population. Consequently inbreeding depression and reduced fitness can occur in the progeny. Inbreeding depression is a reduction in the fitness of the progeny of closely related parents, because these progeny are homozygous at more loci for deleterious recessive alleles than the progeny of more distantly related parents. Deleterious recessive alleles arise by mutation and are present in most populations, although the frequency of these deleterious alleles is typically low because of selection against them.

Alternative viewpoints: The overview and theoretical background presented above represents a widely accepted consensus among evolutionary biologists and conservation geneticists. The ISAB concurs with this consensus. Nevertheless, we are aware of the existence of dissenting viewpoints, the viewpoint held by CRITFC being one.

The ISAB was briefed by representatives of CRITFC on the reasons for their divergence of opinion from the generally accepted model. In this presentation, the CRITFC representatives challenged the presumption that wild salmon populations are optimally adapted, concluding this is a hypothesis frequently cited in the literature as fact without adequate support. Regarding genetic divergence of hatchery-reared salmon they propose an alternative conceptual framework where natural mortality in the wild is primarily random and hatchery rearing increases fitness in the population by decreasing mortality from random effects. In their opinion domestication selection is minimal and genotypes advantageous in the wild have a better chance of survival in the hatchery environment than in the wild because they are not eliminated by genetic drift. Finally, CRITFC proposes that by intentionally interbreeding hatchery-reared salmon with wild salmon, new adaptive genotypes could be established, contributing to the restoration of self-sustaining salmon populations

The ISAB acknowledges that claims of local populations being optimally adapted might profitably be reviewed in some depth. A population's relative fitness will of course be constrained by its genes, which are a product of the population's history and breeding structure. As the environment changes and as the populations genetic attributes change, so we would expect its relative adaptive fit to the environment to change. Some of the existing genotypes within a population will be more fit than others in that new environment; natural selection will favor those. Across the numerous semi-isolated subpopulations that make up a salmon metapopulation we expect some will be very well adapted and others less so. We believe that the issue is not whether a given population is "optimally fit" for that environment, but rather how would certain management actions (e.g., allowing hatchery fish to interbreed in the wild) affect the relative fitness of that population in the future.

Population geneticists propose that small populations of endangered species could accumulate a substantial number of mildly deleterious genes and are consequently at risk of "mutational meltdown" leading to extirpation (Gabriel and Burger 1994). The ISAB certainly believes this is one of the conceptual and strategic problems facing the technical recovery teams and stakeholders within the framework of recovery plans for ESA listed populations. One option that is sometimes proposed to reduce this hazard would be to consider intentional introductions of small numbers of individuals from other populations. The ISAB believes that because of the high risk associated with loss of fitness due to outbreeding depression, deliberate introductions of genetic variation to counteract perceived inbreeding difficulties must be considered very carefully before implementation. It would be dangerous to assume that any wild population would be improved genetically through interbreeding with hatchery-reared salmon. One reason for this high level of caution is that the technical and analytical tools currently available are insufficient to identify which populations are at risk, how to select donor individuals, and how to perform the introductions

Empirical Evidence for Genetic Concerns: There are various studies providing empirical evidence of hatchery-reared salmon and steelhead interacting with wild salmon and the consequences these may have for wild salmon abundance. Many studies evaluate the stocking of juvenile hatchery salmonids into habitats occupied by conspecific individuals. Virtually all of these studies provide information useful for managing artificial production programs. Interpreting these studies in the context of whether there can be excess hatchery-reared salmon spawning with wild salmon is not always straightforward. As an example, Rhodes and Quinn (1999) observed similar performance of hatchery and naturally reared coho salmon during summer months in common stream environments. In this instance however, the parents were of mixed hatchery and wild origin and common to both cohorts. Egg incubation for both groups was in a hatchery environment. The test groups were formed after hatching: one group was moved to low density natural rearing in a stream and the other maintained at high density in a hatchery. Three months later the hatchery-reared coho were added to the naturally rearing test group for subsequent rearing under natural condition and comparison to the naturally reared group. The study provides a valuable example that dissimilar early rearing experience (hatchery versus natural) of hatchery salmon does not necessarily lead to differences in performance during subsequent freshwater rearing. These performance traits are not a measure of fitness; in fact some performance traits may have little or no impact on fitness. In addition, this study does not inform us how interbreeding between dissimilar hatchery and wild parents could affect the fitness of an introgressed wild population, which is the condition we need to consider.

Similarly, Berejikian *et al.* (1997, 1999) collected wild coho smolts and reared them to adulthood in captivity. These captive-reared salmon to spawned with wild salmon in test enclosures and produced viable offspring (Berejikian *et al.* 1997). Paternal half-sib fry from captive-reared females dominated their half-sibs from wild females. This was attributed to differences in egg color and possibly could be modified by changing diets (Berejikian *et al.* 1999). These studies were conducted to evaluate the efficacy of strategies to employ captive-rearing in maintaining critically depressed wild salmon and steelhead populations. This captive-rearing strategy is very different from hatchery programs that release smolts that return to spawn as adults after migrating to ocean environments.

To keep this summary reasonably succinct, and focused on the consequences of hatchery-reared adults spawning in the wild, we are not reviewing all of the available literature on hatchery-wild salmon interaction. Empirical evidence for domestication of hatchery fish, of the success of hatchery fish spawning in the wild, and of the consequences of interbreeding between hatchery-reared and wild salmon is summarized.

There are life-history and behavioral characteristics in hatchery salmon attributed to domestication selection. In comparison to wild salmon, hatchery-reared adults generally return from the ocean and spawn earlier in the year and frequently at younger ages. Although this is the most commonly cited and accepted evidence of genetic domestication in anadromous populations, there is additional evidence. Crossbred steelhead x domestic rainbow trout juveniles risked exposure to predators more often than wild steelhead (Johnsson and Abrahams 1991). Steelhead from a hatchery population exhibited more aggressive behavior and were preyed upon by sculpins more frequently than wild steelhead (Berejikian 1995, Berejikian *et al.* 1996). Similarly, hatchery coho salmon exhibited increased agonistic behavior that was attributed to additive genetic variation (Swain and Riddell 1990, Riddell and Swain 1991). Morphology of hatchery coho salmon is altered from their natural counterparts although the genetic basis for the observation is less certain (Fleming and Gross 1989, Swain *et al*. 1991). Faster juvenile growth rates, together with a feeding response rather than a fright response to the presence of people, is additional ancillary evidence of acclimatization to culture (Vincent 1960).

When hatchery-reared adults migrate onto natural spawning grounds, there are at least three end points of interest: whether or not the hatchery-reared salmon spawn, whether hatchery-reared adults produce offspring equally well as wild salmon, and whether interbreeding between hatchery-reared and wild salmon affects the fitness of the wild population? Evidence demonstrates that hatchery-reared adults will spawn in the wild. Hatchery-reared chinook, coho, and Atlantic salmon have reduced mating success compared to their wild conspecifics, particularly the hatchery-reared males (Chebanov and Riddell 1998, Fleming and Gross 1993, Fleming *et al.* 2000).

There are three studies with steelhead and one with chinook salmon that compare the survival of progeny from hatchery-reared adults with those of their wild counterparts in natural settings. Reisenbichler and McIntyre (1977) produced wild, hatchery, and wild x hatchery steelhead families and compared their performance both in the hatchery environment and in small tributary streams in the Deschutes River basin. Contrasted at emergence through age-1, families with wild ancestry had better survival than hatchery or hatchery x wild families in streams, whereas in a hatchery the hatchery families survived best. Chilcote *et al.* (1986) and Leider *et al.* (1990) produced genetically marked Washougal hatchery summer steelhead smolts that they released in the Kalama River. After migrating to the ocean they returned as adults to spawn naturally in the river. The hatchery and wild components of the adult spawning population and their progeny could be enumerated using the genetic mark. The proportion of underyearling hatchery progeny was less than expected based on the proportion of hatchery-reared adults. The relative survival of the progeny of hatchery-reared adults continued to decline through the smolt and returning adult life stages.

Hulett *et al.* (1996)(cited from Reisenbichler and Rubin 1999) produced three year classes of genetically marked Elochoman winter steelhead smolts and released them in the Kalama River. After migrating to the ocean, they returned as adults to spawn naturally in the river. The hatchery and wild component of the adult spawning population and their progeny were enumerated using the genetic mark. The relative survival of the progeny of hatchery-reared adults was evaluated as smolts and returning adults. In two of the three year classes wild steelhead survived better to the smolt stage and in one year class the hatchery steelhead survived better. Relative production of returning adults from wild steelhead exceeded the production from hatchery steelhead in all three year classes.

Reisenbichler and Rubin (1999) produced two year classes of hatchery and wild summer steelhead and both released them into the Clearwater River as button-up fry and maintained them in a hatchery environment. Comparisons at age-1 demonstrated reduced survival of hatchery steelhead in the wild, and reduced survival and growth of the wild steelhead in the hatchery. Finally, Reisenbichler and Rubin (1999) evaluated Warm Springs River spring chinook salmon of hatchery and wild-origin in the Little White Salmon River. Relative survival of hatchery chinook test groups released as button up fry in January and evaluated in August was less than wild test groups.

Evidence to evaluate the fitness effects of interbreeding between hatchery-reared and wild salmon is largely unavailable. One study (Currens *et al.* 1997) demonstrates the potential deleterious effects of interbreeding between hatchery-reared domestic rainbow trout and resident wild trout. *Ceratomyxa shasta* is a myxosporean parasite of salmonid fishes common within the Deschutes River basin, which causes lethal infections. Susceptibility to infection varies among species and populations of trout and salmon. Populations inhabiting regions where the parasite occurs exhibit resistance and populations from regions where the parasite is absent are often quite susceptible. In the Metolius River, Oregon coastal strains of hatchery rainbow trout have been stocked to provide recreational angling. Genetic and morphological analysis indicates these hatchery trout have interbred with native resident rainbow trout. When challenged by exposure to *C. shasta* the hatchery rainbows are highly susceptible, native Metolius rainbows interbred with hatchery rainbows are intermediate, and native Deschutes River steelhead least susceptible.

The ISAB recognizes that all of these studies have limitations because of difficulty in design and execution. We would like to reiterate that taken together they none-the-less provide convincing evidence that:

- Domestication selection genetically alters hatchery populations in a relatively few generations.

- Hatchery-reared adults returning from the ocean and spawning in the wild generally produce progeny that do not survive as well as progeny from adults of wild-origin.

and suspicion that:

- Interbreeding between hatchery-reared adults and wild fish can reduce the fitness of the wild population.

ISAB conclusions:

- The ISAB believes there is substantial empirical evidence of deleterious interactions, both demographic and genetic, from allowing hatchery fish to spawn in the wild. The genetic hazards accompanying the intentional facilitation of interbreeding between populations, whether they are of wild or hatchery origin, are too substantial to be ignored. These hazards become particularly important when the outcome of these management actions is irreversible and involve ESA listed species.

2. *If it is possible to have more hatchery fish than can be spawned in a biologically sound manner, what factors should be considered in evaluating at what level of spawning the adverse effects on natural populations outweigh potential benefits? Can the ISAB suggest any general guidelines about how to determine this level? How will this level vary with factors such as stock history, broodstock and rearing protocols, duration of the program, etc.?*

All of the presenters conclude, and the ISAB concurs, that neither theoretical nor empirical evidence establishes threshold levels below which hazards to wild populations can be ignored. Quantitative treatment of the risks and benefits reveals a management conundrum. The relationship between benefits and risk, and the trade off between different types of risk is complex and cannot be avoided. Typically, both benefits and risks increase together. For example, when there is a very low proportion of hatchery-reared adults spawning with wild populations, genetic risks would not be particularly great, but at the same time, the potential demographic boost to the wild population would also be quite small, certainly insufficient to meet management objectives. On the other hand when there is a high proportion of hatchery-reared adults spawning with wild populations, demographic boosts are conceptually possible, but risks of genetic and ecological hazards become significant. If these hazards materialize they would offset any demographic boost, and the program would be unable to meet management objectives. Similarly, program design elements to reduce one hazard, for example inbreeding hazards, often can increase other hazards, for example, domestication hazards. Consequently there are no simple formulas or guidelines to determine these levels to make outplanting or supplementation risk-free.

The scientific evidence does not support indiscriminately permitting hatchery-reared salmon to spawn naturally throughout the Columbia basin. Decisions to permit hatchery-reared adults to spawn in the wild should be based on the needs of wild populations and the ability of the habitat to support additional reproduction, not based on the availability of hatchery-reared adults returning from the ocean. The Northwest Power Planning Council's Fish and Wildlife Program of 2000 presents a general framework for considering under what circumstances different approaches to natural spawning of artificially produced fish are appropriate. The decision to permit hatchery-reared salmon to spawn in the wild should properly be made in the larger context of subbasin assessments and provincial recovery planning. The Washington Department of Fish and Wildlife has developed a benefit-risk assessment procedure derived from earlier efforts of Mike Ford (NMFS) and Ken Currens (Northwest Indian Fisheries Commission). At a minimum, this type of assessment is needed for each wild population and hatchery program. WDFW's benefit-risk assessment discusses relevant factors such as stock history, broodstock and rearing protocols, duration of the program. We refer you to their treatment rather than repeating it here.

During the presentations at the February ISAB meeting, we heard the argument that basin managers should consider hatchery fish equivalent to wild fish until proven otherwise, using a "null hypothesis" of no difference. Conceptually, this is a misapplication of statistical hypothesis testing. More importantly, in arenas such as the regulation of pesticides and reclamation of soils EPA guidelines formally reverse the classical tests and the burden-of-proof. In these cases pesticides are not considered safe and contaminated soils not considered clean until they are proven to be "bioequivalent" to placebos and reference sites, respectively. Statistical procedures for this reverse hypothesis testing are available (McDonald and Erickson 1994). There is no scientific basis to support a "null hypothesis" of equivalence of hatchery-reared and wild fish.

Our most serious concerns associated with having hatchery-reared salmon spawn in the wild center around the demographic and genetic interactions between hatchery and wild stocks. Concerns are different in streams where wild salmon have been extirpated, and there is little likelihood of natural recolonization. In this case, a well designed program to try to establish a run from scratch with hatchery-reared adults of a stock chosen for that purpose is more reasonable. From a genetic standpoint the key to success would lie in the chosen source of the broodstock, one that is compatible with the environment in the recipient habitat. From an ecological standpoint, the key to success would lie in having the reasons that caused the extirpation corrected, whether that represents local habitat degradation or downstream migration blockage.

Finally, monitoring is required to evaluate the outcome of natural spawning by hatchery-reared adults. Since the end point of interest is understanding the contributions the hatchery-reared adults make to subsequent recruitment, sophisticated genetic markers capable of identifying individuals produced by hatchery-reared adults is required. A well-designed, large-scale experiment designed specifically to answer that question needs to be initiated. The ISAB urges that the Basin stakeholders join together in support of a basinwide experiment designed to assess the success of the supplementation strategy in general. That experiment would require the production of a large number of genetically tagged individuals, as well as an alteration of the annual stocking regimes at different sites throughout the basin for a number of years. The long-term benefits from this experiment, however, would be substantial.

3. *Are there any technical hatchery management recommendations that might reduce the frequency or magnitude of the occurrence of these excesses?*

Reevaluate the program scale. The numbers of smolts released are based on average anticipated survival rates. Since survival rates vary, substantial surplus hatchery-reared adults can be anticipated on a periodic basis. If surpluses become the norm rather than the exception, then the survival rates used to calculate the smolt release numbers could be too low. Reducing the numbers of smolts released could have added benefits of reduced costs and reduced ecological impacts during the juvenile migration.

4. *Within the context of reforming hatchery practices to reduce impacts to wild populations, under what circumstances should mitigation/enhancement hatchery programs be terminated, relocated, or broodstocks switched to local stocks?*

The recent NMFS Federal Columbia River Power System Biological Opinion (December 21, 2000) and the Basinwide Recovery Strategy conclude they are unable to assess the impacts of hatchery releases on wild populations because of insufficient monitoring and evaluation. The inability of regional managers to assess the impacts of hatcheries should alarm all of the basin constituencies. The absence of adequate evaluation makes the task of reforming artificial production more challenging. Realistically, years of data are needed to assess these impacts. Because the region does not have the luxury of years of data, important decisions on altering programs will need to be made with the data that are available.

One decision that needs to be made is determining what level of impact is acceptable to individual populations and Evolutionarily Significant Units (ESU's). A second is determining how that impact can be assessed with limited data. Once those decisions are made, it will be necessary to assess the potential for alteration of each hatchery program. Hatchery Genetic Management Plans are currently being prepared for Columbia basin hatcheries and the Northwest Power Planning Council is forming an Artificial Production Advisory Committee to advise the Council on artificial production reform and realignment in the Columbia basin. Perhaps these groups could serve as vehicles to begin this process.

Hatchery programs that exceed allowable impacts should be considered for termination, relocation, or restructuring, possibly with local broodstocks. Likely candidates for such overhaul would be those programs that have high stray rates or hatchery return facilities that are easily bypassed, making containment unsuccessful, or programs that use genetically divergent broodstocks. Switching to local broodstocks is a strategy receiving much consideration within the Columbia basin. Although the ISAB certainly encourages this effort, this type of alteration may not decrease the impacts of hatchery programs on wild salmon populations. When using locally derived broodstocks individual genetic and ecological interactions may be less severe than when using long domesticated stocks, but there may be an increased incidence of these less severe interactions. The end result could be an increased overall net effect.

5. *What use can be made of "excess" hatchery fish, apart from allowing them to spawn in the wild or the hatchery, that would provide benefits to society and/or wild salmon populations?*

This is largely a policy question that the region is better able to answer than the ISAB. Dr. Waples' written comments indicated the U. S. Fish and Wildlife Service produced a range of feasible, options and we refer you to those sources. There are obvious suggestions: harvest the surplus at or near the hatcheries in fisheries, capture the fish at the hatchery, process and distribute them for human or pet food, or use them for nutrient enrichment in streams (given the appropriate consideration to fish health guidelines). To this list the ISAB would suggest adding the use of some of the surplus for adult passage experiments at hydroelectric projects.

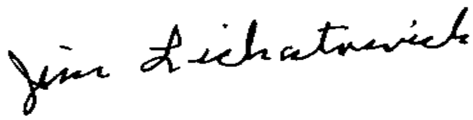
6. *If euthanasia of excess fish is unavoidable, are there guidelines for acceptable methods? If so, what are they?*

Legally appropriate euthanasia methods can be found in the 2000 Report of the AVMA Panel on Euthanasia published in the Journal of the American Veterinary Medical Association (2001; volume 218(5): 669-696). This document is referred to specifically by the Code of Federal Regulations and by all of the major policy guidelines concerning animal welfare in the US. http://www.avma.org/resources/euthanasia.pdf

Guidelines for the Use of Fishes in Field Research (1988) from the American Society of Ichthyologists and Herpetologists (ASIH) the American Fisheries Society (AFS), and American Institute of Fisheries Research Biologists (AIFRB). GUIDELINES FOR USE OF FISHES IN FIELD RESEARCH . Fisheries , Vol. 13, No. 2, p. 16-23, 1988. http://www.utexas.edu/depts/asih/pubs/fishguide.html

Even though the ISAB believes that permitting surplus hatchery-reared adults to indiscriminately spawn in the wild is unwise, we recognize that killing them is distasteful and a potential public relations nightmare. We encourage you to consult with commercial aquaculturists and fish processors to explore methods that are as benign as possible. The Western Regional Aquaculture Center is located at the University of Washington, Seattle: http://www.fish.washington.edu/wrac/.

Sincerely,



Jim Lichatowich, Chair
Independent Scientific Advisory Board

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Independent Scientific Advisory Board
for the Northwest Power Planning Council
and the National Marine Fisheries Service
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July 16, 2001

Mr. Frank L. Cassidy Jr., Chair
Northwest Power Planning Council
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Dr. Usha Varanasi, Science Director
National Marine Fisheries Service
2725 Montlake Blvd, East
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Ref: Hatchery Surplus Review

Dear Dr. Varanasi and Mr. Cassidy:

The ISAB and/or your offices have received letters from Drs. Andre Talbot, James Lannan, and Ernest Brannon critical of our recent letter report summarizing our consensus position on the issue of whether or not it is possible to have more hatchery-origin adult salmon spawn than can be used in a biologically sound manner. The ISAB members have discussed these letters individually as they have been delivered to us, and then collectively at our June 26, 2001 meeting in Portland, Oregon. Although we responded to Dr. Brannon with a brief letter dated June 19, 2001, as a general rule the ISAB prefers not to respond to authors of criticisms of our consensus evaluations because it adds little new guidance to the region and can be quite time consuming. The criticism we received in this case, however, included charges that we were not objective and that we failed to provide a complete and balanced review. Because these charges attack the fundamental notion of independent scientific review and the credibility of the ISAB, we believe that we should respond to them.

All three letters suffer from a common set of shortcomings: they fail to recognize the specific nature of the questions that the ISAB was asked, by you, to answer; they misconstrue the scope of the answers that we provided; and they contain some factual errors. Much of the criticism centers around the misconception that our letter report to you about hatchery surpluses was intended to constitute a general review of the potential risks and benefits of supplementation programs in their various forms. Because our letter report limited its scope to your actual questions, we believe that this criticism is misplaced. In fact, the National Marine Fisheries Service asked very specific questions regarding whether it is possible to have more hatchery-origin adults spawning for either supplementation or mitigation programs than can be used in a biologically sound manner. We were not asked to address wider questions about supplementation in general. In our report we presented our appraisal of the theoretical hazards to wild populations from presence on their spawning grounds of excessive numbers of individuals from hatchery populations. The evidence from experimental studies available in the peer-reviewed literature convinces us that these theoretical hazards are sufficiently likely, and serious, that they should not be ignored when contemplating allowing hatchery origin fish to spawn in the wild. We believe that these risks are in fact serious enough to warrant reconsidering the assumed benefits of supplementation in general, and we hope that you share that level of concern.

The letter writers acknowledge these risks, but chose to minimize them. In his letter Dr. Talbot states, "Members of the ISAB should know that CRITFC does recognize the potential risks posed by artificial propagation, and that we pursue artificial propagation only after conducting a strict assessment of the benefits and risks of doing so (e.g. PRRG 2000)". In his letter Dr Brannon states, "Yes, there are risks, and hatchery programs need to improve to meet enhancement needs in this new century, but those risks were emphasized at the exclusion of the indifferent and positive effects that hatcheries can have on wild populations". From these statements the ISAB is left with the impression that these scientists are not disagreeing with the hazards we identified, but with our level of concern for them. Because genetic resources cannot be regained once lost, concerns over the introgression of hatchery and wild populations is prudent, not alarmist. In fact, a legitimate, more cautionary approach toward this issue within the Columbia River Basin would switch the "scientific burden of proof" from the position of having to show that harm results from allowing hatchery fish to spawn in the wild to one of having to show that no harm results from such actions.

The experimental studies that we cited to support our conclusions were criticized by the letter writers because of limitations in their experimental designs. In our letter report, we acknowledged that the experimental studies we cited were imperfect: "The ISAB recognizes that all of these studies have limitations because of difficulty in design and execution." Given the inadequate monitoring of the hatchery program in the Northwest, inference from the available imperfect studies will remain important in evaluating artificial propagation. The fact is that there has not been an adequate experimental evaluation of either the benefits or the risks to wild populations from hatchery production or supplementation. All of the experimental evaluations to date have limitations, so the best that can be done at the moment is to synthesize the balance of experimental evidence in light of widely recognized evolutionary theory. The peer-reviewed literature does not present a body of evidence contrary to our conclusions.

The letters raise the complaints that we did not consider Dr. Lannan's analysis of census data on naturally spawning Oregon coastal coho salmon, nor did we review material submitted by Dr. Talbot. These complaints are without substance. We continue to be disappointed that, despite our request, Dr. Lannan has so far failed to produce his analysis. Dr. Talbot's transmittal of several journal papers was received after we had completed our assignment. We were aware of that material, but even after reexamination of it, find nothing that alters our concern regarding the potential for negative impacts of hatchery fish on depressed wild populations. We emphasize that all of the material cited in our review was drawn from the peer-reviewed published scientific literature, as is appropriate to maintain the highest level of scientific quality control in a review of a topic that is so contentious.

Dr. Lannan claims to be disappointed that we did not follow the advice of Dr. Busack, and evaluate the questions on a case-by-case, hatchery-by-hatchery basis. Our charge was to evaluate the hatchery surplus issue in general and not to conduct the case-by-case review of individual hatchery programs advocated by Dr. Lannan. We would like to state clearly however, that we strongly support the need for case by case analyses; we even made that recommendation in our letter report: *"Decisions to permit hatchery-reared adults to spawn in the wild should be based on the needs of wild populations and the ability of the habitat to support additional reproduction, not based on the availability of hatchery-reared adults returning from the ocean. The Northwest Power Planning Council's Fish and Wildlife Plan presents a general framework for considering under what circumstances different approaches to natural spawning of artificially produced fish are appropriate. The decision to permit hatchery-reared salmon to spawn in the wild should properly be made in the larger context of subbasin assessments and provincial recovery planning. The Washington Department of Fish and Wildlife has developed a benefit-risk assessment* *procedure derived from earlier efforts of Mike Ford (NMFS) and Ken Currens (Northwest Indian Fisheries Commission). At a minimum, this type of assessment is needed for each wild population and hatchery program. WDFW's benefit-risk assessment discusses relevant factors such as stock history, broodstock and rearing protocols, duration of the program."*

The ISAB recognizes that salmon produced by the artificial production program can form an important resource for the citizens of the Columbia River Basin. The extent to which this program is impacting listed wild populations of salmonids and the extent to which supplementation can contribute to recovery remains uncertain. Evaluating and reforming the artificial production program has been, and is likely to remain, highly challenging. The programs of both the National Marine Fisheries Service and the Northwest Power Planning Council recognize the experimental nature of hatcheries, yet we see little evidence of the type of experimentation that is needed to answer the overall questions concerning the costs and benefits of supplementation and the use of hatcheries in general. The ISAB has long advocated a large scale, well designed experimental program to address just such questions. A similar position was recently taken by another committee of independent scientists, NMFS' Salmon Recovery Science Review Panel (http://research.nwfsc.noaa.gov/cbd/trt/rsrp.htm). Unless studies of this nature are funded and carried out, arguments concerning the true worth of supplementation programs will continue. The ISAB remains interested in conducting a review of the broader questions concerning the effects of supplementation, and in that process we would be happy to provide advice on the design of monitoring and evaluation efforts needed to help resolve the critical uncertainties associated with the still experimental program of supplementation.

Sincerely,

/s/ All ISAB

Peter A. Bisson
Charles C. Coutant
Daniel Goodman
Robert Gramling
Dennis Lettenmaier
James Lichatowich
Eric Loudenslager
William Liss
Lyman McDonald
David Philipp
Brian Riddell

CC: Dr. James Lannan; Dr. Andre Talbot (CRITFC); Dr. Ernest Brannon (U of Idaho)

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