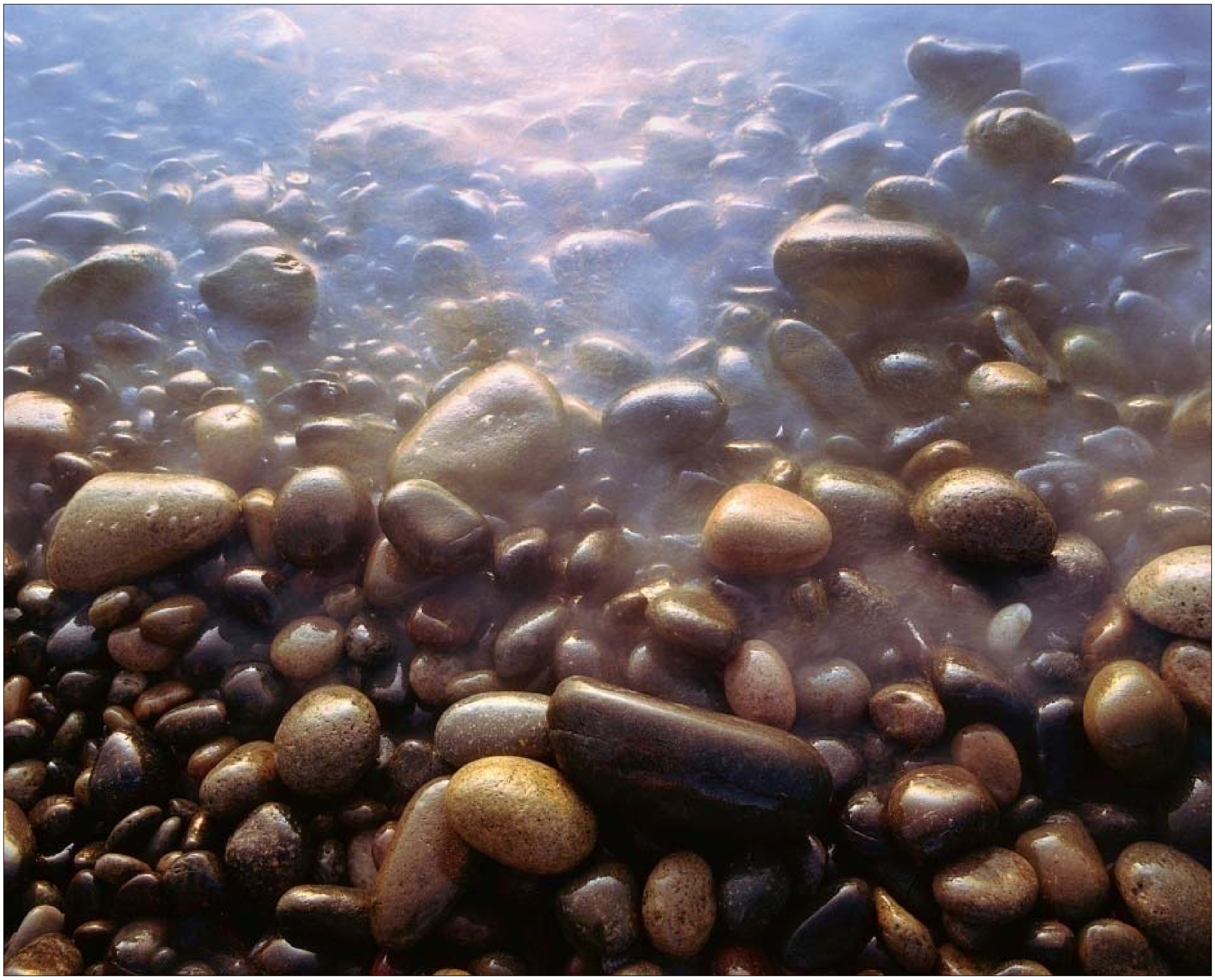

Issue Summaries

of the FCRPS 2008 Biological Opinion

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Issue Summaries

of the FCRPS 2008 Biological Opinion

The purpose of these Issue Summaries is to provide a general overview of the underlying issues in FCRPS Biological Opinion and the various documents upon which it is based, including the Supplemental Comprehensive Analysis. These Issue Summaries are not intended to interpret or change the FCRPS Biological Opinion in any way and if there are any inconsistencies between this summary and the biological opinion, the latter controls. Only the FCRPS Biological Opinion is the legal document called for by the Endangered Species Act, Section 7(b).

For a list of all literature cited, see the Supplemental Comprehensive Analysis, Chapter 12

ISSUE SUMMARIES OF THE FCRPS 2008 BIOLOGICAL OPINION

Issue Summary: Hydrosystem Operations to Improve Juvenile Passage Survival

Statement of Issue

Improving juvenile passage survival through the FCRPS hydrosystem has been a focus of fish protection efforts for at least 30 years. Efforts include improvements to dam passage survival, juvenile collection and transportation systems, and efforts to improve in-river conditions. Ongoing research, monitoring, and evaluation efforts are aimed at informing an adaptive management program to further improve juvenile survival.

Given the best available information, what is the best combination of operations and structural improvements to meet juvenile passage survival performance standards in the 2008 FCRPS Biological Opinion?

Background

Hydrosystem operations and structural improvements at the dams[1] are designed to achieve dam passage performance standards of 96% per dam passage juvenile survival for spring migrants and 93% per dam passage survival for summer migrants. The FCRPS Action Agencies proposed a combination of operations and structural changes based on the unique migration paths, timing and needs of various species. NOAA Fisheries reviewed these actions, and added additional measures to improve juvenile survival through the FCRPS Biological Opinion's Reasonable and Prudent Alternative (RPA).

Water passed through spillways (spill) has been used for many years as an important non-turbine route of passage for migrating juvenile salmon and steelhead at the mainstem Snake and Columbia River dams. The volume and timing of spill is often debated for a number of reasons. Spill is generally effective at passing fish and survival rates are typically high, however, it is not always the best route of passage and has several limitations, including:

1. Spill gates open about fifty feet below the water surface. Diving to reach these relatively deep openings is contrary to the natural preference of migrating fish, and many fish may be delayed behind a dam where they are vulnerable to predators.
2. Excessive spill can cause supersaturated dissolved gas levels which can lead to gas bubble disease.
3. Too much spill, too little spill, or mechanical problems can result in poor tailrace egress conditions which can lead to substantial juvenile mortalities in the spillway or other juvenile passage routes due to injury or from predators.

[1] The effects of dams and the increases in survival that have resulted from structural and operational improvements since 1995 are described in Ferguson et al. 2005 and Williams et al. 2005.

4. Spill levels that are too high and or too low can also affect adult passage by increasing entrainment (fall-back) or by blocking access to the fish ladders. Several projects have limits on spill operations because of these concerns.

5. Low flow conditions may limit the amount of spill that is available

A recent trend in passage improvements has been to provide migrating fish with passage route near the surface. An example of these surface bypass devices are new spillway weirs that allow migrating fish to enter a dam's spillway close to the surface of the water and exit in the tailrace. These spillway weirs and other surface collection devices provide more surface-oriented passage and allow fish to pass through the dam in a less stressful manner. Surface passage routes tested to date are generally very effective at passing juveniles, have been shown to reduce delays in the forebay (which decreases vulnerability to predators), and can have survival rates better than or equal to those measured in adjacent spillway bays.

However, as long as the dams are operated, some fish will enter the turbine units. To reduce this impact, two general strategies have been employed. First, screened juvenile bypass systems have been constructed and operated to reduce the number of fish entering the turbine units. Second, older turbine units are being replaced with newer turbine units that are designed to minimize physical areas and hydraulic conditions that are known to be harmful to fish.

Lastly, because transport operations at collector projects are affected by spill and surface passage route operations (increasing spill and surface passage route effectiveness results in decreasing proportions of fish transported), the relative benefit of transport to various species (i.e., Snake River spring/summer Chinook and steelhead – see Issue Summary: Methodology for Evaluating Hydrosystem Effects) must also be considered when formulating configurations and operations to optimize both passage survival and number of returning adults.

Scientific Reviews of Spill & Surface Passage

Ferguson et al. (2005) and **Williams et al. (2005)** reviewed the available information regarding juvenile survival through passage routes at the FCRPS mainstem projects. Their review supports continued reliance on spill and the development of surface passage alternatives (with proper consideration of egress conditions, adult passage issues, etc.) as viable tools for achieving juvenile performance standards.

Summary of View and Comments

The **State of Oregon, CRITFC** and the **Save Our Wild Salmon (SOS)** coalition suggest that, in general, spill is the best approach to juvenile passage.[2] They suggest that spill increases in 2006 and 2007 have contributed to some of the highest juvenile survival rates on record. SOS is especially critical of surface bypass improvements as a means of improving power production rather than a means to improve juvenile passage survival.

Alternative hydro operation scenarios were discussed extensively (and several scenarios were modeled using the most current version of the COMPASS model available at the time as part of these

[2] See CRITFC comments, p. 60-66, Oregon comments p. 11-25 and SOS comments p. 11-14.

discussions) within the **Remand Collaboration Hydro Workgroup** and the **Policy Work Group (PWG)**.[3]

Approach in the FCRPS Biological Opinion

Spill is an effective tool for providing safe passage at the mainstem hydroelectric projects. Indeed, the final FCRPS Biological Opinion RPA calls for increased spill levels in the spring at John Day dam and in the summer at Bonneville dam to improve juvenile survival.

However, as noted above, spill, by itself, is not a "silver bullet." The effectiveness of spill to increase survival is variable and dependent on individual project configurations. Spill does not pass all fish quickly and can be limited by a number of biological and physical constraints including 1) tailrace egress conditions that degrade with low or high spill levels subjecting fish to increased predation vulnerability, 2) tailrace hydraulic conditions from high spill that cause poor adult passage, and 3) high total dissolved gas levels caused by high spill can exceed biological limits.

Transportation of yearling juvenile migrants is also an important consideration. Studies indicate that transportation benefits Snake River steelhead juveniles under almost all conditions. Throughout the migration season, transported Snake River steelhead juveniles almost always return more adults than juveniles migrating in-river. On the other hand, the transportation benefits to Snake River spring/summer Chinook are more variable. Earlier in the migration season, spring/summer Chinook migrants generally return more adults than transported juveniles. Later in the migration season, transported spring/summer Chinook appear to perform as well or better than in-river fish. Since the amount of spill affects the percentage of fish transported (more spill equates to less fish transported), it is important to balance the spill-transport operations to optimize survival for both species using spill and transport operations.

NOAA Fisheries has required, through the RPA in the FCRPS Biological Opinion, the FCRPS Action Agencies to work cooperatively with NOAA Fisheries and other regional parties to develop Configuration and Operations Plans (COPs) for each of the mainstem hydroelectric projects (see RPA Actions 18 through 25). These COPs will consider all pertinent biological information (forebay delay, tailrace egress conditions, etc.), and the available tools (spill, surface bypass, juvenile bypass system improvements, turbine improvements) to achieve the dam performance standards and the overall survival improvements assessed in the COMPASS model for in-river migrating fish.

NOAA Fisheries has determined that in-river survival estimates were generally high for yearling Chinook salmon in 2006 and 2007, and higher than other recent years for steelhead smolts. However, until complete adult returns can be assessed (complete returns from these years will not be available until 2010) it is premature, to support a "maximum spill strategy" at the Snake River collector dams at this time, especially when considering the potential response of Snake River steelhead to a reduced transportation scenario (See Issue Summary: Methodology for Evaluating Hydrosystem Effects). NOAA Fisheries is extremely interested in the adult returns from the 2006 to 2008 outmigrations, and will incorporate these findings into the FCRPS Biological Opinion's adaptive management processes.

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[3] See PWG Meeting Notes, August 7-9, 2006 and August 23-25, 2006

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Issue Summary: Libby & Hungry Horse Operations

Statement of Issue

ESA listed salmon and steelhead and ESA listed resident fish (bull trout and white sturgeon) could both benefit from water stored in the Montana reservoirs of Hungry Horse and Libby. The FCRPS is responsible for addressing the needs of both resident and anadromous fish species. Analyses have shown that current operations to achieve anadromous fish flow objectives in the lower Columbia River adversely affect listed resident fish. The Action Agencies and some parties have supported changes recommended by the State of Montana and the Northwest Power and Conservation Council to better protect listed species while minimizing effects on flows for listed salmon and steelhead. Other parties have opposed these changes, contending that there would be adverse effects to salmon and steelhead, or that mitigation must be provided for these flow modifications.

Is there an operation that retains sufficient water in Montana to minimize negative impacts on the ESA-listed upstream species while not jeopardizing downstream ESA-listed salmon and steelhead?

Background

Beginning with NOAA Fisheries' 1995 Biological Opinion on the FCRPS, an RPA action required both Libby and Hungry Horse to draft 20 feet from full by the end of August to increase flow to benefit ESA-listed juvenile Snake River fall Chinook salmon as well as ESA-listed adult steelhead in the lower Columbia River. The state of Montana opposes this operation on the basis that it harms the resident fish populations, including ESA-listed bull trout and listed white sturgeon (Montana 2008a). As an alternative operation Montana has proposed that these projects be drafted 10 feet from full by the end of September in most years, and a 20' draft in the lowest 20% of flow years by the end of September. The Montana proposal shifts water releases from the July and August period into September and later periods.

Scientific Review of the Respective Operations

Peak production for Montana's ESA-listed and resident fish species occurs in July, August and September. Stable or gradually declining flows are important in order to protect bull trout critical habitat and the aquatic food resources on which these fish depend (Montana 2008a). **Montana Fish, Wildlife and Parks** is conducting a series of field experiments including biological and physical modeling and tracking of fish in the Flathead and Kootenai Rivers (Montana 2008a). The physical models indicate the flows that occur from the current 20' draft produce lesser quality habitat than would occur from the Montana proposal.

In 2003, as part of the Mainstem Amendments (NPCC 2003) to its Fish and Wildlife Program, the **Northwest Power and Conservation Council** unanimously recommended that the Montana operation be implemented, and evaluated on an experimental basis. The Council sought confirmation that the benefits to upstream resident fish would not be offset by harm to fish downriver. The Council also recommended an increased draft in the lowest twenty percent water years to aid during these lowest of flow years.

In 2004, the **Independent Scientific Advisory Board** (ISAB 2004) evaluated whether there would be a measurable effect of Montana's proposed reservoir operation (10 feet vs. 20 feet summer draft) on the lower Columbia River listed salmon populations. The ISAB's concluded that the impact was believed to be small and the existing tools were inadequate to assess whether the net effects were negative or positive during the July-September period. The ISAB also concluded that the Montana resident fish would benefit both in the reservoirs and downstream from implementing this proposal. In addition, the ISAB recognized that a large percentage of returning Snake River fall Chinook salmon adults are from juvenile fish that over-wintered in the reservoirs; thus, the life-history pattern complicates the assessment of this stock in relation to the flow proposal. The ISAB also acknowledged the benefits of lower flows to returning adults.

In 2004, **NOAA Fisheries** (NMFS 2004a) modeled the effect of Montana's proposed operation and evaluated the effect on flow, temperature, and juvenile survival (Montana 2008a). The decrease in flow was calculated to be approximately 7 kcfs decrease during a period when the flow in the river averages about 160 kcfs. The evaluation of the flow change on temperature was performed using a temperature model developed by EPA. It indicated there would be about a 1 degree increase in temperature in the lower Columbia River by reducing flows by about 7 kcfs. For the affected Snake River fall Chinook, (i.e., those juveniles migrating in the lower Columbia River primarily in July and August), the estimated affect on juvenile survival was less than a 1% relative decrease. The overall effect on the ESU is negligible. While none of the measures were positive, all of the estimates were very small and need to be considered in light of the purported negative affect of the 20' draft on upstream listed populations.

Summary of View & Comments

The **State of Montana** argues that the Montana operations should prevail because of the certainty of high biological value of maintaining water in the reservoirs during the critical summer months for ESA-listed bull trout and sturgeon, and because of the uncertainty in downstream flow benefits to Snake River fall Chinook and various steelhead ESUs (Montana 2008a). In addition, Montana points out that considering their population growth rate and extinction risk probabilities, Snake River fall Chinook are in relatively better condition than any of the other Columbia Basin listed fish, and that given their tendency to over-winter in the reservoir, few Snake River fall Chinook would receive any benefit of the 20' draft.

The FCRPS Action Agencies and other regional parties support the Montana operation as a better balance between the competing needs of listed fish, consistent with the recommendations of the Northwest Power and Conservation Council. In their 2008 Memoranda of Agreement with the FCRPS Action Agencies, **the Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Warm Springs Reservation, the Confederated Tribes of the Umatilla Indian Reservation and the Confederated Tribes of the Colville Reservation, the Columbia River Inter-Tribal Fish Commission (CRITFC) and the State of Idaho** have also endorsed the proposed Montana operation.

Critics of the Montana operation, including the **State of Oregon** (Oregon 2008)**,** emphasize the importance of meeting summer flow objectives at McNary over any other operation for listed resident fish. They contend that although the benefits of flows to survival may not be practically measurable, this does not mean that survival is not increased.

The Montana operation is currently part of the *Columbia Basin Fish and Wildlife Program* adopted by the Northwest Power and Conservation Council. It was discussed within the **Remand Collaboration Hydro Workgroup** and the **Policy Work Group (PWG).** In its December 2005 Status Report (PWG 2005), the PWG stated that its goal was to seek solutions for ESA-listed salmon and steelhead which take into account impacts on other species, such as Montana's resident fish. The PWG was unable to reach consensus on a specific recommendation.

Approach in the FCRPS Biological Opinion

NOAA Fisheries believes that the current operation of a 20' draft by the end of August harms Montana's ESA-listed resident fish, and does not provide substantial benefits to Snake River fall Chinook. The Snake River fall Chinook ESU has a high population growth rate and a low extinction risk (NMFS 2008a). Modest flow reductions are unlikely to substantially affect the thermal regime of the Columbia River or the survival of the ESU. Given the life history of the species, few actively migrating juveniles are in the lower river in the late summer.

NOAA Fisheries agrees that an evaluation of an experimental draft is appropriate (see RPA Action 4). The Bonneville Power Administration (BPA) committed to fund and implement the Montana Fish, Wildlife, and Parks' (MFWP) proposal for evaluation of the biological and physical effects of this operation on the fisheries upstream and downstream of Hungry Horse and Libby dams in Montana. The study will utilize MFWP's current biological baseline data as a basis for comparison. While there are no specific studies or research planned to evaluate the effects in the lower Columbia River, implementation of the Water Quality Plan (see RPA Action 15) should enhance temperature modeling capabilities in the entire Columbia River, providing another tool for assessing the potential effects of this flow regulation operation on water temperatures as advised by the ISAB and NRC.

The MFWP's study results will be used to determine the benefits to resident fish associated with the new reservoir operations relative to the baseline. The FCRPS Action Agencies propose to continue the experimental draft into the future unless information gathered informs future policy considerations that the experimental drafts of Libby and Hungry Horse reservoir operations are biologically unsound. While no study in the lower river is planned, any new information that may become available relative to salmon will be considered.

Results of these studies will be considered and discussed through adaptive management, in consultation with the Regional Implementation Oversight Group as described by the FCRPS Action Agencies in Chapter 2 of the FCRPS Biological Assessment.

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Issue Summary: Snake River Fall Chinook Life History & Management Actions

Statement of Issue

Recent information has indicated that late migrating Snake River fall Chinook salmon, unlike earlier-migrating juveniles which exhibit the classic subyearling life-history strategy typical of this ESU, do not necessarily migrate to the ocean in the first year of life, but instead may adopt a yearling life-history strategy. These juveniles spend their first summer and winter within the reservoirs (or upper estuary) and resume migrating the following spring as age-one fish (also called reservoir-type juveniles). A substantial proportion of returning adult SR fall Chinook at Lower Granite Dam exhibit yearling annuli on their scales, indicating that both the historic subyearling, and more recent reservoir-type life-history strategies are contributing to the productivity of the ESU.

Given the multiple life-history patterns of Snake River fall Chinook, what is the appropriate flow management strategy?

Background

In the past, nearly all Snake River fall Chinook salmon were thought to migrate to the ocean as subyearlings – primarily in the summer months (Connor et al. 2005). Summer flow objectives (June 21 to August 31) were designed to enhance migration conditions for these subyearling migrants by incrementally increasing flows and reducing summer temperatures – primarily within the lower Snake River (NMFS 2000b, 2004a). However, important information relating to the life history of Snake River fall Chinook salmon has recently been discovered: 1) a substantial number of juvenile SR fall Chinook salmon are adopting a yearling life-history strategy that contributes substantially to the overall adult returns, 2) the propensity for juvenile fall Chinook to migrate declines markedly through July, and 3) the passage timing of juveniles PIT tagged in rearing areas upstream of the head of Lower Granite has shifted earlier (about four weeks earlier for those from Hells Canyon) during the past decade. These new factors were debated by the PWG and caused NOAA Fisheries to reconsider the emphasis of the summer flow augmentation program in the development of the FCRPS and Upper Snake biological opinions.

Scientific Review of the Respective Operations

A substantial amount of research has occurred relating to Snake River fall Chinook salmon since their listing under the Endangered Species Act. The following review focuses on the publications and information that has substantially influenced the present understanding of juvenile life history and the relationship between survival and conditions within the mainstem Snake and Columbia River dams.

Smith et al. (2003) found that the survival rates of migrating Snake River subyearling Chinook salmon (1995 to 2000) from release points within Hells Canyon to Lower Granite Dam tailrace 1) generally decreased as the release date became later (from 45% to 76% for the earliest release groups in late May or early June to 20% or less for the latest release group in early July) and 2) were positively correlated with exposure indices of flow and turbidity and negatively correlated with exposure indices of temperature, and these factors were highly correlated with each other and with release date.[4] They concluded that flow, turbidity, and temperature have plausible biological consequences for rearing and actively migrating fish, and survival is probably influenced by all of them.

Connor et al. (2005) found some fall Chinook salmon juveniles in the Snake River basin spent their first winter in a reservoir and resumed seaward movement the following spring as age one fish (expressing a reservoir-type life history). Reservoir-type juveniles migrate at much larger sizes than their subyearling counterparts (222 mm vs 139 mm for wild origin fish) and should be considered a successful life-history strategy as they make up a substantial proportion of adult returns (14% to 52% for wild origin fish and 27% to 86% for hatchery origin fish). They further noted that summer flow augmentation (primarily from cool water releases from Dworshak Reservoir on the Clearwater River)

> "provides the highest level of protection for the later-migrating fall Chinook salmon juveniles that are most likely to exhibit the reservoir-type juvenile life history. Given the lack of thermal refuge in the contemporary spawning areas, mortality of these later-migrating fish would be high without summer flow augmentation (range of estimates, 78–87%). Therefore, we believe that the reservoir-type juvenile life history is a successful response to large-scale changes in historical habitat that has been enabled or at least enhanced by summer flow augmentation. We also suggest that the decision by managers to save some water in July and August for release in September should further enhance the reservoir-type juvenile life history, provided this decision does not result in temperatures above 20^{o}C in Lower Granite Reservoir during July and August."

More detailed investigations of the behavior of juvenile fall Chinook salmon within Lower Monumental reservoir were conducted in 2007. Preliminary results indicate that the joint probability of migration <u>and</u> survival was high (0.84 to 0.96) between June 16 and July 1, decreased between July 4 and July 11 (0.46 to 0.78), and again between July 14 and July 18 (0.09 to 0.19) (McMichael et al. 2007b). The majority (76%) of the fish that ceased downstream migration did so in the stratified (downstream half) of the reservoir. This pattern of declining proclivity to migrate for fall Chinook salmon has also been recently observed in the Columbia River downstream of Bonneville Dam (McComas et al. 2008).

Lastly, the median dates of passage for juvenile wild Snake River fall Chinook salmon trapped and PIT tagged in the Snake River and redetected migrating past Lower Granite Dam has moved earlier in the year by about four weeks over the past 15 years (Figure 1). Thus, an increasing

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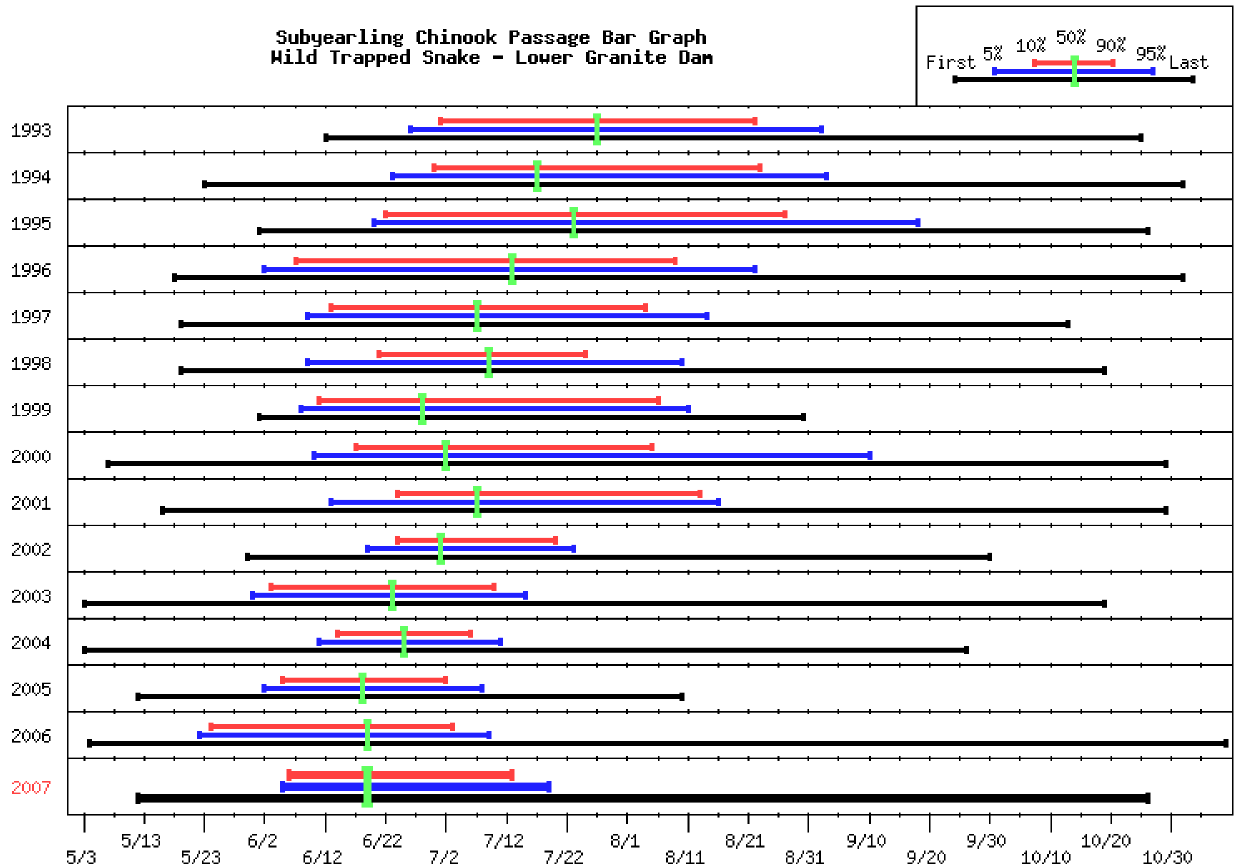
[4] Smith et al. (2003) also found that migration rates (km traveled per day) were substantially higher (about 20 to 60 km / day) in river reaches downstream of Lower Monumental Dam than in river reaches upstream of this location (1 to 20 km / day) – indicating that juveniles were spending considerable amounts of time rearing in the Lower Granite, Little Goose, and Lower Monumental pools in the years considered in this study.

proportion of these fish are migrating when flows and turbidity are higher and temperatures are cooler, which should result in higher survival rates for subyearling migrants (see discussion of Smith et al., above) compared to those observed a decade or more ago.

Figure 1. Passage timing of juvenile wild Snake River fall Chinook salmon trapped and PIT tagged in the Snake River and redetected at Lower Granite Dam (Source: DART 2007b)



Key to Figure 1:
For each year, the median passage date is indicated by a single vertical bar. The top horizontal line indicates 10 - 90 % passage dates, the center horizontal line indicates 5 - 95% passage dates, and the bottom horizontal line shows first and last detection dates.

Summary of View & Comments

CRITFC and the **Nez Perce Tribe** suggest that management actions should support both ocean-type and reservoir-type fish. They suggest that although not all of the fish are migrating, those that do need the benefits of additional flow and spill to improve their survival.[5]

Approach in the FCRPS Biological Opinion

After considering the available information, NOAA Fisheries finds that a two-pronged management strategy is necessary to assure that river conditions are adequate for both subyearling (ocean-type fish) and yearling (reservoir-type fish) SR fall Chinook salmon. First, when subyearling smolts, primarily from the Snake River below Hells Canyon Dam, are actively migrating (primarily June and early July), flow augmentation operations (from Reclamation's upper Snake River project and from Dworshak Dam) should be provided to both enhance flows and maintain adequate temperatures. Second, when the slower-growing and later-migrating juvenile fall Chinook salmon from the Clearwater River have generally ceased migrating and have instead begun to rear within the reservoirs (primarily in late July, August, and September), maintaining adequate rearing temperatures, rather than flows, is of primary importance. NOAA Fisheries believes that water releases at Dworshak Dam has been consistent with this approach in recent years and has provided good rearing conditions for the reservoir-type fish. Furthermore, Reclamation's proposed operation (as requested by NOAA Fisheries) of releasing the Upper Snake flow augmentation water (up to 487 kaf) in May and June (prior to refill), and reducing July and August releases, is consistent with maintaining adequate flow and water temperature in the lower Snake River for the subyearling outmigrants from the Snake River. NOAA Fisheries believes that these two operations are consistent with providing the best conditions for addressing the requirements of both the subyearling and yearling Snake River fall Chinook salmon life-history strategies.

The summer spill operation begins in mid-June and continues until the end of August at the Snake River Projects. The effect of this operation on the return rate of fall Chinook has yet to be determined, as complete adult return information for the last three years will not be available until 2012.

One certain trend observed over the past three years (2005-2007) has been a shift in the out-migration timing of subyearling Chinook salmon in the Snake River. The out-migration timing of subyearling Chinook in 2005-07 occurred earlier in the year relative to years past. In 2005-07, the 95th percentile of the run based on passage index values had passed Lower Granite Dam by August 1. In years prior, 1997-2004, the mean 95th percentile passage index passage date occurred later, near the end of August. Furthermore, the percent of total passage index that was exposed to and passed Lower Granite Dam during August spill was 5.9 percent in 1997-2004 as compared to ≤1.2 percent in 2005-07.

As a result of this run timing shift, a substantial portion of the spill provided during the summer spill period (especially in August) to facilitate downstream passage of Snake River subyearling Chinook salmon, occurs after nearly all of the fish that may be expected to out-migrate during the summer months have already passed through the system.

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[5] CRITFC comments p. 64 and Nez Perce comments p. 7

Based on this recent passage timing information for years when summer spill occurred, NOAA Fisheries has developed a plan to adapt Snake River summer spill operations to better coincide with the observed passage timing of the subyearling Chinook out-migration in the Snake River. This plan includes real-time tracking of subyearling Chinook collection at each collector dam (Lower Granite, Little Goose, and Lower Monumental dams) to evaluate run timing, then either continuing spill in August if adequate numbers of Chinook are passing each dam, or curtailing spill if the number of collected fish at a given dam has dropped below 300 individuals for three consecutive days either on or after August 1. An added safeguard provision is included in the plan that specifies spill will resume if the number of fish collected at a given dam subsequent to spill curtailment exceeds a 500 fish threshold for two consecutive days at that dam. NOAA Fisheries initially considered a 1,000 fish summer spill curtailment threshold however, to provide an added level of certainty regarding the coincidence of spill operations and fish passage, chose a 300 fish collection curtailment threshold rather than a 1,000 fish threshold. NOAA Fisheries' plan successfully adapts Snake River summer spill operations to the observed timing of the subyearling Chinook salmon out-migration, rather than choosing a specific date to end spill on the Snake River that may not align well with fish passage timing for a given year when summer spill occurs. The added safeguard provision to resume spill if fish collection numbers increase above 500 fish for two days after curtailment, offers added certainty that spill will be provided at a dam if actively migrating fish are present to benefit from the operation.

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Issue Summary: Methodology for Evaluating Hydrosystem Effects

Statement of Issue

In order to compare the relative effects of alternative hydropower operations on salmon survival and return rates, a modeling approach is needed to estimate juvenile salmon survival through the FCRPS and the effects of FCRPS passage on ocean survival and adult returns. The model must be able to employ passage survival estimates and equations that were derived from a collaborative review of all available passage and survival data for Snake River spring/summer Chinook and steelhead.

Does the 2008 FCRPS Biological Opinion utilize the best available science to estimate survival through the FCRPS and the effects of FCRPS passage on ocean survival and adult returns?

Background

Comparisons of alternative hydrosystem operations for the 2004 FCRPS Biological Opinion were made using the SIMPASS (NMFS 2004a) passage model. This model was criticized for being overly simplistic in its approach to estimating passage survival through the FCRPS. In 2005, it was determined that a more comprehensive fish passage model should be developed. The NOAA Northwest Fisheries Science Center conducted a review of alternatives for model development, considering which of the alternatives would more effectively estimate FCRPS passage. It was decided to modify an existing computer model, CRISP (developed by the University of Washington), to meet this need. A collaborative group was formed to oversee development of the model, participants included NOAA Fisheries, U.S. Fish and Wildlife Service, Army Corps of Engineers, Oregon Department of Fish and Wildlife, Columbia River Inter Tribal Fish Commission (CRITFC), Washington Department of Fish and Wildlife, Bonneville Power Administration and other tribal and agency members.

Development tasks were assigned to three working groups: the Dam Passage group, the Reservoir Survival group, and the post-Bonneville Survival group. The first tasks comprised collection, summation, and review of historical and current fish passage survival data for spring Chinook and steelhead.[6] A summary of what had been determined by the collaborative working groups to be the best available passage and survival data was provided to the entire model development group. Based on these data, mathematical relationships were developed to describe key processes of fish survival and migration. Hypotheses (such as reservoir survival functions) and the equations that represent the hypotheses in the model were subjected to a process of

[6] Route specific passage and survival studies rely on several sources of fish to represent the populations of interest (i.e., yearling Chinook, steelhead, etc.). One such source is "run of river" fish (migrants that are collected at a dam, tagged, and released upstream of the project or river reach of interest). Thus, passage route and survival information at the Snake River projects is derived almost exclusively from juveniles from Snake River ESUs/DPSs. At the Lower Columbia River projects, a mix of fish from the Snake, Upper and Middle Columbia river ESUs/DPSs are used in these studies and so incorporated in passage route and survival estimates.

proposal, review by the Model development group, and response to the review, before being incorporated into COMPASS.

The COMPASS model employs a series of mathematical equations that estimate survival through the successive reservoirs and dams of the FCRPS. The model simulates daily river flows, temperatures and dam operations. Fish enter the system at a rate based on observed distributions of fish passage, and pass through the system at a rate based on the estimated fish travel time under the conditions of the analysis. Starting at the upstream end of the FCRPS, an equation estimates how many fish survive passage through the reservoir, then other equations estimate the proportion of fish that pass the dam by each of the various routes available (spill, juvenile bypass, turbine unit, etc.), the survival of these fish, and the proportion that are collected for transportation. This process is repeated through each dam and reservoir in the FCRPS until the fish reach the Bonneville tailrace.[7] The post-Bonneville effects of FCRPS passage and resulting adult returns is estimated using an equation that describes the relationship between day of Bonneville tailrace arrival and adult return rate (derived from multi-year PIT tag studies – see Post Bonneville Functions and Figures 1 and 2 below).

The model was designed to incorporate the option of including a range of different hypotheses and their accompanying equations. For example, two different reservoir survival hypothesis and the equations that allowed them to be incorporated into the model were developed by NOAA Fisheries and CRITFC. Other hypotheses were proposed, but never reached the level of development where they could be incorporated into the model.

The COMPASS modeling team has made a considerable effort to demonstrate the capabilities of the model. The current documentation provides extensive analyses providing diagnostics of model fits to the underlying data, sensitivity analyses demonstrating how the model responds to varying conditions (river flow, water temperature, spill proportion, and timing of transportation). Further, all relationships used in the model are fully documented with model parameters provided. In addition, the team has characterized model uncertainty in response to data variability.

Post Bonneville Functions

Estimates of the effects of FCRPS passage on smolt survival after leaving the FCRPS and adult returns are estimated by an equation that describes the relationship between day of Bonneville tailrace arrival and adult return rate (derived from multi-year PIT tag studies). The data used to develop these relationships is illustrated in Figures 1 and 2. It should be remembered that these smolt-to-adult returns (SARs) are only calculated from the Bonneville tailrace through adult return to Lower Granite Dam and thus includes the year-specific effects of passage through the FCRPS, harvest, straying, etc., that affected the survival of adults migrating from the Bonneville tailrace to Lower Granite Dam in that year. The raw data for a particular year is slightly different than the function used in the model (which incorporates all of the years illustrated) but the general patterns of transported steelhead SAR equaling or exceeding in-river SAR for most

[7] Reach survivals (which includes the effects of both dams and reservoirs) within the model were calibrated using the available PIT tag survival estimates for Snake River stocks, including those obtained from the 2007 outmigration.

of the migration season, and in-river Snake River spring/summer Chinook SAR exceeding those of transported Chinook until relatively late in the migration season are evident.

Figure 1. Relationships between post-Bonneville juvenile-to-adult survival (to Lower Granite Dam) of Snake River steelhead versus day of juvenile arrival below Bonneville Dam from 1998-2002 (excluding 2001 because too few in-river fish arrived below Bonneville Dam to make a valid estimate in this year). Solid lines represent in-river migrants and dashed lines represent transported fish. Dotted lines denote the 95% C.I. about the mean response.

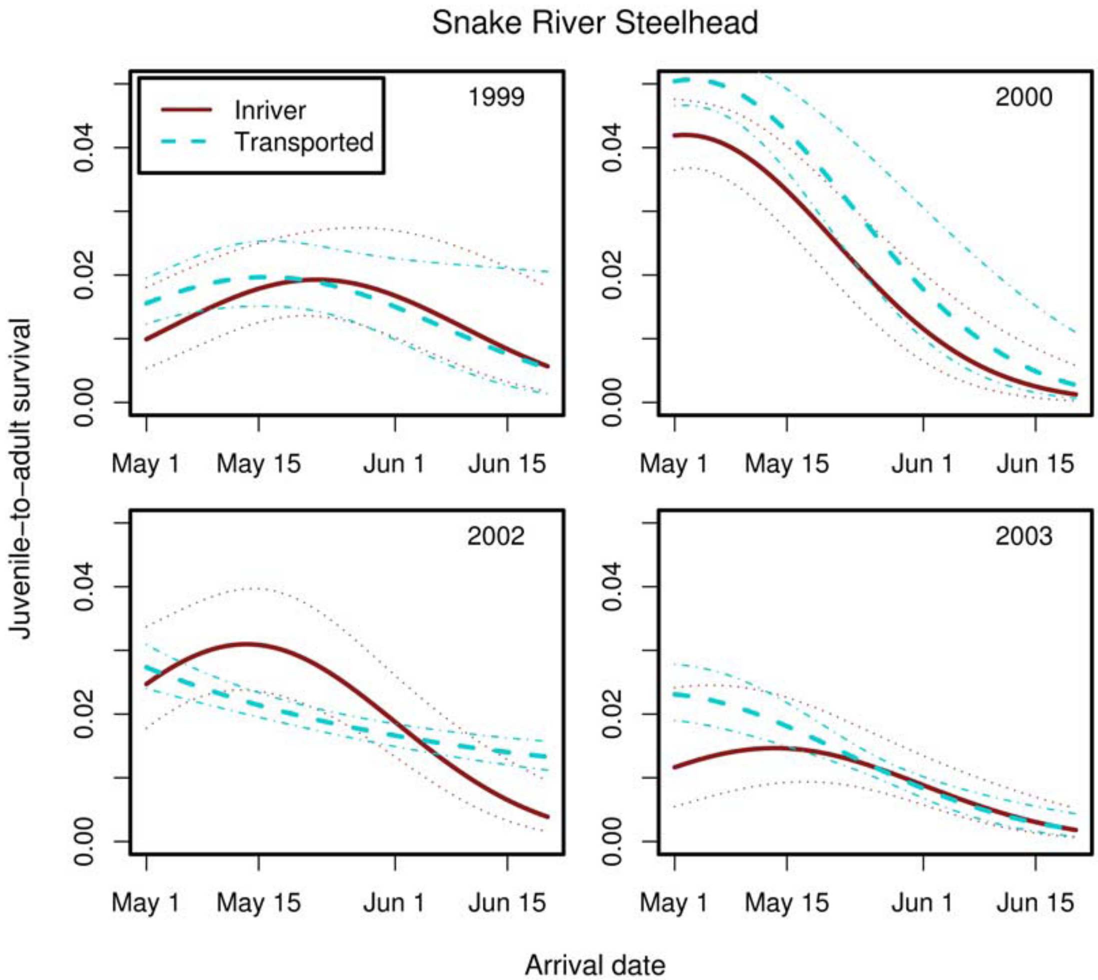
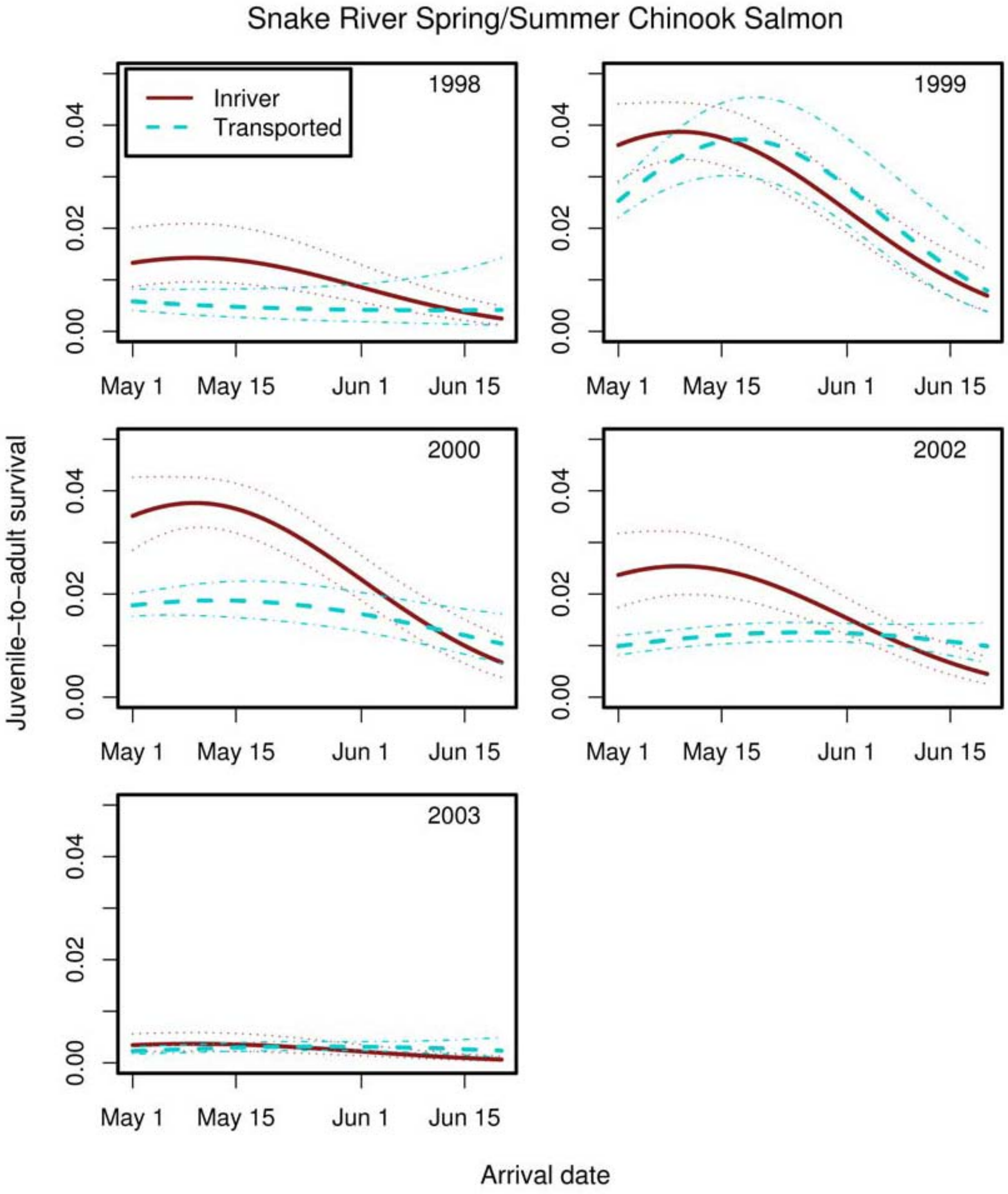


Figure 2. Relationships between post-Bonneville juvenile-to-adult survival (to Lower Granite Dam) of Snake River spring/summer Chinook salmon versus day of juvenile arrival below Bonneville Dam from 1998-2002 (excluding 2001 because too few in-river fish arrived below Bonneville Dam to make a valid estimate in this year). Solid lines represent in-river migrants and dashed lines represent transported fish. Dotted lines denote the 95% C.I. about the mean response.



Scientific Reviews of the COMPASS model

COMPASS has undergone extensive review by the **Independent Science Advisory Board** (ISAB), which is consistent with the stated objectives of developing a peer-reviewed, collaborative model, employing the best available data. There were four rounds of review. The first two, in April and December 2006, primarily concerned the portion of the model describing FCRPS passage. The third review was focused on equations describing post-Bonneville effects of FCRPS passage. The fourth review in March 2008 concerned the entire model and the prospective modeling runs for the 2008 FCRPS Biological Opinion.

The first review focused on the downstream migration component of COMPASS. The ISAB (2006a) felt the model was realistic, providing the following statement:

> Since the model uses a daily time step, it should have the potential to portray the downstream movement of fish through the hydrosystem realistically and with sufficient detail to capture the impact of hydrosystem and river variability. It divides the model into individual modules for passage through the individual reservoirs and dams. It accounts for the spread of passage times through reservoirs. It separates the various modes of dam passage (bypass, spill, turbines) and will account for day/night differences. It separately tracks transported fish. These are all critically important functions and all are treated pretty much as one would imagine them being treated.

In this review, the ISAB provided several suggestions concerning statistical analyses. In response to the team's efforts to address their concerns, the ISAB replied that "The ISAB was encouraged by the efforts of the COMPASS team."

In their second review, the ISAB (2006b) stated:

> In March 2006, the ISAB completed its first review of the then partially completed COMPASS model specifically addressing several questions regarding the model capabilities, complexity, data usage, statistical protocols, documentation, and graphical interface (ISAB 2006-2).[8] The ISAB concluded that the new COMPASS model should prove to be a welcome addition to the analytical tools available to both scientists and managers alike. The ISAB's critique was explicitly intended to provide a series of strong but constructive suggestions to facilitate the continuing development of what should be a valuable new modeling tool for the region.
>
> The COMPASS model has improved markedly since our first examination of it in March 2006.

In this review, the ISAB raised several concerns related to characterizing model uncertainty, the form of reservoir survival relationships, and modeling dam passage. The COMPASS modeling team has put extensive effort into addressing these concerns over the past year. In response to the reviews, the ISAB is currently reviewing the final version of the model that has incorporated new model algorithms

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[8] www.nwcouncil.org/library/isab/isab2006-2 htm

In their third review, the ISAB (2007b) reviewed the post-Bonneville survival component of COMPASS. Several agencies proposed post-Bonneville survival relationships, including those addressing "latent" mortality (mortality related to passage through the hydrosystem but expressed outside of the hydrosystem) of in-river migrants and transported fish. Although, the ISAB did not endorse a single hypothesis over the others, they did offer the following comments:

> The ISAB concludes that the hydrosystem causes some fish to experience latent mortality, but strongly advises against continuing to try to measure absolute latent mortality. Latent mortality relative to a dam-less reference is not measurable. Instead, the focus should be on the total mortality of in-river migrants and transported fish, which is the critical issue for recovery of listed salmonids. Efforts would be better expended on estimation of processes, such as in-river versus transport mortality that can be measured directly.
>
> Estimates based on limited time series have a high degree of uncertainty, and ocean conditions that affect survival will vary on several time/space scales. Thus there will be considerable uncertainty in estimates of post-Bonneville survival, and the ISAB recommends that this uncertainty be accounted for as efforts to reduce it continue. Estimates of the uncertainty should be bounded and incorporated in simulation models and annual management planning processes.
>
> The ISAB also recommends that a logit modeling approach be investigated as a potential alternative framework for future modeling of post-Bonneville mortality.

The modeling approach adopted in the COMPASS prospective modeling for the 2008 FCRPS Biological Opinion reflects all these comments. First, the prospective modeling does not include estimates of overall latent mortality, but instead focused on overall return rates of in-river migrants and transported fish and the relative performance of the two groups of fish. In addition, the COMPASS documentation demonstrates the uncertainty in model predictions arriving from a variety sources, including year to year variability in return rates. Finally, the post-Bonneville survival relationships were based on a logit modeling approach, as suggested by the ISAB.

The iterative review process during model development has greatly strengthened the model. The ongoing feedback has allowed the modeling team to respond to ISAB suggestions and incorporate them into the model. The COMPASS modeling effort of the FCRPS Biological Opinion collaborative process follows the recommendations from each of the ISAB reports.

Summary of View & Comments

The **State of Oregon** suggests that the alternative model, the Comparative Survival Study, should be used to model proposed hydrosystem actions.[9] They also raised a number of technical issues addressed in the Response to Comment document.

Approach in the FCRPS Biological Opinion

NOAA Fisheries utilized the COMPASS model in the FCRPS Biological Opinion to estimate survival through the FCRPS and the effects of FCRPS passage on ocean survival and adult returns. As mentioned above, COMPASS has undergone extensive review by the ISAB, which is in line with the stated objectives of developing a peer-reviewed, collaborative model, employing the best available data.

[9] See CRITFC comments p. 8 and Oregon comments p. 15

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Issue Summary: Methodology for Evaluating Tributary Habitat Effects

Statement of Issue

In order to evaluate the benefits of potential habitat projects, the Remand Collaboration Habitat Workgroup (Habitat Workgroup) needed a standardized methodology that was applicable across all populations subject to this consultation.

Does the habitat evaluation methodology used in the 2008 FCRPS Biological Opinion represent the best available science?

Background

The FCRPS Action Agencies estimated survival benefits attributable to tributary habitat actions that are, or could be, implemented with funding and/or technical assistance from the Action Agencies. To compile these estimates, the FCRPS Action Agencies used information and methods produced in conjunction with the Habitat Workgroup.

The Habitat Workgroup was charged by the Remand Collaboration Policy Work Group (PWG) to evaluate the method used in Appendix E of the 2004 Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp) (NMFS 2004a) and decided to update the method used in Appendix E of the 2004 FCRPS BiOp. The Habitat Workgroup developed a general standardized methodology which could be used to evaluate the physical and biological benefit of habitat projects to listed salmon and steelhead and could be applied throughout the Columbia Basin. The results of their deliberations are described in Appendix C of the Comprehensive Analysis (Corps et al. 2007a).

Science Summary

The **Remand Collaboration Habitat Workgroup** was asked by the Remand Collaboration Policy Work Group (PWG) to develop a general standardized methodology which could be used to evaluate the physical and biological benefit of habitat projects to listed salmon and steelhead. The Habitat Workgroup was also challenged in that empirical data relating habitat change to survival change was lacking for most populations under investigation.

The methodology developed by the Habitat Workgroup is based on linkages between the current status of population-specific habitat limiting factors, changes to those limiting factors, the resultant change to habitat quality and the translation of that habitat quality change into fish survival response. The Habitat Workgroup first evaluated the effect of implementing all projects identified in completed or developing Recovery and subbasin Plans in order to estimate the total overall improvement that might be possible through implementation of identified actions.

The developed approach to estimating habitat benefits relies on the following sequence of steps:

1. Identify the primary factors limiting the recovery of salmon and steelhead populations,

2. Identify the tributary habitat actions (or types of actions) that could be implemented to address those limiting factors,
3. Estimate the current habitat function,
4. Estimate the habitat function that could be obtained by 2018 (within 10 years) by implementing all tributary habitat restoration actions that were identified as planned by 2018,
5. Estimate the habitat function that could be obtained after 2018 (within 25 years) by implementing all tributary habitat restoration actions that were identified as planned by 2018, and
6. Convert estimated overall habitat functions to survival estimates.

The FCRPS Action Agencies then used this approach to estimate the survival benefits associated with discrete projects that they proposed to implement between 2007 and 2009, and to estimate the survival improvements which would result from their commitments to improve habitat quality for specific populations (RPA table 5).

The FCRPS Biological Opinion habitat evaluation methodology uses a logical path for obtaining estimates of the habitat condition and survival improvement potential from habitat actions. Briefly, the logic path is based on stepping down from individual populations to population-specific limiting factors, from the population-specific limiting factors down to the subarea of each population affected by each limiting factor, and from each population subarea to the degree that actions implemented to address those limiting factors would improve habitat quality in that subarea. This logic path provided the basis for estimating changes in habitat function for salmon and steelhead populations as a result of implementing habitat actions. Local biologists provided information for steps 1-5, the products of which the FCRPS Action Agencies use to complete step 6 based on general habitat/survival relationships developed within the Habitat Workgroup.

This approach is based on best available information from local field biologists and recovery planners and general empirical relationships between habitat quality and fish survival. Local biologists and recovery planning processes identified, from recovery plans, primary limiting factors and tributary habitat actions needed to address those limiting factors. These biologists then estimated the change in habitat function that would accrue if habitat actions were completed as intended. Professional judgment by expert scientists provided a large part of the determination of habitat function in all locations simply because of the limited extent of readily-available empirical data and information. Although NOAA Fisheries recognizes that empirical data and information provides the best insight for determining habitat functioning and fish survival, the extent of readily-available empirical data was not adequate to make a precise determination of habitat function and fish response uniformly throughout the Columbia River Basin.

The FCRPS Action Agencies will report in Annual Progress Reports on the status of habitat project implementation. These reports will include quantitative descriptions of those physical metrics which will document project implementation and estimate the physical and biological benefits achieved relative to commitments. At the Comprehensive reviews on 2013 and 2016, they will report progress toward overall habitat quality improvement targets and population-specific survival benefit. Where population-specific survival benefits are not achieving Progress Guidelines above, the FCRPS Action Agencies will identify and accelerate as necessary implementation of processes or projects to ensure that all past and current objectives will be achievement by the next comprehensive report (see RPA Action 35).

Summary of View and Comments

The Habitat Workgroup's methodology utilizes the best available information regarding key limiting factors, habitat improvement potential, habitat action effectiveness, and the expert views of local biologists. The component of this method used by the FCRPS Action Agencies to quantify habitat changes and to translate those habitat changes into calculated survival estimates was not formally endorsed by the Remand Collaboration Habitat Workgroup. Some critics did not endorse a numerical approach to expressing habitat functionality and potential improvements.

The Save Our Wild Salmon Coalition[10] suggested that another method developed by **Budy and Schaller** be utilized. However, that method is not directly applicable to the FCRPS Biological Opinion. Budy and Schaller described habitat potential to achieve long-term recovery, or delisting from ESA. It concluded that recovery is not achievable by tributary habitat improvement alone. However, this biological opinion evaluates whether the Prospective Actions, when properly added to other management sectors, such as, hydro, harvest, hatchery, along with other ESA considerations, avoids jeopardy and puts the listed species on a trend to recovery. The difference in the two standards is significant. In addition, consistent with Budy and Schaller's conclusion, the FCRPS Biological Opinion builds on a comprehensive strategy across the life-cycle of salmon and steelhead and does not rely on a single "H" to achieve its biological goals.

In particular, Budy and Schaller described a "Best Case" scenario that assumed all habitat problems were corrected immediately. The Habitat Workgroup took a more realistic approach, recognizing that habitat improvement takes time to complete and in many cases even more time to realize a benefit.

Several commenters misunderstood the difference between changes in survival for all potential actions in long-term sub-basin or recovery plans and changes in survival from the Reasonable and Prudent Alternative actions in the FCRPS Biological Opinion. Although changes in survival all from actions brought forward from long-term recovery plans and sub-basin plans were one step in the habitat methodology, the relevant evaluation in the FCRPS Biological Opinion focuses on survival changes based on the specific actions identified in the Reasonable and Prudent Alternative for 2007-2009, and overall survival commitments for the remainder of the ten-year period.

[10] See SOWS comments, p. 18

Approach in the FCRPS Biological Opinion

The Habitat Workgroup's methodology utilizes the best available information regarding key limiting factors, habitat improvement potential, habitat action effectiveness, and the expert views of local biologists. NOAA Fisheries' estimate of the effect of the FCRPS habitat program is based only on the estimated population or species -specific survival benefits listed in the Reasonable and Prudent Alternative which will accrue from full implementation of the specific actions and achievement of survival commitments identified in the Prospective Action. Only those species-specific survival benefits that will accrue during the ten-year term of the FCRPS Biological Opinion were used in the jeopardy analysis.

Issue Summary: Climate Change Considerations

Statement of Issue

Climate change has potential negative implications for the current and future status of ESA-listed fish in the Pacific Northwest. Alterations to the hydrograph, water temperature increases, and habitat alterations are a few likely effects of climatic variation.

Given the best available information, how does the FCRPS Biological Opinion account for the effects of climate change on listed anadromous fish species over the 10-year term of the 2008 FCRPS Biological Opinion?

Background

Average annual Northwest air temperatures have increased by approximately 1 degree C since 1900 or about 50% more than the global average warming over the same period. The latest climate models project a warming of 0.1 to 0.6 degrees C per decade over the next century. The **Independent Scientific Advisory Board** (ISAB 2007c) reviewed a large body of recent literature and described potential impacts of this climatic variation on anadromous salmonids in the Columbia River basin. These effects, according to the ISAB, may alter Columbia basin precipitation and temperature levels in the basin and alter in-land habitats.[11] In a basin reliant on cooler winter temperatures to store a spring/summer water supply in the snowpack, alterations to the precipitation and temperature regimes may have the following physical impacts within the next forty or so years:

- Warmer air temperatures will result in a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a shift to more rain and less snow, the snowpacks will diminish in those areas that typically accumulate and store water until the spring freshet.
- With a smaller snowpack, these watersheds will see their runoff diminished and exhausted earlier in the season, resulting in lower streamflows in the June through September period.
- River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures will continue to rise, especially during the summer months when lower streamflow and warmer air temperatures will contribute to the warming regional waters.

Such responses to warming air temperatures and precipitation alterations will not be spatially homogeneous across the entire Columbia River Basin. Following anticipated air temperature increases, the distribution and duration of snowpack in those portions of the basin at elevations high enough to maintain temperatures well below freezing for most of the winter and early

[11] For details of the potential physical effects of climate change in the Columbia River Basin, as described by the ISAB, please see Chapter 5, Environmental Baseline, of the Supplemental Comprehensive Analysis.

spring would be less affected. Low-lying areas that historically have received scant precipitation contribute little to total streamflow.

Additionally, the ISAB identified the likely effects of projected climate changes on Columbia basin salmon. These long-term effects may include, but are not limited to, depletion of cold water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species (please see Chapter 5, Environmental Baseline, of the Supplemental Comprehensive Analysis for a detailed overview of these effects).

Strategies for Responding to Climate Change

Changes in environmental conditions resulting from climatic variation may negatively affect ESA-listed salmon and steelhead. To effectively mitigate for the effects of climate change on listed salmonids, the ISAB (2007c) recommends planning now for future climate conditions by implementing protective tributary, mainstem, and estuarine habitat measures; as well as protective hydropower mitigation measures. In particular, the ISAB (2007c) suggests increased summer flow augmentation from cool/cold storage reservoirs to reduce water temperatures or to create cool water refugia in mainstem reservoirs and the estuary; the protection and restoration of riparian buffers, wetlands, and floodplains; removal of stream barriers; implementation of fish ladders; and insurance of high summer and autumn flows (for further detail of ISAB climate change recommendations please see Section 8.1.3 of the Supplemental Comprehensive Analysis). The FCRPS RPA employs a number of these recommended actions in important areas, (see SCA Section 8.1.3).

It should be noted that while the effects of climate change on Columbia basin salmon and steelhead are likely to be broadly adverse, the best strategies for addressing these effects are not well defined.[12] For this reason, NOAA Fisheries adopts a broad spectrum of actions combined with extensive research, monitoring, and evaluation to fine-tune future responses to climate change effects, including out-year habitat enhancement measures required by the RPA.

Summary of View and Comments

In response to the 2007 Draft FCRPS Biological Opinion, **Oregon, CRITFC the Nez Perce Tribe and the Save Our Wild Salmon Coalition** recommend a more thorough treatment of

[12] For example **Battin et al**. (2007) suggest that river basins *"that span the current snow line appear especially vulnerable to climate change, and salmon recovery plans that enhance lower-elevation habitats are likely to be more successful over the next 50 years than those that target the higher-elevation basins likely to experience the greatest snow-rain transition."* **James T. Martin** (2007) suggests focusing protection efforts on watersheds with the best long-term habitat benefit (i.e., areas with minimal impact from development and population growth): *"[p]rioritizing protection/restoration efforts highest in those watersheds that have the greatest potential over the longest term, with respect to producing wild salmon, even despite the probable effects of future development and climate change*" will produce the greatest long-term benefit. Martin's protection and restoration strategy targets higher-elevation watersheds because they, according to Martin, will yield the greatest long-term habitat benefit.

climate change in the final document, including explicit treatment of changes in climate affecting freshwater life history stages.

Approach in the FCRPS Biological Opinion

Methodology

NOAA Fisheries has substantially expanded its consideration of climate change effects and responses in the final Biological Opinion. Because it is not possible to determine with certainty the effects of climate change over the next ten years, NOAA Fisheries applied a conservative approach to both future ocean and future inland climate conditions. The effects of climate change are considered both quantitatively and qualitatively. In addition, the Biological Opinion explicitly considers actions that are consistent with the ISAB's mitigation recommendations (see ISAB recommendations in Section 8.1.3 for further detail).

Ocean Climate Assumptions

NOAA Fisheries applied a quantitative methodology to variation in ocean conditions. In particular, NOAA Fisheries modeled three climate scenarios that address the potential survival of salmon and steelhead in the ocean over the next ten years.

The ISAB (2007c) stated that global climate change in the Pacific Northwest is predicted to result in changes in coastal ecosystems and salmon production that "may be similar to or potentially even more severe than those experienced during past periods of strong El Niño events and warm phases of the PDO." Our primary scenario assumes that future climate will be similar to that which has occurred over the past 20 years. NOAA Fisheries applies the ICTRT's (2007c) 1980-2001 "Recent" ocean climate scenario. As described in SCA Section 7.1, this period is dominated by El Niño and warm PDO events, representing climatic conditions that are much worse than average historical climate conditions. However, because of the uncertainty in future climate effects, a sensitivity analysis of alternative weather and climate scenarios is included in the Aggregate Analysis Appendix of the Supplemental Comprehensive Analysis.

A second climate scenario looks at the worst of the poor ocean conditions in the last 20 years by applying the ICTRT's (2007c) "Warm PDO" climate scenario to all future years. This responds to the ISAB's (2007c) comment that ocean climate may be potentially even more severe than in recent years. The ISAB (2008) commented that future climate change may result in ocean conditions even worse than those captured in the "Warm PDO" ocean climate scenario. However, while that may be true over a longer time period, it is unlikely to apply to the period of the actions and the metrics considered in this opinion.

A more optimistic, alternative climate scenario (the ICTRT 2007c "Historical" scenario) affecting early ocean survival is also included as a sensitivity analysis. This scenario is included because ICTRT (2007c) stated that, while at this time it is not technically possible to identify likely specific future conditions, the alternative future scenarios discussed in this section "bound a likely plausible range of future scenarios." It also responds to a comment on the 2007 Draft Biological Opinion that the 1980-present base period is biased toward poor ocean conditions because it is too short to include periods of more favorable climate. The "Historical" climate scenario represents a longer historical period of 50 or more years that encompasses both good and bad ocean conditions. Survival under the historical climate scenario is 37% higher than the

"Recent" period survival for Snake River spring summer Chinook salmon , 44% higher for Upper Columbia spring Chinook salmon, and 11-19% higher for listed interior Columbia River steelhead (ICTRT 2007c).

Freshwater Climate Assumptions

Expected changes in climate can also affect survival during freshwater life stages, as described in SCA Section 5.7 and ISAB (2007c). NOAA Fisheries did not attempt to explicitly model quantitative effects of climate change on survival during freshwater life stages; rather, SCA Section 7.1.2 describes use of a qualitative approach. The primary reason for not attempting quantitative modeling is lack of available information regarding effects of climate change on survival of anadromous salmonids of the Columbia basin over the 10-year term of this Opinion. The sole quantitative approach that we are aware of is that of Crozier et al. (2008), which is based on instantaneous attainment of expected 2040 climate conditions and its affect on life-stage survival, abundance, and population growth rate (lambda). Crozier et al.'s (2008) estimated reduction in life-stage survival, compared to survival estimated under current climate conditions, is significant (18-34% decline in parr-smolt survival with combination of 10 climate prediction models) but the applicability of this estimate to the base period survival estimates used in the SCA analysis is unclear (i.e., it is not clear whether the 18-34% decline is relative to the SCA base period survival or relative to another survival rate). Additionally, the instantaneous implementation of 2040 climate is of questionable relevance to the time period under consideration in the SCA, especially without a modeled ramp-up to the 2040 condition. Finally, Crozier et al. (2008) note that density-dependent processes compensated for declines in parr-smolt survival to some extent. This is an important study and analytical approach to evaluating effects of climate change on anadromous salmonids of the Columbia basin, but at this point additional information is needed before attempting to quantify effects of climate change on freshwater survival over the course of the Prospective Actions and the analytical horizon used in the SCA.

The primary qualitative method NOAA Fisheries uses to evaluate the Prospective Actions with respect to climate change affecting freshwater life-stages is to determine the degree to which the Prospective Actions implement recommendations by the ISAB (2007c) to reduce impacts of climate change on anadromous salmonids. The specific recommendations against which the Prospective Actions are evaluated are described in Table 7.1.2.1-1 and in Section 8.1.3 of the SCA. NOAA Fisheries also evaluated the Prospective Actions on the basis of the extent to which the Prospective Actions include:

- monitoring climate change effects on listed salmon and steelhead;
- a mechanism for continually updating and synthesizing new information regarding the effects of climate change on listed salmon and steelhead; and
- mechanisms for modifying implementation plans as necessary to respond to new information about climate change.

Mitigating for the Potential Effects of Climate Change

As stated above, the ISAB provided a series of mitigation recommendations to address the anticipated effects of climate change (ISAB 2007c).[13] These recommendations were taken into consideration in the development of NOAA Fisheries' reasonable and prudent alternatives. By tracking the limiting factors that result from climatic variation and subsequently affect listed species, the FCRPS Action Agencies will be able to adjust their selection of projects accordingly.

Under RPA Action 34, for instance, the Action Agencies will implement an array of habitat improvement projects including, but not limited to: enhancing riparian habitat conditions (e.g. fencing) that would improve stream shading, and the acquisition of water for the purpose of improving summer flows. These actions should improve tributary water temperature conditions. RPA Action 35 requires periodic evaluations of the effectiveness of these tributary habitat enhancement measures and the identification of additional habitat projects in the event that the projected performance of these projects does not meet the specified objectives. The criteria for such additional projects will include consideration of the anticipated effects of global climate change.

The FCRPS Action Agencies are currently funding a number of these projects, such as the Methow Salmon Recovery Board's proposal to reconnect a side channel of the Methow River. This project will address limiting factors by increasing off-channel rearing and over-wintering habitat; restoring and improving riparian habitat; increasing instream complexity; restoring natural floodplain processes; restoring natural channel process; restoring-improving riparian forest habitat; adding wood complexes in the mainstem; installing a rock structure to keep a majority of flow in the mainstem; breaching an existing levee; and connecting side channels (Corps et al. 2007b, Attachment B.2.2-2).

Hydro actions also implement ISAB recommendations. For example, RPA Actions 4 and 15 relate to Dworshak releases in July and August for Snake River migrants. These RPA Actions require that the Action Agencies regulate outflow temperatures at Dworshak in order to maintain Lower Granite tailwater temperatures at or below the water quality standard of 20 degrees C. In addition, they require the expansion of a water temperature modeling program. For full detail of the ISAB's recommendations, as well as the corresponding RPA Actions committed to in this Opinion, please see Section 8.1 of the Supplemental Comprehensive Analysis.

The full breadth of long-term climate change (ISAB 2007c) is unlikely to be realized in the ten-year term of this Opinion. For instance, as stated above, the Crozier et al. (2008) study is based on instantaneous attainment of expected 2040 climate conditions and its affect on life-stage survival, abundance, and population growth rate. The term of this FCRPS Biological Opinion

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[13] The ISAB's climate change recommendations fall into the following categories: Planning Actions, Tributary Habitat, Mainstem and Estuary Habitat, Mainstem Hydropower, and Harvest. The full range of these recommendations incorporate flow augmentation strategies, subbasin planning efforts, restoration activities etc. Please see Section 8.1 of the Supplemental Comprehensive Analysis for further detail.

ceases in 2018. NOAA Fisheries has, however, taken proactive measures within this term to ensure that variation in climate conditions will be addressed either through RPA Actions, as addressed above, or through the adaptive management supported by reporting requirements of this opinion. Through this process, the Action Agencies, in selecting their projects, will focus their efforts on the most recent limiting factors. If, during this time period, fish habitat effects of climate change are determined to be limiting factors, the FCRPS Action Agencies will allocate project funding accordingly. This allows the FCRPS Action Agencies to address specific, localized impacts of climate change. Measures are in place to ensure that as climatic variation arises, the FCRPS Action Agencies will be able to adaptively manage to these conditions.

Issue Summary: Why the 2008 FCRPS Biological Opinion Does Not Include Removal of the Four Lower Snake River Dams

Statement of Issue

Breaching of the Snake River Dams has been a regionally debated issue for several years. Dam breaching is a complex issue, and there are a range of regional views regarding biological benefits, economic consequences, and other environmental effects. It is certain, however, that breaching all four lower Snake River dams can at best help four of the 13 listed salmon and steelhead species in the Columbia River basin; would create adverse impacts to navigation, cultural resources and recreation; and would result in loss of power generation and potential increased environmental effects due to carbon emissions from replacement power. Authorization and funding for dam breaching would also have to be provided by Congress.

Is removal of the Lower Snake River dams a viable option as either an RPA or a contingency in the 2008 FCRPS Biological Opinion?

Background

Regional debate over breaching the four Lower Snake river dams goes back to the early 1990's when it was discussed at the Regional Salmon Summit and later referenced in the 1995 Biological Opinion that called for evaluating such an action. In July 2000, the four Northwest governors recommended "an aggressive non-breach" strategy for salmon and steelhead recovery (Kempthorne et al. 2000). The U.S. Army Corps of Engineers formally rejected a dam breaching proposal again in June 2006 (Corps 2006b) because it is inconsistent with the authorized purposes established by Congress for the lower Snake River dams. Dam breaching would have far-reaching impacts on recreation, transportation, navigation, power production, air quality, and the region's economy – and so was not considered by the Corps to be a "reasonable and prudent alternative" under the ESA.[14]

In 2007, a Bonneville Power Administration (BPA 2007) analysis found that the power benefits of the dams could only be replaced with natural gas fired turbines, and that the cost of replacing the power lost with dam breaching had increased significantly since the U.S. Army Corps of Engineers' comprehensive study. That same year, a separate analysis by the Northwest Power and Conservation Council confirmed BPA's finding that the power would need to be replaced

[14] Reasonable and prudent alternatives are "recommended alternative actions identified during formal consultation that can be implemented in a manner consistent with the intended purposes of the action, that can be implemented consistent with the scope of the Federal agency's legal authority and jurisdiction, that are economically and technologically feasible, and that the director believes would avoid the likelihood of jeopardizing the continued existence of listed species or the destruction or adverse modification of designated critical habitat" [50 CFR §402.02].

with natural gas and further quantified the additional carbon dioxide emissions that would result from that replacement.

During the course of the remand collaboration process, some PWG members and Remand Parties requested that the FCRPS Action Agencies evaluate a dam breaching alternative as part of the Remand Collaboration (American Rivers 2006). The Action Agencies did not agree and PWG members themselves were divided on whether to model the scenario. Some parties urged the federal agencies to pursue Congressional authorization and consider breaching the four lower Snake River dams as a contingency plan for species recovery (SOS 2008 and Nez Perce Tribe 2008). However most of the sovereign parties focused on better defining the key elements of aggressive non-breach - or All H - strategy to improve the survival and recovery prospects for ESA-listed salmon and steelhead.

Scientific Reviews of Four Lower Snake River Dam Removal

The **2000 FCRPS Biological Opinion** (NMFS 2000b) evaluated the impacts of dam breaching on the biological requirements of eight listed species of salmon and steelhead over their life-cycle. It reviewed impacts of dam removal during the actual deconstruction (or transition) period and over the longer-term. One key input to the model was the assumption about delayed mortality. The model utilized three alternative hypotheses regarding delayed mortality in the breaching study. The model results varied significantly, depending on which delayed mortality assumption was applied (NMFS 2000b). But there was limited and conflicting information to assess which delayed mortality hypothesis was the most valid.[15] Dam breaching by itself, the 2000 Biological Opinion concluded, would not recover listed salmon and steelhead. Instead, the 2000 FCRPS Biological Opinion established a comprehensive strategy to improve hydrosystem, habitat, and hatchery life-stages for listed salmon and steelhead as a more effective program for the fish. The same all-H approach continues today and is included in the 2008 FCRPS Biological Opinion.

In a seven-year effort from 1995 to 2002, the Corps conducted a comprehensive study of four major alternatives to improve juvenile salmon passage through the hydropower system on the lower Snake River. In the **Lower Snake River Juvenile Salmon Migration Feasibility Study** (Corps 2002), one of the alternatives studied was breaching the four lower Snake River dams to return a 140-mile stretch of the river to a more natural free-flowing state. The Corps conducted an extensive evaluation of the effects of breaching the dams on all users and resources, along with other alternatives. Numerous analyses were done to assess the effects on fish, wildlife, water quality, navigation, irrigation, recreation, Tribal and other cultural resources, sediment, and the cost to implement.

[15] During the FCRPS remand collaboration, several agencies proposed post-Bonneville relationships, including those addressing "latent" mortality (mortality related to passage through the hydrosystem but expressed outside of the hydrosystem). The ISAB (2007b) reviewed various latent mortality hypotheses and concluded "that the hydrosystem causes some fish to experience latent mortality, but strongly advises against continuing to try to measure absolute latent mortality. Latent mortality relative to a dam-less reference is not measurable. Instead, the focus should be on the total mortality of in-river migrants and transported fish, which is the critical issue for recovery of listed salmonids. Efforts would be better expended on estimation of processes, such as in-river versus transport mortality that can be measured directly."

The study determined that the economic and environmental impacts of dam breaching would be substantial and the action by itself would not likely recover the four listed stocks of salmon and steelhead in the Snake River. Additional mitigation actions would still be needed to address habitat, hatchery, and harvest problems for Snake River listed salmon and steelhead. Dam removal would not help the other nine listed species.

The Corps analysis indicated that Congress would have to provide the authority and appropriations to implement dam breaching. In addition, the analysis concluded that dam breaching could take 10 years to implement, once the authority and funding were in place. As a result, it was estimated that it would take more than 20 years for breaching to provide a benefit to fish (not a short-term alternative).

Because of these findings, the study recommended major system improvements for fish passage to improve fish survival at the four lower Snake River dams. Ultimately, based on regional discussions and ESA consultation, the Corps decided to pursue this option at the four Snake River dams as well as at the four lower Columbia River dams. This alternative consisted of actions such as: removable spillway weirs, turbine upgrades, and improvements in bypass systems – all of which have recently been implemented and are further being advanced in this 2008 FCRPS Biological Opinion.

Other Considerations about Dam Removal

To breach the lower Snake River dams, the earthen portion of each dam would be removed to return the river to a free-flowing state. The concrete-and-steel structures that currently provide power and navigation could remain in place but would be inoperative. Barge traffic through the lower Snake to Lewiston, Idaho would be curtailed and power production at these facilities would stop. These are Congressionally authorized purposes of the lower Snake River dams that cannot be changed without Congressional action. No such proposals are currently pending or under consideration.

In late 2006, the **Save Our Wild Salmon coalition** produced a report called *Revenue Stream, An Economic Analysis of the Costs and Benefits of Removing the Four Dams on the Lower Snake River*. The report examines the economic impact of dam removal and salmon recovery in the Pacific Northwest. The study estimated net increased revenues from recreation and tourism opportunities.

The **Independent Economic Analysis Board** (IEAB) of the Northwest Power Planning Council concluded the Revenue Stream report "cannot be viewed as a credible alternative to the Corps Lower Snake EIS analysis of the impacts of removing the four lower Snake dams" because the report had a number of analytical deficiencies, including lack of documentation, use of outside analysis that the IEAB had previously found deficient and lack of transparency about sources. The IEAB also noted that the report's authors erroneously chose not to address the likely distribution of costs and benefits over time or to discount future costs and benefits (IEAB 2007).

A 2007 **Bonneville Power Administration (BPA)** paper on Dam Breaching (BPA 2007) was developed to update information on the value of the power generated at the lower Snake River dams in terms of both economics and air quality. BPA used the assumptions in the Council's Fifth Power Plan to calculate the economic value of the power from the lower Snake River dams.

The analysis concluded that even if substantial new cost-effective conservation and wind resources were identified – beyond what the Council's Plan had called for – that it would cost electricity customers $400 million to $550 million annually to replace the power capabilities that would be lost if the dams were breached. BPA also noted that hydropower is the key resource the region relies on to back up the growing development of wind energy. Because the wind doesn't blow all the time, BPA noted, the power from the lower Snake River dams and other dams in the region is used to support or "firm up" wind energy.

The lower Snake River dams generate 1,022 average megawatts of emissions-free electricity per year, enough to power the city of Seattle. According to a 2007 study conducted by the **Northwest Power and Conservation Council** (NPCC 2007), removing the dams and replacing the power with the most likely fossil-fuel resource, would add 5.4 million tons of carbon dioxide every year to the region's air, contributing to the atmospheric carbon dioxide burden and possibly influencing climate change. The Council concluded that meeting the region's carbon reduction goals will be very challenging and that removing the lower Snake River dams would be "counterproductive."

Summary of Views and Comments

Save Our Wild Salmon urged the federal agencies to include a dam removal provision in the final Biological Opinion. While breaching would benefit four of 13 listed species, Save Our Wild Salmon suggests the water quality benefits of dam removal would aid the other nine species downstream. Given the work that needs to be accomplished prior to removal (e.g., removal studies, identifying how to most efficiently replace power and accommodate other uses of the dams), Save Our Wild Salmon suggests that NOAA Fisheries could include an "off-ramp" from dam removal if the Federal Action Agencies provide clear and convincing scientific evidence that such an action is not necessary to protect Snake River salmon and steelhead (SOS 2008).

Approach in the FCRPS Biological Opinion

Based on the best scientific information available, it is biologically not necessary to include dam breaching as an RPA action or contingency to achieve the survival and recovery of the listed salmon and steelhead species. Consistent with the previously discussed findings that breaching alone would not recover the stocks, the FCRPS Action Agencies are required to pursue a comprehensive program addressing the range of factors affecting fish survival. This aggressive non-breach strategy was also described in the 2000 FCRPS Biological Opinion.

Since 2000, there have been significant improvements that should translate to increases in survival across the salmon life-cycle, including:

- The Corps has installed removable spillway weirs (RSW) at Lower Granite, Ice Harbor, and recently at Lower Monumental dams on the Snake River. These RSWs have proved to be effective at passing juvenile fish, reducing fish delays upstream of the dams, and, most importantly, increasing survival for these fish without breaching.

- To benefit a broader group of listed fish (Upper Columbia and Mid-Columbia) a similar approach for improved survival is being taken at lower Columbia River dams.

- New turbine technologies are being tested at Ice Harbor dam that will increase turbine survival for juvenile fish.
- As a result of these structural improvements and hydro operations for fish passage, in 2006 and 2007, the NOAA Science Center found that juvenile spring chinook survival through the eight federal dams on the Columbia and Snake Rivers was the highest yet measured. Juvenile fish survival today is higher than was estimated in the 1960s when there were only four dams in place.
- Extensive habitat improvements have been funded and implemented by the FCRPS Action Agencies, with additional survival benefits for listed fish.

Also, under the ESA, the action is necessarily limited to operating the FCRPS consistently with authorized project purposes. Currently, none of the responsible Federal agencies has Congressional authority to significantly alter the Snake River dams. Therefore, absent new Congressional action, it is not possible that such an action would be reasonably certain to occur or otherwise meet ESA standards for inclusion in the FCRPS Biological Opinion.

Adverse environmental effects from dam breaching are also an important consideration. Water quality for all downstream species would be negatively impacted by movement of sediment following dam breaching. An estimated 100-150 million cubic yards of impounded sediments have accumulated upstream of the Snake River dams. The Corps' Lower Snake River Feasibility Study estimated approximately one-half of this material would migrate downstream and end up in the McNary reservoir. The biological implications of the sediment movement are uncertain but would likely result in high turbidity loads for 5-7 years following breaching (Corps 2002).

In addition to water quality and other effects (Corps 2002), these include the air quality implications of replacement power resources (NPCC 2007), moving backwards rather than forwards in regional goals to decrease carbon emissions (NPCC 2007), and loss of ability of integrate other renewable resources into the regional power grid (BPA 2007). Considering the potential for climate change, these environmental considerations also argue against pursuing Snake River dam breaching.

The 2008 FCRPS Biological Opinion supports a comprehensive, All-H strategy including continued fish passage improvements at the Snake River dams such as surface collection and bypass improvements, as well as offsite actions including habitat and hatchery improvements, to meet the needs for listed fish. This approach benefits not only Snake River fish, but also Upper Columbia and Mid-Columbia salmon and steelhead.

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