Western Division
American Fisheries Society

Review of the 2009 Adaptive Management Implementation Plan for the 2008 Biological Opinion Regarding the Federal Columbia River Power System

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Introduction and Background

The American Fisheries Society (Society) is the oldest and largest professional society representing fisheries scientists and managers. The Western Division (WDAFS) was established as the first Division of the Society in 1948, and now includes chapters from thirteen Western States, British Columbia, the Yukon Territories, and U.S. Islands and Trust Territories of the Western Pacific. Some 3,500 strong, our members represent a tremendous array of fisheries workers involved in all aspects of the fisheries profession. The collective diversity and expertise of WDAFS members is the basis of an intimate and unparalleled familiarity with fisheries resources and issues within our geographic region. WDAFS objectives are to provide a forum for exchanging technical and policy information, promote understanding by regional, Federal, and state policy-makers of the nature and extent of fishery matters of concern to the membership, facilitate timely exchange of information to chapters and the general membership, and provide a vehicle for the active participation of individual members in Society business and professional activities.

Because of the expertise within its membership, the WDAFS has provided a number of resolutions or reviews pertinent to the recovery of Columbia Basin fish runs and fisheries. After careful consideration and deliberation, in 1999, the WDAFS resolved that:

> *If society-at-large determines that Snake River salmon and steelhead are to be restored or recovered in their native ecosystem, then one biologically required action is to eliminate or greatly reduce impacts to salmon and steelhead from the four lower Snake River dams by removing, breaching, or bypassing the dams, or otherwise allowing the lower Snake River to flow freely, without impoundment.*

The WDAFS also provided a thorough review of the 2004 Biological Opinion on the Federal Columbia River Power System (WDAFS 2005). In this document, the WDAFS continues its service by providing a review of the Adaptive Management Implementation Plan (AMIP) issued by the federal government in September 2009 as an addition to the 2008 Biological Opinion for the Federal Columbia River Power System. The review is intended to provide information useful to the WDAFS membership, and to parties currently involved in litigation of the 2008 Biological Opinion. Our primary purpose is to help improve the Biological Opinion, which we think will increase the opportunity for recovery of salmon and steelhead in the Columbia River Basin.

Status of Salmon and Steelhead in the Columbia Basin

Salmon and steelhead, along with lamprey, bull trout, white sturgeon, and other native fish populations, have declined precipitously in the Columbia River Basin over the past 150 years. Salmon and steelhead runs once averaged 10-16 million fish annually (Northwest Power and Conservation Council 2009), but runs in recent years have rarely reached 2 million. Furthermore, the majority of the fish now originate from hatcheries placed throughout the basin. The decline of salmon and steelhead has resulted in the listing of 8 salmon Evolutionarily Significant Units (ESUs) and 5 steelhead Distinct Population Segments (DPSs) within the Columbia River Basin as threatened or endangered under the Federal Endangered Species Act (ESA).

Columbia Basin Hydropower
Many human activities have contributed to the decline in salmon and steelhead run sizes, including construction and operation of dams throughout the Columbia Basin for hydroelectric power, flood control, navigation, irrigation, and recreation. The Columbia River and its tributaries form one of the most intensively developed river basins for hydroelectric power in the world.

The listings under the ESA require those that operate the Federal Columbia River Power System and market the power generated to indicate, through a biological assessment, that proposed operations pose "no jeopardy" to ESA-listed salmon and steelhead. As the regulating agency, NOAA Fisheries must then determine, through a biological opinion, whether the proposed operations do or do not pose jeopardy. The 2004 Biological Opinion, with its finding of "no jeopardy" was challenged in court, and subsequently remanded by the judge hearing the case. The result was the subsequent 2008 Biological Opinion, which continues to be challenged in court. In an attempt to bolster the 2008 Biological Opinion and avoid a court ruling finding it inadequate, the federal government issued the AMIP in September 2009. Although the judge has ruled that he can't consider the AMIP as a separate attachment, he has indicated that he will consider it if it is completely integrated into the Biological Opinion.

If accepted by the court, the biological opinion and AMIP will guide hydropower operations and affect fish recovery efforts, including those on the lower Snake River, for up to ten years, pending regular "check-ins" regarding status of the ESA-listed salmon and steelhead. Because of the scope and importance of this issue, and because of its standing resolution, the WDAFS formed a special Snake River Committee. The committee had a number of objectives, one of which was to review the AMIP and provide technical comments to the WDAFS Executive Committee. The following review meets that objective.

Review of the Adaptive Management Implementation Plan

Although the AMIP provides some useful information and includes some beneficial actions, the WDAFS has a number of concerns, and finds the AMIP to be inadequate for ensuring the protection of threatened and endangered salmon and steelhead in the Columbia River Basin. Rather than use a precautionary principle to protect threatened and endangered salmon and steelhead, the AMIP seems to use a precautionary principle to support the 2008 Biological Opinion and to defend the status quo.

A specific concern is the repeated use of the term "best scientific information". The WDAFS is of the opinion that the AMIP does not always use the "best scientific information". We provide many examples of this in the following sections.

Our review of and comments on the AMIP are summarized in two sections: (1) general comments, and (2) comments relating directly to "best scientific information". These two sections are followed by Appendix A, which assesses responses to comments made on an early draft of the AMIP and on AMIP-related issue papers, and Appendix B, which summarizes recent peer-reviewed publications related to effects of hydropower on Columbia Basin salmon and steelhead, with an emphasis on the Snake River.

General Comments

The AMIP proposes to expand data collection and model refinement to better assess status and trends of species or ESUs. Although some effort was made to address cause and effect, there is almost no detail about how this would be achieved, or how large uncertainties will be addressed. Thus, it appears that there is undue emphasis on more monitoring and modeling than on implementing beneficial actions. A logical assumption therefore is that the primary output will be merely that declines are more accurately documented.

The spatial scope of the AMIP is primarily on species or ESUs, a scale that is inadequate for conservation and protection of the populations that make up an ESU. Major population groups (MPG) and populations are mentioned, but there is no detail on how useful information will (or can) be collected or on how these data will be used. For example, monitoring at the MPG level may be used to help develop early warning indicators but even if all the uncertainties about the types of data to collect were addressed, useful data sets for assessing abundances or trends would not be available for many years.

The goal of any robust juvenile monitoring program should be early detection of substantial changes in abundance, productivity, or survival. The AMIP appears to focus on recruits per spawner (productivity), and the importance of diversity does not appear to be a factor or a consideration. However, loss of diversity such as a shift in migration timing or loss of life histories might be a logical outcome of a change in freshwater productivity (e.g., from climate change on habitat). For example, if recruits per spawner is measured only as smolts produced from a monitored stream, this might mask an overall loss of productivity if migratory types and life histories such as fry and parr migrants are lost or reduced.

Regarding contingency plans and response actions to declines in fish numbers: In general, actions do not seem aggressive or encompassing enough to address significant declines, especially given the uncertainty about the robustness of the triggers. Specifically, if rapid response actions have already been identified that can 'immediately improve fish survival' and 'provide immediate survival benefits', then the obvious question is why wait for even greater declines than have occurred historically to occur before initiating these actions? In reality, the only rapid response action that identifies any 'action' detail is for predator control. Likewise, long-term contingency actions are ones that would supposedly 'improve the survival of fish experiencing the significant decline' and again, even if the listed actions address the causes of decline, why wait to implement them?

Response actions do not appear to be aggressive enough for addressing 'significant' declines. In respect to the potential for climate change to affect freshwater habitat, the AMIP does not actually identify any aggressive actions and seems content to monitor the situation. Examples of more aggressive actions might be to identify existing high quality habitats that may be keys for buffering effects of climate change to (1) ensure those habitats are protected, and (2) purchase areas outright or secure conservation easements.

Assessments and models do not appear to address a potential decline in what we consider to be baseline or reference conditions, which are dynamic. The use of past abundance data to project future trends or to assess trends can be erroneous; likewise the assumption of baseline habitat condition as being stable when assessing effects of actions may produce erroneous results.

Regarding dam breaching: Compared to other actions in the contingency plans, which are addressed generally and suggest movement toward implementing the action, the breaching of the Lower Snake River dams takes a tortuous path just to initiate a study. Technical studies needed for decisions about dam breaching would begin only if a significant decline trigger is tripped for a Snake River species and if an analysis of all H's (hydro, habit, hatcheries, and harvest) is completed that concludes dam breaching is necessary to address and alleviate the trigger conditions. An action just to initiate a study is considered a contingency of last resort because the status of Snake River fish is assumed to be improving (however temporary that might be) and the 2008 Biological Opinion concludes dam breaching is not needed to avoid jeopardy. The objectivity of this assumption is questionable because the AMIP states that best available science does not support moving forward with dam breaching (although it provides no documentation to support this statement), and emphasizes uncertainty about whether short-term negative effects of breaching may compromise long-term benefits. The AMIP seems to place a huge amount of weight on the uncertainties here, more so than elsewhere. The uncertainties about dam breaching stand in the way of even conducting a 'science driven' study. In contrast, the AMIP provides an air of certainty that other prescribed actions provide the robust contingency plan the Court was seeking, despite several reviews that identify large uncertainties.

Best Scientific Information

Benefits of Transportation

1. An April 21, 2008 memo from the Fish Passage Center to Ed Bowles (Oregon Department of Fish and Wildlife) indicated significant bias in evaluating benefits of transportation from tagging at Lower Granite Dam (LGR). Were this memo and the Comparative Survival Study reports indicating that the actual benefits of transportation are much lower than reported in the NOAA Fisheries studies reviewed?
2. Transportation occurs from LGR, Little Goose (LGO), and Lower Monumental (LMO) dams. Data indicate that adult returns decline the further downstream fish are collected for transportation (LGR > LGO > LMO), yet it appears that the analysis on whether and when to transport used data only from LGR.
3. Recent avian predation and direct in-river survival research indicates that as more fish migrate in-river, predation rates decline (survival increases) through predator swamping, and the lower predation rate that does occur is more compensatory (sick/injured fish are more likely to be eaten). From the Independent Scientific Advisory Board (ISAB) of the Northwest Power and Conservation Council (2008a): "As smolt density increases, the proportion killed by predators will likely decrease because mortality due to predation appears to be depensatory (based both on theoretical expectations and limited empirical evidence). Increasing spill percentage could increase the number of in-river migrants and temporarily buffer all potential prey species inhabiting the river from predation risk. If such depensation occurs, the relative benefit of

transportation could decrease as spill percentage increases. It seems that this potential benefit of spill has not yet been considered in comparing alternative spill-transport scenarios."

4. The AMIP does not fully consider the significant structural and operational changes that have been implemented in the hydrosystem since smolts out-migrated in the dataset used to evaluate benefits of transportation for the 2008 Biological Opinion. Theses changes were intended to, and should, improve direct and latent survival on in-river smolts, which if realized, will further reduce the relative benefits of transportation.

Habitat Improvement Biological Benefits

1. Generally, the habitat projects identified in the AMIP are likely beneficial and should be implemented. When expert judgment is used to select which habitat action to implement, usually the actions with the most likely survival improvements are selected first. Yet the AMIP states "Because future projects will be selected using the improved habitat selection criteria and strategies that were used for the 2007-2009 projects, NOAA Fisheries is **confident** (emphasis added) that they will yield greater habitat benefits for salmon than did the first projects in the 2000-2006 period….therefore achievement of survival improvements committed to over the ten year implementation of the RPA is reasonable."

2. Focus of the AMIP has been on ensuring implementation. However, the bigger concern is that the assumed survival improvements appear unrealistically high.

COMPASS Model

1. COMPASS does poorly at predicting outcomes of conditions outside of the narrow range of mainstem conditions that occurred when the data used to build COMPASS were collected.

2. COMPASS did not predict, and there has been no apparent evaluation of, the dramatic change in Snake River D-values (differences in latent mortality between in-river migrants and transported fish) from the 2001outmigration year. This D-value indicates that the degraded in-river migration conditions in 2001 dramatically increased the latent mortality of in-river fish, suggesting that improving in-river migration conditions could reduce latent mortality.

3. COMPASS did not predict the dramatic increase in Snake River steelhead in-river survival for the 2007 out-migration.

4. COMPASS did not predict the dramatic increase in Snake River steelhead in-river survival for the 2009 out-migration.

Latent Mortality Effects and Opportunities to Reduce It

1. The scientific information reviewed in the AMIP appears to be primarily limited to information in support of the 2008 Biological Opinion. For example, we found no mention of the Plan for Analyzing and Testing Hypothesis (PATH) workgroup results and conclusions. PATH was a 5 year collaborative effort of regional experts from differing perspectives on the reasons for declines in Snake River salmon. The PATH weight-of-evidence process found that latent mortality from hydrosystem passage had the most scientific support. The PATH decision analysis determined that dam breaching was the most effective and least risky recovery action across all hypotheses about delayed mortality. It appears that the PATH conclusions, its collaborative weight-of-evidence hypothesis testing framework, and its decision analysis have been dropped by NOAA Fisheries without scientific justification. Williams et al. (2005) states "Due to the perceived complexity of PATH products by some NMFS (NOAA Fisheries) scientists not involved with PATH, a matrix model was developed in 1999 to evaluate the status

of listed Snake River spring-summer Chinook salmon stocks." The NOAA Fisheries matrix model relied on hypothetical mortality reductions without empirical justification or feasibility analysis (Kareiva et al. 2000). For example, Karieva et al. (2000) use their model to estimate that an 11% reduction in first year mortality would be adequate for recovery, but do not explain that this equates to a 200% – 300% increase in first year survival, which is likely not feasible. The WDAFS has previously commented on our concerns with using this approach to identify mitigation actions (WDAFS 2005). We are also concerned that the lead author on the NOAA Fisheries matrix model was one of the "Independent" Scientists selected to evaluate the 2008 Biological Opinion.

Rapid Response Actions

1. The AMIP repeatedly states that rapid response actions will be quickly implemented if pre-defined biological triggers are met: "Actions will be ready for prompt implementation when triggered to deliver survival benefits in response to the indications of significant fish declines." Our review of *Appendix 5: Rapid Response Actions* left us with different conclusions. First, that prompt implementation of actions to deliver survival benefits is generally not specific or certain to occur. Second, most actions listed would have likely occurred even if the AMIP did not exist.
2. The Hydro Actions section of Appendix 5 states "If a Significant Decline trigger is tripped, the Action Agencies and NOAA Fisheries, in collaboration with the Regional Implementation Oversight Group and appropriate technical groups (hydro coordination team), will review the current status of the biological research at the dams and discuss where additional project survival benefits could be gained in relation to the specific species in question….This discussion will inform the spill and transport operations that the Action Agencies will implement." There is no commitment to implement hydro actions to improve survival, and these analyses and discussions would be likely to occur anyway if abundance of ESA-listed species declines further.
3. For Predation Management Rapid Response Actions, the only actions committed to are increased avian predator hazing and increasing the USDA pikeminnow dam angling program from one to three crews. The WDAFS agrees with the conclusion drawn by the ISAB (2008b) that restoring habitat by allowing normative river processes to act is one of the best measures to protect native species from non-native species.
4. For Harvest Actions, Appendix 5 acknowledges that current mainstem and tributary fisheries are already abundance-based and therefore would already be curtailed under low abundance conditions. The only action committed to further reduce mainstem harvest is that NOAA Fisheries will use the procedural provisions in the US v. Oregon agreement to seek the consensus necessary to modify the agreement. This agreement already allows any party to the agreement to seek a consensus to make changes, so this does not appear to be a commitment to deliver prompt survival improvements.
5. Appendix 5 accurately states that of the listed species, only Snake River fall Chinook salmon are significantly harvested in the ocean. NOAA Fisheries does commit to "take action to reduce harvest in U.S. ocean fisheries, and seek to negotiate further reductions in Canadian fisheries". However, because most ocean harvest of Snake River fall Chinook salmon occurs in Canadian fisheries, there is no certainty that prompt survival improvements will occur. Most ocean fisheries on listed salmon are already curtailed or eliminated based upon stock abundance, and this does not appear to be a commitment to additional actions.
6. The only action that is committed to in Appendix 5 is to develop Rapid Response Contingency Plans for each species of the interior Columbia Basin. Appendix 5 does state that

these actions are intended to be temporary in nature. We note that the Snake River sockeye salmon safety net program was intended to be temporary in nature when it began, but has changed over time and the AMIP regards it as effective management.

Biological Triggers

1. The AMIP does not have biological triggers for the endangered Snake River sockeye salmon and attempts to justify this by stating that this species is "effectively managed under ongoing contingency actions". The primary contingency action preventing extinction of this species is a captive broodstock program that was intended to be only a short-term emergency action. "The Redfish project is intended as a stop-gap measure until migration and rearing habitat improvements can be implemented to increase survival" (Flagg et al. 1996). The WDAFS believes it is inappropriate to not have biological triggers for this species or to rely on a captive broodstock program indefinitely to avoid extinction.

References

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Williams, J.G., S.G. Smith, R.W. Zable, W.D. Muir, M.D. Scheuerell, B.P. Sandford, D.M. Marsh, R.A. McNatt, and S. Achord. 2005. Effects of the federal Columbia River power system on salmonid populations. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-63, 150p.

Appendix A
Specific Concerns about AMIP Issue Papers and Trigger Documents

After an Independent Science Panel review of an early draft of the AMIP, NOAA Fisheries developed a series of issue papers to address shortcomings and concerns. These issue papers were sent to four reviewers for comments. Below, these comments are organized by subject, along with an assessment by the WDAFS whether or not the comments were addressed in the final AMIP.

Spatially Explicit Life Cycle Modeling

Comment: Need to incorporate explicit knowledge of population location and relative spatial position of population because of correlative response to conditions; need to consider straying or dispersal; need to get a sense of risk to the whole ESU rather than one index stock or subpopulation at a time.

WDAFS Assessment: Although the AMIP addresses the issues about spatial patterns of populations [page 22, #5], it does not provide details about how to identify populations, or how many populations to add.

Life Cycle Modeling

Comment: Little success at linking habitat features to salmon productivity, let alone climate variability; how is model going to link climate variability to salmon productivity; acknowledge uncertainty and clarify what is new or different from the decades of life-cycle modeling that has already been done? Invest in and enforce coordination of data already being collected rather than just expanded habitat status and trend monitoring.

WDAFS Assessment: Generally, it appears much effort will be expended on life-cycle modeling, but the AMIP does not address some of these questions. Rather it emphasizes "the need for better information about recovery actions at the species level and across the salmon life cycle" by expanding existing models. This does not seem to be the proper scale for such models. It seems unrealistic to assume that a more complex model will provide reliable estimates of how actions will change life-stage specific survival and its effect on long-term viability. Finally, it appears there is a tremendous amount of faith in existing models, but insufficient documentation of how much and how well they have been tested and evaluated by real-life changes in populations.

General Comments on Objectives

Comment: (a) "Improved understanding of relationships between habitat quality and fish response": Need to sharpen this objective and develop series of answerable questions in logical sequence. (b) "Effects of non-native predator/competitor species in mainstem reaches and tributaries": Most of what is listed under this is 5–10 research goals, this should be sharpened into series of questions and clarify priorities and logical sequence.

WDAFS Assessment: The noted absence of detail was not addressed in the AMIP or appendices. Much of what is listed is reasonably logical if the primary objective of RM&E is to collect more data; but there is no direction on priorities, use of existing data sets, or importance of these types of information in assessing risk and preventing population declines.

Triggers
Comment: Need for the peer-reviewed science behind the triggers, weakness in using Beverton-Holt to distinguish between production functions with salmon data; need to use different production functions and density-independent models because population is fluctuating around some level and you can't distinguish dynamics from random walk. If parameters of density-dependent models are flat or ridge-like then many forms of model can fit data similarly. If threshold set for trigger is sensitive to the parameter values then triggers would be suspicious. How did analysis account for parameter estimation uncertainty, were point estimates of the parameters used?
WDAFS Assessment: These comments refer to a draft document that discusses a prospective analysis on Snake River Chinook to assess four year running averages; Appendix 4 of AMIP did not include detail so it is uncertain if NOAA Fisheries addressed these concerns; however, the figures in Appendix 4 are the same as in the draft document suggesting the methodology was not changed.

Comment: Suggest use of unexpected consecutive declines rather than just abundance level trigger (too conservative). Suggest doing the probability of 2, 3, 4, etc. consecutive years of decline to derive number of consecutive declines that is unexpected.
WDAFS Assessment: This may have been partially addressed through the use of geometric means of four consecutive years as a measure of short-term trend; but it is unclear how the development of trigger levels incorporated the 'unexpected' element. Appendix 4 states that conditions represented by trigger would be 'significant deviations from the biological expectations in the 2008 Biological Opinion' [page 1, paragraph 2]. It is unclear how this might relate to various run predictions and departures from the expected.

Comment: Four-year averages for unexpected severe decline trigger were used to avoid false negatives, but can mask a lot. Should analyze existing data and assess the data year by year and run by run to identify what number of years of decline would not give a false negative about decline. Should also assess with distribution of model runs for certain number of years would it be surprising to see X straight years of decline, and the short term fate of populations in runs that experience X straight years of decline. Is there some threshold for which a crash is likely after X straight years of decline but for fewer, recovery is likely?
WDAFS Assessment: The justification for a 4-year running average is that it corresponds to generation time and that the ICTRT risk assessments threshold was expressed in terms of a 4-year sum of abundance; page 2, paragraph 5. It is not clear how much of reviewers' comments were incorporated; some may be incorporated into exceedance curves, but there is not enough detail in Appendix 4 to assess if the issue of straight years of decline was analyzed.

Comment: Should be developed for major population groups (MPG), maybe even populations, and not just ESUs. Actions that cause decline or redress will usually be at MPG level not ESU; IF idea is to be proactive, not just reactive.
WDAFS Assessment: Appendix 4 states that data are currently at species level and that under the Early Warning Indicator a main activity will be to provide additional resources to monitor rigorously and quickly at the MPG and population level [page 2, paragraph 3 and page 4, paragraph 1]. However, the use of redd counts at the population level is considered 'less timely

and more prone to sampling error' [page 2, paragraph 3] and no alternative is suggested, which leaves a large gap with no apparent strategy for addressing this information need.
Comment: Early warning trigger needs to be at least at MPG level because that is where triggered actions are likely to have an effect.
WDAFS Assessment: See above. This is a serious shortcoming.

Comment: Uncertain about the various model runs that established hard & soft triggers; e.g., what fraction of runs reaching the X-trigger crashed in the short term after that?
WDAFS Assessment: No detail provided in AMIP concerning number of models, model assumptions, model runs, or the data used to develop the alternative models and model outputs,

Exceedence Curves
Comment: Analysis with fitted Beverton-Holt production functions do not really provide that much support to use of exceedence curves. How robust are resulting trajectories in exceedence curves to variation in parameter values? In terms of exceedence curves, should subsample time series and examine to what extent the curves change as a function of difference times used to generate them (20, 25, 30 years), and how long before curves stabilize? If curves have not stabilized by 40 years of data, need to account for that instability.
WDAFS Assessment: No detail was provided in the AMIP on whether these comments were incorporated.

Adaptive Management
Comment: Outline adaptive mgt. process to reinforce there is a clear pathway from science components to implementation.
WDAFS Assessment: Some of this is touched on in the AMIP, specifically development of contingency actions if triggers are met; however, as outlined in Figure 1 [page 15], the process for implementing additional actions is not clear. In addition, the science components are not always clear. For example, at the 2013/2016 check-in the performance standard that triggers action is 30–50% of a species' populations have a decreasing trend, but the source for those data is uncertain because elsewhere in the AMIP there is a noted lack of data to assess population trends.

Habitat Actions
Comment: Challenge of implementing enough habitat actions in a short period to detect a response at the fish in/fish out level.
WDAFS Assessment: This comment refers to the Intensively Monitored Watersheds component of enhanced RM&E [page 24, E], the goal of which is to 'clarify connections between restoration actions and the fresh-water survival of salmonids' partially to efficiently implement rapid responses to significant declines. However, habitat restoration is not listed as one of the rapid response actions or long-term contingency actions in the AMIP. IMW work is to be a 'formal cause and effect experiment', but there is no detail on the framework or how cause and effect will be measured or how variables will be controlled.

Research Monitoring and Evaluation (RM&E)
Comment: Coordinate broad RM&E efforts with efforts within intensively monitored watersheds (IMW) so IMW results can be extended to other watersheds.

WDAFS Assessment: This appears to be addressed in a general way in the AMIP [page 25, paragraph 2], but no information is provided on how this will be achieved.

Climate Change
Comment: Need to compile information collected for other purposes & interpret it in light of predicted impacts of climate change.
WDAFS Assessment: This appears to be addressed in only a very general way in the AMIP, with no quantitative projections [page 21, topic #2].

Non-Indigenous Species
Comment: What is linkage between ongoing research & modeling & triggers that govern the actual activities now and in near future? Are there existing data that could be incorporated into predictions and triggers now? What happens after research in these areas is done, how exactly will that information be integrated with other factors in implementing actions?
WDAFS Assessment: This comment is on an issue paper and this topic does not appear to be addressed in the AMIP. One of the points in this comment that applies to other aspects of AMIP is that linkages are not always clear about how certain measures translate into specific and targeted actions, and there seems to be a reliance on a lot of additional, future information that will be gathered.

Appendix B
Review of Peer-Review Literature Pertinent to Snake River Dam Breaching

Of the 46 journal articles reviewed, none indicated that the four dams on the lower Snake River should not be breached, but 6 were equivocal (NRC 1996; Zabel & Williams 2000; Kareiva et al. 2000; Levin and Tolimieri 2001; Welch et al. 2008; Rechisky et al. 2009). Before 1800, the Columbia River appears to have supported 7-30 million adult anadromous salmon per year distributed among 200 stocks (Chapman 1986; NPPC 1986; Nehlsen et al. 1991). Those runs have been reduced by 2 orders of magnitude, currently only 8 stocks are considered healthy (Huntington et al. 1996), and Snake River fall Chinook, Snake River spring/summer Chinook, Snake River sockeye, Snake River steelhead, bull trout throughout its range, and Kootenai River white sturgeon are threatened or endangered.

The focus of the AMIP is protection of the hydrosystem status quo. Mundy et al. (1994) concluded that in-river versus transport studies were fundamentally flawed because both were geared to minimal disruption of the hydrosystem. The NRC (1996) concluded that hatcheries cannot compensate for salmon production limited by poor ocean conditions, poor natural production, or high mortality. Dams and reservoirs block or slow migration; alter flow velocities, water chemistry and temperature; and foster increased piscivory and disease. Consequently, when dams contribute to substantial declines in salmon runs, dam removal becomes a clear rehabilitation alternative (NRC 1996), although it may be costly. Williams et al. (1996) concluded that techno-arrogance, or a belief that human technology could replace natural ecological processes in producing salmon, underlay the current management of Columbia River salmon. Instead, they called for a normative river with greater naturalness, including natural spawning and rearing, unimpeded migratory passage, natural flow regimes, natural riverine and estuarine habitats, assemblages dominated by native species, and survival rates sufficient for sustaining and rebuilding populations, repopulating currently vacant habitats, and returning sufficient nutrients to sustain productivity in oligotrophic habitats.

The lower Snake River dams have been identified as sources of direct or delayed salmon mortality. Schaller et al. (1999) reported that survival rates of Snake River salmon were markedly lower than those of Columbia River salmon following the completion of the Snake River dams. Those declines could not be accounted for by altered harvest, habitat declines, climate change, or hatchery practices. Zabel and Williams (2000) argued that the declines reported by Schaller et al. (1999) were confounded by stock differences, delayed declines following dam construction, and incomplete age composition data. Schaller et al. (2000) responded that genetic and behavioral differences of upper and lower river salmon were minor and overlapping, the hydrosystem continued to be altered after dam construction, and that recruitment and population performance were insensitive to age structure. They also found that migration distance had no effect and that pre-hydrosystem runs of upper river stocks were relatively stable from 1939 until hydrosystem development. Kareiva et al. (2000) reported that the lower Snake River dams altered salmon spawning habitat, increased salmon migration mortality, and caused acute declines in Snake River salmon. Passage improvements have reduced direct dam mortality, but even with 100% mainstem survival, Snake River spring/summer Chinook salmon are likely to decline to extinction under current conditions (Kareiva et al. 2000). They added that modest reductions in estuarine or first year mortality would likely reverse those declines, but did not indicate how that might occur. Dambacher et al. (2001) found that dam breaching could reverse the decline of spring/summer Chinook salmon based on estimated average first-year survival and delayed mortality in the estuary and ocean resulting from hydrosystem passage, which was not considered by Kareiva et al. (2000).

Salmon survival differences in major segments of the Columbia River drainage have been the focus of sudy. Using a BACI design, Levin and Tolimieri (2001) reported that recruits per spawner declined in the upper Columbia River, but not in the Snake River, relative to the middle Columbia River, suggesting that upper Columbia dams, versus Snake River dams, be the focus of rehabilitation efforts. However, the data they present indicate that spawners and recruits per spawner in both sub-basins decreased relative to the middle Columbia, especially in later years. DeRiso et al. (2001), used spawner-recruit data and multiple Ricker stock-recruit models to estimate differential Chinook mortality between 7 Snake River and 6 lower Columbia River stocks. They found that recruitment was reduced by an average of 42-85% as a result of dam passage and that year effects were insignificantly correlated with climate indices and water travel time.

In its review of the 2004 Biological Opinion Remand, the WDAFS (2005) concluded that by focusing on non-hydrosystem offsets (such as predation, hatcheries & transportation), the proposed actions would not ensure survival or recovery of the majority of the ESU's, but would continue to violate water quality standards for temperature and dissolved gases and lead to jeopardy of the majority of listed stocks. The reviewers also noted that the transportation system favors larger hatchery fish and jeopardizes smaller juveniles such as sockeye and fall Chinook, and that the reference condition accepts a hydrosystem that has led to substantial salmon losses and ESA listings.

Recent tagging studies offer additional insights into the location of delayed salmon mortality. Welch et al. (2008), using >125 mm hatchery steelhead and Chinook smolts and pit and acoustic tags, estimated that survival to the estuary differed insignificantly between the un-dammed Thompson-Fraser and the dammed Snake-Columbia Rivers. However they did not indicate their sample sizes or the number of acoustic receivers in the Columbia estuary (detection accuracy). They also noted that detection efficiencies were 37-100% and that delayed mortality in the ocean may differ between the two river systems. Rechisky et al. (2009), using acoustic tags implanted in smolts >140 mm fork length, observed no difference in survivorship between middle Columbia and Snake River hatchery spring/summer Chinook salmon at the Willapa Bay, Washington, ocean tracking array. They noted that the mean arrival time of 5 days to the receiver array would have limited estuarine delayed mortality effects, as might the effect of smaller smolts, and the hatchery source of the fish.

Other than the dams themselves, the major expenditures for mitigating losses of Columbia River salmonids have been on hatcheries. However, Meffe (1992) and Williams et al. (1996) warned that salmon management focused on hatchery production without ecosystem rehabilitation is doomed to failure because it does not address the root causes of declines and may accelerate extinction processes through genetic changes and competition with wild fish. Levin et al. (2001) also demonstrated a negative relationship between wild Chinook salmon survival and releases of hatchery spring/summer Chinook, especially when ocean productivity was low.

Budy (2001) summarized the differences in modeling perspectives of NOAA Fisheries and other institutions that result in alternative recovery options. PATH is a decision analysis tool that indicates management actions that are least risky and most robust to remaining uncertainties, and that facilitates decisions based on full consideration of uncertainty and risk. PATH analyses concluded that dam breaching alone had significantly higher probabilities of achieving survival and recovery than transport options, and that habitat improvement or harvest reductions alone will be insufficient to increase survival and recover stocks. A NOAA Fisheries model (CRI) explores the demographic effects of alternative reductions in mortality at different life stages under current conditions. The CRI model results indicated that even with 0% direct in-river mortality, stocks would continue to decline, and that dam breaching alone was unlikely to recover salmon. However the effectiveness of breaching hinges on the degree of delayed mortality caused by the hydrosystem and experienced by salmon in the estuary or ocean. For Snake River spring/summer Chinook, the most risk-averse actions include dam breaching, harvest moratoria, and substantial improvement in hatcheries and habitat. For fall Chinook and steelhead, dam breaching alone is likely to lead to recovery. Both PATH and CRI indicate that dam breaching has the greatest potential for recovering Snake River salmon and steelhead. By incorporating delayed mortality into CRI, the CRI and PATH results produced consistent rankings of the expected benefits from management options: dam breaching had a much greater benefit than maximum transportation, habitat improvements will provide minimal benefit, and reduced harvest will offer minimal benefit to spring/summer Chinook because harvest is now minimal. Hinrichsen and Fisher (2009) found that regional and common Ricker models were superior to population-specific models, that the former two models produced markedly different estimates of delayed mortality, and that the model used in PATH is over parameterized.

The hydrosystem has facilitated increased predation by piscivorous fishes. Peterson and Kitchell (2001), using bioenergetics models, estimated that northern pikeminnow predation on smolts was 68-96% greater in warm years than in cold years, despite an only 2C difference in water temperature. This has important implications for continued global warming in the future. Based on abundance estimates and gut content studies, predation of juveniles in some hydrosystem reservoirs may reach 40% of a salmon run (Rieman et al. 1991; Vigg et al. 1991; Fritts & Pearsons 2004; Waples et al. 2007; Sanderson et al. 2009), providing important bottlenecks to juvenile survival. Levin et al. (2002) reported that survival of juvenile Chinook salmon was less in sites with brook trout than in those where brook trout were absent. The ISAB (2008) noted that the Columbia hydrosystem improved habitat conditions for alien species, and that the reservoirs in particular provided hotspots and large source populations for alien piscivores. The reservoirs, climate warming, and human economic and population growth are expected to exacerbate the effects of alien species on salmonids. The ISAB concluded that restoring natural thermal and flow regimes would aid native species persistence with alien species.

Following or concurrent with the above modeling projections, a number of papers were published examining why dam breaching is the key to Snake River salmon rehabilitation. Bugert et al. (1997) found no difference in adult return rates between transported and in-river migrating juvenile fall Chinook salmon, suggesting that it is the hydrosystem, not how the fish move through the system, that limits smolt-adult-returns to less than 1%. Peters and Marmorek (2001), using PATH, found that the causes of estuarine and ocean mortality were the most influential uncertainties surrounding spring/summer Chinook recovery, and given those uncertainties that breaching was the most risk averse action, meeting recovery goals over a wider range of assumptions than other actions. Also using PATH, Peters et al. (2001) found that breaching was the most risk averse option for fall Chinook, yielding greater long-term escapement than maximizing transportation under most hypotheses and model assumptions. Maximum transportation and breaching yielded similar results, only by assuming high estuarine and marine survival rates of transported fish, severe reductions in harvest, and insensitivity of upriver survival rates to dam construction or breaching. Using marked fish, Williams et al. (2001) estimated that smolt-to-adult returns of wild Snake River steelhead and spring/summer Chinook salmon remained below historic levels, despite reduced direct mortality of juveniles. Dauble et al. (2003), using historical, geographical and geological analyses, determined that the Columbia River above John Day Dam and the lower Snake River have high potential for spawning by fall Chinook salmon if normative flow regimes and water levels are established. Keefer et al. (2008), using pit tags, determined that steelhead kelts were disproportionately wild females in the Columbia/Snake system and that the number of kelts was an order of magnitude lower for the Snake River versus the Columbia River, reflecting distance and hydrosystem challenges of the former. In addition, outmigration rates were significantly lower than in unimpounded rivers of comparable size. Halsing and Moore (2008), using salmon-passage, age-structure and cost-effectiveness models, found that dam breaching produced the greatest improvement in mean annual population growth rate among the cost-effective options for Snake River Chinook salmon. Transportation was cost-effective only if it was assumed to have high effectiveness. Wilson et al. (2009) stated that Halsing and Moore's passage model was inappropriate because of over parameterization, unfounded assumptions, and underestimates of direct and delayed transportation mortality. They reported the average differential dam-passage versus in-river transportation mortality at 39%, and noted that in-river migrating Snake River smolts arrive at the estuary days to weeks later than they would without dams. Late-arriving smolts had a lower smolt/adult ratio than early arrivers and lower ocean survival.

There have been a number of studies suggesting that delayed mortality in the estuary or ocean may be the major sources of losses, rather than direct mortality at the dams. Focusing on delayed mortality in a literature review, Budy et al. (2002) reported that smolt mortality per dam may be as high as 10% and reservoir mortality may reach 20% versus 37-68% delayed mortality in the estuary or ocean following dam passage or transportation. They concluded that dam breaching would increase survival of Snake River Chinook salmon by reducing delayed mortality resulting from the hydrosystem. Examining tagged fish, Muir et al. (2006) observed greater post-hydrosystem mortality for smolts transported early in the season, but greater mortality for in-river migrating smolts later in the season. Both wild and hatchery migrating smolts grew 5-8 mm, but transports did not grow; rather, they were more vulnerable than migrants to northern pikeminnow and hake predation. Muir et al. concluded that delayed mortality was likely a result of differential size and timing of ocean entry. One might conclude that poor estuary habitat was the cause of the smolt mortality, versus delayed mortality from upriver dams. However, using spawner/recruit data and productivity and survival models, Schaller and Petrosky (2007) found that Snake River stream-type Chinook survived only 1/3-1/4 as well as downriver stream-type Chinook salmon, presumably because of greater delayed hydrosystem mortality in the estuary and ocean. Zabel et al. (2008) reported that hydrosystem effects on juvenile Snake River salmonids may be expressed as delayed mortality from stress and disrupted migration timing.

Several researchers have also examined the efficacy of improving tributary habitat conditions. Through use of productivity and survival rate models, Petrosky et al. (2001) found that declines in Snake River Chinook salmon following completion of the hydrosystem were not associated with major productivity or survival changes in the spawning-rearing life stages, indicating that freshwater habitat was not the major limiting factor. However significant survival declines did occur in the smolt-adult life stage coincident with hydrosystem completion, poorer climate conditions, and hatchery management. They concluded that improved freshwater spawning and rearing conditions were unlikely to offset those impacts and ensure recovery because most of the Snake River Chinook stocks spawn and rear in wilderness areas with good to excellent habitat. This contradicts the CRI modeling estimates that suggested that substantial habitat improvement would lead to recovery. Wilson (2003) applied sensitivity, elasticity and perturbation modeling to an age structure matrix under varying assumptions of transportation effectiveness. He found that dam breaching has greater potential for increasing population growth rates than habitat restoration, except under the most optimistic transportation assumption. He then fit the model to historical data and found no reduction in egg-to-smolt survival, indicating that neither habitat deterioration nor hatcheries caused the observed stock declines at those life stages. Rather, the large historical decreases in smolt-to-adult survival were associated with the direct or delayed effects of dam passage and transportation on salmon mortality. McHugh et al. (2004) predicted Snake River spring/summer Chinook egg-smolt survival rates by modeling commonly used physical habitat parameters. They found that the potential for improving survival via habitat rehabilitation was high for few populations and low or nonexistent for most; however, they noted that the potential for lower survival resulting from possible habitat deterioration was great for all populations. Through use of mechanistic habitat models and population viability measures, Budy and Schaller (2007) estimated that there was little room for habitat improvement for half the Snake River spring/summer Chinook populations. They concluded that a recovery strategy relying on tributary rehabilitation to mitigate delayed and direct mortality from dams is risky with low probability of success. Thompson (2006) reported that only 2 of 79 publications documented that in-stream structures benefited fish populations. In a study of existing livestock exclosures in northeast Oregon, Bayley and Li (2008) determined that the exclosures were too little and dispersed to effectively improve conditions at population or catchment scales. Following a review of 345 stream habitat rehabilitation studies, Roni et al. (2008) concluded that priority should focus on protecting existing high-quality streams and catchments, and recovering connectivity and catchment processes before initiating habitat improvement projects.

Economic costs are frequently given as reasons for not breaching the Snake River dams; however the preponderance of economic studies have yielded opinions contrary to that assumption. Blumm et al. (1999), summarizing a number of economic studies and legal exposure under multiple federal statutes and treaties, concluded that the costs of breaching outweigh the costs of upper Snake River drawdowns for flow augmentation. In its cost-benefit analysis to Congress, the Army Corps of Engineers estimated that the proposed lower Snake River dams would only return 15 cents in benefits per dollar of costs (Blumm et al. 1999). HARZA Northwest (1996) estimated that breaching would increase salmon survival by 72% at a cost of $75-153 million per year versus transportation and flow augmentation benefits of $200 million per year. The NPPC's (1998) rate structure analysis indicated that drawdown of the lower Snake River dams and John Day reservoir was affordable except under the highly unlikely scenario of power priced at $13/mWh. In a worst case scenario, the drawdowns would increase Pacific Northwest power rates by 10%, but those rates are 40% lower than the national average. Using a travel-cost demand model, Loomis (2002) estimated that the total cost of breaching the four lower Snake River dams would be offset by increased recreational benefits alone. Blumm et al. (1999) also concluded that remaining legal issues may further increase the costs of retaining the Snake River dams. Those legal issues include the lack of incidental take permits for Idaho Power dams in Hells Canyon, water quality violations of Snake River dams, unsettled Indian Treaty fishing and water rights, and the Pacific Salmon Treaty with Canada wherein the USA is obligated to provide 1:1 replacement for Canadian fish migrating to the Alaska fishery with Columbia River fish migrating to British Columbia.

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