

INDEPENDENT SCIENTIFIC ADVISORY BOARD
851 SW 6th Avenue, Suite 1100, Portland, OR 97204

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Letter / Memorandum (ISAB 98-4)

**To: The Northwest Power Planning Council
The National Marine Fisheries Service**

**Re: The Scientific Basis for Juvenile Fish Passage
Improvements In the Federal Columbia River Power System:
John Day Dam Extended Length Turbine Intake Screens and
Bonneville Dams Bypass System Outfalls**

**First Report:
The ISAB Corps Capital Construction Project
Review**

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Table of Contents

INTRODUCTION2
 Definition of the Assignment.....2
 Preparation of the Response3

JOHN DAY EXTENDED-LENGTH SCREENS4
 Council Questions on John Day Extended Length Screens4
 John Day Conclusions11
 John Day Recommendation:.....12

BONNEVILLE FISH-BYPASS OUTFALL RELOCATION.....13
 Council Questions on Bonneville Hydroelectric Projects Bypass Outfall Relocation13
 Bonneville Outfall Relocation Discussion.....21
 Bonneville Recommendation.....22

REFERENCES23

INTRODUCTION

Definition of the Assignment

This report responds to a request for assistance from the Northwest Power Planning Council (Council) dated January 7, 1998 on issues related to the planned capital construction projects of the U. S. Army Corps of Engineers (Corps or COE) (i.e., the Corps’ Columbia River Fisheries Mitigation Program, or CRFM Program).

The U.S. Congress, in its appropriations bill for FY 98 directed the Council, with assistance from the Independent Scientific Advisory Board (ISAB), to review the mainstem Columbia River capital construction program of the Corps. The review is to evaluate the technical need for costly fish passage strategies at mainstem dams. The Northwest Power Planning Council document of January 7, 1998, identified sets of general and specific questions that Council staff initially felt would help focus the review by the ISAB (Appendix A). Subsequent discussions with the ISAB narrowed the focus at the outset to near-term and long-term assignments. The three near-term assignments are:

1. Role of mainstem fish bypass measures in an ecosystem approach for the Columbia/Snake rivers;
2. Review of the scientific basis for future investment in extended-length bar screens at John Day Dam;
3. Review of the scientific basis for juvenile fish passage improvements at Bonneville Dam.

Long term assignments to be completed in December include reviews of the COE’s programs for surface bypass and dissolved gas abatement (tentatively scheduled for completion in September 1998) and a comparative evaluation of multiple technologies for aiding downstream passage of salmonids.

The Council established a policy context for the review of the CRFM Program concerning possible major alternatives for future configuration of mainstem hydroelectric dams presently under consideration in the region. The following four future alternative system configuration scenarios provided sideboards for the 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.

Preparation of the Response

The ISAB used the Council's scoping document (Ruff 1998) as a guide for its review. Each of the Council's questions was adapted to the specific circumstances of the project being reviewed. We attempted to provide a direct answer to each of the Council's question, with an explanation.

Information for the review was derived from a number of sources. The ISAB received both oral presentations and written documents for its review. The COE staff briefed the ISAB on January 20 and February 17. Each briefing was attended by representatives of other organizations in the Columbia River basin, who also were offered time to provide their views and documents. Lists of the agencies participating and the documents tendered are available on request from Erik Merrill at the Council.

The full ISAB initially discussed the scope of the review and the desired product. A subcommittee of the ISAB reviewed documents and prepared the initial draft report. The draft was reviewed and modified by other ISAB members. This final report is a consensus document of the Board.

JOHN DAY EXTENDED-LENGTH SCREENS

The Corps of Engineers proposes to install extended-length submersible bar screens, ESBS, in the turbine intakes at John Day Dam as a replacement for the standard-length submersible traveling screens now in place. The purpose of the proposed operation is to increase the percentage of the juvenile emigrant salmonids guided into the bypass system for the powerhouse, thereby decreasing the complementary percentage of the emigrants passing through the turbines. This is expected to increase the survival of the emigrants passing John Day Dam based on the theory that emigrants passing through the bypass have higher survivals than emigrants passing through the turbines.

Council Questions on John Day Extended Length Screens

1. How does the concept of John Day turbine intake screening fit within the context of restoration of normative conditions to the Columbia River ecosystem?

The proposal for installation of the John Day extended length screens does not accommodate the natural ecological processes and juvenile salmonid migratory behaviors needed to sustain salmonids in the Columbia River basin, as explained in reviews such as *Upstream* (National Research Council (NRC), 1996) and *Return to the River* (Independent Scientific Group (ISG), 1996).

Screens at turbine intakes at John Day and elsewhere in the Columbia River mainstem inherently run counter to the behavioral characteristics of emigrating of juvenile salmon and steelhead. During periods of active downstream migration, juvenile salmonids characteristically are concentrated in the highest velocity regions of a river, which occur in the thalweg and upper third of the water column. Being drawn into or actively sounding into deep turbine intakes is not a normal behavior of downstream migrants, with the result that many fish are delayed at dam forebays. Delay in the forebay increases risk of mortality for juvenile salmon and steelhead through predation, exposure to high temperatures and communicable diseases.

One aspect of screening turbine intakes that could be considered consistent with natural ecological processes and juvenile salmonid migration behaviors are the location of the screens in the upper portions of the turbine intakes, and diversion to the gatewells. These aspects take advantage of the natural tendency of migrating juvenile salmonids to return to the surface after diving into the turbine intake.

On the other hand, these factors are not likely to apply equally to all species and populations. Due to inherent differences in size, swimming abilities and behavioral responses to bar screens, some populations, species and life history types may experience increases in survival while others may be harmed. Management actions that favor normal ecological processes and support of the typical juvenile salmonid migratory behaviors, such as surface spill and surface bypass, may provide benefits to a broader variety of populations, species and life history types than do remedies such as turbine intake screens.

2. What is the record of effectiveness of John Day turbine intake screening to mitigate for the mortality that would otherwise be inflicted by mainstem hydroelectric dams, and how would the implementation of extended length screens contribute to improving this record? Please address the following specifics in answering this question: a. How has John Day turbine intake screening contributed toward meeting salmon recovery goals? b. What are the positive impacts of John Day turbine intake screening facilities? c. What negative impacts have the facilities incurred?

Definition of terms: Fish guiding efficiency, **FGE**, is the proportion or percentage of juvenile salmon entering the turbine intakes that are diverted into the bypass system. Fish passage efficiency, **FPE**, is the proportion or percentage of juvenile salmon passing the hydroelectric project by routes other than turbines. When all of the river's flow is going into the powerhouse there is no spill, and the FGE is equal to the FPE. At times when not all of the river's flow is entering the powerhouse, FGE is less than FPE. Neither FGE nor FPE taken alone is a measure of survival experienced by juvenile salmon or other emigrants during hydroelectric project passage. Hydroelectric project survival is the proportion or percentage of the juveniles that pass the dam alive during a specified time interval, such as the migration season. The term, "nominal", is given to a numerical survival value when it is applied to a route of passage at a hydroelectric project other than the project at which the survival was actually estimated empirically.

The record of effectiveness of turbine intake screens is uncertain. Large incremental improvements in FGE have been steadily made over the last 20 years at the mainstem dams operated by the COE, as well as at dams operated by other parties. For example, during the 17 years of service at John Day Dam, before standard traveling screens were installed, COE staff estimated that only 2% of juveniles entering the turbine intakes exited via orifices into the "gatewell salvage systems". When standard screens were installed in 1985, FPE for wild yearling chinook improved to about 64% (Table 4 in Anderson et al., 1998). [Note that in the absence of spill at John Day, FGE is equal to FPE]. Similar fish passage efficiency improvements were also realized at other projects during the 1980s when turbine screens were installed. Despite these dramatic improvements in fish passage efficiency, no corresponding improvement in the return rates of wild adult stream type salmon and steelhead above Bonneville Dam has occurred and the downward trend in salmon abundance has continued (National Research Council, 1996; Whitney et al. 1997). Either survival in passing dams was not improved or the improvement was masked by changes in survival elsewhere (often suggested to occur in the estuary or ocean).

The interim objective in both the Fish and Wildlife Program of the Northwest Power Planing Council (FWP) and National Marine Fishery Services' (NMFS) Proposed Recovery Plan is 80% FPE and 95% survival of juveniles past each project (i.e., 95% project survival). The COE expected with the installation of extended-length submersible bar screens (ESBS), to achieve 55%-84% improvement of FGE or 3% project survival improvement for spring migrants and 20-60% improvement of FGE or 4% project survival improvement for summer migrants (IT Briefing Summary). These improvements, if actually achieved, would contribute to the goal of 95% project survival. Installation of ESBS was estimated to increase FGE relative to standard length submersible bar screens (SBS) for yearling spring chinook (58% to 84%), steelhead (86% to 94%), sockeye (41% to 79%), and subyearling chinook (32% to 60%) (Fredericks and Graves memo to Hydro Files, April 9, 1997; Brege et al., 1997; Krcma et al., 1986; Brege et al., 1992; Whitney et al. 1997).

Interpretation of the record of effectiveness of John Day turbine intake screening to mitigate for the mortality that would otherwise be inflicted by turbine passage would depend on how many of the juveniles were passed by the primary non-turbine alternative route, spill. Spill can occur during the migration season either involuntarily when river discharge exceeds the turbine capacity of the dam or voluntarily when spill is used as a management tool to pass juveniles. To evaluate the effectiveness of ESBS, the ISAB sought to verify expected improvements under operational scenarios that included or excluded passage of juvenile salmon by spill. Our efforts to match calculations of effectiveness of ESBS by the Corps and NMFS have highlighted many uncertainties, which are discussed in the answer to Question 3 below. Our calculations suggest that 80% FPE possibly could be achieved with ESBS for yearling chinook, steelhead, and perhaps for sockeye, but probably not for ocean type chinook over the course of an entire annual migratory season. The ISAB calculated that, assuming no juveniles are passed by spill, the reduction in nominal total project mortality of yearling chinook with extended-length screens relative to the standard screens might be 3.1%. The calculation used average numbers that were provided in agency documents for FGE of both screens, mortality in turbines, and mortality in the bypass systems (principally the Fredericks and Graves memo, Anderson et al., 1998, and summaries in Whitney et al., 1997). 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 COE.

Spill decreases the relative improvement in survival of juvenile salmon due to the ESBS. For example, 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 is 1.5% or less. A question for fisheries managers is whether there is a greater increase in survival by voluntarily spilling water or by minimizing spill and depending on screens and fish bypasses to protect fish from turbines.

However, the more important question is whether a putative improvement in project survival of a few percent following installation of extended-length screens will contribute in a meaningful way to recovery of stocks at risk of extinction or to protection of healthy stocks. The answer to this question 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. Analysis that addresses this question quantitatively and currently is not available. The analysis will require thoughtful collaboration between biologists and economists.

When considering species other than juvenile salmon and steelhead, the application of ESBS is indeed uncertain. Any changes in the 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. Impingement of juvenile Pacific lamprey has been demonstrated for the John Day ESBS, but the proportion of migrants affected is not known.

3. What are the major uncertainties or research questions associated with increasing the ability of John Day turbine intake screens to divert juvenile emigrants to the bypass system?

- a. The 80% fish passage goal and the 95% survival goal at each hydroelectric project are policy decisions. It is uncertain how these goals might relate to an expected improvement in the relationship between the numbers of downstream migrants and numbers of returning adults.

- b. 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 dramatic 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, 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 (especially 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 detecting the effects of small, incremental increases in downstream survival of juveniles at a project such as John Day Dam.
- c. The following uncertainties involve the estimation of FPE and project survival. These uncertainties render estimates of FPE and project survival at John Day Dam problematic.
- There is an uncertainty with respect to the number used for downward adjustment of the estimates of FGE for standard screens. In calculating project survival, a downward adjustment of 20% in measured FGEs for screens in the Snake and lower Columbia rivers was made, due to the location of the fyke net array directly below the screens. The fyke array is thought to have pushed more water and fish upward than would have occurred in its absence (Anderson et al., 1998). The basis for this adjustment is tenuous. If the unadjusted FGE number 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 (69%, Anderson et al., 1998), 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.
 - The estimate of bypass mortality (2%) used in calculating project survival may be too conservative. Bypass survival studies have not been conducted at John Day Dam. Numerous uncertainties are associated with bypass survival studies at other dams, which influence their applicability to John Day. Furthermore, NMFS studies at Snake River dams indicate that bypass mortality can be highly variable (0.6-7%; Bill Muir, NMFS, personal communication). Analysis of the sensitivity of project survival to variation in bypass mortality was not available, but it is likely that small changes in bypass mortality could lead to large changes in benefits ascribed to ESBS.
 - Recent empirical studies of project survival of species and life history types at John Day Dam for standard length screens are lacking. Thus, project survival for standard-length bypass screens at John Day must be extrapolated from other sources or earlier studies for determination of expected improvement in survival with ESBS. The use of actual estimates of survival is preferred over the use of nominal figures.
 - Estimation of improvement in project survival is complicated by difficulties in selecting the appropriate FGEs from among those that have been measured (Anderson et al. 1998; Fredericks and Graves memo to Hydro Files April 9, 1997; Whitney et al., 1997). Moreover, the use of average FGEs in determining project survival may bias survival estimates. 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. (Whitney et al 1997). Analysis of the sensitivity of project survival estimates to variation in FGE was not available.

- Detecting effectiveness of small increases in downstream survival of juveniles at John Day on adult returns will be difficult. Rigorous modeling studies were not available to assess the probability of detecting effects of small increases in survival at John Day Dam on smolt to adult return rates (SARs), given variability in survival due to fluctuations in freshwater and ocean conditions.
- d. Increased gatewell turbulence is a consequence of extended-length screens. During orifice blockages, fish in the gatewell cannot exit as intended and smolts would be subjected to increased turbulence for extended periods of time. The actual effects on salmon and other species of prolonged exposure to these higher levels of turbulence have not been measured, however the effects are likely to be harmful. Even in the absence of orifice blockages, turbulence may lead to higher levels of descaling than current designs of standard screens. Knowledge of the effects on survival of juvenile salmon and other species of prolonged exposure to high turbulence, and the effects of descaling on survival of juvenile salmon are uncertainties relevant to understanding the effects of extended length screens at John Day Dam.
- e. There are uncertainties of the effects on fish of increased debris loads in the bypass systems. An unintended consequence of extended screens is their ability to guide more debris into gatewells where it then travels into the bypass system. Although there are programs to check and clean orifices at each project, much of the increased debris goes into bypass systems. Bypass systems have not been specifically designed to minimize the effects of increased debris load on juvenile emigrant salmonids. John Day Dam has an open flume system that makes handling of debris problems easier, nonetheless experience in coping with debris from extended length screens is limited. Debris in dams can pose a serious mortality problem for juvenile emigrant salmonids (Matthews 1992).
- f. There are uncertainties in the development of the engineering criteria. Options for engineering features include angle of deployment of the screen, porosities of backing plates, configurations of vertical barrier screens, location and diameter of orifices, and numerous other features of a complete bypass system. Prototype tests are designed to help select the best combination for the particular project, but these are not necessarily the final features of the full system, as evaluation continues once it is in place.
- g. The following uncertainties are associated with the spill alternative (necessary for a comparative evaluation of ESBS):
- The mix of species included in spill is not known. This is important for measuring the true effects of using spill as a supplement to the FGE of intake screens for achieving the 80% fish passage goal.
 - Spill passage efficiency curves (percentage of emigrants passed as a function of percentage of river flow spilled) are not available for John Day Dam. Because we do not have the spill passage efficiency curve, it is not possible to evaluate the feasibility of passing a particular percentage of emigrants under the operational scenarios posed by the Council. The assumption of a 1:1

relation between proportion of flow spilled and the proportion of the emigrants passed via spill is unlikely to be universally valid at all spill levels (Whitney et al. 1997). Relating levels of spill with levels of adult returns, and smolt to adult survivals will be difficult, just as it has been with evaluation of the effectiveness of bypass systems.

4. How does the existing level of scientific uncertainty affect the use and management of John Day turbine intake screening?

Scientific uncertainty about the effect of the turbine intake screening on the recovery of salmon populations makes use and management of the John Day turbine intake screens difficult to objectively evaluate in terms of long-term population viability. The use of turbine intake screening at John Day needs to be approached with substantial caution in view of the uncertainty.

5. How does the existing level of scientific uncertainty affect the question of whether or not to proceed with increasing the ability of John Day turbine intake screening to facilitate entrainment of juvenile emigrants to the bypass system?

The small nominal increase in survival from installation of ESBS and the existing level of scientific uncertainty concerning the actual magnitude of the nominal increase make it difficult to justify proceeding with installation of ESBS at John Day dam at any cost. The high cost of ESBS makes justification even more dubious, but must be tempered by costs of spill as an alternative. Economic uncertainty (beyond the scope of the ISAB review) needs to be considered.

6. What is the relative likelihood that increasing the ability of John Day turbine intake screening to facilitate diversion of juvenile emigrants to the bypass system will contribute to achievement of the goals of the NMFS Biological Opinion, the Council's Fish And Wildlife Program, or the tribes' 1995 Anadromous Fish Restoration Plan, *Wy-Kan-Ush-Mi Wa-Kish-Wit – Spirit of the Salmon*?

There are a number of goals that could be identified in the three documents referenced. We highlight three of them for our purposes here, the 80% fish passage and 95% survival goal (which are related), an increase in numbers of adult salmon or recovery (which in theory is related to the preceding two), and maintenance of diversity of the salmon stocks.

- a) FPE and project survival goals may not be met for some species and life history types. The 80% FPE goal probably would be achieved by ESBS for yearling chinook, steelhead and coho, and perhaps for sockeye, but it would not be achieved for subyearling chinook. It is difficult to discern whether any increases in project survival would result in increased adult returns.
- b) Biodiversity may not be protected. Ample evidence is available to demonstrate that the collection efficiency of each bypass system varies by species, life history type and population. The FPE goal, if implemented over the long term, could increase survival of some stocks/life histories that pass through the existing system at an optimal time, while the

survival of other stocks/life history types that pass through the system at other times could be unaffected or adversely affected. The FPE goal 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. There is a critical clash 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 individual stocks or spawning populations, while the Corps uses a seasonal average FPE criterion that ignores biodiversity at the stock level. Nearly all evidence for the effectiveness of turbine intake screens has been presented as composite numbers that average across the migration season, for a species (i.e. steelhead) or a life history type of a species (i.e. yearling chinook). These averages are insufficient for ensuring that changes in downstream survival (if detected) would preserve biodiversity.

7. What scientific information is available to compare the John Day fish passage strategies, standard length turbine intake screens versus extended length screens?

a. Are there significant limitations in the scientific information used to evaluate the different John Day turbine intake fish passage strategies? If so, how can the region best fill these information gaps?

The following are significant limitations in scientific information used to evaluate the different John Day turbine intake fish passage strategies. Please refer also to the uncertainties discussed above.

- There is a substantial likelihood that the screening and bypass system selectively favors some life history types/populations/species over others. A constant (average) FGE for each species/life history type was used to estimate seasonal FPE and project survival. FGE can vary with time of year, degree of smoltification, time of day, and other factors that would cause differences in project survival of individual populations emigrating at different times of the year (Whitney et al. 1997).
- We lack rigorous modeling of juvenile survival at a project level. We also lack modeling of the overall life cycle survival. Inferences from these modeling efforts are essential to support the decision to install ESBS. It would have been useful to see model projections pertaining to the sensitivity of juvenile survival at a project as well as life cycle survival. These models should address variability in important factors such as in FGE and bypass mortality. Such models, although imperfect, are available for comparative analyses.
- The use of nominal survival figures creates substantial uncertainty. The nominal increase in juvenile survival through John Day Dam following installation of ESBS is an extrapolation from experience in other localities. Each hydroelectric project is different, hence the concern that experience in other localities does not necessarily apply to John Day. The lack of empirical data pertaining to survival of juveniles at John Day to support installation of ESBS, the uncertainties of bypass survival studies, and potential variability of bypass mortality all lead us to seriously question the magnitudes of the projected benefits of John Day ESBS. Detecting effectiveness of small increases in survival and the lack of data make it difficult to undertake rigorous modeling studies that assess the resulting influence on smolt to adult return rates. This problem is exacerbated by the relatively large variability in

survival due to fluctuations in freshwater and ocean conditions. In short, estimated increases in project-specific survival are so small that even if they occur we may never be able to evaluate their effects on adult returns. Given that we presently have no estimates that apportion adult returns to the effects of turbine intake screens at any single hydroelectric project, it is unlikely that estimates of the cumulative effects of ESBS installed over multiple projects on smolt to adult return rates will be forthcoming.

- We lack empirically demonstrated benefits in SARs from installation of standard length screens, or analytical evidence that installation of screens has slowed decline of some salmon stocks.
- The lack of rigorous comparison (via modeling or other studies) of alternative scenarios to extended length screens such as improved spill efficiency and surface bypass, for achievement of not only 80% FPE and 95% survival but also significantly greater SARs, is a significant limitation in scientific information.

b. Within the constraints of the four operational scenarios provided by the Council, is the effectiveness of John Day standard length turbine intake screens adequate to achieve the interim performance objective of 80% fish passage efficiency and 95% juvenile fish survival at each dam

Under all scenarios, we believe that, with the existing levels of uncertainties, there is inadequate scientific justification to conclude that the objectives will be achieved.

c. Does the proposed implementation of extended length turbine intake screens at John Day Dam have a high probability of achieving the expected biological benefit (salmon survival improvement) without undue risk to other anadromous and/or resident fish populations?

The ESBS likely will favor some species, life history types, and stocks over others and could be detrimental to some species such as Pacific lamprey. The extent of the effects on different stocks is unknown.

d. Does the proposed implementation of extended length turbine intake screens at John Day Dam provide potentially interim (within the next 10 years) biological benefits, or is it consistent with longer-term increasingly normative system configuration strategies?

Improvements in FGE of turbine intake screening are not consistent with longer-term increasingly normative system configuration strategies. Existing turbine intake screening may be used in conjunction with a program to implement normative strategies. However the search for effective means of improving survival of the full diversity of salmon and steelhead populations needs to be expanded.

John Day Conclusions

The incremental approach to salmon restoration embodied in the John Day Dam extended length bypass screen program involves activities that (1) rely on expensive technology and (2) focus on very narrow segments of the life history of the species/population, without linking the segments to the entire life cycle. Incremental approaches often are fragmentary and lack a unifying conceptual foundation and a context in a well-defined restoration strategy. Each incremental activity is acknowledged to bring about only a small increase in survival but the

cumulative increase in survival from all incremental activities is assumed to lead to significant survival advantages for the target species. Reliance on small-scale incremental approaches stems in part from reluctance to make larger-scale, longer-term changes that could have a higher probability of measurable success. Extended-length screens are an incremental technology that provides improvement in average, seasonal FGE over standard screens at diverting migrants from the turbine intake. However, there is uncertainty over whether increased FGE, if achieved, will translate into increased measurable project survival and increased adult returns.

John Day Recommendation:

Implementation of the COE program to install extended-length screens at John Day Dam does not appear to be justified. Instead, the ISAB recommends pursuing existing surface spill alternatives and funding research toward possible deployment of a surface-flow bypass system. Where conventional or extended-length screens are already deployed, integrate their continued use with future installations of new facilities designed to mimic natural processes. Mitigation measures need to improve survival of the full range of diversity in salmon and steelhead populations, while taking into account impacts on other species. We are aware that with the existing screens spill is required in order to supplement the FGE of the screens and move toward the 80% fish passage goal. We are also aware that gas supersaturation restricts the amount of spill so that the 80% goal can not be achieved (Fish Passage Center, 1994; Whitney et al., 1997). Nonetheless we are recommending that strategies other than extended length screens that offer to achieve the 80% goal within gas supersaturation guidelines be pursued.

BONNEVILLE FISH-BYPASS OUTFALL RELOCATION

The COE proposes to relocate outfalls of the bypass systems at both powerhouses in order to move bypassed juvenile salmonids away from 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 (COE briefing to the ISAB). The ISAB has focused its work in this report primarily on evaluating the proposed bypass outfall relocation. However, the concerns expressed over the future of mechanical bypass in the portion of this report dealing with John Day extended length screens also apply to Bonneville.

Council Questions on Bonneville Hydroelectric Projects Bypass Outfall Relocation

1. How does the concept of Bonneville outfall relocation fit within the context of restoration of normative conditions to the Columbia River ecosystem?

The existing bypass outfalls artificially concentrate the juveniles and deliver them to locations where they are highly vulnerable to predation. Concentration of the juveniles into a relatively small volume of relatively slow moving water at a hazardous location is not preferable to alternative means of passage designed to recognize and take into account the natural ecological processes and migratory behaviors needed to sustain salmonids in the Columbia River basin, as explained in reviews such as *Upstream* (NRC, 1996) and *Return to the River* (ISG, 1996). Avenues of passage, such as spill, more closely mimic natural situations and processes that emigrating juvenile salmonids encountered in their evolutionary history. Consequently, such means of passage should be less selective over the entire range of stocks and life history types than foreign or unnatural passage routes. Identifying and implementing more natural passage routes would increase normative conditions at Bonneville and should result in a decrease in juvenile mortalities. (See also the response to Question 1, John Day extended length screens.)

Outfalls are an integral part of bypass systems. The access of emigrants to these bypass systems differs among populations, species, and life history type, artificially altering the individual fitness of emigrants, and ultimately the fitness of populations that comprise the total annual emigration. This is particularly true for later and smaller emigrants that are more vulnerable to predation than are the earlier, larger emigrants. For the long-term, additional and more substantial commitments to normative conditions, such as may be possible with surface bypass collection and spill (with reduced gas concentration), are expected to be required for further improvement of survival of juvenile salmon and steelhead. 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. 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 Bonneville outfall relocation should help reduce artificial selection against later and

smaller emigrants, relocation is not supportive of restoring normative conditions to the extent that the turbine-intake screening and bypass systems, including outfalls, continue to concentrate the juveniles. As a longer term consideration, any advantage of relocation of the outfall might be expected to decrease with time as the current type of predator alters its behaviors in response to relocation of the prey, or as other types of predators are able to take advantage of the concentrated prey.

2. What is the record of effectiveness of Bonneville bypass outfalls to mitigate for the mortality that would otherwise be inflicted, and how would the relocation of the outfalls contribute to improving this record?

Apparent survival rates of subyearling chinook salmon passing through either bypass systems were about the same, or lower, than those of fish passing through turbines of either powerhouse. Ledgerwood et al. (1994) evaluated survival through the bypass system and turbine at the first powerhouse. Survival was lowest through the bypass system, followed by the turbine, and downstream release. Petersen et al. (1993) documented that predatory cyprinid fish (*Ptychocheilus oregonensis*), commonly known as northern squawfish, are abundant near shore in the tailrace at the first powerhouse, and that fish of this species on both sides of the river actively fed on juvenile salmonids that were released at the present bypass outfall. [Note: Some Native Americans find the standardized common name for this predator published by the American Fisheries Society (Robins et al. 1980) to be offensive (Keith Hatch, Columbia River Inter-Tribal Fish Commission, personal communication). Given the current dispute over the standardized common name, we chose to use only the generally accepted form of the binomial, *P. oregonensis*, to refer to this species.]

There have been numerous studies of mortality rates of juvenile salmon (subyearling chinook) in and below the bypass system at the second powerhouse (Dawley et al., 1988; 1989; 1996; Ledgerwood et al., 1990; 1991; Gilbreath et al., 1993; summarized by Whitney et al., 1997). For two experimental lots of subyearling chinook, one passing through the turbines and the other through the bypass, downstream recovery rates of turbine fish were similar to, or slightly higher than, those of the bypassed fish. Recovery rates of subyearlings passing via spill were higher than those for subyearlings passing by either turbine or bypass. Excessive delay of fish in the bypass system has been documented, although these studies did not find exhaustion to be a factor in the delay. The excessive delay may have been due to the use of fish taken directly from a hatchery (unsmolted) for the evaluations. A summary of the results from 1987 - 1990 provided by Gilbreath et al. (1993) can be used to estimate mortality in the tailrace below the outfall as 6.8%. Note that Gilbreath et al. (1993) made this estimate by comparing the recoveries of an experimental lot of bypassed juveniles to those of a downstream release (Whitney et al., 1997). Ledgerwood et al., (1994) reported that at the second powerhouse there appeared to be back eddies or shore areas where predator numbers concentrate.

At the first powerhouse, the present bypass outfall is located in the tailrace near the north shore in low velocity water where *P. oregonensis* are concentrated. At the second powerhouse, the present bypass outfall is located in mid-channel, in the type of location advised by Shively et al., (1996), however, the support structure for the outfall itself provides refuge for *P. oregonensis* that can dart out to take juveniles in passing. In addition, the outfall is below the surface, requiring that the conduit be pressurized. Current criteria for conduits require open, non-pressurized systems (NMFS/NOAA 1994 - Appendix D).

a. How have Bonneville bypass outfalls contributed toward meeting salmon recovery goals?

So far, 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. Contributions toward other salmon emigrants' recovery is unknown, but it is probably reasonable to conclude that whatever benefits may have accrued from the bypass system are probably negated for emigrants of size equal to or smaller than subyearling chinook with somewhat similar timing. 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 *P. oregonensis* predation (several studies by the USGS/BRD, Cook, Washington).

b. What are the positive impacts of Bonneville bypass outfalls?

There are no positive impacts of existing Bonneville bypass outfall locations for emigrants of size equal to or smaller than subyearling chinook with somewhat similar timing, and the expected benefits of the bypass for other species and life history types are highly uncertain.

c. What negative impacts have the facilities incurred?

Total rates of mortality for subyearling chinook emigrants passing through the bypass system (including mortality at and immediately below the current bypass outfalls) is comparable to that experienced with passage through the turbines. For larger, earlier emigrants, even if the outfalls are not a negative factor, the fish passage efficiencies at Bonneville Dam have been historically poor.

3. What are the major uncertainties or research questions associated with increasing the ability of Bonneville bypass outfalls to facilitate survival of juvenile emigrants?

There are uncertainties with the potential adverse effects on juvenile salmonids of transit through a flume that would be about 1.7 miles long (CRITFC submission at the ISAB briefing), including uncertainties with respect to stress and physical injury that might be added during transit. The adverse impacts, if any, of the pipeline will be added to those of the existing screen guidance systems (CRITFC, 1998).

As for effects of the release location on predation, information indicates that though juveniles will be released in higher velocity river flow, they will be more concentrated and some of them simply may swim to lower velocity shoreline water to recover from stress associated with the bypass, and predators may follow (Oregon State University telemetry studies cited in CRITFC, 1988). On the other hand, the juvenile salmon exiting the re-located outfall are expected to have more time to re-orient and recover before encountering predators near shore than at the present outfalls. There is additional uncertainty with respect to the length of time positive effects may exist, because it is possible that existing types of predators may alter behavior in response to changing prey density, and other types of predators may be attracted to the new outfalls.

Although an attempt has been made to consider all features of the new outfall that would reduce predation on the juveniles that exit, please note that their 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.

4. How does the existing level of scientific uncertainty affect the use and management of the Bonneville bypass outfalls?

For subyearling chinook, the bypass system cannot be trusted as a mitigation measure at present due to the nature of the outfall problem (Ledgerwood et al., 1991; Dawley et al., 1992; Gilbreath et al., 1993; Ledgerwood et al. 1994; Dawley et al. 1996). Demonstration of benefits is necessary because outfall relocation may not work as intended. Uncertainties also exist for other stocks and species. The use of mechanical bypass at Bonneville Dam needs to be approached with substantial caution in view of the uncertainty regarding the effect of outfall location on survival of emigrants that pass through it.

5. How does the existing level of scientific uncertainty affect the question of whether or not to proceed with increasing the ability of Bonneville bypass outfalls to facilitate survival of juvenile emigrants?

There is no doubt that the present bypass locations cause artificially elevated levels of mortality (Ledgerwood et al., 1991; Dawley et al., 1992; Gilbreath et al., 1993; Ledgerwood et al. 1994; Dawley et al. 1996). The need for relief is certain. The degree to which salmon and steelhead are dependent on the bypass for improved survival is a matter of decisions about developing proposed alternative passage routes for fish. None of the passage routes except intake screens and spill have been shown to be feasible at this time. Surface bypass systems are under development elsewhere in the basin for possible general deployment, but would probably still require a bypass outfall. We presume that the proposed outfall would be used if surface collection replaces or augments screening of turbine intakes at Bonneville.

Increased efficiency of turbines might improve the rate of survival of juvenile salmon passing through the powerhouse (Whitney et al., 1997). As is the case with outfall relocation, changes in turbine efficiency as they relate to decreased juvenile salmonid mortality would require a number of years to implement, evaluate and fine tune. The potential benefits of increased turbine efficiencies would depend on the size of the emigrant, to name one key stock- and life history-specific variable.

6. What is the relative likelihood that increasing the ability of Bonneville bypass outfalls to facilitate survival of juvenile emigrants will contribute to achievement of the goals of the NMFS Biological Opinion, the Council's Fish And Wildlife Program, or the tribes' 1995 Anadromous Fish Restoration Plan, Wy-Kan-Ush-Mi Wa-Kish-Wit – Spirit of the Salmon?

There are a number of goals that could be identified in the three documents referenced. We highlight three of them for our purposes here, the 80% fish passage and 95% survival goal (which are related), an increase in numbers of adult salmon or recovery (which are also related), and maintenance of diversity of the salmon stocks.

Passage Goal.

The 80% fish passage goal of the three entities (Council, NMFS and Tribes) can not be achieved at Bonneville Dam with the existing bypass systems (Whitney et al., 1997). The existing intake screens have been judged to be unsatisfactory in performance. The FGE for screens at the first powerhouse is thought to be 38% for fish migrating in the spring (Anderson et al., 1998) and 10% in summer (Fredericks memo), while at the second powerhouse, FGE is thought to be 44% in spring (Anderson et al., 1997) and 40% in summer (Fredericks memo). The existing dam configuration does not permit spill to be provided in amounts sufficient to achieve the goals, because of limits on the amount of gas supersaturation and negative effects on upstream passage of adults created by spill. Other measures, such as surface bypass, have yet to be demonstrated effective in achieving fish passage around the turbines (Whitney et al., 1997), but relatively little effort has gone into development of alternatives to date. Improvements in the intake screen systems called for by NMFS and the Council will be counterproductive without modifications of the outfalls to reduce predation, because the expected result would simply be more fish released into the areas of high predation with mortality rates comparable to those that occur in passing through turbines.

Survival Goal.

As a rule, the 95% survival goal is expected to be achieved if the 80% passage goal is achieved (Whitney et al., 1997). This assumes no extraordinary mortalities are associated with bypass passage, as has been the case at Bonneville Dam. Simultaneous efforts are underway to explore alternative measures for improving survival of juvenile salmon at Bonneville Dam. All but spill are in the developmental stages, and while they have the potential for improving fish passage and survival, their actual effectiveness is unknown at this time. An integrated plan for fish passage at Bonneville is needed that goes beyond piecemeal additions to technology such as relocating the outfall, even though that incremental improvement appears valuable.

Other measures that might improve survival at the project are as follows:

Spill.

At present, in order to meet the 80% fish passage and 95% survival goal, spill is provided to supplement the FGE of the turbine intake screens. In practice, the 80% fish passage goal can not be achieved at Bonneville Dam because of the need to limit spill amounts below those that would lead to excess levels of gas saturation (Whitney et al., 1997). In 1995, as an example, only 55% to 62% of the fish were estimated to have passed at Bonneville Dam through combinations of spill and the turbine intake bypass system (Fish Passage Center, 1995; Whitney et al., 1997). The remainder passed through the turbines. Mortality in turbines at the first powerhouse was estimated to range from 11 to 15% by Holmes (in Whitney et al., 1997), and about 4% by Weber (1954) and 2 to 3% by Ledgerwood (1993). Holmes estimates may have been high since some releases were made in the forebay instead of directly into the turbine (Iwamoto and Williams 1993).

Simultaneous efforts are underway by the COE to develop engineering solutions at the spillway and tailrace that should make possible release of larger volumes of spill without producing gas supersaturation that now limits the amount of spill. For evaluating potential benefits of these options, the COE has developed some preliminary projections of improvements

in survival that might be achieved at the project. Until tests are conducted, these must be regarded as speculations. (Bonneville Fish Passage, Presentation Team to ISAB, February 17, 1998). Under most flow conditions, it is unlikely, even with these modifications that spill alone could be provided in sufficient amounts to achieve the 80% or 95% goals without substantially exceeding gas supersaturation limits.

Improved spill effectiveness.

Spill effectiveness is assumed to be represented by the ratio 1:1 at Bonneville Dam (J. Ferguson, COE, briefing to ISAB), i.e. the percentage of river flow that is spill is equal to the percentage of fish that are passed in spill. Spill effectiveness has been improved at projects where it has been tried, either by modifying spill to draw water from nearer the surface, or by spreading the same volume over a 24 hour period (Whitney et al., 1997). There are no direct measurements of spill effectiveness at Bonneville Dam, however, the 1:1 ratio is unlikely to be realized at all spill levels (Whitney et al., 1997).

Extended-length Screens at Bonneville Dam.

The COE began testing a prototype extended-length screen at Bonneville Dam in April 1998 (John Ferguson personal communication). The proposed Recovery Plan calls for installation of a prototype extended-length screen at the second powerhouse in 1999. Any estimate of possible improvement in FGE for juvenile salmonids that might result from installation of extended-length screens would have to wait for results of prototype tests. The poor performance of standard screens at the second powerhouse, installed without prototype tests, underscores this conclusion. Forecasting survival benefits resulting from increased FGE would be purely speculative and unwarranted, given past problems with bypass systems at Bonneville.

Development of a Surface Bypass System

Development of a surface bypass is called for by the Biological Opinion. The COE has ongoing feasibility studies, that have included model studies, and there are plans for a prototype test in 1998 (SCT Measures Work Sheet, 17 Dec 97).

Predator control

With predators acting as a major source of mortality for juvenile emigrants (Riemann et al. 1991), changes in predator abundance and distribution through control efforts and changes in system operations have the capacity to influence the efficacy of all mainstem passage measures, including ESBS and bypass outfall relocation. Since 1990 a program of controlling *P. oregonensis* at known feeding stations below the COE dams has been conducted (Vigg et al. 1990; Parker et al. 1993). In particular, predation is thought to be the principal source of mortalities experienced by juvenile emigrants at the Bonneville bypass outfall (Dawley et al. 1996). Nominal catch rates for the predators below Bonneville have declined by a half to two thirds during the history of the program. Indicators of predator abundances in other nearby locations below Bonneville, such as tailrace density and boat restricted zone (BRZ) density have also declined (Vigg et al., 1990; Parker et al., 1993).

In the longer term, designing routes of juvenile passage that do not artificially enhance the ability of native predators to catch smolts is desirable as a move toward normative conditions. For example, spill has been shown to disrupt concentrations of predators below dams. High rates of predation by Caspian terns on juvenile salmon and steelhead at a dredge

spoil island (Ken Collis, CRITFC, personal communication) downstream near the mouth of the Columbia River were recently discovered. We note that the degree to which the apparent savings of smolts due to removal of fish predators may have been offset by the bird predation is a matter of some concern.

Maintenance of Diversity.

As we pointed out in our transportation review (ISAB 98-2), the bypass systems are inherently selective with respect to species and stocks, due to differences among species and stocks in their response to intake screens and bypass systems. This results in species and stock differences in FGE. Because one mechanism by which the outfalls increase mortality is predation, the outfalls necessarily add another element of artificial selection, since rates of predation are controlled by size of the prey and the water temperature. Smaller, later emigrants are much more highly vulnerable to the effects of the present outfall location than are larger earlier emigrants. Such selectivity, as pointed out above, has the potential of narrowing the phenotypic variability of the stocks, thereby reducing the population fitness (Kapuscinski and Lannan 1986).

7. What scientific information is available to compare the present and proposed Bonneville bypass outfalls to each other, and to other fish passage strategies such as turbines and spill?

Whether or to what degree the relocation will provide relief from the presently extraordinarily high levels of bypass mortality cannot actually be determined until after the bypass outfalls are relocated. However existing information indicates that relocation could provide some relief by releasing the juveniles in areas that are less favorable to predators. There is a considerable volume of research that has established the following information: First, predation at or directly below the outfall of the second powerhouse leads to losses that may be similar to losses in passing through the turbines, (Dawley et al., 1992; Gilbreath et al., 1993; Ledgerwood et al., 1991). While these studies demonstrated that mortality of juveniles within the conduit itself was low, there remained a question whether their transit through the system might have increased their vulnerability to predation (Dawley, NMFS, personal communication). Mortality of subyearling chinook juveniles associated with the bypass at the first powerhouse (either in transit or after exiting) is high enough to counteract any positive effects of diversion from the turbine intakes (Ledgerwood et al. 1994). It is clear that predator abundance is high at the present outfall locations (Petersen et al., 1993), so that mortality at the outfalls and in the tailraces is an integral component of overall bypass mortalities.

Secondly, water velocity and depth criteria for locating bypass outfalls to minimize predation by *P. oregonensis* are well established and documented (Poe et al., 1993; Faler et al., 1988; Shively et al., 1996; NMFS/NOAA, 1994 - Appendix D). They have been developed by laboratory studies of the swimming ability of *P. oregonensis* at various velocities of flow (Mesa and Olson, 1993), and by observations of radio tagged *P. oregonensis* in the river (Faler et al., 1988; Shively et al., 1996).

a. Are there significant limitations in the scientific information used to evaluate the Bonneville fish passage strategies (outfall relocation)? If so, how can the region best fill these information gaps?

Studies at Bonneville first powerhouse do not distinguish mortality rates of salmon experienced in passage at the outfall, or in the tailrace below it, from mortalities in the rest of the bypass system. Estimates of mortality of subyearling chinook salmon passing through the entire first powerhouse bypass relative to downstream release groups have been made (Ledgerwood et al. 1994). However, circumstantial evidence on the presence and behavior of *P. oregonensis* in the vicinity suggests that losses in the vicinity of the first powerhouse outfall are probably high. On the other hand, there is no direct evidence of the effectiveness of the new release location or of the ability of migrants to tolerate a 1.7-mile-long pipe. Both will be evaluated in post-construction monitoring. There is a lack of information on the differential effects of the outfall on survival of different species and life history types, by size and season. The degree to which research is warranted to fill these information gaps depends on the role and purpose of mechanical bypass, as determined by the overall salmon recovery strategy.

b. Within the constraints of the four operational scenarios provided by the Council, is the effectiveness of the new Bonneville bypass outfalls to facilitate survival of juvenile emigrants strategies adequate to achieve the interim performance objective of 80% fish passage efficiency and 95% juvenile fish survival at each dam?

The four policy operational scenarios do not appear to affect the situation at Bonneville Dam. While this question is not relevant to the relocation of the outfalls at Bonneville Dam *per se*, it highlights the need for setting long-term goals in evaluating fish passage. The existing intake screens alone will not achieve the 80% or 95% short-term goals. Spill or other measures would be required to achieve the short-term goals. Obviously, an increase in FGE with improved screens would actually be harmful if the diverted fish are released from the bypass into an area where they would experience a rate of mortality that might be higher than they would experience passing the dam by other routes. In this case attainment of short-term goals would actually be injurious to salmon recovery.

At Bonneville Dam the effectiveness of bypass will have to be evaluated after the outfall relocation is complete. Because spill is now required to achieve the FPE goal, there is a need to know the species composition of fish in spill and the relative efficacy of spill and other measures for passage of juvenile emigrants.

c. Does the proposed implementation of bypass relocation at Bonneville dam have a high probability of achieving the expected biological benefit (salmon survival improvement) without undue risk to other anadromous and/or resident fish populations?

The relocation of the bypass outfall has no known expected benefits or risks for species other than salmon and steelhead as averages over the season. The bypass outfall relocation is likely to reduce rates of predation at the outfalls for all species and stocks that are diverted by the intake screens to a degree that depends on the size of the emigrant and the season of emigration. Rigorous evaluation and appropriate modification (i.e., adaptive management) will be required to assess the results of the outfall relocation.

d. Does the proposed implementation of bypass relocation at Bonneville dams provide potentially interim (within the next 10 years) biological benefits, or is it consistent with longer-term increasingly normative system configuration strategies?

There are both interim and long-term benefits of relocation, although the long-term benefits are less certain than the short-term. In the interim, the relocation will solve the predation problems of the existing bypass systems. On the basis of currently available information, intake screens and the associated bypass systems are expected to be a part of future, long-term salmon recovery programs where hydroelectric dams are operated to produce power at times when juvenile emigrants are present. Increasing normative strategies such as those that rely on surface bypass and higher spill amounts may render the bypass outfall location relatively less important to recovery than it would otherwise be, but the feasibility of these remains to be demonstrated. Benefits of relocation of the outfall may decrease with time if predator populations expand, adapt and diversify in response to the change in habitat in order to take advantage of a concentration of prey.

The outfall is part of the turbine intake bypass system that includes screens known to operate selectively on different species and life history types, as we have pointed out in several places, including our response to the questions on John Day Dam in this report. The search for more effective means of improving survival of the full diversity of salmon and steelhead populations needs to be expanded. Until such means are developed, the decision to relocate the outfalls at Bonneville Dam must be made in consideration of alleviating the presently high mortalities of subyearling chinook through the existing bypass system. These mortality rates are extreme enough that the question of selectivity of the system over time is secondary to the question of immediate survival.

Bonneville Outfall Relocation Discussion

More individual fish and more stocks pass Bonneville Dam, the lowermost project on the Columbia River, than at any other project on the river. Because of this, fish passage improvements at Bonneville Dam are the "keystone" for realizing the benefits of restoration efforts upstream (FWP: NWPPC, 1987). Ideally, Bonneville Dam ought to possess a project survival superior to any other on the river, yet its bypass system is the poorest in terms of FGE and survival of fish exiting the bypass (Whitney et al., 1997). Given the lack of success of past mitigation attempts at Bonneville Dam, what sort of measures should be tried next?

The relative importance of bypass outfall relocation, as well as the desirability of improving FGE at Bonneville Dam, is a function of the success of alternative measures for improving survival of juvenile salmon at the project such as improved spill effectiveness, surface bypass and gas (supersaturation) abatement. The availability of surface bypass and the feasibility of gas abatement will influence the policy decisions on what proportion of the juvenile salmon and steelhead would be passed via spill. Policy makers need to recognize that decisions for expenditures on FGE improvements, and expenditures for 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 Bonneville Dam.

From our long-term perspective, measures designed to improve survival of juvenile salmon may be viewed as being intended to lead to increases in abundance of adults, though the effects may be smaller than can be measured with present methods. The inability to date to relate improvements in survival of juveniles to improvements in adult returns may be due to numerous factors, including inadequacies in the data or in the approaches used. 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.

The fact that few of the measures undertaken in the past on behalf of salmon can be demonstrated to have led to increases in adult populations (restriction of fishing, enforcement, hatcheries and transportation) leads us to the conclusion that new approaches must be developed and tested. 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.

Bonneville Recommendation

The high mortality inflicted upon juvenile salmon by predators at the present bypass outfall locations justifies relocation of the outfalls to locations and habitats where predation rates are expected to be significantly reduced. In addition to relocation of the outfall for the juvenile bypass system, we encourage integrated, long-term planning and study of other planned alterations. Other planned alterations to the juvenile fish passage facilities scheduled at Bonneville Dam, 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 measures (COE briefing to the ISAB). The ISAB recommendation for bypass outfall relocation does not constitute a blanket endorsement of additional changes to the rest of the bypass system at Bonneville Dam. The concerns expressed over the future of mechanical bypass in the portion of this report dealing with John Day extended length screens also apply to Bonneville.

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