

Report of the Independent Scientific Advisory Board

**Review of the U.S. Army Corps of Engineers'
Capital Construction Program**

Part III.

**Overview of the U.S. Army Corps of Engineers'
Capital Construction Program**

Independent Scientific Advisory Board
for the Northwest Power Planning Council
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EXECUTIVE SUMMARY

The Independent Scientific Advisory Board (ISAB) is responding to a request from the Northwest Power Planning Council for assistance with a congressional query. The direction from Congress identified a concern about a lack of agreed upon priorities and a set of principles and criteria for setting those priorities in the Corps Capital Construction Program. We believe the perception of a lack of prioritization stems from two sources, 1) the lack of agreement on the technical bases for action (due to uncertainties in available information), and 2) the fact that it may be necessary to provide more than one technological approach to achieve the passage goals set by the National Marine Fisheries Service (NMFS) and the Northwest Power Planning Council (Council). The U.S. Army Corps of Engineers' (Corps') capital construction program for fish passage at hydroelectric projects in the mainstem Columbia and Snake rivers (the Corps of Engineers' Columbia River Fisheries Mitigation Program or CRFMP) is to an extent a reflection of the region's plans and assumptions for salmon restoration. Even so, we believe the CRFMP is insufficient for restoration efforts partly because of its lack of balance in application of measures across species and life history types. Evidence of insufficiency comes from the continuing low adult returns in most runs. We recognize that the hydroelectric system is one of many natural and anthropogenic factors that could be impacting salmon abundance, however the steady downward trend is symptomatic of a chronic problem. Unfortunately the possible role of hydroelectric passage in causing mortalities after passage, delayed mortality, is one of the major missing pieces in the Columbia Basin research program. We advise caution in making inferences about future salmon abundance based on estimates of survivals measured within the hydroelectric system until the effects of delayed mortality can be ruled out.

Regional salmon restoration plans and their implementation by the Corps can benefit from more biologically driven decisions addressing a broader diversity of life history types and species. Other grounds for decisions, such as the desire to retain familiar technologies, politically driven choices of projects and sites, and narrow concepts of the species and stocks to be protected, need to be exchanged for tests based on the criteria of biological effectiveness. Some of the projects we reviewed met these criteria very well, although others did not. Common

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principles from our review of projects need to be incorporated into revised plans. A process for developing and incorporating new biological and ecological insights of value for fish passage should be an integral part of the fish passage design process.

The prioritization of projects sought by the Congress, in part to lessen costs, will emerge only after a suitably diverse array of recovery options is identified and evaluated for short and long-term biological and economic effectiveness. The process of identification and evaluation in a region-wide context has just begun and we encourage it. It is important to recognize that short-term effectiveness is based on the hydroelectric system as it is now, and long-term effectiveness takes into account other major system configuration options. It is also important to note that seemingly redundant fish-protection systems, also of concern to the Congress, are sometimes necessary in the search for the most effective approaches. Given the current need for increased information on fish behavior relevant to fish passage to guide program development, we regard the present capital construction program, with some exceptions, as a set of short-term actions that can be taken to meet the immediate needs of fish passing hydroelectric projects.

Each project review raised similar issues, either as commonalties or contrasts with other reviews. Principles and guidelines of biological effectiveness were derived from a synthesis of these project reviews.

Guidelines: Our test of biological effectiveness for a proposed action considers whether the action is (1) consistent with the behavior and ecology of the species, (2) supportive of the physical and biological conditions required for successful completion of normal life history requirements for the species, (3) based upon a valid scientific rationale to indicate that the action is capable of assisting in accomplishing the specific objective, and (4) consistent with an ecosystem approach in protecting other species that could be the subject of listing in the future.

The commonalties and principles are summarized as follows.

Spill: The general principle is that all juvenile passage alternatives should be evaluated against the baseline of spill. As an avenue of hydroelectric project passage, spill more closely mimics natural situations and ecological processes than other available routes. Spill should be considered as an alternative when the improvements anticipated from other bypass technologies are not large enough to meet the passage goals.

Options Are Interrelated: The efficacy of any bypass technology at a project, such as bypass outfall relocation or improving fish guidance efficiency of screens at Bonneville, is a function of the potential success of alternative measures for improving survival of juvenile salmon, such as improved spill effectiveness, surface bypass development, or gas (supersaturation) abatement.

Long-Term vs. Short-Term Goals: The Corps' program is largely focused on the short-term whereas salmon recovery requires a long-term perspective, as well. The standard sequence of proposal, study, design, and implementation (with bidding and construction schedules) is too slow and inflexible for salmon recovery.

Biodiversity: Biodiversity of salmon and steelhead stocks may not be protected by the intake screen systems in use or by other planned technologies. There is ample evidence that the collection efficiency of each bypass system varies by species, life history type and population.

Inconsistent Measures of Performance: There is a critical clash of performance measures between the upper-river salmon restoration programs and Corps mainstem passage programs. Upper river programs, such as many ESA-driven actions, employ performance criteria focused on sizes of individual stocks or spawning populations, while the hydroelectric management decisions are based on averages for all stocks combined that are weighted toward the most abundant species and stocks. It is inconsistent to protect genetic diversity of listed stocks in the watersheds, only to relax that protection in the hydroelectric system. The principle we see is the need for the common "currency" of stock specific performance for measuring performance of system improvements. Stock specific performance is the ideal standard, however technically challenging it may be to attain.

More Emphasis Needed on Adult Passage: The Corp's capital program gives insufficient attention to adult salmon and steelhead. More attention should be given to identifying and correcting adult passage problems. The principle we see here is that the few returning adults represent the survivorship of many thousands of initial smolts and they should be given higher priority than they have in the past.

How to Schedule Salmon Recovery Measures: The question of what *most* needs to be done for fish passage (juvenile and adult) seems to have been slighted in deference to the on-going momentum of existing projects and funding cycles. The concept is that clear criteria based

on biological needs for successful fish passage are required to do the sort of prioritization among projects over time required by the Congressional mandate. The lack of agreed technical criteria, combined with a wide diversity of opinion, both confuses the implementation of policies and leads to seemingly duplicative efforts.

Importance of Premises and Hypotheses: An explicit statement of biological premises is a valuable aid for efficient development of fish passage technologies. The premises and assumptions form testable hypotheses that clearly guide further research and development, thus reducing both simple trial-and-error approaches and the tendency to keep making relatively minor adjustments to existing technologies without a good biological basis. We advise that all projects be made to list their premises explicitly and summarize the evidence in support of those premises before construction and testing of prototypes proceeds.

Site Specificity v. General Solutions: Application of the biological principles of fish behavior and physiology has been subsumed under questions of building structures to fit the features of a particular dam. The principle here is to foster a design process that meets the generic needs of fish first and then adjusts the design to the specific characteristics of the dam secondarily. Put emphasis on commonality of purpose and function first. We suspect that a more cost-efficient process of dam modification for fish passage can result.

Diversion v. Destination: In planning bypass options, the methods of diverting smolts at dams should be separated from the destination of the fish after the dam is bypassed, as well as from the particular downstream purposes, such as transportation, the diversion might serve. The principle is that the method of diversion of smolts does not necessitate any particular destination following diversion.

The following ecosystem perspective was developed.

The Ecosystem Approach: The proposed improvements in the CRFMP falls short of an ecosystem approach that would seek to implement measures designed to maximize the proportion of migratory fish species protected. The CRFMP projects largely represent additions or replacements for technologies that have been developed to enhance the survivals of a portion of the native migratory fish species impacted by the dams. The species that is excluded from fish passage design criteria today is tomorrow's listed species.

Biodiversity Issues: Considerations of biodiversity were almost uniformly lacking in the plans for the CRFMP projects we reviewed. The ISAB has repeatedly stressed biodiversity measures as one of the most important aspects of an ecosystem approach. The Council has identified maintenance of biodiversity as an objective in the Fish and Wildlife Program. We state and answer some critical questions we would like to see addressed as projects are conceived, designed, and prioritized for implementation.

INTRODUCTION

The U.S. Congress, in its Conference Report on the FY 1998 Energy and Water Development Appropriations Act, directed the Northwest Power Planning Council, with assistance from the ISAB, to review the mainstem capital construction program of the Corps at hydroelectric projects on the Columbia and Snake rivers. The review was to evaluate the technical need for various fish passage strategies at mainstem dams (i.e., the Corps' Columbia River Fisheries Mitigation Program, or CRFMP). The CRFMP has received diminished support from the Congress, apparently because of a perception that there are insufficient governing priorities for improvements in the hydropower system and an insufficient technically sound and agreed-upon basis for those priorities. Members of the Northwest Congressional delegation such as U.S. Senator Patty Murray (D-WA) have expressed concern about a lack of priorities and a set of principles and criteria for setting these priorities. Senator Murray wrote the heads of the Northwest Power Planning Council and the Northwest Region of the National Marine Fisheries Service on December 10, 1997;

My hope and expectation is that an outside review by the Council with the assistance of the ISAB will ... increase public understanding of the governing priorities for improvements in the hydropower system and the basis for those priorities. I also believe that a priority framed scientific review of the scientific assumptions and principles underlying or embedded into these priorities will also result in broadened agreement. ... In undertaking the review, I would encourage the Council to articulate a clear and understandable set of principles and guidelines that will govern the formulation of its recommendations.

In view of this charge, the ISAB has provided some principles and recommendations upon which the Council and the region may build. However, we note that the past perception of a lack of agreed upon priorities may be inconsistent to a degree with the current circumstances.

The perception of a lack of agreed upon priorities might arise from two sources, uncertainties present in available information, leading to differences of opinion on priorities, and a possible need to provide more than one passage alternative in attempting to achieve the passage

goals of NMFS or the Council. The region has a process for implementing hydroelectric fish passage measures that is controlled by the responsible federal entities, as advised by the non-federal entities. The Corps routinely submits proposed projects for the CRFMP to a non-binding regional review in the interagency Regional Forum, which includes the fact finding System Configuration Team (SCT) and its system of technical subcommittees, and an executive level decision making body, the Implementation Team. When priorities cannot be agreed upon within the SCT process, priorities are established by the tenets of the federal 1995 Biological Opinion on the Operation of the Federal Columbia River Power System, as defined by the National Marine Fisheries Service, and as implemented by the Corps. As stated by the Corps (November 26, 1997 letter from R. H. Griffin to J. Etchart), the CRFMP consists of measures identified in the NMFS 1995 Biological Opinion. In addition to the Biological Opinion, the CRFMP makes an attempt to incorporate measures consistent with the Council's Fish and Wildlife Program, and the treaty fishing tribes' *Wy-Kan-Ush-Mi Wa-Kish-Wit --Spirit of the Salmon*.

Definition of the Assignment

The ISAB is responding to a request from the Northwest Power Planning Council (January 7, 1998) for assistance in fulfilling a congressional mandate for review of the U. S. Army Corps' of Engineer's Fiscal Year (FY) 1998 Capital Construction Program (see Policy Context for the Review, below). In early 1998, the Council staff and the ISAB worked together to focus the review. This report is the last in the series developed by the ISAB to respond to the Council's request. Our first report (ISAB 98-4, June 9, 1998) covered questions from the Council about the ecosystem context for mainstem fish bypass measures, about proposed installation of extended-length turbine intake screens at John Day Dam, and the proposed relocation of the juvenile fish bypass conduit at Bonneville Dam. Our second round of reports was submitted to the Council on September 29, 1998 and responded to questions regarding development of surface bypass for juvenile salmonids (ISAB 98-7) and abatement of supersaturated gas caused by hydroelectric project operations (ISAB 98-8). The third pair of reports, includes ISAB 99-2, which reviews adult fish passage measures in the Corps capital construction program and this report, ISAB 99-4, which provides an overview of the Corps' overall capital construction program.

Purpose of the Report

This report provides a summary and overview of the ISAB's examination of the overall program and selected projects, and provides a comparative assessment of 1998 projects. There are over 50 measures in either an implementation phase or study phase in the FY 1998 CRFMP (Appendix Table). Most include funding for more than one fiscal year. Implementation is defined to mean final design and construction of a measure after a decision to proceed has been made, often in the Endangered Species Act consultation process. Many projects are in various stages of investigating the engineering, biological benefits, implementation schedules, and costs for undecided measures.

Our previous reports examined some of these projects in specific detail and often with a specific focus. We believe the issues discussed in those reports merit consideration in a larger context. Consequently, in this final overview report, we discuss the issues common to all of the projects reviewed in this series, identify principles and guidelines for their review, and place the projects in a larger ecosystem context. Our overall objective is to further understanding about how the measures included in the Corps Capital Construction projects contribute to restoration and recovery of salmon and steelhead in the Columbia Basin. Findings on the individual projects based on past reports in this series are presented in Appendix A. Responses to some questions from the Council that reside in the interface between science and policy are presented in Appendix B.

Policy Context for the Reviews

For the review of the CRFMP, the Council staff established a policy context concerning possible major alternatives for future configuration of mainstem hydroelectric dams presently under consideration in the region (Decision Memorandum of January 7, 1998 from James Ruff to Council members). The following four future alternative system configuration scenarios provided sideboards for the ISAB review:

- 1) All existing mainstem dams, including dam modifications, remain in place and operational for the foreseeable future.

- 2) All dams remain in place except that the four lower Snake River projects are breached to provide a natural river condition in the Snake River within the next 5-10 years.
- 3) All dams remain in place except that a lower Columbia River project, such as John Day Dam, is breached or lowered within the next 10 years.
- 4) Dams remain in place except that the four lower Snake River projects are breached to provide a natural river condition in the Snake River and John Day Dam is breached or lowered in the Columbia River within the next 5-10 years.

During 1999, the region will receive additional guidance on operational scenarios. The National Marine Fisheries Service is scheduled to issue a longer term Biological Opinion on the operation of the federal Columbia River hydroelectric system in 1999.

COMMON ISSUES AND GUIDELINES IN PREVIOUS REPORTS

Each project review raised similar issues, either as commonalities or contrasts with other reviews. In this section we examine these issues in a broader context than just their relationships to the particular construction project of FY 1998. Taken broadly, the issues are more likely to yield clear and understandable principles and guidelines that can direct not only the specific project, but the approach to all such measures. We have summarized the issues and provided a guiding principle for each, and we also examined our reviews of past projects to identify common guidelines that were applied during our evaluation. These guidelines have been collected into a “Test of Biological Effectiveness.” We start by explaining the guidelines, as a context for understanding the common issues and principles.

Test of Biological Effectiveness

Our test of biological effectiveness for a proposed action considers whether the action is (1) consistent with the behavior and ecology of the species, (2) supportive of the physical and biological conditions required for successful completion of normal life history requirements for the species, (3) based upon a valid scientific rationale to indicate that the action is capable of assisting in meeting requirements to accomplish the specific objective, and (4) consistent with an ecosystem approach in protecting other species that could be the subject of listing in the future. Examples of specific objectives relevant to the Corps’ capital construction program are providing the means for juvenile or adult fish to pass a dam alive, and maintaining or enhancing the health of juveniles and adults passing the dams. A key feature of the test of biological effectiveness is the concept of enhancing the conditions essential to the life history requirements of the species.

Common Issues

Projects in the Context of Policy Options

The Council established a policy context for the ISAB review, with four configuration options given as our sideboards (see Policy Context for the Reviews, above). All but the first option included some dam breaching or major reservoir lowering. We found it difficult to

consider these alternatives in our review of the Corps' capital construction projects because all projects seemed to presume the first option (all existing dams remain in place and fully operational for the foreseeable future). This focused our reviews in three directions: (1) Is the project worth doing at the site specified? (2) Is the project worth doing as a general fix for the relevant generic problems of all federal dams? and (3) Is the project worth doing at a dam that might be breached or lowered in the next decade (or other reasonable time interval)?

We took different directions with each review, although we introduced some generic considerations in all reviews. The Bonneville conduit relocation was the most site specific, with the John Day extended-length screens only slightly more generic. Despite the site specificity of the several adult construction programs, we took a generic approach to the whole adult passage situation, and did not critique any specific project in detail. Both the surface bypass and gas abatement programs are inherently basinwide, so we took a broad perspective for these. Only in the case of the gas abatement program did we specifically break down our recommendations according to alternative fates of the dams, recognizing that implementing gas abatement at the lower Snake River dams might have valuable short-term benefits even if dams are breached.

Alternative future configuration options do not seem to have been part of the decision-making process for the projects we reviewed. For example, we wondered about the question of priorities for testing a prototype surface bypass system at a dam with high guidance efficiency of its intake screens that was also a prime target for breaching. The principle here is that for reasonable review of the technical feasibility and priority of projects under different system configuration scenarios, it would be helpful for the project sponsors to have considered these scenarios. This is not to say that work at Snake River projects should be deferred until a decision is made about dam breaching. As explained elsewhere in this report, short-term survival needs of fish should be met to avoid extirpation.

Spill

Some avenues of passage, such as spill, more closely mimic natural situations and processes that emigrating juvenile salmonids encountered in their evolutionary history than others. Consequently, such means of passage should more closely reflect natural selection over the entire range of stocks and life history types than more unnatural passage routes. Because spill is now required to achieve the fish passage efficiency (FPE) goal, there is a need to know both

more about spill (e.g., the species composition of fish in spill) and the relative efficacy of spill and other measures for passage of juvenile emigrants. Identifying and implementing more natural passage routes would increase normative conditions at each dam and should result in a decrease in juvenile mortalities.

Spill should continue to be considered as an alternative when the improvements anticipated from other bypass technologies are not enough to achieve the fish passage goals of NMFS or the Council. At the same time, it must be recognized that the use of spill decreases the value of some projects by lowering their anticipated level of improvement in survival. Such a reduction in anticipated survival benefits was shown for the extended-length submersible bar screen (ESBS) at John Day Dam. ISAB calculations suggest that when fifty percent or more of the emigrants are spilled, the difference in nominal survivals between standard and extended-length screens at John Day Dam would be 1.5% or less.

As noted earlier, a major question is whether there is a greater increase in survival by intentionally spilling water to improve survivals for fish or by minimizing spill and depending on constructed technologies such as screens and fish bypasses to protect fish from turbines.

The general principle we see here is that all juvenile passage alternatives should be evaluated against the baseline of spill. The biological baseline is <2% mortality in spill, followed by increasing in-river mortality when gas supersaturation is generated above about 120%. Note that ranges of survival in spill can vary substantially from the baseline, depending on the project and proportions of flow spilled.

Options Are Interrelated

The efficacy of any bypass technology at a project, such as bypass outfall relocation or improving fish guidance efficiency (FGE) of screens at Bonneville, is a function of the potential success of alternative measures for improving survival of juvenile salmon, such as improved spill effectiveness, surface bypass development, or gas (supersaturation) abatement. The availability of surface bypass and the feasibility of gas abatement will influence the policy decisions on outfall location, screens, and what proportion of the juvenile salmon and steelhead would be passed via spill. Decisions for expenditures on FGE improvements or outfall relocation ought to be balanced against the probability that other means may be developed for elevating the fish passage efficiency and the project survival at the particular dam.

The general principle is that decisions about fish passage measures at a project should be made with the suite of all available alternatives clearly identified, and the interactions among alternatives explored. Options used in tandem may be better than any one alternative used alone. Experience shows that it is not alone sufficient to make modifications of existing technologies.

Long-Term vs. Short-Term Goals

There is a temporal aspect to fish-passage measures that commonly appeared in the course of our review. The Corps' program is largely focused on the short-term whereas salmon recovery requires a long-term perspective, as well. Timing for Corps' projects seems to be governed by the budget cycle, as represented in the Appendix Table. There is a standard sequence of proposal, study, design, and implementation (with bidding and construction schedules) that pervades project thinking. This may be fine for the implementing agency, but it is not sufficient for the overall project selection process involving interagency strategic planning for what is needed most for salmon recovery.

From a long-term perspective, capital expenditures designed to improve survival of juvenile salmon should be viewed as leading to increases in abundance of adults. The same criterion ought to be applied to any of the measures designed to restore or recover salmon populations. Unfortunately, few of the measures undertaken over the past 20 years in the mainstem have led to a measurable increase in abundance of adult salmon. The current inability to relate improvements in survival of juveniles from a capital project to improvements in adult returns is disturbing. It may be due to numerous factors, including inadequacies in the data or in the approaches used for measurement, or in the masking of effects by variables that have not been measured. Nevertheless, we advise that in making decisions on measures for salmon protection and enhancement, there be a continued focus on long-term rather than short-term goals. This will call attention to the fact, as experience tells us, that large improvements in salmon survival are going to be required, if we expect to be able to detect them.

However, the short-term perspective is needed, too. Measuring every action against the standard of full salmon recovery is unrealistic. No action, alone, will lead to recovery (at least it seems unlikely, based on past experience). We must expect modest gains in the short term from

nearly every action we take. If a clear biological standard is applied to prospective actions, many short-term actions could have markedly positive effects on salmon survival.

Two general principles emerge. One is that the long-term goal of adult returns must be kept in mind even as short-term remedies are proposed and built. The second is that markedly new approaches must be developed and tested instead of minor adjustments to present technologies. Innovative and creative approaches need to be fostered, yet examined and tested rigorously, so that the effective actions can be quickly recognized and modified further as needed.

Biodiversity

Biodiversity of salmon and steelhead stocks may not be protected by the intake screen systems in use or by other planned technologies. Ample evidence is available to demonstrate that the collection efficiency of each bypass system varies by species, life history type and population. This was a recurring concern about each construction project. The FPE goal, if implemented over the long term, could increase survival of some stocks and life history types that pass through the existing system at an optimal time, while the survival of other stocks and life history types that pass through the system at other times could be unaffected or adversely affected. The FPE goal for each technology should reflect the need to achieve high passage efficiency and survival for *all* stocks and/or species throughout the entire seasonal migration period. Each of the individual stocks must pass through the selective mortality bottleneck imposed by the mainstem dams. This goal may be unattainable, but dam modifications can still be constructed to maximize the likelihood of all species and stocks being protected.

The principle is simple--strive to make dam modifications that will benefit the suite of species and stocks using (or that once used) the river system. Where designs are favoring one segment of the suite, multiple systems may be needed to include the other species and stocks.

Inconsistent Measures of Performance

There is a critical clash of performance measures between the upper-river salmon restoration programs and Corps mainstem passage programs. Upper river programs, such as many ESA-driven actions, employ performance criteria focused on sizes of individual stocks or spawning populations, while the management decisions, such as levels of spill or choice of construction projects, are based on an average value for each stock that is weighted toward the

most abundant species and stocks. The most abundant species and stocks originate in hatcheries, however most of the listed species are wild. The effectiveness of turbine intake screens, for example, has been presented to the managers as composite numbers that average across the migration season for a set of species (steelhead and coho) and life history types of a species (i.e. yearling and subyearling chinook) based on their expected relative abundance in past years. These averages, while they represent the best judgment of experienced persons for that measure of performance, may be insufficient for the higher measure, that of ensuring that changes in downstream survival would have a beneficial effect for the particular stocks. This is particularly important when there are endangered or threatened species involved, because there is large variability from year to year in the relative abundance of the species and stocks

Because none of the individual technologies developed at the Corps projects to date can by itself meet the performance criteria set by NMFS or the Council (let alone the standard we are implying here), it will be necessary to think in terms of suites of measures, for example the combination of spill with intake screens for passage of juveniles. In addition, the focus for measuring performance should be on the benefits each year to the threatened and endangered stocks, not on the average mix of stocks encountered over a series of years.

The principle is the need for the common "currency" of stock specific performance for measuring performance of system improvements. Stock specific performance is the ideal standard, however technically challenging it may be to attain. When proposed improvements can be denominated in a common currency, some expensive dam modifications may be revealed to be trivial or even have negative biological benefit. Other modifications, we hope, would show higher benefits, leading to a better ability to prioritize actions.

More Emphasis Needed on Adult Passage

The Corp's capital program gives insufficient attention to adult salmon and steelhead. More attention should be given to identifying and correcting adult passage problems. The adult-oriented projects were, in general, focused at a specific local problem. The ISAB had to rethink overall adult passage considerations and put the planned construction projects for adults into that context. We found problems ranging from major discrepancies in counts of upstream migrants at dams to inadequate consideration of major sources of probable mortality, such as fallback requiring multiple passage at a single dam. The uncertainties simply in counting adults under

current conditions seem to loom high in priority for resolution, since so much depends upon their accuracy. These counts are important for the Corps in evaluating the effectiveness of passage at the dams; to the Council for evaluating effectiveness of measures under the Fish and Wildlife Program; to NMFS for assessing the condition of endangered stocks; and to the management entities for setting and maintaining appropriate spawning escapements and harvest levels.

The principle is that the few returning adults represent the survivorship of many thousands of initial smolts and they should be given higher priority than they have in the past.

Scheduling Salmon Recovery Measures

Although it is generally agreed that there is too much to be done for everything to be carried out at once, we saw little evidence of adequate biologically based time phasing of federal construction projects across the whole mainstem. The question of what *most* needs to be done for fish passage (juvenile and adult) seems to have been slighted in deference to the on-going momentum of existing projects and funding cycles. There did seem to be recognition that Bonneville Dam, as the lowermost dam on the system, can destroy the benefits of improvements at all other sites, and thus should receive high priority attention. Surface bypass development has been on a fast track, but largely at the Lower Granite Dam prototype site, a dam where high fish guidance efficiency with screens has been achieved, a dam identified as first in line as a collector dam for fish to be transported by barge or truck, and a dam that may be breached. The logic behind this prioritization was not clear to us, though it seems to have come about as a result of the inability of the "stakeholders" to agree on whether or not to proceed with transportation as the primary mode of operation in the Snake River. We were reminded at each briefing that the Corps goes through an extensive consultation process through the System Configuration Team (SCT), Fish Facility Design Review Work Group (FFDRWG), and other agency interactions, but rigorous technical prioritization seems deficient. More attention is needed to locate the worst offenders in fish passage (among dam projects and fish passage systems) and time phasing to ensure that they receive priority attention, including fast-track development.

The principle is that clear criteria based on biological needs for successful fish passage are required to do the sort of prioritization among projects over time required by the Congressional mandate. The lack of agreed technical criteria, combined with a wide diversity of opinion both confuses the implementation of policies and leads to seemingly duplicative efforts.

Importance of Premises and Hypotheses

It was refreshing to see in our analysis of surface bypass development that the program had specifically laid out the biological premises of the work and planned the research to address those premises as testable hypotheses. We do not necessarily agree that all the premises are correct, but applaud the effort to state them explicitly as an aid to finding and testing alternative hypotheses. To a certain extent, the relocation of the bypass outfall at Bonneville Dam also had a stated basis in tested biological hypotheses, in this case about relative risk of predation in tailwater zones having different velocities. In contrast, the proposed extended-length screens seemed to have as their basis only the premise that a little more adjustment of an existing (and not fully effective) mechanical device would make it better and good enough to meet passage goals. It would be useful to see the biological premises for extended-length screens further developed to include hypotheses about the entire sequence of events leading to successful screening. These hypotheses would need to address delay of surface-migrating fish in dam forebays, behavioral and physiological reactions of fish being drawn into deep turbine intakes from surface waters, tendency of fish to follow flow once committed to the turbine intake, surface-seeking behavior of fish in intakes that guides them to gatewells, and so forth.

The principle we derive from these comparisons is that explicit statement of biological premises is a valuable aid for efficient development of fish passage technologies. The premises and assumptions form testable hypotheses that clearly guide further research and development, thus reducing both simple trial-and-error approaches and the tendency to keep making relatively minor adjustments to existing technologies without a good biological basis. We advise that all projects be made to list their premises explicitly and summarize the evidence in support of those premises before construction and testing of prototypes proceeds.

Site Specificity v. General Solutions

It is a frustrating fact of life that every dam in the federal hydroelectric system is unique and solutions of its fish-passage problems require site-specific attention. As we considered the Corps' FY 1998 projects individually and looked at the underlying biological problem in relation to overall salmon survival, we were constantly faced with the need for not one solution, but eight or more, depending on whether the mid-Columbia projects were to be part of the solution.

We developed the impression, however, that site specificity was often unduly overriding inherent commonalities. Despite an exceptionally clear statement of general biological premises for the surface bypass program, for example, we saw applications at each site taking a largely trial-and-error approach. Application of the biological principles of fish behavior and physiology has been subsumed under questions of building structures to fit the features of a particular dam.

The principle is to foster a design process that meets the generic needs of fish first, and then adjust the design to the specific characteristics of the dam secondarily and to put emphasis on commonality of purpose and function first. We hope that a more cost-efficient process of dam modification for fish passage can result.

Diversion v. Destination

In evaluating bypass options, there is a tendency to link the methods of diverting smolts at dams with particular destinations after the dam is bypassed (or particular purposes for the diversion). This linkage is not essential or even desirable for evaluating options. The linkage may be inevitable for spill (spilled fish always are destined for the in-river tailwater). The destination is not necessarily fixed for other passage routes. For example, surface bypasses may divert fish to the spillway (as done in the Lower Granite Dam prototype), to bypass piping leading to the tailwater, or to the smolt transportation system. Extended-length screens can also divert fish through the bypass piping to in-river passage or to transportation. The historical destinations from particular bypass technologies should not constrain the future destination options. Presently installed piping can also be changed to other destinations.

The principle is that diversion technologies and destinations should not be linked in the pursuit of alternative configurations.

ECOSYSTEM PERSPECTIVE

The Ecosystem Approach

The proposed improvements in the CRFMP largely represent additions or replacements for technologies that have been developed to enhance the survivals of a portion of the native migratory fish species impacted by the dams. This falls short of an ecosystem approach that would seek to implement measures designed to maximize the proportion of migratory fish species protected. The species that is excluded from fish passage design criteria

today is tomorrow's listed species. Each modification tends to focus on improving survival of a segment of the life history of salmon, without linking the segment to the rest of the life cycle or evaluating the sensitivity of the overall population growth rate to the magnitude of the possible improvements. The effectiveness of improvements at a single project is difficult to assess because the projected increases in survival are so small that they would be difficult to detect against a background of natural environmental variation. The critical assumption that remains to be validated, therefore, is that the cumulative increase in survival from all such activities in the mainstem must lead to significant survival advantages for the listed species, with no negative effects on other native species.

Biodiversity Issues

Biodiversity measures include life history type diversity and genetic diversity within species, and native fish species diversity within the Columbia River basin. The ISAB has repeatedly stressed biodiversity measures as one of the most important aspects of an ecosystem approach. Considerations of biodiversity were almost uniformly lacking in the plans for the CRFMP projects we reviewed. We repeat and answer some critical questions we would like to see addressed as projects are conceived, designed, and prioritized for implementation.

1. *Can the Corps' capital improvements contribute to achievement of restoration goals related to biodiversity (FWP goals and ESA goals)?*

We believe current configurations of bypass systems and other capital improvements contribute to erosion of biodiversity by selectively favoring certain life histories, stocks, and species over others. If means cannot be found to allow bypass systems and other capital improvements to be configured to achieve some measure of protection for biodiversity, we see continued erosion of biodiversity to be inevitable. The Corps should develop a process to question whether proposed improvements in technologies, combinations of technologies, or alternative technologies can meet some biodiversity standard. Based on the answers, the Corps should be prepared to seek out technologies and other solutions for circumventing dam and reservoir mortality that would be

most likely to achieve biodiversity goals.

2. *Are measures of performance that are being used to evaluate improvements appropriate for assessment of impacts on survival of life histories and stocks, and on biodiversity?*

There is a serious inconsistency between the performance criteria established by the National Marine Fisheries Service that are focused on individual spawning populations of salmon above the dams, and performance criteria used in the mainstem that are based on seasonal averages for all major life history types combined. Monitoring and evaluation of salmon recovery in the watersheds approaches each spawning population as a unique entity with requirements for survival that cannot be surmised from the requirements of other populations. At the opposite pole of specificity, monitoring and evaluation of hydroelectric mitigation programs, such as turbine intake screens and juvenile transportation, presume that seasonal averages estimated from a subset of one life history type of one listed species during one part of the migration season apply to all populations in all watersheds at all times of the year. This lack of geographic and biologic resolution in the design, implementation, monitoring and evaluation of hydroelectric mitigation programs is contrary to the objective of protecting the genetic diversity of listed species.

3. *Have mainstem dams and reservoirs acted as powerful selective forces, eliminating or seriously depressing many life history types or stocks?*

Current measures of survival to assess effectiveness of improvements at dams may be only measures of the “survival of the survivors,” that is, those few stocks that, at least up to the present, have been able to adapt to the current hydropower system configuration. The issue is significant for two reasons: (1) The relatively high values recently measured for mainstem passage survival of some species may refer only to those stocks that have been able to adapt to the juvenile transportation system, or to passage through mainstem dams and reservoirs, while those that were not able to do so no longer exist. (2) In *Return to the River* we argue that habitat degradation and loss of connectivity among habitats has suppressed life history and stock

diversity. Major life history types (e.g., subyearling migrants) and stocks have been extirpated or severely reduced in abundance. Natural production of spring chinook salmon is largely confined to relatively small, isolated populations in headwater streams where habitat is apparently still relatively pristine. The challenge is to decide if the best opportunities for restoration can be found in maintaining or increasing abundance of the few remaining stocks (just managing the “survivors”), or on reestablishing extinct and recovering severely depressed stocks? If the latter, dams may have contributed to the demise of those stocks that could not adapt to the present hydropower system configuration. Consequently, major changes in the hydropower system could be needed for restoration of the full diversity of stocks.

4. *Does the Corps need a new conceptual foundation, or framework, for assessing fish passage through dams that takes into account normative behaviors and conditions, life history and stock diversity, and is more consistent with management efforts in other parts of the basin?*

We believe it does. The principles outlined above based on our review of selected projects provides a beginning for such a new framework.

ANSWERS TO GENERAL QUESTIONS POSED BY THE COUNCIL

Technical Elements of the Review

The Congress and Council intended to use the ISAB for scientific review of technical questions and issues related to the CRFMP. The ISAB’s work products were to include responses to the technical questions and issues submitted by the Council, as developed by the Council in public meetings with the region’s fish and wildlife managers, the SCT, and others. In this section we summarize our answers to those questions (questions quoted in Italics), from a broad overview perspective of the projects we reviewed. Details are in the specific project reports and in the discussions of common issues above.

Fish Passage in an Ecosystem Context

1. *How does the concept of fish passage facilities at mainstem dams fit within the context of the Columbia River ecosystem?*

Passage facilities at mainstem dams belong within the context of the Columbia River ecosystem only to the extent that they permit the successful completion of the life cycle of the full diversity of the basin's native anadromous fishes. Normal migratory movement at each mainstem dam site is an essential feature of the Columbia River Basin ecosystems that contain anadromous fishes. Anadromous fishes such as salmon, steelhead, sea-run trouts, Pacific lamprey, sturgeon and smelt, must be able to complete all phases of their life cycles, including both upstream and downstream migrations in the mainstem as essential life-cycle features. Dams that have totally blocked migrations of anadromous fishes have demonstrably changed the ecosystems of the upstream watershed. In order for fish populations and communities of unblocked regions to remain intact, passage must be successfully completed within the normal time period. Whenever dams are to coexist with anadromous fishes, engineered facilities to make fish passage as normal as possible are essential.

Effectiveness of Fish Passage as Mitigation

2. *What is the record of effectiveness of fish passage facilities to mitigate for the effects of mainstem hydroelectric dams?*

No one really knows all of the effects of the hydroelectric system, however we have some information on short-term effects for juveniles and adults of some species and life history types that pass through the system. Columbia River dams with fish passage facilities have an impressive record of accomplishment compared to dams without passage facilities. All of the anadromous fish species above Bonneville Dam would have been extirpated prior to 1950 in the absence of fish passage facilities. Anadromous fish species are extirpated above Columbia River basin dams without fish passage such as Chief Joseph, Hells Canyon, Bumping Lake dams, and many others.

Short-term survival during passage appears to be reasonably good for some species and life cycle stages and not for others. Fish passage facilities are not equally effective for all

anadromous species, nor for different life cycle stages within a species. For example, the majority of adult fall chinook salmon ascending above Bonneville Dam at the lower end of the federal hydroelectric system appear to eventually reach their destinations alive, however the same is not true for juvenile fall chinook entering the opposite end of the system at Lower Granite Dam. Existing fishways were not designed for sturgeon and are an obstacle to their passage. Adult Pacific lamprey appear to be only marginally successful at passing dams, and juvenile lamprey can actually be killed in screens designed to keep juvenile salmon and steelhead out of turbines. As measured by short-term survival, passage of the larger “stream-type” juveniles of spring chinook and steelhead appears to be highly successful under the current operation of the hydroelectric system. Short-term survival rates measured through sections of the federal hydroelectric system for the past five years are apparently somewhat higher than was thought to be the case before these measurements. Note that during the same time period operation and configuration of the federal hydroelectric system was changed under the Biological Opinion in order to promote the survival of fish remaining within the hydroelectric system.

It is perplexing that gains in short-term survival within the hydroelectric system have yet to be translated into long-term increases in adults in the fisheries and on the spawning grounds. Despite substantial improvements in short-term survivals for juveniles of species such as spring chinook and steelhead, these species have declined along with other native anadromous species, such as Pacific lamprey, for which no specific fish passage provisions were made.

The paradox may be due to how “effectiveness” has been defined for fish passage facilities. Due to relatively narrow federal mandates, fish passage effectiveness has long been defined as the percent of adults or juveniles clearing the dam project alive, which has been denoted “short-term” survival in the text above. But the restoration of salmon runs depends on long-term survival of juveniles to returning adults, and on survival of adults exiting the hydroelectric system to the point just after successful spawning. If passage through the hydroelectric system damages juveniles to the extent that some are incapable of completing the life cycle, or if it taxes adults to the point where some cannot spawn successfully, this would mean that mitigation for fish losses is not succeeding.

Meeting Salmon Recovery Goals

3. How have these facilities contributed to meeting salmon recovery goals?

Salmon recovery goals, including run doubling and recovery of listed species, are not being accomplished. The effectiveness of fish passage measures on long-term survivals has yet to be demonstrated, so the effectiveness of fish passage facilities in meeting salmon recovery goals remains to be seen. To this point in time, the most that can be said is that hydroelectric fish passage measures appear to have prevented the immediate extirpation of a subset of the anadromous fish so far studied. The Council's Independent Scientific Review Panel noted that documentation is lacking for how actions contribute to salmon recovery during implementation of the Fish and Wildlife Program.

Many of the passage facilities have been evaluated for some of the listed salmon species with respect to short-term survival. Some facilities have been shown to improve the short-term survivals of some types of listed salmon (see above), however the passage measures are not equally effective for all species and stocks. Current research is inadequate in that it does not measure the effectiveness of passage measures to the spawning grounds, to the lower river, to the estuary or to the ocean.

Positive Impacts of Fish Passage Facilities

4. What are the positive impacts of passage facilities?

Wholesale extirpations of anadromous fish species have been avoided due to adult and juvenile fish passage facilities. When the standard of comparison is passage through turbines, there has been a marked improvement (positive) in short-term survival of juveniles for spring chinook, for coho, for steelhead, and to a lesser extent for fall chinook and sockeye. When the standard of comparison is the natural river, it is not clear that fish passage facilities have had positive effects beyond prolonging the process of extirpation.

Negative Impacts of Fish Passage Facilities

5. What negative impacts have the facilities incurred?

When the hydroelectric system is operated to maximize power production, any migratory fish species, including any anadromous species or life history type, that falls outside the design

criteria of the fish passage facilities is selected against. Each species is selected against in inverse proportion to the degree that it is adapted to the passage device. Fish passage facilities work best for adult salmon and large juvenile salmon. The protection provided by turbine intake screens only extends to a small fraction of fall chinook juveniles, and screens do not protect any portion of the juvenile lamprey or sturgeon from the injuries inflicted by turbine passage. If turbine intake screens are the only juvenile passage protection provided, species that fall outside the design criteria are disadvantaged.

As noted above, the standard of measure for judging positive and negative impacts has to be the survival and passage rate in the free flowing reach that once sustained salmonid populations. We have been lulled into believing that impacts of passage facilities have been positive for some species because we have used the extreme condition with the dams in place as the standard for comparisons (e.g., mortalities of juveniles in passing through turbines and complete dam blockage for adults). When judged against the natural system, it is possible, but difficult, to establish that all of our fish-passage efforts are still in the net negative realm.

Major Uncertainties of Fish Passage

6. What are the major uncertainties or research questions associated with improving mainstem passage?

- a. The major uncertainty is the biological standard to which actions should be held. In many cases, the biological community does not know what that standard should be. Engineering standards have often been used by default. To be successful, we must, design with nature, and evaluate and learn from the long-term consequences of our actions.
- b. A critical biological uncertainty is an adequate knowledge of fish behavior and its use in designing fish passage facilities. Passage is the result of fish behavior in response to cues obtained from the environment in which the fish pass. It is not the culmination of exquisite engineering of structures and hydraulics conducted in the absence of fish behavioral information. We have so condoned the separation of engineering from fish behavior that most engineering for fish passage facilities is now conducted in scale models in the Corps' Waterways Experiment Station in Vicksburg, Mississippi, where no live salmonids can interact with the proposed passage schemes.

Adult fishways work because the behavioral cues associated with downstream water flow are generally provided from dam tailwater to top of the fish ladder. These cues became understood at the Bonneville Engineering Facility when designs were tested with real fish. Fishways currently show their major failure because those cues are not provided at the ladder's upstream exit and into the quiescent reservoir (where fish become disoriented and tend to fall back through turbines or spillways).

Juvenile bypasses function successfully when the downstream-migrating fish have the normal behavioral cues of the upper water column and downstream flow. We are beginning to understand that "downstream flow" is recognized by young salmon and followed by use of cues from mild turbulence, although funding has not been available to fully develop these ideas into applications. Surface bypasses will show dramatic improvements in performance when fish behavior that normally guides fish in river flows is used to attract fish to entrances and keep them there. When natural mechanisms are used, the systems will become nearly self-supporting, with little requirement for expensive upkeep.

- c. A third major uncertainty is the accuracy of adult salmon counts at dams. Long believed to be a reasonably accurate record of adult passage, this ISAB review has identified deficiencies that suggest this record may be unreliable for judging the success of passage measures or signs of recovery. Fish counts at dams should be evaluated thoroughly for their accuracy, and if inaccuracies are confirmed, then measures to correct these inaccuracies must be found. Further, the relation between dam passage numbers and returns to watersheds needs to be clarified. Dam counts do not appear to be appropriate measures of spawning escapements at the watershed level.
- d. Another major uncertainty is the effect of temperature on fish passage, not just at dams, but through the entire mainstem hydroelectric system. Both adults and juveniles are exposed to directly lethal or near-lethal temperatures in the river environment in summer, if current records are accurate. Some of the most endangered stocks migrate in the warm seasons. The whole temperature issue needs examination, evaluation, and resolution based on biological performance criteria.
- e. The long-term effect of hydroelectric system passage on juveniles and adults is a major uncertainty that serves as the source of confusion and controversy in implementing fish

passage measures. The possible role of hydroelectric passage in causing mortalities after passage, delayed mortality, is one of the major missing pieces in the Columbia Basin research program. There are literally thousands of unique passage routes that can be traveled by a juvenile salmon as it moves through the hydroelectric system. Some migrants may have encountered eight turbines and others may have encountered eight spillways, while most would have encountered a combination of turbines, spillways and bypass systems. We believe a reasonable hypothesis is that a migrant's chance of survival after exiting the hydroelectric system depends to some extent on its route of passage through the system. It appears prudent to take delayed mortality as an operating hypothesis until proven untenable. We therefore advise caution in making inferences about future salmon abundance based on estimates of survivals measured within the hydroelectric system until the effects of delayed mortality can be ruled out.

Uncertainties Impact Use and Management of Fish Passage Measures

7. How does the existing level of scientific uncertainty affect the use and management of mainstem fish passage measures?

Present uncertainties, the resistance of the region to identifying uncertainties, and the inability to resolve known uncertainties have, in hindsight, fostered misguided passage approaches and slowed development of new approaches. Fish passage could be much more effective if more were learned about basic aspects of fish behavior that control the effectiveness of fish passage devices.

Uncertainties over the levels of short-term survival for juvenile spring chinook and steelhead in passing through the Snake River into the lower Columbia River have led some to uncertainty about approaches to mitigation for the effects of hydroelectric passage. Prior to the 1990's, survivals were widely believed to be low enough to require transportation in barges and trucks of all juveniles collected in bypass systems, as essential mitigation. Improved technology in estimating short-term survivals of spring chinook and steelhead has recently indicated relatively high levels of in-river survival for these species. With the measures in place for diversion of the juveniles away from turbine intakes, hydroelectric project passage may not be as dangerous as it once was for these species. This is an uncertainty that is heightened by additional

uncertainties over delayed mortality, and the effects of transportation on the other listed species, fall chinook, sockeye and steelhead.

It is possible that uncertainty with regard to the dam counts for some species of salmon has led to overharvest of these species in the ocean. With respect to fish counts at dams, no salmon restoration or recovery program can be effective if the basic enumeration of returning adults is defective to any major extent. How far off we are is not known, and it needs to be resolved.

Uncertainty or false certainty about the effects of adult passage on spawning success may have led the region to underestimate the importance of evaluating and improving adult passage measures. Temperature effects in the hydroelectric system may be reducing the spawning success of salmon, and especially fall chinook. No passage methods can be judged effective if temperatures in the hydroelectric system are preventing successful reproduction in spite of adult fish passage facilities at the dams.

ANSWERS TO SPECIFIC QUESTIONS POSED BY THE COUNCIL

Each of the specific questions addressed to the ISAB by the Council was used as a guide for preparation of the individual reports on the major projects. These major project reports were listed in the background section and summarized in the section on summaries of previous reports in this series. Some of these questions are appropriate to answer more broadly here.

How Projects Were Selected for Review

1. *In reviewing the Corps' mainstem capital construction projects in general, the Council asks that the following specific projects be used as examples or models for examining issues.*

The reader is referred to our individual reports on these subjects, or the summaries at the beginning of this report.

Fish Passage Contributes to Recovery Goals

2. *What is the relative likelihood of any of the different fish bypass strategies to achieve the goals of the NMFS Biological Opinion, the Council's fish and wildlife program, or the tribes' salmon restoration plan?*

With respect to recovery and run doubling goals the likelihood is zero. Fish bypass strategies are certainly not going to succeed without support in the other localities of the life cycle; spawning, freshwater rearing, estuarine and ocean rearing. We believe the likelihood is good for one or more of the technologies to make *contributions* toward meeting the goals if biological standards are the primary scientific basis for making decisions. Extended-length screens are the least likely to achieve the goals among those reviewed. Dissolved gas abatement and relocation of the bypass outfall at Bonneville are valuable and biologically sound approaches for contributing to meeting the goals, although neither will attain them alone. Surface bypass technologies have promise for making major contributions to the goals, provided the critical element of juvenile fish behavior in dam forebays is given more attention. Adult improvements are a big question mark, although an expanded program has potential for important impact.

Scientific Information to Compare Strategies

a) *What scientific information is available to compare different mainstem fish passage - strategies?*

The width and breadth of scientific information is inadequate, however there are promising technologies that have recently been put to work and more are on the horizon. Most important are the recent estimates of short-term survival of juvenile salmon made possible by the PIT tag technology coupled with statistical methods for analyzing the data on recoveries of individually marked fish. Other biological data take the form of estimates of numbers or percentages of fish passed through a small percentage of the available routes. Unfortunately, the existing estimates of short-term survival during hydroelectric passage do not take into account delayed mortalities of juveniles, or pre-spawning mortality and incidence of unsuccessful egg deposition in adults.

Detailed scrutiny of the effectiveness of alternative bypass technologies has led to renewed attention to passage through turbines. Improvement in fish survival during turbine passage may be possible. We understand there are designs for "screw turbines" and other

designs that promise to decrease mortality of individuals passing through them. Estimates of mortalities and quantification of the actual causes of death, injury, and disorientation are uncertain. These limitations are being rectified by new field studies using balloon tags, laboratory studies of effects of pressure and shear, and by programs to design more fish-friendly turbines. The U.S. Department of Energy, in cooperation with the Corps, is funding design modifications to the basic Kaplan turbine used in the basin and designs for radically different turbine concepts capable of replacing existing turbine systems (DOE Hydropower Program, c/o P. Brookshire, Idaho Operations Office, Idaho Falls). The region can participate in these innovations through installation of prototype systems at mainstem facilities.

Such a focus on direct mortality experienced in passage through the turbines must not lose sight of the fact that significant levels of indirect mortality have been measured as fish that are disoriented or otherwise affected by turbine passage are rendered vulnerable to heightened predation in tailraces or at bypass outfalls. Studies of survival should be aimed at identifying the locations where losses are highest, either reservoir, forebay, turbine, tailrace, bypass outfall, spillbay or other, in order to be able to effectively address the problem.

Limitations in the Scientific Information

b) Are there significant limitations in the scientific information used to evaluate the different fish passage strategies? If so, how can the region best fill these information gaps?

There are limitations imposed by the lack of information on delayed mortality of juveniles and adults, the lack of passage route specific mortality information for juveniles, the lack of life history type and stock specific mortality information, and the lack of known accuracy and precision of adult passage estimates. All of these information gaps impose significant limitations on the use of available information. How the region moves to fill them depends a great deal on the future configuration of the hydroelectric system. Our answer to this question presumes the hydroelectric system remains more or less intact. Other approaches can be suggested when system reconfigurations are considered.

Typical data on FGE and resulting estimates of FPE are highly variable. While they may be sufficient for decisions on installing full arrays of bypasses, they fall short with respect to their application for estimating the performance of the full array in diverting juveniles away from

the turbine intakes. It is this performance that governs the management decisions for application of spill or alternative passage measures to achieve the FPE goal.

Juvenile fish behavior ultimately determines the success of downstream fish passage measures. Basic information is needed on juvenile fish behavior in hydraulic fields of different characteristics that can be used to develop functional passage systems. This information is lacking from laboratory experimental flume studies and has only recently been obtained in the field. There is almost complete reliance on physical scale models of hydraulics for design of fish-passage facilities in absence of integration with observations of fish behavior.

Decommissioning of the Bonneville engineering test facility for adult salmonids and shifting of such work to the Corps' Waterways Experiment Station in Vicksburg, Mississippi has created this situation. This dislocation has had the detrimental effect of skewing available information almost completely toward engineering rather than biology.

Information gaps should be filled by new laboratory and field research that is focused on species-specific fish behavior relevant to passage through dams and reservoirs. Physical scale model research in absence of concurrent fish behavior observations should be replaced with a new bioengineering test facility on the Columbia/Snake mainstem that can include actual juvenile and adult migrants (re-establishing a facility similar to the old Bonneville facility, perhaps at the same location). Research output should include biological metrics in relation to hydraulic patterns rather than gross measures such as FGE and FPE. Field studies must begin to use scientifically valid experimental designs. For example, surface bypass experiments typically have changed the engineering structures each year and thus have not allowed adequate reference situations for testing the biological effects of manipulations.

Scientific information used to evaluate different bypass strategies often has been collected for purposes different from the current use. Sites of research often differ from the sites of application. These situations have led to limitations in applicability. All relevant data should be used, but the limitations need to be recognized. The premises and goals for the original research need to be clearly laid out and peculiarities of experimental sites stated. For future research, goals and assumptions need to be stated clearly, including intentions to use the data in broad applications, before the experimental site is selected. The conclusion is that the goals and assumptions for the research need to be clearly laid out before the experimental site is selected.

Adequacy to Achieve Performance Objectives

c) Is the effectiveness of any of the different fish passage strategies adequate to achieve the interim performance objective of 80% fish passage efficiency and 95% juvenile fish survival at each dam?

While the 80% FPE and 95% juvenile fish survival standards were substantial improvements over the absence of measurable standards, combining all stocks and species together under a single set of mainstem performance measures is not consistent with stock-specific recovery measures now being taken in the watersheds. It should also be noted that the turbine is not always the passage route with the lowest survival. Even so, no single fish passage measure is sufficient to achieve the FPE and survival standards at each dam for all species passing the project. Some technologies are better than others, but multiple technologies will be needed to achieve the standards while protecting biological diversity.

In general, a multiple bypass strategy is probably most likely to achieve the goals, given the present state of performance of the technology. This is for three reasons. First, no single technology is likely to cover all fish migration trajectories, and it may require both intake screens and surface bypasses, for example, to have a high probability of intercepting most migrants. Second, species and some stocks have different migration behaviors that make it more likely that one technology rather than another may intercept them. Having more than one technology in place at a dam increases the likelihood that each migration behavior will be accommodated. Third, environmental variability is to be expected. Some bypass systems may work better at high flows, for example, than at low flows. Natural passage success probably varied similarly among flows and temperatures, and their timing through the migration season. Having several technologies operating at dams will increase the likelihood that one or more of the passage routes will be effective in any one environmental situation. Apparent redundancy of passage systems may be necessary, and actually not be redundant at all when viewed from the perspective of biodiversity and environmental variability.

Risk to Other Species

d) Does the measure proposed for implementation, or the range of potential implementation alternatives, have a high probability of achieving the expected biological benefit

(salmon survival improvement) without undue risk to other anadromous and/or resident fish populations?

This question exemplifies the problem with an overall goal of 80% fish passage efficiency and 95% survival at each dam. For example, for what salmon species and life history types are biological benefits desired? As noted in the answer above, there is inevitable technological selectivity among salmon species and stocks (akin to gear selectivity in harvest or experimental fish sampling). Three levels of interaction need to be evaluated: (1) effectiveness for the target or principal species/stock, (2) effectiveness for other species/stocks (perhaps omitted from the planning), and (3) actual damages to non-target species/stocks. Protecting a diversity of species and stocks through passage measures should be a goal, not just an aggregate numerical percentage.

Technologies that most closely approximate the natural physical and biological conditions of migration would seem most likely to accommodate diverse species/stocks. These technologies would be considered more normative, in the context of the Independent Scientific Group's report, *Return to the River*. Surface bypasses with adequate hydraulic attraction flows in forebays seem to match the requirements most closely for salmonids that migrate in the upper waters of the normal river. This approach, however, discriminates against species that migrate primarily near the bottom of the river, such as lamprey. New bypass approaches may be necessary to accommodate these deep-water migrants. No technology tested to date has sought to effectively pass these deep-water fish. Our impression is that relatively little is being done in this regard, with the exception of installation of a number of more "fish friendly" turbines at Bonneville Dam. The capital construction program should recognize that some fraction of listed species and perhaps large fractions of other species will continue to be passed through the turbines. We recommend continued research on design of more "fish friendly" turbines and replacement of turbines with better designs when feasible

Short-term v. Long-term Strategies

e) Do some strategies provide potentially interim (within the next 10 years) biological benefits while longer-term system configuration strategies are being evaluated, selected, and implemented?

All strategies that assume the present configuration of the hydroelectric system are, by definition, short-term strategies. All of the CRFMP projects fall into the short-term category. There is considerable value in carrying out these measures even for the short-term before major hydropower system configuration changes might be adopted (their success might significantly alter the selection of such major changes, whereas any failures are unlikely to harm to fish populations). In general, if biological criteria are foremost, relatively inexpensive and effective approaches to enhancing fish passage in the short term can be identified. Some examples follow.

(1) "Surface bypasses" for juveniles exist at some dams now in the form of ice/trash sluiceways and spillways that have been or can be retrofitted with surface overflow gates. These should be used or modified expeditiously to accommodate migrants during an interim period before wholly new surface bypass structures can be designed, tested, and installed at each site.

(2) Existing intake screens should be used to most advantage without adding extended length screens or other major modifications. These screens may not be the most desirable biologically, but they have helped reduce mortality in turbines and can continue to do so.

(3) Prototype surface bypasses in place at a few dams can be modified with enhanced attraction flows in dam forebays to improve the opportunity for discovery of entrances by migrants. The work would be experimental, but with a probability of success. No costly structural modifications would be necessary.

(4) Gas abatement strategies in the form of spillway deflectors and other relatively straightforward modifications can be implemented (or completed) with high effectiveness in the interim.

(5) Juvenile bypass outfalls at dams other than Bonneville can be evaluated and possibly modified quickly and inexpensively to reduce predation losses in tailwaters, relying on the extensive research, analysis, and engineering design work at Bonneville.

(6) Adult fallback at dams may be prevented by installing attraction flows in dam forebays at the upstream ends of fish ladders. The attraction flows would be situated along reservoir shorelines immediately upstream of ladder exits. They would guide fish upriver and reduce disorientation in the forebays that have few or no hydraulic migrational cues. The necessary cues are well known from research on attraction flows at fishway entrances in dam tailwaters, conducted over 40 years ago.

(7) In the long-term, if the hydroelectric system remains fully or partially intact, protection of biodiversity, including genetic diversity, requires development and installation of “fish friendly” turbines. Surface and mechanical bypass cannot adequately protect the diversity of even the listed species, let alone the full biological diversity of all of the migratory fish species that utilize non-turbine hydroelectric fish passage. The portions of the listed and non-listed species that inevitably pass through turbines require protection.

(8) The hydroelectric system has provided habitats and circumstances such as passage through turbines that allow increased opportunity for predators to take juvenile salmon and steelhead. Efforts should be continued to identify the locations and reduce such losses where possible.

APPENDIX A: SUMMARY OF PREVIOUS REPORTS IN THIS SERIES

Based on our belief that projects must meet the criterion of biological effectiveness before economic considerations are brought forward, we can rank current major projects, as follows. All but extended-length screens pass our test, and are recommended for continuation in parallel (with some suggested alterations in direction, as detailed in separate reports). We emphasize that this broad-scale review is only the first step in an evaluation process that must be undertaken of all planned projects if biological effectiveness is, indeed, to be a major determining factor in how funds are spent and work allocated.

John Day Extended-length Screens (ISAB 98-4)

Synopsis

Although the overall goal of diverting downstream migrants from turbines is biologically effective, the planned project represents minor improvements on an existing technology. The existing turbine intake screen technology has inherent biological limitations. Limitations are exemplified by the paradox that bypass technologies increase short-term hydroelectric system survivals for juveniles of some species without measurable increases in adult returns for these same species, and for most others as well. Those proposed minor improvements have uncertain benefits at this site (based on many uncertain assumptions), and may injure unacceptable

numbers of fish that should be protected. Rather than proceeding farther along this biologically questionable line of development, our review suggests that greater benefits are more likely to be obtained from development of surface bypass technology. Existing screens could be left in place (with appropriate maintenance) to supplement any other systems that are developed when necessary to reduce overall mortalities

Test of Biological Effectiveness

An extended-length screen in the turbine intake seems inconsistent with the broad pattern of normal salmon smolt behavior, including surface orientation in dam forebays, resistance to rapid change in depth, and tendency to follow flow. Both submergence to turbine depths and screening from the turbine flow are contrary to normal fish behavior. However, once fish are in the turbine intake, fish guidance to gatewells above is consistent with the natural reaction to return to the surface as soon as possible after being drawn to unnatural depths.

Summary

The ISAB calculated that, assuming no juveniles are passed by spill, the reduction in nominal total project mortality of yearling chinook with the proposed extended-length screens (ESBS) relative to the existing standard screens might be 3.1%. The calculation used average numbers that were provided in agency documents for fish guiding efficiency (FGE) of both screens, mortality in turbines, and mortality in the bypass systems. Reduction in mortality of subyearling chinook with the new screens relative to the standard screens was taken to be 3.0%. These figures are comparable to those of the Corps. If the screen bypass is used in conjunction with spill, the gain would be less.

In addition to the daily variability in the amount of spill, there are other important uncertainties regarding the actual value of these expected gains in survival of juvenile migrants. For example, uncertainty is introduced by the practice of making a downward adjustment in the estimates of FGE for standard screens based on an inadequately documented comparison of fyke-net catches in extended-length screens (ISAB 98-4). If the unadjusted FGE is used, the expected improvement in survival due to installation of ESBS is lowered. For example, if the unadjusted FGE figure for yearling chinook is used, the estimated total mortality would be 5.4%, giving a 1.6% improvement in survival with extended screens, compared to the 3.1% improvement estimated with the adjustment. As another example, estimation of improvement in

project survival is further complicated by difficulties in selecting the appropriate FGEs from among those that have been measured. These average FGEs are not appropriate for determining project survival as it applies to all populations of the listed species and other species, which must pass the dams during their life history. Measured FGEs vary not only among species and life history types, but also with time of year, degree of smoltification, time of day, and other factors. Analysis of the sensitivity of project survival estimates to variation in FGE was not available. Changes may be positive or negative.

When considering species other than juvenile salmon and steelhead, the application of ESBS is uncertain. Any changes in the fish passage efficiencies (FPEs) generated by addition of the ESBS for other anadromous species, such as Pacific lamprey, and other migratory species, such as the catostomids, are unknown.

However, the ISAB viewed the more important question to be whether an improvement in survival at the project of the uncertain magnitudes discussed above will contribute in a meaningful way to restoration or recovery of stocks of salmon or steelhead. A major uncertainty regarding the effectiveness of turbine-intake screens (both conventional and extended-length) is highlighted by the fact that dramatic improvements in FGE over the last 20+ years at most Columbia basin mainstem dams have not been matched by improvements in returns of adult salmon and steelhead to spawning grounds above Bonneville Dam. In addition, there is no documented evidence that installation of screens has slowed the decline of salmonid stocks. However, the same may be said of most of the juvenile passage measures taken over the past 20 years. It is recognized that documentation of improvements in numbers of returning adults is complicated by the difficulty of separating the mortality that occurs during dam passage from the mortalities experienced in other parts of the life cycle, such as in the estuary and ocean. Furthermore, evaluations of smolt to adult survival in Columbia River salmon generally lack statistical power sufficient to have a reasonable chance of proving that observed small effects of small increases in downstream survival are “real” at a level of certainty to be generally accepted by the scientific community.

We recommended against the proposal to install extended-length screens at John Day Dam. Instead, we recommended pursuing surface spill alternatives and funding research toward possible deployment of a surface-flow bypass system at this project. We urged

mitigation measures to improve survival of the full range of diversity in salmon and steelhead populations, while taking into account impacts on other species. In making these recommendations, we were aware that existing screens require spill in order to supplement the FGE of the screens to move toward the 80% fish passage goal of NMFS and the Council. We were also aware that maximum limits on gas supersaturation could at times restrict the amount of voluntary spill before the 80% FPE goal could be achieved with existing screens. Nevertheless, we recommended that strategies other than extended length screens that offer to achieve the 80% goal within gas supersaturation guidelines be pursued.

We also point out that the question of whether an improvement in survival of the uncertain magnitudes discussed above will contribute in a meaningful way to restoration or recovery of listed species needs to be weighed relative to the costs of the installation and the alternative costs of lost power generation if survival is managed by voluntary spill. In the language of the Council's Independent Economic Advisory Board, "Even with fundamental uncertainty or disagreement regarding the biological effectiveness of proposed projects, cost-effectiveness analysis may provide useful information for rating alternative projects."

(Proposition 4, Page 30, IEAB 99-1, Northwest Power Planning Council, Portland, Oregon).

Bonneville Bypass Conduit Relocation (ISAB 98-4)

Synopsis

A straightforward engineering design will discharge juvenile fish bypassed from the turbines at Bonneville Dam (both powerhouses) to a zone of higher velocity where it is expected they will avoid the predator-rich tailwater zone of low water velocities. This project is based on sound biological relationships and demonstrated problems with fish survival in the Bonneville tailwater. This project is expected to yield benefits in both short and long term, because it lies downstream of all of the hydropower system. Actual effectiveness needs to be monitored.

Test of Biological Effectiveness

This measure is based upon a valid scientific rationale to indicate that the action is capable of assisting in accomplishing the specific objective.

Summary

It is well documented that the present bypass outfall locations at Bonneville Dam lead to artificially elevated levels of mortality for downstream migrants; the need for relief is certain. The existing outfalls appear to have negated whatever benefits may have accrued to subyearling emigrants from the bypass system because of high mortalities experienced at and below the outfalls. For larger, earlier emigrants, such as spring chinook and steelhead, the negative effects of the outfalls could have been less than that observed for subyearling emigrants. The new location for a combined outfall should decrease predation, based on environmental characteristics of the site and experimental characterization of predation by the northern pikeminnow (*Ptychocheilus oregonensis*).

The Corps proposes to relocate outfalls of the bypass systems at both powerhouses in order to move bypassed juvenile salmonids away from the known concentrations of predators. In addition to relocation of the outfall for the juvenile bypass system, planned alterations scheduled at Bonneville Dam to the juvenile fish passage facilities include increasing FGE of intake screens at both powerhouses, replacing the existing bypass conduits at the powerhouses, joining the two conduits to a common outfall, investigating surface bypass, and implementing gas abatement strategies (Corps briefing to the ISAB). The ISAB focused its report primarily on evaluating the proposed bypass outfall relocation.

An improved bypass outfall was considered in light of alternative passage routes for fish. None of the passage routes except intake screens and spill have been shown to be feasible for Bonneville at this time. Surface bypass systems are under development elsewhere in the basin for possible general deployment, but this technology would probably still require a bypass outfall. We presumed that the proposed outfall would continue to be used if surface collection replaces or augments screening of turbine intakes at Bonneville.

We recommended that the proposed bypass relocation proceed. To the extent that bypass relocation can reduce mortalities for those juvenile salmon and steelhead that may enter the powerhouses, outfall relocation would be supportive of recovery of endangered salmon stocks, and it should reduce artificial selection against later and smaller emigrants that are heavily preyed upon. Relief from the present situation, where high outfall mortalities are known to be occurring, through relocation of the combined bypass outfall to deeper, swifter water more

typical of the riverine migration pathway would contribute to restoration of normative conditions, at least in the short-term.

Although the ISAB attempted to consider all features of the new outfall that would reduce predation on the juveniles, effectiveness cannot be predicted with certainty. Post construction evaluations will be required as uncertainty and unanticipated results are common factors to be considered and evaluated in the implementation of new technologies.

Surface Bypass (ISAB 98-7)

Synopsis

Surface bypass development has attempted, as few other measures have, to match dam bypasses for juvenile salmonids to the perceived normal behavior of the fish. Success should have major biological benefits for passing fish at dams without delays and with high survival. Progress has been less dramatic than anticipated, however, because only the gross behavior patterns of fish (e.g., surface orientation, flow following) have been incorporated into engineering designs. More research-scale projects are needed to reorient the work away from engineering trial and error and toward a better matching of designs to the particulars of fish behavior. Benefits should be evaluated in terms of returning fish safely to the river. The promise of this work for the long term could be substantial, but adequate time and funds will be necessary for it to come to full fruition. Test devices (e.g., at Lower Granite Dam) may have short-term benefits if modified to incorporate new biological information and left in place as operating systems.

Test of Biological Effectiveness

Surface bypasses are consistent with the life history requirement of most downstream-migrating salmonids for passage in the upper third of the water column of the river. Such a structure to collect fish near the surface above turbines for bypassing the dam has a good scientific rationale for being successful, especially if more of the natural behavioral cues are incorporated into the designs. An example of a passage success where the known behavior and ecology of the species coincided with project design is the ice and trash sluiceway at the Dalles Dam, which is utilized by juvenile salmon for surface bypass. Even though the Dalles sluiceway was not designed originally as a fish passage measure, the natural behavior of the migrating

juvenile salmonids brings them into the sluiceway where survival is quite high compared to passing through project turbines, or to spill under some conditions. The best known example of successful surface bypass, Wells Dam, is another case where the natural behavior of the emigrating juveniles fortuitously coincided with the basic design of the project to permit high project survivals with relatively limited structural modification.

Summary

The effectiveness of turbine intake screens for diverting downstream-migrating salmonids away from turbines seems to have approached an upper limit where large increases in the fraction of juveniles diverted are not likely to occur (as evidenced by the ISAB's review of John Day extended-length screens). As alternatives to turbine intake screens are considered, developers hope to make use of the natural behavior of migrating juvenile salmon, which places them predominantly in the upper portion of the water column. Where spill can be drawn from the surface, it has been observed to be more effective in attracting fish than spill drawn from deeper water. Similarly, smolts were observed to preferentially pass through trash and sluiceway gates that spilled water from the surface.

The primary source of encouragement for surface flow bypass development was the success at Wells Dam in the mid-Columbia Reach. Wells Dam includes the first successful surface flow bypass system for juvenile salmon. Testing of a prototype began in 1983. Full installation across the powerhouse was complete in 1989. Studies over the next three years showed that the bypass was successful in passing 89% of the juvenile fish that passed the dam, both in spring and summer. To date, it is the only system in the Columbia Basin that achieves the 80% fish passage standard without the addition of spill.

Unfortunately, the surface bypass technology developed at Wells Dam is not directly transferable to other dams on the Snake River or mainstem Columbia River. The design of Wells Dam, the hydrocombine, is fundamentally different from the design of all other Snake and Columbia mainstem dams. Hydrocombines have the spillway located directly above the powerhouse, whereas the other mainstem dams have spillways located separately from the powerhouse.

Presently, prototype surface bypass collection (SBC) systems are being investigated by the Corps at Lower Granite Dam, and Bonneville Dam powerhouses and by Chelan County

Public Utility District (P.U.D.) at Rocky Reach Dam and by Grant County P.U.D. at Wanapum Dam. In all cases, significant progress has been made in identifying the relative effects of features of the prototypes.

Feasibility analyses have also been conducted for The Dalles and John Day dams. Tests by the Corps at Bonneville, The Dalles and John Day dams were of a preliminary nature, but the results are promising enough to justify larger scale testing. The Dalles Dam in particular, offers the potential for development of a surface flow bypass because the ice and trash sluiceway, located above the turbine intakes, already operates in that mode. It passes 40% or more of the fish approaching the powerhouse in its present configuration. There is a strong possibility that its effectiveness can be improved by design modifications.

The ISAB concluded that the preliminary tests in surface bypass collection system prototypes indicated that the surface flow bypass technology showed sufficient promise to warrant continuing development assuming the system of hydroelectric dams retains its present configuration and operations. This recommendation was not a blanket endorsement of surface bypass technology, since the efficacy of surface bypass technology will need to be established for each individual dam. The concept will need to be adapted to the configuration of each dam through development and testing of a prototype.

Dissolved Gas Abatement (ISAB 98-8)

Synopsis

Straightforward engineering approaches and designs can be implemented at all spillways to reduce the supersaturation of spilled water, which will have important biological benefits for fish survival in the river, both juveniles and adults, during both involuntary spill and spill managed to aid juvenile migrations. Benefits will accrue in the short term, even if some dams are breached in a decade time frame.

Test of Biological Effectiveness

The gas abatement program is consistent with the salmon species' life history requirements for river water that is not so supersaturated that gas bubble trauma and reduced survivorship occurs. Abatement actions are intended to return the river to the condition that meets biological and ecological requirements.

Summary

The ISAB evaluated how the Corps' Gas Abatement Program at mainstem dams fit in the context of the Columbia River ecosystem and evaluated the effectiveness of the Program to mitigate for the effects of mainstem hydroelectric dams (including both positive and negative aspects). The ISAB identified major, relevant uncertainties or research questions in the Gas Abatement Program and how the uncertainties affect the use and management of gas abatement measures under several scenarios of hydroelectric system reconfiguration and over several time frames.

Spilling water (as opposed to putting it through the powerhouse) to pass downstream-migrating juvenile salmonids over mainstem dams has been demonstrated to yield higher survival than passage through all turbines and most of the engineered bypass systems under most conditions so far tested. Spill is therefore used as a management tool to pass juvenile emigrant salmonids safely past dams. Note that spill must occur at a project during all times when river flows exceed powerhouse capacity. However, spill contributes to an increase in total dissolved gas saturation (TDGS) in the river downstream of dams such that conditions well above the generally accepted water quality standard of 110% can be created. Monitored levels have exceeded those demonstrated to be lethal to juvenile salmonids in laboratory studies because of gas bubble disease (GBD).

Despite potential detrimental effects of elevated TDGS, NMFS' Endangered Species Act Section 7 Biological Opinion (NMFS 1995) includes as a "reasonable and prudent alternative" the spillage of water at dams during the migration season for the protection of juvenile spring/summer chinook salmon. Under the Biological Opinion, NMFS directed the U.S. Army Corps of Engineers to achieve 80% fish passage efficiency (FPE) using spill. (This coincides with the Council's directive in the Fish and Wildlife Program.) Because the prescribed spill program is likely to cause TDGS to exceed 110%, NMFS seeks annual waivers of these standards by state water quality control agencies in order to implement the spill program.

The region has been investing in a multi-pronged approach to the gas problem. It includes biological research on the effects of dissolved gas saturation, monitoring in-river amounts and effects (biological signs) of dissolved gas saturation, and a program to minimize the amount of TDGS induced by the hydropower facilities (the Corps' "Gas Abatement Program").

The National Marine Fisheries Service's Biological Opinion (1995) for Operation of the Columbia River Hydro System detailed that the Corps of Engineers should develop and implement a gas abatement program at all projects. The original goal of the program was to determine how the projects could be modified to comply with the federal and state water quality standard for total dissolved gas saturation (110% up to the ten-year, seven-day peak flood event; USACE 1996).

A wide range of gas abatement devices has been explored, which range from established technologies such as flow deflectors ("flip lips") on dam spillways that prevent deep plunging of spilled water to exotic spillway designs that incorporate elaborate baffles to facilitate air equilibration. The program has conducted systematic evaluations of engineering feasibility, efficacy, and cost for the suite of alternatives. Field studies of gas entrainment at existing spillways have shown that reducing the depth of the plunge basins at dams would be effective in reducing gas supersaturation, but there is concern about potential loss of juvenile salmon through physical injury.

We advised that the Corps' Gas Abatement Program, which is important for rectifying supersaturation of waters of the Snake and Columbia rivers with dissolved gases by the hydropower system, should continue, with high-priority. Gas supersaturation is a problem in high-flow years with inadvertent spill whether or not spill is used as a management approach for aiding salmon passage in other years. Attainment of the standard of 110% throughout the hydropower system appears unlikely to be possible in high flow years with the majority of dams in place. Nonetheless a program of modifications of dams to reduce gas supersaturation to the lowest levels practicable without reducing emigrant survivals could have benefits to salmon and other components of the ecosystem. The modifications may be considered useful whether or not selected dams are breached or drawn down if they are viewed in two time frames, short term (<10 years) and long term.

Additional biological studies are not immediately necessary for continuation of the gas abatement program, except for evaluation of potential damages from abatement devices themselves. Studies of depth distribution of biota, of adult responses to dissolved gas supersaturation, and of ecosystem responses would be of especially high priority if attainment of a specific safe level of gas supersaturation in the river (above 110%) is to be justified on

biological grounds. However, the ISAB believes that full justification of a specific “safe” saturation value other than 110% on the basis of biological research is not likely to be possible in a reasonable length of time if we are to conserve the dwindling resources. The alternative of proceeding with gas abatement to the lowest level practicable is preferable on biological grounds. Cost considerations inherent in the term “practicable” are not a technical judgment appropriate for the ISAB.

Adult Fish Passage (ISAB 99-2)

Synopsis

The capital construction projects for adult passage were needed. Most verged on operations and maintenance. However, we discovered some uncertainties with respect to survival of adults that were not addressed in the planned projects. A further evaluation of adult passage considerations is needed, including detailed review of the basic enumeration system at dams (which are fraught with uncertainties). When current recovery efforts are insufficient, a revisiting of problems believed solved, such as adult fish ladders, is appropriate to see if new approaches are needed. Our initial review suggests that the recovery effort for adult salmon needs revisiting. Current planned projects will have both short-term and long-term benefits. Evaluation and research may have some short-term benefits, but will be primarily long term.

Test of Biological Effectiveness

Adult passage improvements are consistent with providing for the normal completion of the life cycle through simulation of normal river passage for anadromous salmonids. Adult passage for other anadromous species, including lamprey is problematic, and protection of biological diversity requires the program to take the needs of non-salmonids into consideration.

Summary

We concluded that the adult salmonid passage measures proposed by the SCT as well as the Corps' Capital Construction projects relating to adult passage should be implemented, as the actions are both necessary and desirable. Benefits derived from these actions apply to short- and long-term scenarios of dam configuration.

Nevertheless, our technical evaluation concluded that the subject of adult passage at Columbia River dams has not been adequately dealt with. There appears to be a widely held

assumption in the region that problems of adult passage have, for the most part been solved. The Corps' adult passage measures address what we considered to be minor fixes and adjustments of existing systems. While these planned site-specific measures are supportable, they are not sufficient to ensure that adult spawning migrations are unimpeded and completed with minimal mortality induced by passage.

Problems with adult passage deserve more attention than they have received. Many questions remain about the effects of delay or extra energy expenditure en route upstream on the ultimate ability of adults to spawn successfully. Uncertainties about adult passage must be viewed in a larger context than simply a project-by project review of desirable modifications of ladders and their associated facilities at mainstem and Snake River dams. Our review shows that the questions associated with adult passage are not well resolved, and better information is needed than we now have available to us. Resolution of these uncertainties will require regional action and coordination, as the responsibility for these issues does not lie solely with the Corps.

We went on to conclude that there is an overarching problem with the counts of adults in the ladders. Such a basic problem has serious implications for the application of these numbers by the Corps for determining the effectiveness of fish passage facilities, for the Council in determining the effectiveness of measures under the FWP, for NMFS in monitoring the status of endangered stocks, and for the harvest management entities in setting and maintaining appropriate escapement goals and harvest rates.

We therefore formulated recommendations for improvement of the situation with respect to the accuracy and precision of the counts of adult passage at the dams.

1. More emphasis should be placed on adult passage measures and their monitoring and evaluation by the Corps, the Council, NMFS and the harvest management entities.
2. Include an annual operating project to determine the accuracy and precision of the counts of adult salmon passing the dams.
3. Critically evaluate sources of bias in estimation of escapement to spawning grounds and hatcheries.
4. The research program on temperature and its effects needs to be examined and expanded.

With respect to alternative hydroelectric system configurations, the need for programs associated with adult passage at the dams would be decreased under the dam removal scenarios. Similarly, it seems likely that problems such as temperature elevation, gas supersaturation, and lack of attraction flows would be reduced in proportion to the number of dams removed. Drawdown scenarios present a more complex situation, upon which we could not comment.

APPENDIX B: CONTRIBUTION TO POLICY ELEMENTS OF REVIEW

The ISAB's technical review of the Corps' capital construction projects is to be used by the Council to address specific policy questions posed by the Council. Considering its status as a science board, and consistent with its charter and generally accepted protocols governing scientific reviews of complex agency undertakings, the ISAB believes it can contribute its technical expertise to relevant policy. This section suggests how the ISAB information might be used for each of the policy questions listed in our prior reports.

Do Biological Benefits Warrant Expenditure?

Do the expected biological benefits of a project warrant the expenditure for implementation? The biological benefits need to be weighed against costs and goals. There are technical questions related to costs that the ISAB did not consider. (See Report 99-1 of the Independent Economic Advisory Board for background on economic considerations.) Goals require assimilation of expectations by the regional population, but may already be well expressed in the available plans. Input appropriate from the ISAB is provided in the summaries of reports given above.

Potential Conflicts with Other Measures

Are there potential conflicts in implementing a measure with ESA-related federal responsibilities? With Council's fish and wildlife program? With the tribal restoration plan? Mainstem passage measures, such as extended length screens, conflict or fail to conform to the ESA-related federal responsibilities to protect the biological diversity of the listed salmon species. Specific federal programs have been undertaken in cooperation with the states and

tribes to protect individual spawning populations within the listed species. Mainstem passage measures, on the contrary, are not designed or intended to provide protection to other than certain types of individuals from among the populations of some of the listed species. Turbine intake screens, for example, are most effective for fully smolted yearling emigrants typical of most spring chinook and steelhead, and least effective for the unsmolted subyearlings typical of fall chinook. Those mainstem passage measures in the programs that tend to homogenize the salmon populations by selecting against individuals that deviate from averages established by the mitigation measures appear to be in conflict with federal salmon recovery responsibilities.

Independent Engineering Review

What means are available to obtain independent engineering review of the Corps' engineering design, scheduling, cost estimation, and construction practices for mainstem capital fish passage improvement projects? Although this is a legitimate question and one that probably needs answering, our review suggests that the biological rationales for the projects are the problem in reaching cost effectiveness for the overall salmon recovery program. The engineering procedures used by the Corps for implementing its projects are an impediment to cost effectiveness to the extent that they do not take into account a reasonable range of biological concepts and alternatives. No amount of heightened engineering, fiscal, and administrative responsibility can make up for a biologically flawed approach due to deficient biological understanding or hypothesis. Independent scientific peer review of individual projects at the planning stage is one means to address biological deficiencies in the engineering review process.

Criteria for Prioritization Are Needed

What criteria are used by the Corps to select capital construction projects to bring forward to the SCT for consideration, prioritization, and implementation? What criteria are used by the SCT to prioritize annual CRFM Program expenditures? Here, in the ISAB's view, lies the main problem. We address not what criteria are used, but what criteria should be used. Projects must have a sound technical (biological, ecological) basis related to salmon restoration before any other step is considered. Unfortunately, many of the projects we have reviewed exhibit a narrowness of focus that excludes examining the project's relation to salmon recovery

as a whole. These projects provide justification for implementation in terms solely based on the project specific benefit, without considering the three bigger questions of sufficiency, integration, and efficiency of the entire program. The real standard for judging the merits of one project relative to another is not solely the project specific benefit to be provided. The right questions to be answered in justifying a project would consider the salmon recovery program as a whole. These are questions of sufficiency, integration, and efficiency.

- (1) Sufficiency: Whether the entire collection of project specific efforts adds up to a program whose cumulative effect is sufficient to meet the restoration or recovery goal.
- (2) Integration: Whether the entire collection of project specific efforts is well coordinated in their effects, so that project specific improvements in one location, or one phase of the life cycle, is amplified by other project specific improvements in other locations or other phases of the life cycle.
- (3) Efficiency: Whether the entire collection of project specific improvements is efficient, so that the present allocation of effort among the individual projects achieves as large a total return as is possible at this total level of investment.

Appendix Table. CRFMP, SCT Measures Worksheet, FY 99 Program.

FY00 Activity/Description	FY99 SCT Equiv. Score	FY 99 Allocation (000's)	FY00 Estimate (000's)
FY99 SCT Equiv. Score refers to criteria scores for each project determined by the SCT. A higher score equals a higher ranking.			
<u>LOWER GRANITE</u>			
Extended Length Screens - Complete the retrofit or replacement of the existing perforated plates and connections.	369	950	1,510
Juvenile Bypass Facility - Reinitiate design of the new facility, which includes a new flume, holding & loading facility, and channel modifications.	0		970
Surface Bypass Program - Final test of the Lower Granite SBC and BGS. Estimate includes M&E, E&D and potential structural modifications. Final objective and scope of effort to be determined through regional coordination process.	600	3,725	8,260
Additional Barge Moorage - Construction of the two new 75k barges in 97-98 requires the expansion of the existing barge moorage facilities. Design will be completed and a contract awarded for construction in FY01.	na		330
Auxiliary Water Supply - Placeholder for implementation of recommendations from evaluation to be completed in 1999.	324		350
<u>LITTLE GOOSE</u>			
Extended Length Screens - Complete the retrofit or replacement of the existing perforated plates and connections.	364	1,200	1,510
Trash Shear Boom - Install trash boom.	364		4,010
Auxiliary Water Supply - Placeholder for implementation of recommendations from evaluation to be completed in 1999.	324		350
Adult PIT Detectors - Placeholder. Initiate design.			110
<u>LOWER MONUMENTAL</u>			
Auxiliary Water Supply - Placeholder for implementation of recommendations from evaluation to be completed in 1999.	324		350
Adult PIT Detectors - Placeholder. Initiate design.			110

	SCT score	FY99 allocation	FY00 estimate
<u>ICE HARBOR</u>			
Flow Deflectors - Construction completed in FY99		3,800	
Auxiliary Water Supply - Placeholder for implementation of recommendations from evaluation to be completed in 1999.	324		350
AFEP - Closeout costs for '99 work.			60
<u>McNARY</u>			
Extended Length Screens/JBS - Complete the retrofit or replacement of the existing perforated plates and connections. Install orifice shelters for turbine units 1 through 6. Conduct cylindrical dewatering test. Complete replacement of the existing gates and stoplogs along collection channel.	386	3,450	8,570
Fish Ladder Exit Mods. - To simplify and improve the fish ladder exits, the existing tilting weirs will be replaced with fixed vertical-slot control weirs.	200	350	890
Adult PIT Detectors - Placeholder. Initiate design.			110
<u>JOHN DAY</u>			
Monitoring Facility - Operational spring 1998. Complete construction and post-const. Evaluations in FY 98. FY 99 & 00 funding for follow-up corrective actions.	600	1,700	1,180
Flow Deflectors (bays 1 and 20) - Evaluate end bays installation and navigation issue in FY99. Prepare P&S if warranted in FY00; construct in FY 01.	100	250	1,770
PH Surface Bypass - Skeleton bay design suspended (FY 99). Investigate 4-unit skeleton bay installation per SCT request in FY99. For FY 00, placeholder for followup on 4-unit study.	312	200	590
Spillway Surface Bypass - Initiate evaluation of spillway mod alternative to PH skeleton bay in FY99. Complete in 00. Placeholder for FDM for modified spillway and testing spillway weirs in FY 00.	332	140	1,770
Biological Studies - 24-hour spill test in FY 99. Continue HA and radio tracking studies in FY 00.	599	1,900	2,950
Drawdown Study - Conduct Phase I study in FY 99. Complete in FY 00. Further study pending Congressional direction, not assumed to start in FY00.	600	3,300	

	SCT score	FY99 allocation	FY00 estimate
John Day Mitigation Relocation Evaluation (Ringold) - Continue collection and evaluation of permanent relocation. (incl. marking, tagging, transporting) FY99 & 00.	284	200	180
John Day Extended Length Screens - Modify prototypes and bio. tests (including lamprey) in FY 99. Engineering and continued lamprey studies, tugger hoist and maintenance pit mods in FY 00. Decision to procure perm screens in FY 00.	215	2,600	4,130
THE DALLES			
Emergency Auxiliary H2O Supply Study - Initiate FDM for combined water supply and sluiceway outfall relocation in FY99. Start P&S for outfall relocation in FY 00.	355	500	1,120
Adult Channel Dewatering - Initiate design letter report for fishway dewatering improvements in FY99 (Adult pass. Improvs LCO). P&S in FY00.	210	300	730
Spillway and Sluiceway Survival Study - Continue survival studies thru FY 00.	435	2,000	2,720
The Dalles Surface Bypass - In FY 99, biological behavioral studies and additional blocked trashrack tests. FY00, continued bio studies w/ development of blocked trashracks. Placeholder in FY 00 for dev. of surface bypass system.	435	1,650	2,920
The Dalles Juvenile Bypass System - Continue deferral of P&S preparation for conventional screened bypass pending surface bypass/spill survival evaluations.	0	0	0
BONNEVILLE			
PH2 DSM, Monitoring and Outfall Relocation - Continue const. for FY 99 outfall and FY 00 monitoring facility completion. Initiate post-construction bio .tests in FY99.	600	21,900	3,780
PH1 DSM, Monitoring and Outfall Relocation - Continue P&S for potential FY 00 construction start with completion in 2002.	407	5,000	4,130

	SCT score	FY99 allocation	FY00 estimate
PH2 Gatewell Debris Cleaning - Complete letter report (FY 98 funds). Compl.P&S and const. prototype gatewell cleaning system in units 11 & 12 in FY00 for FY01 test.	0		1,180
Surface Bypass - FY99: PH1- limited retest., design for mods to cover units 1&2 for FY00 retest. PH2 - design for chute entrance mods and outfall siting. Initiate high flow outfall study and limited guidance device study. FY00: PH1 - modify prototype and test. PH2 - continue design, potentially start const. for permanent corner collector. Continue high flow outfall studies. Initiate FPE study.	357	6,650	15,340
PH1 FGE - Defer FGE retests until FY00. Also test fish behavior in 00 for potential relocated trashrack test in FY01.	304	300	2,360
Flat Plate PIT Tag Detector - Placeholder for support for NMFS development of technology in FY 99 and 00.	284	50	60
PH 2 FGE - In FY99, initial study to include literature review , model studies, and alternatives report. Placeholder in FY00 to continue studies, if warranted, include. continued model studies and design of prototype measures.	200	800	1,770
Adult Fallback - FY99, review past data, compare modeled flow conditions with fish behavior data, and initial analysis of alternatives. In FY00, placeholder funds to continue studies, if warranted.	386	300	590
PH 2 Fish Units Intake Debris (adult passage improvement) - Evaluation of alternatives to adress debris buildup in front of intake. Followup in FY00 with initiation of FDM for selected alternative, if warranted.	390	200	200
PH 2 AWS (adult passage improvement) - Evaluation of alternatives for auxiliary water supply emergency back-up. Followup in FY00 with FDM/letter report on recommended alternative.	328	200	200
SYSTEM			
Gas Abatement Study - In FY99, complete 60% report, alternative evaluations and num. model; initiate system-wide analysis. In FY00, complete analysis and final report and recommendations (\$ include both NWP and NWW).	344	1,500	950

	SCT score	FY99 allocation	FY00 estimate
Gas Fast Track - Initiate model constr, tests and development at Bonn., McNary, and LoMo. Spill pattern and survival tests at IH. FY00, continue development at Bonn, McNary and LoMo. Decision doc for Bonn. Start L. Goose development. Survival studies at IH and JD. Phys. injury study at IH.	348	3,500	5,900
Turbine Passage Survival - Cam optimization study at McNary, MGR test at Bonn., modeling and bio evaluation at McNary. FY00 - Repeat McNary biological evaluation and Bonn MGR test, complete fish dist. studies, complete Ph I.	360	3,250	2,900
Adult Passage Improvements L. Col - Evaluate JD fish ladder jumping. Implement auto. trash rake @ B1 AWS Valve FV1-1. Initiate auto trash rakes at 3 other intakes. FY00, continue JD study, complete 3 trash rakes, and placeholder for follow on studies or other new measures. (Note: also see The Dalles for fishway dewatering).	210	1,900	1,960
Lower Snake River Feasibility Study - Final wrap-up and completion activities associated with the final Feasibility Report/EIS. Prepare ROD.	600	4,250	890
Turbine Model Study - The Lower Granite turbine model will be completed in 1999.	599	100	0
Aux. Water Supply in Fishladders/Snake River Projects - Recommendations identified in this report (completion in 1999) will be applied to specific lower Snake River Projects.	328	185	
Fish Ladder Temperature Control Evaluations - Alternative engineering solutions will be proposed and evaluated and a prototype will be designed and installed at a Snake River project.	317	60	710
Separator Evaluation - Second year of biological testing of the prototype separator at IH.	599	1200	890
Dispersed Release (Short haul Barging) - Evaluation of feasibility of dispersed released strategy. Investigate vessel and test loading facility designs. No funds proposed for FY 99 or 00.	N/R	0	0
McNary/Ice Harbor Fallback Evaluation - A prototype system will be installed at Ice Harbor and will be tested. If effective, a final system will be installed at both IH and McNary.	352	100	710

	SCT score	FY99 allocation	FY00 estimate
Multiple Bypass Evaluation (AFEP) - Investigate the post-passage survival of juveniles that are diverted through multiple bypass systems. Determine the effects of fallback passage through the juvenile fish facility on the success and rate of upstream passage of adult salmon.	100	740	770
Estuary PIT Recovery (AFEP) - Assess relative abundance and timing, and migration patterns and effects of dredging of migration through the estuary and near shore environment of PIT-tagged juvenile chinook salmon release for the evaluation of transportation and in-river migration from Lower Granite, McNary, and other release groups where applicable.	100	560	770
Adult PIT - FY99/00, provide support, review and coordination for NMFS/BPA research and testing at Bonneville.	400	150	180
Lower Columbia Feasibility study - Initiate scoping for overall study, seek Cong. Approval for McNary drawdown study. Placeholder to initiate study in FY00, including initial McNary drawdown study	200	150	5,900
TOTAL		81,260	100,040

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February 16, 1999