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**Memorandum (ISRP 2009-28)** **July 17, 2009**

**To:** W. Bill Booth, Council Chair

**From:** Eric Loudenslager, ISRP Chair

**Subject:** Final Review of BiOp proposal Chum Salmon Enhancement in the Lower Columbia River (2008-710-00)

## Background

At the Council's March 12, 2009 request, the ISRP reviewed Washington Department of Fish and Wildlife's (WDFW) proposal, Chum Salmon Enhancement in the Lower Columbia River. This proposal is intended to meet needs identified in the 2008 Biological Opinion (BiOp) for the Federal Columbia River Power System by promoting recovery of lower Columbia River chum salmon populations through development of an integrated program for chum salmon habitat restoration and supplementation/reintroduction. On April 28, 2009, the ISRP provided its initial review and requested a response from WDFW on seven specific points (ISRP 2009-14[1]). On June 8, 2009, WDFW provided a response.

## ISRP Final Recommendation

*Meets Scientific Review Criteria in Part (qualified)*

Overall, the planning and integration activities in the proposal are justified but qualified in that the scheduling and timing sequence of the tasks during the first year need to be revised. Three-Step development should follow the habitat, genetic, stock assessment, and supplementation evaluations. The evaluation of chum salmon supplementation in the Columbia River would be enhanced by providing a critical review of the Hood Canal summer chum supplementation program which has now been underway for several years. The Three-Step Master Plan should serve as the adaptive management plan and include monitoring and evaluation (M&E) that reflects what was learned from the planning and integration analyses. A single Master Plan for chum salmon in the Lower Columbia River (LCR) that integrates habitat restoration and any supplementation and reintroduction is preferable to a plan for each tributary or population component (Cascade, Gorge, etc).

[1] www.nwcouncil.org/library/isrp/isrp2009-14.htm

**Objective 1: Habitat restoration and chum channel site assessment.**

***Meet scientific review criteria***

This objective, which is centered on planning, will require the proponents to develop a much clearer understanding and articulation of the specific factors that are limiting chum salmon restoration and recovery. The plan would benefit from a more comprehensive and quantitative approach for ranking projects than was demonstrated in the proposal or response to ISRP's review. Identification of preferred habitats and sites for restoration will require a better understanding of limiting factors throughout the life cycle of chum salmon. For example, the provisional list of criteria and metrics for "Life history stage(s) benefitted" included only two criteria – both related to the adult spawning stage: (1) "Is creation of spawning habitat part of the project?" and (2) "What level of spawner abundance will be supported?" According to the proposal, criteria/metrics "will be finalized prior to assessment." Methods for this finalization process should be provided. Composition of the proposed expert panel and assessment methods to be used by the panel should also be provided.

**Objective 2: Lower Columbia River chum salmon stock status review.**

***Meets scientific review criteria***

The overall stock status as outlined in the project proponents' response is acceptable. In contrast, factors leading to declines in Columbia River chum salmon are not well identified or supported from the proponents' literature review of past studies. The proponents should adequately review this literature as well as their historical unpublished information. They will then be in a position to construct and articulate an objective, ecologically-based rationale regarding specific causes of chum stock decline. Emphasis should be on the specific causes of decline, not just on stock status, which is much better understood. The proposal's genetic and otolith microchemistry components are appropriate, although it is questionable whether important genetics information (beyond that already known) will result from the proposed activity.

**Objective 3: Develop a supplementation/reintroduction strategy for Lower Columbia River chum salmon.**

***Does not meet scientific review criteria.***

Continued supplementation is not justified based on the information provided thus far in the proposal. The proponents need to construct an ecologically-based rationale leading to their conclusions that supplementation is necessary and will be successful in rebuilding the chum stocks. Where they cannot develop such rationale, supplementation should be omitted from the proposal. They should indicate the specific limiting factors (e.g., egg survival, fry survival, etc., rather than simply 3 of 4 Hs) that supplementation is expected to overcome. An adequate review of results of existing efforts at Grays River and Duncan Creek (Objective 2) should be part of this review.

**Objective 4: Population monitoring and evaluation program development.**

***Meets scientific review criteria***

Although the monitoring activities outlined are, in general, appropriate, more emphasis is needed on designing and monitoring activities to provide specific information on factors leading to stock decreases and increases.

**Objective 5: Grays River chum salmon supplementation.**

***Does not meet scientific review criteria***

Our comments on Objective 3 regarding supplementation (which did not meet scientific criteria) apply to this objective. The rationale for supplementation is unclear. The ISRP requests that a clear, succinct train of thought be articulated that has led the proponents down the road to supplementation (and thus a circumvention of key identified limiting factors) in Grays River. This objective indicates that WDFW thinks supplementation is necessary and desirable in this situation. Their rationale for this belief is not clearly articulated for the ISRP to evaluate.

**Objective 6: Removal of invasive vegetation in Hamilton Spring Channel.**

***Meets scientific review criteria***

Reed canary grass will probably have to be removed annually, and that likelihood should be recognized.

**Objective 7: Initiate 3 Step review for at least one top ranked project identified by the habitat restoration and chum channel site assessment.**

***Does not meet scientific criteria***

Three-step development should follow the habitat, genetic, stock assessment, and supplementation evaluations.

**ISRP Final Response Review Comments**

The response clearly represented considerable effort by the proponent. However, several major questions remain unaddressed. Our comments here are intended to assist the proponent by further clarifying and specifying key questions that should be addressed. The ISRP believes that it is appropriate for the ecological bases for proposed stock assessments, supplementation, and restoration be discussed and clarified and should lead to a better understanding of the project basis and rationale.

Our comments below are organized around our initial seven points raised in the April 28 review.

**1. Provide more specific information on factors shown to cause declines in Lower Columbia River chum salmon.**

**and**

**5. Clearly define the specific benefits of the combination of habitat restoration for wild fish and supplementation, including a description of how these elements operate in a mutually beneficial way to restore the chum salmon run.**

Comment: These two questions are clearly linked. The proponents' response effectively summarized the decline of Lower Columbia River chum salmon and the relation of their project to various basin planning documents. Key facts as they outlined them are (a) that chum salmon historically may have constituted about 6% of the total Columbia River salmon run, (b) that their present numbers are less than 1% of their historical levels, (c) very few chums were ever taken far upriver (e.g., few historically taken by tribal fisheries at Celilo Falls), (d) although chum counts above Bonneville have dropped to near zero, the counts never were high, even in the late 1930s (proponents' Figure 5) and (e) abundances of nearly all stocks are at critically low levels (proponents' Table 14). The proponents suggest that with such precipitous declines and low stock sizes it is likely that much genetic diversity has been lost. This bleak status report seems accurate enough, and its presentation was beneficial to the ISRP.

The ISRP was specifically interested in, and requested of the proponents, available evidence supporting the causes of chum decline in the basin and identification of the specific studies used as evidence – studies both within the basin (preferably) and outside the basin (for comparison). On the issue of specific causes of the decline in the basin, there seems to be a serious lack of directed studies by WDFW (the primary agency we would expect to have the information). Papers by Johnson et al. (1997) and a couple of older studies were mentioned, but our request for more recent scientific papers in the area went largely unanswered. In a recent review of viability status of Columbia River Chum in Oregon by McElhany et al. (2007), no mention was made of factors leading to the observed declines. In 1966, Oakley (p. 16) mentioned "deleterious watershed activities such as logging, gravel removal, stream diversion, improper road building and construction of impassable barriers such as dams and culverts" as well as "intensified land use" and "decreasing freshwater spawn and rearing area" as possible contributors to Tillamook Bay chum declines. He concluded, though, that "the coast wide decline has extended to localities which have not suffered pronounced environmental changes. Thus, it appears most likely that some climatological or oceanic factor is responsible for the widespread decline in chum stocks." A decade later, Berry (1975) made no mention of factors affecting abundance of chum on Oregon streams. Although increased knowledge of the importance of estuaries has ensued (Pearcy et al. 1989), our knowledge of specific factors affecting chum declines has lagged. Howell et al. (1985; referenced in proponents' response) identified priority research needs as of 1985 as (1) survival of native Columbia River stocks and introduced stocks and (2) causes of population decline. These information needs evidently remain unmet. The ISRP believes that the proponents should concentrate efforts on these questions.

Lacking solid reasons for the declines based on any *ad hoc* studies involving ecological evidence, the proponents invoked a range of traditional causes (the 4 Hs, with a clear statement that effects of one H, hatchery, were in general minimal). The proponents' use of the 4H's as causes of the decline unfortunately provides little insight into specific ecological mechanisms. They call three of the H's (habitat, harvest, and hydro) "limiting factors" (on page 62 of the response), with no specific ecological basis outlined for giving them this status. In addition, the use of quasi-quantitative rankings in essentially all of the tables responding to this question do not engender confidence that anyone really understands what has led to the declines and has evidence to support the assertions.

Many questions remain. What are the primary causes of the observed declines? What factors are contributing to limits to production at the critical life stage(s)? What experiments if any clearly demonstrate this? Are the primary causes harvest-related (directed and incidental)? At spawning? At incubation or hatching? In the estuary? In the ocean? What are the mortality mechanisms? Harvest? By-catch in ocean fisheries? Siltation of redds? Early predation? Starvation? Diseases? Pollution? Climate change? Competition with other species (hatchery-reared or wild)? What are the impacts of annual releases of up to 80 million hatchery smolts (Chinook, coho, steelhead) in the Columbia River on chum salmon fry in the estuary? Do the trends in freshwater, estuary, or ocean habitat changes correlate with trends in chum recruitment and abundance?

In the absence of a targeted fishery, what specific factors are keeping the stock from naturally rebounding, and at what place or places in the life cycle is the rebound being impeded? The proponents suggested that speculations about depensatory mortality (a result of depressed chum numbers) were invalid (p. 85 response). Yet the lack of a rebound is obvious. Lower Columbia River (LCR) chum salmon seemed to crash in the 1950s, evidently as a result of a combination of directed and incidental harvest, as well as habitat problems. Since the 1960s, the major impacts, according to the response, are hydropower and habitat problems (tributary and estuary). Despite little direct evidence, the importance of habitat problems (tributary and estuary) seems especially plausible. Without an understanding, or at least some clear hypotheses, about the specific causes of chum declines, the proponents cannot effectively plan stock assessment, supplementation, and restoration. It is not clear what life cycle it would be best to intervene in.

It might prove useful to compare the status and trends of LCR chum stocks with trends elsewhere in the species range (Asia, Alaska, BC) and closer to home (coastal versus LCR stocks) to gain insights into causes of declines. Are coastal Oregon and Washington stocks undergoing the same declines, even for stocks having good freshwater rearing habitat? There are coast-wide trends that need to be discussed in the proposal. The Columbia River is near the southern limit of chum distribution, where larger perturbations in returns than nearer the center of the distribution might be expected. Which other North American or Asian stocks overlap in oceanic feeding areas with LCR chum salmon? Broad similarities in trends might argue more for climatic/oceanic factors or ocean harvest effects as opposed to freshwater factors. How does estuary health and status in different locations relate to chum salmon abundance trends? The proponents noted that estuary and near shore habitat was the most consistently mentioned limiting factor in the subbasin plans (but studies are lacking). Sedimentation is also mentioned as a possible cause of decline (but specific studies are lacking).

The rationale for supplementation should also be supported with literature both inside and outside the basin. None of the three documents discussing the usefulness of supplementation for chums (LCFRB 2004 Appendix 6; HSRG (2008), Appendix 7; ODFW Strategy (2009), Appendix 8) discusses ecological mechanisms or specific limiting factors that supplementation is intended to circumvent.

Some "supplementation" has already occurred. What are the results of those efforts in the basin and outside the basin in terms of survival rates, returns, and subsequent Adult (F2) recruitment? What do the supplementation efforts in Hood Canal and spawning channel activities tell us? What do Grays River and Duncan Creek efforts tell us? The proponents evidently think supplementation is necessary to provide enough young fish that, under existing survival conditions (natural mortality and fishing mortality), adult stock size will increase. What do the successes and failures with chum hatcheries, especially in Asia and Alaska, tell us about supplementation and what might happen with supplementation, and why? How do the results of others show potential or the lack of it for LCR chums? Other possible factors of importance that the proponents noted are size of chum fry (i.e., growth) at a given time (wild fish) or time of release (hatchery fish). By undertaking a broader, more ecosystem-based review of chum, including the estuary and ocean, the proposal may gain much of the ecological perspective that it now largely lacks.

In building the arguments for factors leading to declines and for the need for supplementation, some literature that may be useful includes:

Bakkala. 1970. Synopsis of biological data on chum the salmon, *Oncorhynchus keta*, (Walbaum 1792). FAO Species Synopsis 41, Circular 315. U. S. Fish and Wildlife Service. Washington D.C.

Bax, N. J. 1983. Early marine mortailtiy of marked juvenile chum salmon (*Oncorhynchus keta*) released into Hood Canal, Puget Sound, Washington, in 1980. Canadian Journal of Fisheries and Aquatic Sciences 40:426-435.

Berry, R. L. 1975. Status of chum salmon in selected coastal streams of Oregon. Fish commission of Oregon. Information Report 75-2. Clackamas, Oregon.

Fukuwaka, M. et al. 2007. Trends in abundance and biological characteristics of chum salmon. North Pacific Anadromous Fish Commission Bulletin 4:35-43. (Available online at www.npafc.org)

Healey, M. C. 1982. Timing and relative intensity of size-selective mortality of juvenile chum salmon (*Oncorhynchus keta*) during early sea life. Canadian Journal of Fisheries and Aquatic Sciences.

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. Part 3: Columbia River Chum. Prepared for ODFW and NMFS.

Oakley, A. L. 1966. A summary of information concerning chum salmon in Tillamook Bay. Fish Commission of Oregon Research Briefs 12(1): 1-17.

Ryer C. H. and B. L. Olla. 1996. Social behavior of juvenile chum salmon, *Oncorhynchus keta* under risk of predation: the influence of food distribution. Environmental Biology of Fishes. 45:75-83.

Wissmar, R. C., and C. A. Simenstad 1988. Energetic constraints of juvenile chum salmon (*Oncorhynchus keta*) migrating in estuaries. Canadian Journal of Fisheries and Aquatic Sciences 45:1555-1560.

On more specific issues, as part of the proposed restoration and supplementation, the proponents did not describe anticipated quantitative benefits to chum salmon from habitat restoration or supplementation/reintroduction. General narrative text was provided quoting HSRG and NOAA reports that generally support supplementation. Clear statements are needed of how many sites must be recovered for delisting/restoration, the number of those anticipated to be achieved by the project, and the proportion to be achieved through a combination of habitat and supplementation/reintroduction. The proponents did not indicate the scope of improvement targeted or the time period anticipated to be required to achieve self-sustaining status. Table 3 on page 23 provided an EDT estimate of the proportion of historic habitat remaining functional in various tributaries.

Literature shows that chum salmon fry use the estuary and nearshore ocean habitats for rearing, and that habitats in the Lower Columbia River, estuary and Columbia River plume are likely to be important nursery areas. For example, fry from the Duncan Creek population enter the lower river/upper estuary just below Bonneville, 140 miles from the river mouth. A balanced restoration program that provides rearing as well as spawning habitat is required if supplementation/reintroduction is chosen as a strategy. The proponents should plan to integrate their chum habitat restoration strategy with LCREP and other groups concerned with estuarine habitat restoration, in addition to researchers involved in BPA project 20030100 (Historic Habitat Opportunities and Food-Web Linkages of Juvenile Salmon in the Columbia River Estuary and Their Implications for Managing River Flows and Restoring Estuarine Habitat). The ISRP suggests that estuarine habitat restoration site selection and methodology should be guided by the best possible science as results are published from the latter studies and other related projects. Research results showing how chum salmon juveniles use the Columbia River estuary should be utilized strategically so that effort on estuarine habitat restoration can, in fact, lead to improved chum survival. The potential need for restoration of Columbia River Plume rearing habitats might also be considered. For example, the damming of the Columbia River has altered seasonal nutrient transport and primary productivity in the coastal NE Pacific (Whitney et al. 2005). Chum salmon fry use specific riverine plume habitats, i.e., the low-salinity water mass formed by riverine discharge, to “avoid environmental stress, to search for prey patches, and to expend less energy for migration” (Fukuwaka and Suzuki 1998). Hydrosystem management to mimic pre-dam riverine flows at outmigration might be needed to create optimal conditions for early ocean survival of chum salmon fry in the Columbia River plume.

For the removal of non-native reed canary grass "by hand using hand tools only" (page 55; see ISRP 2009 wildlife review[2] for comments and recommendations on invasive weed management), the ISRP has expressed concern that there are no established methods for removal of reed canary grass. Also, some methods of removal could produce increased problems in the future. In any event, reed canary grass will probably have to be removed annually, and that should be recognized in the proposal.

2. **Describe in adequate detail how the proposed efforts will meld with similar activities of Oregon Department of Fish and Wildlife and other entities**.

Comment: The proponents did a good job of clarifying the status of chum in Oregon tributaries and how they intend to interact with ODFW. The proponent states that Oregon has a framework for a chum salmon restoration plan, but no actions or funding are in place. This is unfortunate, but no fault of the proponents. They indicate that, should funding become available, they are more than willing to coordinate and cooperate with ODFW. The ISRP commends their efforts for a close communication and cooperation between the agencies on the chum restoration issues. It would also be highly beneficial in the future that as chum restoration efforts proceed, the two agencies combine their efforts on future proposals and submit them as collaborators, so that an integrated approach is more assured.

We were also interested if any other agencies should be considered (e.g., U.S. Fish and Wildlife Service?). They were not mentioned in the response. This includes coordination with other habitat efforts in the estuary and lower Columbia River. This coordination is not addressed in sufficient detail.

3. **Describe the experimental design for Objectives 2 and 4 (stock status review, population monitoring). These objectives should precede any prescription or rehabilitation plans; i.e., assess limits to population growth, including harvest.**

Comment: The stock status review is intended to provide information on the genetic structure of chum salmon in the Columbia River, abundance estimates for extant populations, and evaluation of the Grays River and Duncan Creek supplementation. Evaluating these metrics provides essential information for chum salmon management and planning. However, it is not clear from the proposal what the deficiencies are in the existing analysis and what is hoped to be achieved from further analysis.

The region has done a biological assessment (abundance and productivity) for the BiOp and VSP analysis by the TRTs for recovery planning. Do the proponents see a need for stock assessment for these three stocks (i.e., Hamilton, Grays, I-205)? Perhaps stock assessments should be focused on identifying and quantifying factors limiting abundance and the ability of natural stocks to recover on their own.

[2] ISRP Final Review of 2009 Wildlife Proposals: www.nwcouncil.org/library/isrp/isrp2009-17.htm

Chum salmon population genetic structure has also recently been evaluated (Small et al. 2006). There are about 1000 more individuals to be genotyped, this is a modest undertaking and may provide increased confidence in the assignments of tributaries to larger population aggregates. With evidently only three groups – Hamilton, Grays, and I-205, the proponents should be able to clearly describe their genetic evaluation strategy.

The evaluation of Grays River and Duncan Creek supplementation appears to be limited to documenting the presence of hatchery-origin adults returning to spawn. This is a worthwhile endeavor, but will not yield information on the efficacy of using the hatchery fish to rebuild the natural population. It is unfortunate that data from this effort cannot yet be used effectively. Results should be compiled as soon as it is feasible. Such an evaluation will require a more rigorous experimental design.

**4. Present a schedule of activities. The timelines for completion of Objectives 2 and 3 by February 2010 appear optimistic.**

Comment: The Chum Project Activities Timeline – Project Performance Year 1 on page 53 raises concerns. The sequence and timing of most of the activities in year one are not consistent with the information needed for planning and integration of chum salmon recovery. For example, in months one and two, under supplementation the proponent plans on completing the Council's Three-Step Review (combined review). In months three, four, five, and six under stock status assessment, a review of the existing supplementation projects is planned. During months six, seven, eight, nine, and ten a population abundance/stock status update is planned. Both the stock status update and the review of supplementation need to be completed before the proponents begin developing a Three-Step plan. A more logical schedule would involve parallel review of existing habitat assessments for chum salmon spawning sites, supplementation that has been underway, and status and trends/VSP data for chum salmon, and initiation of the genetic analysis. Once these tasks are completed a synthesis would identify the likely strategies used for recovery, and this in turn would establish the hypothesis framework for adaptive management and guide M&E designing with sufficient precision.

**6. Describe the adaptive management experiment. The proposal indicates planning for adaptive management of the existing chum salmon supplementation program. Adaptive management *sensu Walters, Hilborn et al.* is an experiment. A description should be added of how planning for adaptive management of such a program is to be conducted; e.g., what sorts of adaptive management <u>experiments</u> could be designed, what hypotheses would be tested, and what the experiments would have to take into account.**

Comment: The revised proposal indicates use of the NOAA Fisheries 2007 – Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance. The proponents' summary of the guidance document appears consistent with best scientific practices for adaptive management as implemented in the Fish and Wildlife Program. However, no actual decision framework is provided within the proposal. The proponent indicates they will use effectiveness monitoring for adaptive management of habitat restoration and use status and trends monitoring to for adaptive management of supplementation and reintroduction. The proponent identifies that the status and trend monitoring will not provide

for a cause-effect relationship between supplementation and status and trend metrics. The ISRP believes this is an inadequate design to determine the efficacy of this highly uncertain strategy. It is also inconsistent with text on page 47 of the response to the ISRP which states *"We also believe a comprehensive population monitoring and evaluation (M&E) plan (includes status and trends monitoring for ESA recovery, and effectiveness monitoring for evaluation of habitat restoration projects and supplementation actions) is needed prior to implementation of prescriptive rehabilitation plans."* The proponent anticipates using up to five approaches for reintroduction of chum salmon into habitats with extirpated populations (page 68): release of adults for natural spawning; incubating fertilized eggs in remote streamside incubators (RSIs); releasing unfed hatchery fry; releasing fed hatchery fry; and natural re-colonization. The ISRP concludes that it would be useful to incorporate these options in a well-designed management experiment.

**7. Provide a clearer description of the reintroduction aspect versus the supplementation aspect of the proposal. Except where needed to rescue a severely diminished local chum population (and where harvest control and/or rapid habitat restoration could not accomplish that), there does not seem to be adequate justification presented for the proposal's "supplementation" component, that is, the artificial propagation that constitutes true supplementation. The proposal's artificial propagation components that are for *reintroduction* may be justified, however.**

Comment: The proponents provide reasonable definitions of reintroduction versus supplementation and a decision tree (Figure 9) on page 69 to explain the approach they plan on implementing. The ISRP is curious about how supplementation would be beneficial under the circumstances where there is a non-viable population but habitat conditions are "properly functioning." The ISRP also raised the question of how supplementation could assist with chum salmon restoration if the limiting factor was degraded spawning and early rearing habitat. The proponent indicated that the Lower Columbia River Salmon Recovery Plan concludes that habitat is available to support much larger populations. The ISRP believes that if this is the case, every effort should be made beforehand, prior to supplementation, to identify the limiting factors (Question 1 above). Supplementation (or any other form of artificial production) will not substitute for correcting the bottle necks in the life-stage survival of chum salmon.

The proponent can address most of the following comments related to pros and cons of supplementation as part of the rationale for supplementation requested earlier. (Question 5).

The proposal needs to clearly distinguish between reintroduction (i.e., into streams from which populations have disappeared) and supplementation of collapsing populations, and supplementation of non-collapsing (though perhaps small) populations. With respect to artificial propagation aspects of the proposal, the functions of reintroduction (attempting to reestablish a new population by stocking for a few years) and conservation (last-resort rescue of a population that is about to disappear) seem sound. A reintroduction, if involving salmon release beyond one year (perhaps for "up to three generations," as described on pages 39, 40, and 93), incorporates supplementation if the target (the reintroduced) population's adults are used as broodstock after year 1 (by definition, "introduced" fish must come from somewhere else). The distinction

between the sort of supplementation involved in the post-year-1 phase of a reintroduction effort and trying to supplement existing populations is not clearly drawn in most cases in the proposal.

Clear distinction is required between supplementation of collapsing and non-collapsing populations. For extant populations, the case for supplementation is easier to make for populations that are on the verge of collapse. An argument for supplementation (Question 1 above) involving non-collapsing populations should objectively evaluate evidence of benefits and risks.

The benefits of such supplementation remain inadequately tested. Some evidence exists that it does not significantly benefit existing wild populations (AHSWG 2008; particularly Appendix D). Moreover, supplementation risks degrading fitness of wild populations (AHSWG 2008).

The proposal as written seems to repeatedly downplay risks of deleterious hatchery effects, and it ignores certain risks altogether. On page 7, under "Factors for Decline," the text implies that negative effects of hatcheries on chum salmon are negligible, and in Table 2, the past, current, *and future* hatchery effects are claimed to be no greater than "negligible" to "low impact" as a cause of chum salmon decline. The proponents feel that negative hatchery effects are minor because "[h]atchery chum populations are less likely to be affected by domestication given their short-term culture." This is reiterated on pages 21, pages 39-40 and on page 92. On page 40, a quotation is included on hatchery-induced risks of low genetic diversity and low effective population size. The proposed project will monitor those genetic attributes as part of the stock assessment M&E component.

Unrecognized in the proposal, however, is reduced fitness via the artificial pairing and spawning in hatcheries that eliminates positive natural selective pressure from such reproductive processes as courtship, redd-site selection, redd building, mate selection, spawning, in-gravel incubation, and fry emergence. The resultant risk is artificial proliferation (higher than natural gamete-to-fry survival) of offspring from poorly fit individuals. (In this regard, poorly fit means they have one or more deficient reproductive behaviors.) Under natural conditions, those fish would not reproduce as successfully as the more fit fish in the population. Upon interbreeding with wild chum, the poorly fit hatchery offspring that do survive to adulthood will reduce fitness of the wild stock. This issue is discussed in Araki et al (2009 and its precursors, e.g., Ford (2002), Reisenbichler and Rubin (1999), and other papers by Araki et al.

On page 10, under "Limiting Factors for Chum Salmon in the lower Columbia River," item 7 asserts: "Historical and current hatcheries practices have not been a limiting factor." No evidence for this is presented. In other regions, hatchery practices are a well-known limiting factor. For example, the success of large-scale hatchery production of chum salmon in Japan is largely dependent on technical innovations such as feeding fry prior to release and timing releases to match ocean conditions optimal for survival (e.g., Kaeriyama 1989). Overlooked is material in LCFRB 2004: Chapter 3 (referenced at that point in the document): two among five listed reasons why hatchery-bred fish differ from wild fish of the same species (page 3-84), namely, artificial selection by hatchery personnel and increased survival of individuals poorly suited to natural habitat (relaxed selective pressure). The latter phenomenon could also apply to reproduction, i.e., increased survival of individuals poorly suited to natural reproduction – with

some of this weakness imparted to wild populations with which the hatchery-bred fish interbreed. The proposal shows no reason why these two factors have not been limiting factors and would not continue to be limiting if the supplementation part of the program were carried out.

If hatchery augmentation – in recent years converted to supplementation – of chum salmon (Table 9) is supposed to have benefitted the Lower Columbia River's wild chum populations, why have the most recent "stronghold" population trends (2002-2008, Figures 2 and 3) shown such steady, drastic decline? Classic recruitment theory predicts populations should increase rapidly at low abundance. Clearly, some unknown factor is now limiting recruitment, which a temporary amplification of abundance via supplementation is unlikely to address.

On page 43, item 4.b. repeatedly mentions "supplementation/reintroduction." This could be taken to mean that supplementation and reintroduction always will be jointly applied, but is that the case? And if a reintroduction program extends beyond one year for reestablishing one stream's population, then the supplementation aspect follows reintroduction, so it's not logical for supplementation to precede reintroduction in the couplet. The definition of supplementation shown in the proposal's glossary (page 85) is vague and incomplete. The commonly accepted RASP (1992) definition is not quoted in the proposal; it should be the glossary's definition: *The use of artificial propagation in an attempt to maintain or increase natural reproduction while maintaining the long term fitness of the target population and keeping the ecological and genetic impacts on non-target populations within specified biological limits.*

Any Three-Step process to develop reintroduction/supplementation needs to consider the advisability of supplementation in the clearer light concerning evidence of hatchery-induced genetic detriments that has developed in recent years. As for implementing supplementation of existing (non-collapsing) populations, the proposal should stipulate that it be done *only after* the procedure has been adequately tested and shown to benefit wild chum salmon populations.

**References**

AHSWG (*Ad Hoc* Supplementation Monitoring and Evaluation Workgroup). 2008. Recommendations for Broad Scale Monitoring to Evaluate the Effects of Hatchery Supplementation on the Fitness of Natural Salmon and Steelhead Populations

Araki, H., Cooper, B. and Blouin, M. S. 2007. Genetic effects of captive breeding cause a rapid, cumulative fitness decline in the wild. Science 318:100–103. (doi:10.1126/science.1145621).

Araki, H., Cooper, B. and Blouin, M. S. 2009. Carry-over effect of captive breeding reduces reproductive fitness of wild-born descendants in the wild. Biology Letters (doi:10.1098/rsbl.2009.0315).

Araki, H., Ardren,W. R., Olsen, E.,Cooper, B. and Blouin, M. S. 2007. Reproductive success of captive-bred steelhead trout in the wild: evaluation of three hatchery programs in the Hood River. Conserv. Biol. 21:181–190. (doi:10.1111/j.1523-1739.2006.00564.x).

Araki, H., Berejikian, B. A., Ford, M. J. and Blouin, M. S. 2008. Fitness of hatchery-reared salmonids in the wild. Evol. Appl. 1:342–355. (doi:10.1111/j.1752-4571.2008.00026.x).

Ford, M. J. 2002 Selection in captivity during supportive breeding may reduce fitness in the wild. Conserv. Biol. 16:815–825. (doi:10.1046/j.1523-1739.2002.00257.x).

Fukuwaka, M., and T. Suzuki. 1998. Role of a riverine plume as a nursery area for chum salmon Oncorhynchus keta. Marine Ecology Progress Series 173: 289-297.

Kaeriyama, M. 1989. Aspects of salmon ranching in Japan. Physiol. Ecol. Japan, Spec. Vol. 1: 625-638

LCFRB (Lower Columbia Fish Recovery Board) 2004. Lower Columbia salmon recovery and fish and wildlife subbasin plan. (www.lcfrb.gen.wa.us/recovery%20planning%20overview.htm)

Pearcy, W. G., C. D. Wilson, A.W. Chung, and J. W. Chapman. 1989. Residence times, distribution, and production of juvenile Chum Salmon, *Oncorhynchus keta*, in Netarts Bay, Oregon Fishery Bulletin 87:553-568.

RASP (Regional Assessment of Supplementation Project). 1992. Supplementation in the Columbia Basin. U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Summary Report Series, Final Report, Project 85-62, Portland, Oregon (http://pisces.bpa.gov/release/documents/documentviewer.aspx?pub=P01830-11.pdf).

Reisenbichler, R. R. & Rubin, S. 1999 Genetic changes from artificial propagation of Pacific salmon affect the productivity and viability of supplemented populations. ICES J. Mar. Sci. 56:459–466 (doi:10.1006/jmsc.1999.0455).

Whitney, F.A., W.R. Crawford, and P.J. Harrison. 2005. Physical processes that enhance nutrient transport and primary productivity in the coastal and open ocean of the subarctic NE Pacific. Deep-Sea Research II 52:681-706.