

GAO

Report to the Chairman, Subcommittee
on Oversight and Investigations,
Committee on Energy and Commerce,
House of Representatives

September 1990

HYDROELECTRIC DAMS

Issues Surrounding Columbia River Basin Juvenile Fish Bypasses



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**Resources, Community, and
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The Honorable John D. Dingell
Chairman, Subcommittee on
Oversight and Investigations
Committee on Energy
and Commerce
House of Representatives

Dear Mr. Chairman:

In accordance with your request, this report provides our evaluation of the controversy surrounding the Corps of Engineers program for assisting fish migration past certain Columbia and Snake River dams.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time we will provide copies of the report to the Secretary of Energy; the Administrator, Bonneville Power Administration; the Chairman, Northwest Power Planning Council; the Secretary of Defense; the Director, Office of Management and Budget; and other relevant agencies. We will also make copies available to other interested parties upon request.

This work was done under the direction of Victor S. Rezendes, Director, Energy Issues, who can be reached at (202) 275-1441. Other major contributors are listed in appendix II.

Sincerely yours,

A handwritten signature in black ink, appearing to read 'J. Dexter Peach'.

J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

Hydropower facilities in the Columbia River Basin have contributed to an estimated 80 percent decline in the numbers of salmon and steelhead trout that migrate to the ocean as young fish and return as adults to spawn. While undertaking numerous efforts to assist fish migration around its dams, the U.S. Army Corps of Engineers decided against constructing bypasses at two dams to help young fish migrate to the ocean because it concluded that the bypasses' economic benefits would not outweigh their costs. However, fish and wildlife agencies, Indian tribes, and others contend that the Corps' decision rests on a flawed analysis.

The Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, asked GAO to examine the Corps' (1) use of benefit and cost analysis and a computer model used to estimate benefits, (2) consideration of other factors in its benefit estimates, and (3) consideration of the views of outside groups in deciding against constructing the bypasses. In addition, GAO agreed to provide information about bypass effects on fish survival.

Background

Since 1933, the Corps and others have constructed 18 major dams on the Columbia and Snake Rivers to generate electric power, irrigate farm lands, provide flood control, and extend barge traffic. While providing benefits, the dams have also reduced the annual fish migrations that are commercially and socially important to the region and have cultural, religious, and economic significance to Indian tribes.

Because of their critical locations on the lower Columbia and Snake Rivers, eight Corps dams represent barriers to a large number of migratory fish. Although the percentage of declining fish migrations attributable to all its dams has not been determined, the Corps, among other actions to offset the impact of the dams, has constructed bypasses at five of the eight critical dams. The bypasses divert young fish migrating downstream away from electricity-generating turbines, where they can be killed or stunned and made easy targets for predators. In 1988 and 1989, the Corps concluded that the cost of building bypasses was justified at only one of the three remaining dams and requested no funds to construct bypasses at The Dalles and Ice Harbor Dams. However, in fiscal years 1988-90, the Congress appropriated money for designing bypasses at the two dams, and the Corps is currently designing them.

Results in Brief

In estimating benefits, the Corps relied heavily on the results generated by a computer model, despite the model's known limitations, and it

excluded from consideration several potential benefits that would have resulted in the bypasses' estimated benefits exceeding their estimated costs. For example, the Corps did not recognize the potential electricity revenues currently foregone by using water to "spill" young fish through dams rather than to generate electricity. In addition, the Corps did not consider some potential noneconomic benefits, such as the fishes' cultural and religious value, although its engineering regulations require that noneconomic benefits be taken into account. Also, the Corps did not adequately involve fish and wildlife agencies, tribes, or others, as its engineering regulations require, in the studies that led to its decision, and did not revise its conclusion after the groups raised valid concerns when the decision was announced.

The bypass controversy is indicative of an underlying issue: the Corps is not obligated to restore the numbers of migrating fish to a specific level and therefore has no benchmark to assess the need for additional fish migration projects. Decisions about the proposed bypasses are further hampered by the scarcity of information about bypass effectiveness in enhancing the survival of migrating juvenile fish.

Principal Findings

Problems With Benefit Analysis and Inadequate Regional Involvement

To estimate the number of additional adult fish that would return from the ocean if the proposed bypasses were constructed, the Corps used a computer model it developed called FISHPASS. The model simulated the likely survival of young fish passing the eight critical dams on their way to the Pacific Ocean, both with and without the proposed additional bypass facilities at the three dams. By applying a dollar value to the number of returning adults, the model calculated the economic benefits of the returning fish. However, local agencies, tribes, and others noted many limitations in the model, and a review by University of Washington researchers concluded that data limitations render FISHPASS inadequate for making precise determinations of economic benefits. The Corps has acknowledged shortcomings in the data used in the model and the resultant effects on the model's reliability.

By changing certain underlying assumptions used to estimate the benefits, the Corps' analysis could have reached the opposite conclusion. For example, the Corps did not recognize the potential electricity revenues currently foregone by using water to "spill" young fish through the two

dams rather than to generate electricity. Bypasses would enable using spilled water for electricity generation, thus causing the bypasses' estimated benefits to exceed estimated costs at both dams. Similarly, the Corps did not consider some potential benefits, such as the cultural and religious value of fish to the Indian tribes, although its regulations require that such noneconomic factors be considered.

Although Corps regulations require it to conduct planning studies in an open atmosphere to obtain public understanding, trust, and cooperation, the Corps did not adequately involve the agencies, Indian tribes, or other groups in preparing reports on which it based its conclusions about the costs and benefits of the two bypasses. Corps officials said that the reports either were considered to be internal documents or were prepared outside the usual planning process. However, because the studies were used to help make bypass decisions, GAO believes that the Corps should have involved groups with an interest in the bypasses.

No Specific Mitigation Objective and Insufficient Information on Bypass Effectiveness

The Corps has no legal obligation to restore the numbers of salmon and steelhead trout on the Columbia and Snake Rivers to a specific level. Establishing a specific mitigation objective would enable the Corps to base decisions about proposed projects on their contribution to achieving the objective, including projects like the disputed bypasses that were previously rejected on a strict economic cost/benefit basis. This would help the Corps and the Congress decide how to assist downstream fish migration in the most cost-effective manner. However, establishing a mitigation objective may be difficult because, according to Corps officials, comprehensive data on fish migrations prior to construction of the dams do not exist.

The ability to base bypass construction decisions on cost effectiveness may be limited because information about bypass effectiveness is scarce and inconclusive. Although many studies of existing bypasses have been conducted, they have focused on the numbers of juvenile fish entering the bypasses and the fishes' condition after passage. Officials of the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the Corps could identify only two studies that, at the same dam, compared bypasses with alternative ways of getting past the dam. While the results are preliminary, the studies raise questions about the studied bypasses' effectiveness. For example, an ongoing Fisheries Service study shows a higher survival rate for young fish passing through hydroelectric turbines than through a bypass.

Recommendations

GAO recommends that the Secretary of the Army direct the Chief, Corps of Engineers, in consultation with fish and wildlife agencies, Indian tribes, and other interested groups, to establish a mitigation objective and determine which measures, such as bypass facilities, are necessary to meet that objective. GAO also makes several recommendations for improving future analyses of the benefits of projects designed to enhance the survival of migrating fish.

Options for Congressional Consideration

Since no specific Corps mitigation objective exists and recent studies have raised questions about bypass effectiveness for increasing the number of migrating fish, the Congress appears to have three main options for bypass facilities at Lower Monumental, The Dalles, and Ice Harbor Dams. They are to direct the Corps

- to proceed with planning or constructing the bypasses as currently authorized, without establishing a specific mitigation objective or further studying bypass effectiveness;
- not to proceed with planning or constructing the bypasses until the Corps has established a mitigation objective and determined that the bypasses are cost effective; or
- to postpone construction of the bypasses until completion of both the mitigation study and additional research on the effectiveness of bypasses in comparison to other alternatives that affect juvenile fish passage and survival.

Agency Comments

GAO discussed the facts presented in this report with officials of the Corps, the Bonneville Power Administration, the Pacific Northwest Power Planning Council, fish and wildlife organizations, a local utility group, and the Office of Management and Budget. The officials generally concurred with the factual information. As requested, however, GAO did not obtain official comments on this report.

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Abbreviations

BPA	Bonneville Power Administration
FWS	U.S. Fish and Wildlife Service
GAO	U.S. General Accounting Office
OMB	Office of Management and Budget

Introduction

Since the 1930s, hydropower development and operations in the Columbia River Basin have caused the number of migrating adult fish to decline by an estimated 60 percent. These anadromous fish, particularly salmon and steelhead trout, hatch in fresh water, migrate to the sea, and return to their hatching ground where most lay eggs and die. During their downstream migration, an estimated 10 percent to 30 percent of the juvenile fish may be killed as they pass through power-producing turbines at each dam. To avoid the passage of juvenile fish through the turbines, the U.S. Army Corps of Engineers (Corps) and other dam operators have spent millions on structural bypass systems and other improvements at some dams.

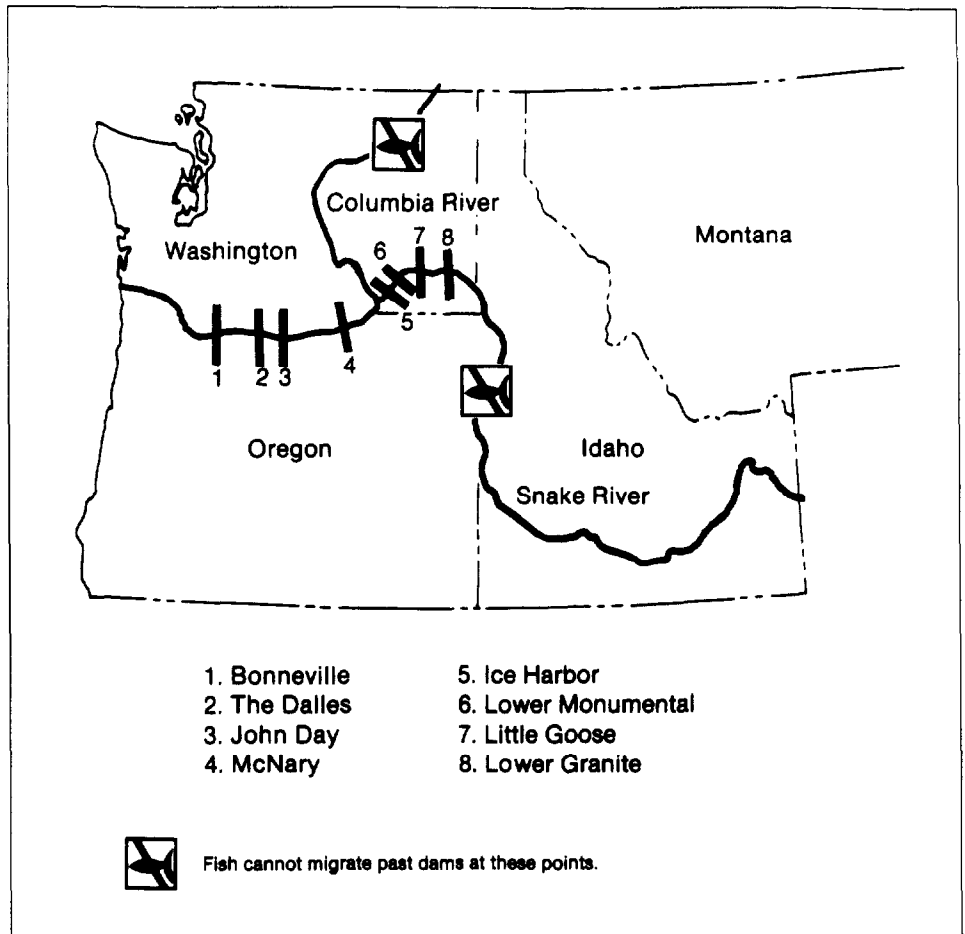
Dams Impede Fish Migration

The Columbia River Basin encompasses parts of several northwestern states and southwestern Canada. Since 1933, 18 major dams have been built on the Columbia River and its main tributary, the Snake River, by the Corps, the Department of the Interior's Bureau of Reclamation, or public utility districts. These dams have hydroelectric facilities that produce a significant amount of the region's electricity, some have navigation locks that extend barge transportation up the rivers, and some have reservoirs that are used for flood control and irrigation.

While providing many benefits, the Columbia River dams present barriers to migrating fish. This is particularly important for eight Corps dams, which because of their critical location on the lower Columbia and Snake Rivers represent barriers to the greatest number of fish, as shown in figure 1.1. Each stream or other tributary in the basin is a potential home for a specific fish "stock," a species or subspecies affiliated with a particular spawning ground. The annual return of adult salmon and steelhead trout, referred to as "fish runs," is of significant economic and social importance to the region and of economic, religious, and cultural importance to local Indian tribes.¹ The average annual run is now an estimated 2.5 million fish.

¹Total fish runs include adult fish that are harvested in the ocean or in the Columbia River before reaching any dams.

Figure 1.1: Columbia and Snake River
Dams on Fish Migration Route



To increase the number of adult fish migrating upstream, facilities such as fish ladders were built to allow the fish to pass upstream.² However, the dams also impede the downstream migration of juvenile fish, which in turn can affect the number of returning adults. Initially, most dams were constructed with two primary ways for juvenile salmon and steelhead trout traveling downstream to get past: (1) in spillage, or water purposely spilled over the dam, and (2) through the turbines of hydroelectric generators.³ It was found that the turbines killed 10 to 30 percent of the juveniles at each dam and stunned, injured, or disoriented others, making them easy targets for predators.

²No ladders were built at the Chief Joseph, Grand Coulee, or Hells Canyon Dams; consequently, fish migration above these dams is no longer possible on the Columbia and Snake Rivers.

³Some dams were constructed with special passages called "sluiceways" to allow ice and river debris to move past the dam; these provided a third route for downstream migration.

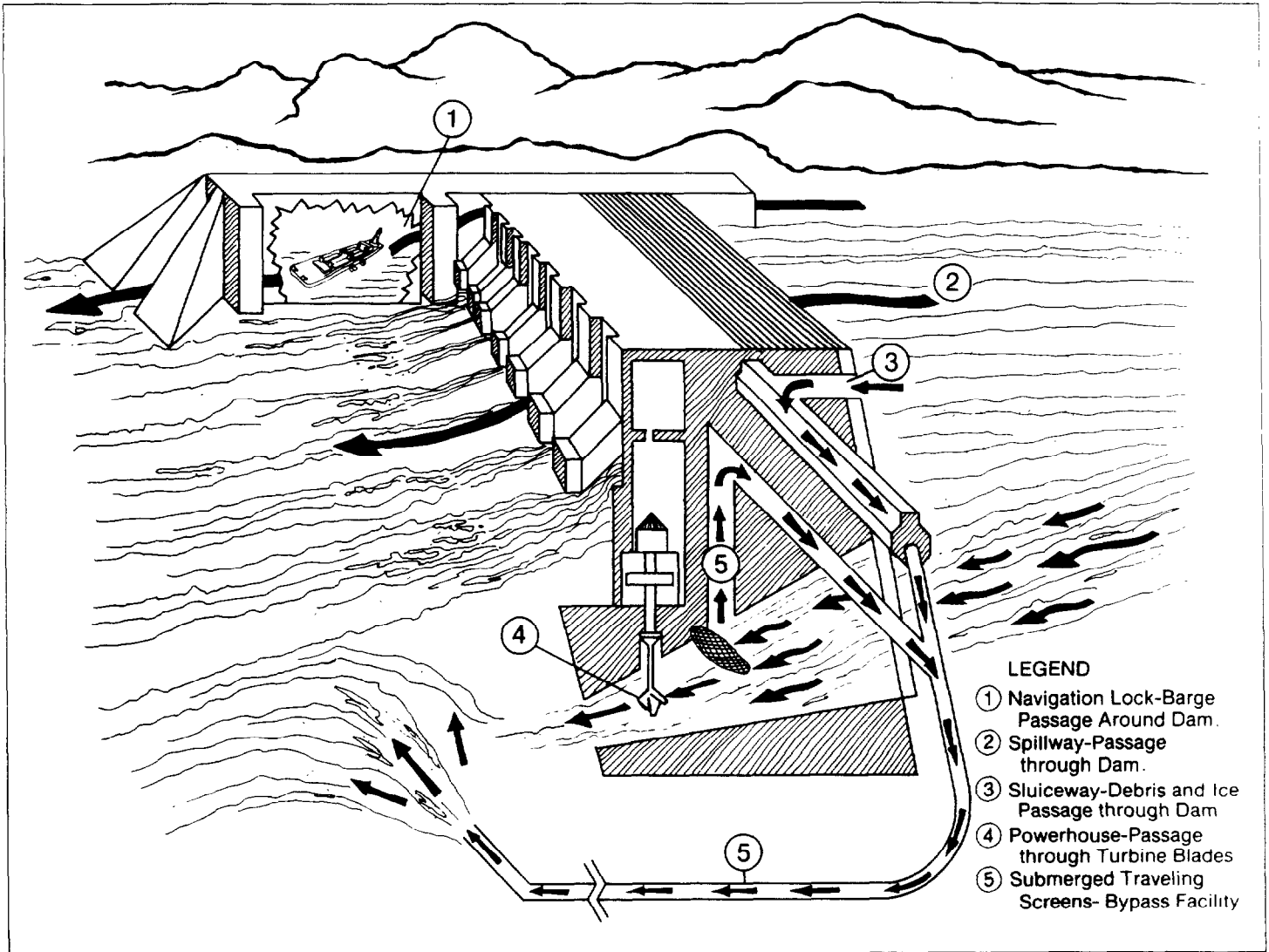
Although the decline in fish runs coincides with the construction and operation of the hydropower dams, the decline is attributable in part to other causes. These include irrigation and flood control measures; overfishing; poor logging, grazing, and farming practices which add to erosion and devegetation of shoreline habitat; and siltation of spawning beds. The total decline from all causes is estimated to be about 80 percent.

Efforts to Improve Downstream Migration

The Corps and public utility districts have spent millions of dollars on structural bypasses and other improvements at some dams to avoid passage of juvenile fish through turbines. These bypasses are designed to divert the juvenile fish away from the turbines and into special conduits that allow them to reenter the river below the dam. In some cases, the conduits are used to collect the fish for loading into trucks or onto special barges, which then proceed downriver and discharge the fish at a point below Bonneville Dam. Bonneville is the last dam before the river enters the sea.

Five of the eight Corps dams on the lower Columbia and Snake Rivers have "traveling-screen" bypass systems, built between 1976 and 1982. Essentially, the screens are rotating devices submerged near the intake openings leading to the turbines; they are used to guide at each dam 19 to 85 percent of juvenile fish (depending on species) away from the intakes toward a special passage conduit (see fig.1.2). Traveling-screen bypasses have not been built at the other three Corps dams: The Dalles, Ice Harbor, and Lower Monumental. The Dalles and Ice Harbor Dams have ice and trash sluiceways which can be used to divert an estimated 13 to 58 percent of the juvenile fish around the turbines and back into the river below the dams. At Lower Monumental, the primary alternative to passing through the turbines is spillage, but construction of a traveling-screen bypass is scheduled for completion in 1992.

Figure 1.2: System for Diverting Juvenile Fish Away From Turbines



The Corps has also constructed eight hatcheries to compensate for losses caused by the four Corps dams on the Snake River, and another hatchery is scheduled for completion by 1991. To compensate for losses caused by the John Day Dam on the Columbia River, two hatcheries were enlarged.

Regional Plans Call for Increasing Fish Runs

In 1980 the Congress passed legislation creating the Northwest Power Planning Council and directing it to plan, among other things, for enhancing and protecting fish and wildlife affected by the Columbia River dams. The Council, an interstate agency, is required to consult with a variety of groups in carrying out its responsibilities. The groups and agencies primarily involved in developing the Council's fish program and their responsibilities are shown in table 1.1.

As an interim goal, the Council's program calls for approximately doubling the existing annual adult fish migration on a sustainable basis, from 2.5 million to 5 million. To help achieve this goal, the program calls for constructing traveling-screen bypasses at Corps dams where such screens do not exist and improving existing bypasses. The program does not specify a time frame for achieving the goal or constructing the bypasses. In 1984 and 1987, the Council program recommended that the Corps install traveling-screen bypasses at The Dalles, Ice Harbor, and Lower Monumental Dams.

Table 1.1: Groups and Agencies With Responsibilities for Columbia River Fish

Groups and agencies	Responsibilities
Bonneville Power Administration, Department of Energy	Marketing electricity from Columbia Basin federal hydroelectric dams; protecting, mitigating, and enhancing fish and wildlife consistent with the Council's program
Columbia Basin Fish and Wildlife Authority	Representing federal and state fish and wildlife agencies and Indian tribes before the Council, Bonneville, and the Corps
Columbia River Intertribal Fish Commission	Providing technical and biological fisheries services to the Nez Perce, Umatilla, and Warm Spring tribes and the Yakima Nation
Federal Energy Regulatory Commission, Department of Energy	Approving and licensing nonfederal hydroelectric projects, taking into account the Council's fish and wildlife program
Fish and wildlife agencies in the states of Idaho, Montana, Oregon, and Washington; National Marine Fisheries Service, Department of Commerce; and the U.S. Fish and Wildlife Service, Department of the Interior	Managing fish resources, including operating hatcheries (all except National Marine Fisheries) and conducting research
Indian tribes—13 tribes in the Columbia Basin	Managing fish and wildlife, constructing and operating hatcheries, conducting research, and improving habitat
Northwest Power Planning Council	Policy-making and planning for electrical power and the Columbia River Basin's fish and wildlife; charged with developing and adopting a program to "protect, mitigate, and enhance fish and wildlife"
Pacific Northwest Utilities Conference Committee	Representing Pacific Northwest utilities in regional planning
Private and publicly owned utilities	Building and operating dams and hydroelectric facilities
State water management agencies in Idaho, Montana, Oregon, and Washington	Regulating water resources
U.S. Corps of Engineers, Department of the Army; and the Bureau of Reclamation, Department of the Interior	Building and operating federal dams, taking into account the Council's program for protecting, mitigating, and enhancing fish and wildlife to the fullest extent practical

The Corps Decided Against Bypasses at Two Dams

According to Corp officials, the Corps is responsible under federal law for identifying adverse effects caused by its dams. However, it is not specifically required to mitigate this damage on completed projects or to follow the Council's plans. To assess whether the Council's recommendation should be followed, the Corps conducted benefit and cost studies for the recommended bypass facilities at the three dams and for other proposed bypass improvements. On the basis of analyses reported in 1988 and 1989, the Corps concluded that, regardless of the impact on attaining the Council's goal, the costs of bypass facilities at The Dalles and Ice Harbor Dams would exceed their benefits. Therefore, according to a Corps headquarters official, the Corps did not seek funds to construct the two bypasses.

Two 1988 reports—one prepared by the Corps' North Pacific Division, (Division) which is responsible for the Columbia River Basin area, and one prepared by a team from Army and Corps headquarters—concluded that traveling-screen bypasses should be constructed at Lower Monumental Dam, but not at Ice Harbor and The Dalles Dams. The Corps sought funding for the bypass at Lower Monumental Dam. A March 1989 report, prepared by the Division's Portland (Oregon) District, found that the estimated benefits did not exceed the estimated costs of constructing submerged traveling screens at The Dalles Dam, and did not recommend that the screens be constructed.

Following the Corps' reports, the Northwest Power Planning Council, Indian tribes, and fish and wildlife agencies questioned many aspects of the methodology and procedures leading to the Corps' conclusions. Generally, the groups believed that the Corps' analyses understated the effective benefits of constructing traveling-screen bypasses. Their concerns included questions about (1) the validity of FISHPASS, the computer model the Corps used to calculate the number of returning adult fish; (2) the Corps' decision not to consider as a bypass benefit the additional revenue possible from using water currently used to spill fish over the dams to generate electricity instead; and (3) the Corps' decision not to consider noneconomic benefits, such as the cultural and religious value of the fish to the Indian tribes, in the analysis. These groups have continued to advocate construction of traveling-screen bypasses at The Dalles and Ice Harbor Dams.

Corps officials at the Division said that, even though the Corps has not recommended the The Dalles and Ice Harbor Dam bypasses for construction funding, the decision is not final. A Corps headquarters official stated that the Corps' proposed budgets for fiscal years 1988-90 did not

request funds for traveling screen bypasses at the two dams. The Corps' budget proposal for fiscal year 1991 did not include funds for bypasses at the two dams. However, planning work for these bypasses has continued by congressional direction; each year, the Congress has appropriated money for and directed the Corps to continue planning the bypasses. For fiscal year 1991, the Senate and House energy and water appropriations bills provide \$2.7 million for continuing bypass work at the two dams.

Objectives, Scope, and Methodology

The Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, asked us to examine a number of issues related to the Corps' decision not to construct bypasses at The Dalles and Ice Harbor Dams. Specifically, we were asked to examine the Corps'

- use of benefit and cost analysis and a computer model used to estimate benefits,
- consideration of other factors in its benefit estimates, and
- consideration of the views of outside groups in deciding against constructing the bypasses.

In addition, we agreed to provide information about bypass effects on fish survival.

We conducted the majority of our work at the Corps' Division in Portland, Oregon. We also conducted work at Corps headquarters in Washington, D.C., and the Division's district offices in Portland, Oregon, and Walla Walla, Washington. We reviewed pertinent Corps reports, studies, and correspondence on the proposed juvenile fish bypass program for the lower Snake and Columbia River dams. In addition, we reviewed laws and Corps engineering regulations applicable to mitigation projects. We visited five of the eight Columbia and Snake River dams where fish bypasses have been installed or are being considered.

To answer the first two objectives, our work took several forms. We reviewed Corps engineering regulations and held discussions with Corps officials and representatives of the Council, fish and wildlife agencies, Indian tribes, and other interested groups. We reviewed the Corps' authority for performing a benefit and cost analysis and conducted a detailed review of the analysis. In our examination of the Corps' use of the FISHPASS computer model, we reviewed the model's user guide, model documentation, and Corps reports that used the modeling results. At our

request, the Corps ran the model assuming that the cost of spill would be included in the benefit and cost calculation and provided us with the results. We also discussed the model with researchers at the Center for Quantitative Science, University of Washington, who are familiar with FISHPASS.⁴ We did not assess the model ourselves to verify its accuracy, reliability, or validity. In our assessment of the potential for the Corps' use of intangible factors, we were assisted by an economist at Washington State University, Pullman, Washington.

To examine the extent to which the Corps considered the views of the Council, fish and wildlife agencies, Indian tribes, and other interest groups, we held discussions with, and obtained documentation from, the Council; U.S. Fish and Wildlife Service, Department of the Interior; National Marine Fisheries Service, Department of Commerce; Bonneville Power Administration (BPA); Pacific Northwest Utilities Conference Committee; Columbia Basin Fish and Wildlife Authority; and Columbia River Intertribal Fish Commission. We also consulted the Oregon Department of Fish and Wildlife and contacted the Fish Passage Center of the Columbia Basin Fish and Wildlife Authority regarding the status of the fish runs.

We reviewed the written concerns on the Corps' decision not to construct the submerged traveling-screen bypasses that these groups sent to the Corps and the Subcommittee Chairman. We identified, in total, 30 specific concerns, which are presented in appendix I. The concerns ranged from assumptions about fish survival in reservoirs, turbines, and sluiceways to the value assigned to harvestable fish.

We discussed the factual information in this report with officials from the Corps, BPA, Office of Management and Budget, federal fish and wildlife agencies, the Council, the Columbia Basin Fish and Wildlife Authority, and the Columbia River Intertribal Fish Commission. The officials generally concurred with the factual information. As requested, we did not obtain official agency comments on a draft of this report. Our work was conducted between May 1989 and March 1990 in accordance with generally accepted government auditing standards.

⁴Bonneville Power Administration has contracted with the University of Washington for a review of the FISHPASS model it used in assessing the impacts of increased power generation on salmon and steelhead.

Limitations in Benefit Analysis and Regional Involvement Raise Questions About Corps Bypass Decisions

The Corps' benefit and cost analysis was not a sufficient basis for its decision against constructing traveling-screen fish bypasses at The Dalles and Ice Harbor Dams. In estimating benefits, the Corps inappropriately ascribed too great a degree of accuracy to the results generated by FISHPASS, which is inadequate to precisely predict the benefits of bypasses. Further, the benefits of building the bypasses would have exceeded the costs if the Corps had included certain additional factors in the analysis, such as the cost of water currently spilled at the dams to assist fish migration.

Although Corps engineering regulations require it to conduct planning studies in an open atmosphere to obtain public understanding, trust, and cooperation, it did not invite regional fish and wildlife agencies, Indian tribes, or others to participate in its studies of the proposed bypasses. According to Corps officials, these studies were outside its normal planning process and the public involvement normally required was not needed. However, because the studies were used to help make a decision about the bypasses, we believe that the Corps should have involved the groups with an interest in the bypasses.

Results Generated by FISHPASS Model Were Used Inappropriately

The Corps inappropriately relied on the benefits calculated by FISHPASS as a precise measure on which to base a recommendation to fund construction. The Corps, other agencies, and regional groups were aware that, due to uncertainties and limitations in the assumptions and data FISHPASS requires to compute benefits, the estimated benefits could not be interpreted as exact amounts. However, in 1988 and 1989 the Corps used FISHPASS results in that way to justify a decision against recommending federal funding for planning or constructing traveling-screen bypasses at The Dalles and Ice Harbor Dams.

FISHPASS Determined Bypass Benefits

The Corps used FISHPASS to simulate the likely survival of juvenile salmon and steelhead passing the eight dams on the lower Columbia and Snake Rivers on their way to the Pacific Ocean, both with and without the proposed additional traveling-screen bypasses at the three dams. In this way, the Corps estimated the numbers of additional (1) juvenile fish that would survive to below Bonneville Dam and (2) adult fish that would return from the ocean, if the proposed bypasses were constructed. The Corps determined a benefit value by applying an average dollar value to the estimated number of returning fish that would be caught by commercial and sport fishermen. The Corps then compared these benefits with estimated costs to build and operate the bypasses.

As shown in table 2.1, the Corps' 1988 analysis concluded that under the best conditions, constructing the traveling-screen bypasses would result in average yearly benefits that exceeded costs by \$586,000 at Lower Monumental Dam, and average yearly benefits that were about \$1.8 million less than average yearly costs at The Dalles and \$870,000 less at Ice Harbor.

Table 2.1: Corps' Estimated Costs and Benefits of Proposed Bypass Facilities

Thousands of dollars			
	Cost	Benefit	Difference
Lower Monumental	\$1,587	\$2,173	\$586
The Dalles	5,905	4,045	(1,860)
Ice Harbor	1,976	1,106	(870)

A 1989 analysis of bypass facilities at The Dalles Dam estimated average yearly costs of \$5,856,000 and average yearly benefits of \$5,610,000. The increase in estimated benefits, compared with the 1988 analysis, resulted from changes in some of the data assumptions, such as the water flows, the number of juvenile fish in the system, and the number of returning adults.

Although Useful for Some Purposes, FISHPASS' Precision Is Limited

University of Washington researchers evaluating FISHPASS concluded in March 1990 that the model may be useful in identifying information gaps or making gross comparisons among alternative proposals, but it is inadequate to precisely predict the actual benefits of alternative fish bypass actions. In addition, the Council, fish and wildlife agencies, and Indian tribes raised numerous concerns about the data and the model (see app. I.) The Corps also has acknowledged shortcomings in the data used to develop FISHPASS estimates and the resultant effects on the model's reliability.

Prior to the Corps' benefit and cost analysis, BPA used a version of the model in 1988 to study the effects that changes in power generation would have on fish in the Columbia and Snake Rivers.¹ Because of controversies that emerged about the model and a recommendation we

¹BPA's version of FISHPASS differed from the Corps' in several important respects. For example, it included only the downstream passage part of the model, while the Corps' version also included the number of returning adults and an economic component for benefit and cost analysis. Also, BPA's version included different stocks of salmon and steelhead, while the Corps' included only spring chinook, fall chinook, and steelhead. Nonetheless, the two versions are similar enough that the concerns raised by the review apply to both.

made in an earlier report for an independent review of FISHPASS,² BPA hired researchers at the University of Washington in 1989 to review its version of the model and the version used by the Corps. One purpose of the review was to “validate” the model—that is, to assess whether users could interpret the results with certainty. The researchers concluded that the Corps’ version of FISHPASS has limitations that preclude being able to validate it.

The researchers’ March 1990 draft report states that FISHPASS’ accuracy for predicting downstream survivals cannot be validated because of an overall lack of biological data. This includes a lack of data on the number of juveniles being guided into the submerged traveling-screen bypasses and the survival of juveniles going through the turbines. According to the draft report, research has been done at only a few dams with one group of salmon, which requires extrapolating limited data into major, but questionable, assumptions about important aspects of fish survival. The researchers have noted that the model may be useful in identifying information gaps or making gross comparisons of proposed alternatives, since it would affect all alternatives in the same manner. However, the draft report states that the lack of data weakens the model as a predictive tool and therefore makes predictions problematical.

Several of the local fish and wildlife agencies and Indian tribes pointed out additional limitations of the model (see app. I). They advised the Corps of their concern that FISHPASS uses specific numerical values for assumptions that have a large range. For example, turbine mortality at a dam may vary from 10 to 30 percent depending on various conditions. However, FISHPASS cannot use the 10 to 30 percent range; it requires a single numeric value, such as 20 percent. Consequently, given the large uncertainty associated with the output results, they said the model should not be relied on to predict fishery benefits. They also pointed out that a more appropriate use of the FISHPASS model may be to rank various fish bypass alternatives for increasing passage of fish downstream.

In 1988 the Army conducted a review of the Corps’ fish bypass program at the request of the Office of Management and Budget and noted that “the level of uncertainty attached to estimates of adult returns is unacceptable.” The Division acknowledged that the results are subject to

²Electric Power: Issues Concerning Expansion of the Pacific Northwest-Southwest Intertie (GAO/RCED-88-199, Sept. 1988).

question because of uncertainties concerning data used in the model. The Corps agreed that the model uses single numerical values and did not consider probability distributions to estimate the expected error range of the model's outputs. The Army report indicated that while the actual degree of uncertainty in the model is not measurable, it must be assumed to be broad.

Results of Benefit and Cost Analysis Are Sensitive to Discretionary Assumptions

The Corps' estimates showed that the costs of traveling-screen bypasses at The Dalles and Ice Harbor would exceed their benefits. However, the estimated benefits could have exceeded the estimated costs by changing certain discretionary underlying assumptions that would have increased estimated benefits.³ Specifically, the Corps did not consider (1) the benefit of using water, currently spilled to assist fish migration, instead to generate electricity, (2) potential differences in the economic value of fish stocks, and (3) the noneconomic value of fish.

Benefit of Avoided Spill

The estimated benefits of traveling-screen bypasses at The Dalles and Ice Harbor would have exceeded the estimated costs if the Corps had included the value of water currently used to spill migrating fish over the dam, as noted by the Council, regional fish and wildlife agencies, and Indian tribes. Construction of traveling-screen bypasses, if effective, may make it possible to increase fish runs without spillage. This would enable the spillage to be avoided in the future, and make the water available to produce power.

In April 1989, BPA; National Marine Fisheries Service; U.S. Fish and Wildlife Service; five Indian tribes; and the states of Idaho, Oregon, and Washington signed a regional fish bypass agreement that provides for spilling water over the spillways of four dams until December 1998, including The Dalles and Ice Harbor, to allow juvenile fish to pass unless effective submerged traveling-screen bypasses are installed. The Corps Division declined to sign the agreement, arguing that (1) the spill was unjustified and (2) increased spillage may have infringed on other Corps responsibilities, such as providing water for irrigation and navigation. However, the Corps plans to continue to implement spill measures within the parameters of the spill agreement as long as there are no unacceptable impacts.

³Changing the same assumptions for the proposed bypass at Lower Monumental Dam would likewise increase the estimated benefits, and would therefore not change the Corps' conclusion in favor of this bypass.

**Chapter 2
 Limitations in Benefit Analysis and Regional
 Involvement Raise Questions About Corps
 Bypass Decisions**

The regional spill agreement had not been signed at the time of the Division's benefit and cost analysis of The Dalles and Ice Harbor bypass facilities. According to a Division official, they did not include the benefit of avoided spill in the analysis because (1) they did not consider spilling water to assist fish migration to be an economically justified measure and (2) when the analysis was prepared, they were not spilling water for juvenile fish at the two dams. Division officials said they made this decision because they do not believe spill is an efficient way to bypass fish and they therefore disagree with having to include it in their analysis.

At our request, the Division recalculated the estimated benefits and costs of proposed traveling-screen bypasses at The Dalles and Ice Harbor Dams. The Corps used the same methodology as in its 1988 report except that it incorporated as a bypass benefit the value of spillage (called for in the agreement). By changing this one assumption, the analysis showed that the estimated benefits of traveling-screen bypasses at The Dalles and Ice Harbor Dams would exceed the estimated costs. Table 2.2 compares the analyses with and without the value of the avoided spill.⁴

Table 2.2: Comparison of Proposed Bypass Projects With and Without Benefit of Avoided Spill

	Ratio of benefits to costs ^a	
	With avoided spill benefit	Without avoided spill benefit
The Dalles	1.02	0.43
Ice Harbor	1.12	0.47

^aAssumes that Ice Harbor bypass is completed in fiscal year 1993 and The Dalles in fiscal year 1996.

We believe the value of water currently spilled to assist fish migration should have been included in the Corps' analysis because regional officials suggest that water will be spilled as long as traveling-screen bypasses are not in place. Corps officials agreed that changing this one assumption would result in the estimated benefits exceeding the estimated costs for bypasses at Ice Harbor and The Dalles Dams. However, they stated that any subsequent analysis should take into account

⁴Officials in the region noted that while the Spill Agreement expires in fiscal year 1999, there is a strong possibility that additional spill will continue as needed; consequently, the analysis included a 50-year period since this is the expected useful life of the bypasses.

revised engineering estimates, which could result in the estimated costs again exceeding the benefits for The Dalles and Ice Harbor bypasses.⁵

Differing Values Among Fish Stocks

Because the Division's version of FISHPASS does not distinguish between different fish stocks, the estimated benefits do not recognize that certain stocks may have a higher value than others. Fish stocks are differentiated on the basis of their spawning ground location. FISHPASS assigns each species of fish a dollar value based on the combined commercial and sport values of the species; thus, all stocks of a particular species are valued equally.

However, as noted by the regional groups, circumstances may suggest that a particular fish stock should be assigned a higher value. For example, due in part to the migration difficulties imposed by the dams, fewer fish return to spawning beds in the Snake River than to those located just above or below Bonneville Dam on the Columbia River. Thus, additions to a particular fish stock with spawning grounds in the Snake River might be valued higher, from a cultural or aesthetic standpoint, because of its scarcity.

For example, in March 1990, the Shoshone-Bannock tribe petitioned the Secretary of the Interior to list the Snake River sockeye salmon as an endangered species, and in May 1990 Oregon Trout, a public interest group, petitioned for rules to list Snake River spring, summer, and fall chinook and lower Columbia River coho salmon. Because the Corps did not distinguish among stocks, potentially threatened or endangered species were not afforded a higher value than that assigned to all other fish on the basis of sport or commercial values.

Value of Noneconomic Benefits

Corps engineering regulations require that project analyses identify and consider noneconomic factors, such as environmental effects, to the fullest extent practicable. However, the Corps did not include noneconomic considerations in its analysis of the proposed bypasses, stating that it did not have a reliable way to place a value on them. While assigning values is difficult, evidence suggests that such factors are applicable to the proposed bypasses. Consequently, we believe the Corps' analysis should have incorporated them.

⁵For example, the Corps officials said that engineering analysis has shown that there is a reduction in electrical generation when a traveling screen is placed in front of a turbine.

A 1989 Corps survey suggests that both fishermen and nonfishermen in the region derive an "existence benefit" from knowing there are fish in the river. The Division initiated the survey to determine how much people in the region would be willing to pay to double the number of fish in the Columbia River. The results of this survey indicate that 54 percent of the nonfishermen and 88 percent of the fishermen are willing to pay higher electricity bills to double the size of the fish populations. The users and nonusers stated they would be willing to pay, through higher electric bills, a combined average of \$68.49 per year to double the fish runs.

In addition, Indian tribes attribute ceremonial, cultural, and religious significance to salmon and steelhead in the Columbia River. For the value of the expected harvest of fish by Indian tribes, the Division used the fishes' commercial value, because the majority of the fish caught by Indians are sold through commercial channels. In the Indians' view, according to the Director of the Columbia River Intertribal Fish Commission, this does not reflect the full value of the fish to their way of life and view of the world. He said the Indians believe that no economic value could ever justify the damage done to the Northwest fisheries. They are especially concerned about particular fish stocks that have been important to them and now are badly depleted by the effects of dams, overfishing, and other factors. They consider the value of a project that restores these depleted stocks to be much greater than the economic value of fish added to already abundant parts of the fishery. (For additional regional comments on noneconomic factors, see app. I.)

We believe the Corps could have done more to consider noneconomic values, such as those mentioned above, in its analysis, even if attaching a precise dollar value was not feasible. The estimate of project effects could have focused on particular fish stocks where nonmonetary values might be quite high. The total value of additional fish in these key locations, such as stocks in Idaho, could be well above the average system-wide value for sport and commercially caught fish. Once effects that have significant nonmonetary values are identified, generally accepted project analysis principles exist that can provide guidance for deciding whether the investment is justified. The Corps' own engineering regulations provide guidance on accommodating nonmonetary values in an analysis.

Although the Division and Portland District analyses showed that the costs of proposed bypass facilities at The Dalles and Ice Harbor Dams would exceed their benefits, the differences were comparatively small;

for example, the estimated excess annual cost of a bypass at The Dalles was \$246,000. In this situation, recognizing the value of noneconomic benefits would have provided a basis for an informed judgment about whether the noneconomic values would be worth at least as much as the excess costs.

The Corps Gave Limited Consideration to Others' Views

Regional fish and wildlife agencies and Indian tribes were not adequately involved in the Corps planning reports that determined whether the traveling-screen bypasses at The Dalles and Ice Harbor Dams should be recommended for Corps funding. Corps headquarters officials stated that because these studies were outside its normal planning process, public involvement was not required. However, because the studies were used to make a decision about the bypasses, we believe that the Corps should have involved the groups with an interest in the bypasses.

Requirements for Coordination With Interested Parties

Corps engineering regulations provide that state and local participation in Corps planning studies shall be encouraged throughout the planning process. Specifically, the engineering regulations provide for the following:

- Planning studies are to be conducted in an open atmosphere to attain the understanding, trust, and mutual cooperation of the public, including state and local governments and Indian tribes, and must provide the public with opportunities to participate throughout the planning process.
- An effective public involvement strategy must be developed and implemented, and the final report must discuss how the information gained from the public was used in the planning process.
- Full consideration must be given to reports and recommendations furnished by the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and state fish and wildlife agencies as required by the U.S. Fish and Wildlife Coordination Act.

In addition, the Corp is required by the Pacific Northwest Electric Power Planning and Conservation Act (the Northwest Planning Act) to coordinate its actions with the Department of Interior, National Marine Fisheries Service, and appropriate state fish and wildlife agencies, to the greatest extent practicable. While the Corp must also take into account the Council's program to the fullest extent practicable, the Corps is not required to implement the Council's recommendations.

Corps Made Limited Coordination Efforts on Bypass Studies

Since 1986, four Corps reports have dealt with the issue of constructing traveling-screen bypasses at The Dalles and/or Ice Harbor Dams. Three of the four reports concluded that the traveling-screen bypasses should not be constructed; one found that bypasses could be justified at Ice Harbor Dam, but it was not made available to the public. In preparing the first two reports, the Corps did not involve the Council, fish and wildlife agencies, Indian tribes, or the public. For the third, the Corps requested the Council to provide written comments on the need for building additional bypasses on the Columbia and Snake Rivers. However, the Council did not believe this was adequate involvement. The Corps did solicit and receive public comments on a draft version of the fourth report but did not substantially change the report's overall conclusions.

Lower Snake River Study

The Lower Snake River Study,⁶ prepared by the Corps' Walla Walla District office, investigated the feasibility of installing traveling-screen bypasses at Lower Monumental and Ice Harbor Dams. The report's benefit and cost analysis showed that traveling screens could be justified at these two dams. Officials from the Council, U.S. Fish and Wildlife Service, and the National Marine Fisheries Service told us they were unaware of the study until we brought it to their attention. Walla Walla District officials confirmed that no one outside the Corps had been involved in this study and that it had not been released since it was considered an internal study.

Goals Report and 1988 Bypass Report

The Goals Report⁷ and the 1988 Bypass Report⁸ concluded that traveling-screen bypasses should be constructed at Lower Monumental Dam, but not at Ice Harbor and The Dalles Dams. Both reports were made available to interested parties only after they were completed. The Goals Report was prepared by the Division, and the 1988 Bypass Report was prepared by a team from Army and Corps headquarters.

The Corps did not allow others to participate in preparation of the Goals Report even when asked. In a September 23, 1987, letter, the Columbia River Intertribal Fish Commission asked that Corps headquarters direct the Division to consult with the Commission in preparing the report. The letter explained that the Commission had made a similar request to the

⁶Lower Snake River Juvenile Fish Guidance Efficiency Study, Incremental Economic Analysis, Reconnaissance Report, April 17, 1986.

⁷Juvenile Fish Bypass Goals, April 4, 1988.

⁸Report on the Columbia River Fish Bypass Program, July 22, 1988.

Division, which had denied the request on the basis of directions from headquarters. The letter stated that the tribes, as co-managers of the fishery resources in the Pacific Northwest, could provide meaningful input to the development of fish passage goals.

On October 14, 1987, Corps headquarters advised the Commission:

At the present time, a working draft of the report is being reviewed by the staff here in Washington. We have always had every intention of sharing the report with you, the Federal and state resource agencies, and all other groups that have an interest in the fish bypass program. However, I believe it would be inappropriate to release the report while it is still under review within the Corps. I am sure you can appreciate the confusion that could result if the report was revised while you were reviewing the original draft. When our review of the report is complete and we have developed a Corps of Engineers position on the issues, we plan to fully coordinate the report with you and all other interested parties. [Underscoring supplied]

A Division official stated that the final Goals Report was issued to the public on April 14, 1988, without prior involvement or review by interested parties. On June 28, 1988, the Columbia Basin Fish and Wildlife Authority provided 15 pages of comments to the Division on the Goals Report. The Corps did not respond; a Corps official advised us that this lack of response was an oversight.

On July 6, 1988, the Council provided comments on the final report, and on August 29, 1988, the Division responded in part as follows:

One concern mentioned in your letter was the lack of Council participation in preparation of the report. I want to emphasize that the Goals Report was prepared as an internal discussion paper intended to look at the incremental economic benefits of the bypass options under consideration. We fully intend to coordinate the project-specific reports with the regional resource, power, and planning agencies.

The Division's detailed response was primarily a rebuttal to the Council's comments. The Corps made no revisions to the Goals Report based on the specific comments made.

The 1988 Bypass Report, prepared by a team from Army and Corps headquarters, essentially affirmed the conclusions of the Goals Report. On June 20, 1988, the Corps team working on the 1988 Bypass Report asked the Council to provide comments by July 6, 1988, on the need for the bypasses. The Council responded on July 6, 1988. Council officials stated that this was not adequate involvement in the study. They also said they did not even see the report until it was issued in final.

1989 Dalles Report

According to a Division official, the only project-specific report on The Dalles or Ice Harbor Dams since the Goals Report concerned a study, begun in 1984, of juvenile fish passage at The Dalles Dam. On January 12, 1987, the Corps' Portland District requested comment on the draft report, which did not recommend funding a traveling-screen bypass at The Dalles. The report showed, of the options considered, that transporting juvenile fish from John Day Dam to a location below Bonneville Dam had the highest net benefits;⁹ however, additional studies were recommended to answer unresolved issues.

The Portland District provided the draft to interested parties and asked for comments. On January 30, 1987, the U.S. Fish and Wildlife Service replied to the draft and stated in part:

No consultation with the fish and wildlife agencies and Indian tribes was provided during the development of this report and the short comment period has not provided sufficient time for a detailed review of the document. Consultation should have occurred during the report development and more time should have been provided for detailed review to ensure that the report provides a complete and accurate evaluation of alternative juvenile fish collection-bypass facilities at The Dalles Dam.

Comments were also received from the Columbia River Intertribal Fish Commission, the State of Idaho, Bonneville, and National Marine Fisheries Service.

The agency comments and the Corps rebuttals were included in the March 1989 final report,¹⁰ but the Corps did not substantially change the overall report conclusions. The estimated benefits did not exceed the costs for submerged traveling screens and they were not recommended for construction, but additional studies were recommended. The report also concluded: "Only the John Day transport appears economically viable."

Corps Officials Stated That
Engineering Regulations
Did Not Apply to Studies

Corps headquarters officials advised us that for normal Corps planning studies, interested parties, the public, and government agencies are involved from the beginning. They said, however, that these four studies were either internal (the case for the first three reports) or were outside the normal Corps planning process (the case for The Dalles General

⁹Net benefits are computed by subtracting the cost of a proposed project from its total estimated benefits.

¹⁰General Letter Report—Juvenile Fish Passage, The Dalles Dam, March 1989.

Letter Report.) Consequently, the Corps does not believe the engineering regulations were applicable and did not seek involvement of other parties.

We believe it is clear that the Corps used the studies to make decisions about the proposed bypasses. Consequently, we believe the Corps should have done more to promote public understanding, trust, and cooperation regarding the proposed bypass facilities.

Officials from the Council, Fish and Wildlife Service, and National Marine Fisheries Service told us that they believed the Corps' effort to involve others was inadequate for the four reports. The officials also stated that their agencies should be involved from the beginning of a study. In their view, to provide comments on a draft report is not adequate involvement.

Conclusions

While benefit and cost analysis can be a useful technique to help make decisions, the results in this instance were not a sufficiently clear basis for the Corps' decision not to construct bypasses at The Dalles and Ice Harbor Dams. The Corps did not sufficiently take into account the limitations of the FISHPASS computer model used in the analysis. In addition, the analysis was sensitive to underlying assumptions; for example, had the benefit of avoided spill been included and had noneconomic considerations, although difficult to quantify, been considered, the estimated benefits would have exceeded the estimated costs. Further, the Corps' decision not to include other parties in the bypass studies was not appropriate given the Corps' use of the studies to make a decision important to others in the region.

Also, while the Corps decided that it was not obligated to include other parties in the studies leading to its decision against building traveling-screen bypasses at The Dalles and Ice Harbor Dams, it is clear that its planning was not characterized by the spirit of public involvement called for by engineering regulations.

Recommendations

Because the Congress has authorized the Corps to plan and construct bypasses at Ice Harbor and The Dalles Dams, we are not recommending that the Corps prepare new estimates of their costs and benefits. However, if estimates of the benefits of proposed projects for increasing the survival of juvenile fish in the Columbia River Basin are made in the

future, we recommend that the Secretary of the Army direct the Chief, Corps of Engineers, to

- use validated models that can identify the degree of uncertainty or provide a probability range;
- recognize the impact of avoiding water spilled to assist fish migration, if such spill is an existing practice;
- consider the status of stocks in addition to species of fish;
- consider the value of intangible factors, quantified to the fullest extent practicable, in the decision-making process, and
- consult with the Council, fish and wildlife agencies, Indian tribes, and other interested parties in carrying out these actions.

Fish Bypass Decision-Making Is Hampered by Lack of Specific Objectives and Data on Bypass Effectiveness

The controversy over the Corps' decisions against constructing traveling-screen bypasses at The Dalles and Ice Harbor Dams is indicative of an underlying issue: the Corps is not obligated to restore Columbia River Basin anadromous fish populations to a specific level. Consequently, the Corps has been unable to analyze proposed projects on the basis of their contribution to a specific mitigation goal, regardless of the magnitude of costs or benefits. Establishing a mitigation goal may be difficult, but the lack of such a goal hampers project analyses and contributes to uncertainty over the Corps' budget.

The ability to make decisions about the proposed traveling-screen bypasses is further hampered by a scarcity of information about their effectiveness in changing the survival of migrating fish. The limited information available about existing bypasses is inconclusive regarding their effectiveness for facilitating the downstream migration of juvenile fish, and thus for increasing the numbers of returning adult fish.

While Difficult to Establish, Mitigation Objective Would Provide Benefits

Over the years, the Corps has undertaken many projects to mitigate for damages to fisheries caused by the Corps' dams; some of these are discussed in chapter 1 of this report. However, according to Corps officials, the extent to which the eight Corps dams have contributed to declines in fish runs has never been fully determined, and the extent of the Corps' remaining obligation to further increase the fish runs is unknown. Thus, the Corps does not know if prior mitigation efforts are sufficient or if more needs to be done.

The Corps, other agencies, and Indian tribes involved in the controversy over traveling-screen bypasses agree that a specific mitigation objective is needed. Further, officials from the Corps and the Office of Management and Budget (OMB) have recognized that establishing a specific mitigation objective will help determine future funding levels. With a specific objective established, the Corps can base project construction decisions on the projects' contribution to achieving any portion of the objective which has not yet been met.

Establishing Mitigation Objective May Be Difficult

Establishing the Corps' mitigation objective may be difficult. Corps officials believe complete data on the Columbia and Snake Rivers' fish runs prior to construction of the dams do not exist. In addition, the size of runs prior to the dams may not represent a realistic goal because the rivers' characteristics may have changed to the point that they can no longer handle migrations of that size.

According to the Council, the dams have changed the rivers from fast-flowing streams to a series of reservoirs. Whereas a juvenile fish could migrate to the ocean in less than a month before the dams were built, migration can now take two to three times as long depending on water conditions. If the journey takes too long, juvenile fish may be physically unable to adjust to salt water once they finally reach the ocean and thus die. Also, a longer time in the river increases exposure to predation.

We believe that establishing a mitigation objective may also require decisions on such matters as the following:

- Will the mitigation objective be based on the number of juvenile fish surviving downstream migration, or will it be based on the number of returning adult fish?
- If the objective is based on the survival of juvenile fish, should an objective exist for each dam, or for the river basin as a whole?
- Will the objective be expressed as an aggregate number of fish, or will it be disaggregated by characteristics such as species or stock, geographic location within the river basin, or classification as wild or hatchery-bred fish?
- Whether based on juvenile or returning adult populations, should the measure be taken daily or seasonally?

Corps, OMB Favor
Mitigation Objective for
Budgetary Reasons

In the 50 years since Bonneville Dam (the first major dam on the Columbia) began operating, the Corps has spent about \$300 million on fish passage at its eight dams, about \$100 million of it for downstream juvenile passage. In addition, over \$200 million has been spent on hatcheries and research. In June 1990, the Corps estimated that if all projects currently proposed were built, including the bypasses at The Dalles and Ice Harbor, the program would cost approximately another \$233.9 million over the next 10 years.

A Corps official stated that while justified fish bypass measures installed in the past have received support in administration budgeting as part of ongoing construction, federal deficits have changed this picture since 1987. OMB officials have expressed interest in establishing a mitigation objective in order to determine the extent of federal responsibility for funding additional projects. Similarly, the Assistant Secretary of the Army for Management and Budget and other officials at Corps headquarters told us they favor a study to help determine their remaining mitigation objective.

Establishment of a mitigation objective has received consideration in proposed Corps budgets. OMB deleted from the budget for fiscal year 1990 funds the Corps had proposed for constructing bypass measures, citing the need for a mitigation study. The administration's proposed fiscal year 1991 budget contained \$1 million to start a 2-year mitigation study. The Senate energy and water appropriations bill for fiscal year 1991 provides for the proposed mitigation analysis, but the House bill directs the Corps to use the \$1 million instead for additional study at Ice Harbor Dam.

Establishing a Mitigation Objective Would Facilitate Project Analysis

Corps engineering regulations require that, when a mitigation objective is established, a technique called incremental analysis must be used to evaluate specific projects. Incremental analysis involves (1) identifying all the measures, or increments, that could be taken to achieve the same objective and (2) ranking them according to their cost effectiveness. Using this approach, the most cost-effective increments (set of projects) can be selected to meet the objective. This would provide the Corps and Congress with a means for deciding how to assist downstream fish migration in the most effective manner.

Incremental analysis may require selecting measures whose individual benefits, in a strict economic sense, do not match their costs since noneconomic benefits are also required to be considered. Thus, this approach could result in selecting construction of bypasses at The Dalles and Ice Harbor, as long as they were determined to be the most cost-effective alternative for meeting the objective, even if their economic benefits were not shown to be greater than their costs.

Bypasses' Effect on Juvenile Fish Survival Is Inconclusive

Our review of the Corps' project analysis revealed that little information is available about the survival effectiveness of traveling-screen bypasses, which further hampers decisions as to whether or not the proposed bypasses should be constructed. The limited information that has been collected paints an inconclusive picture as to whether bypasses have a significant effect in raising the survival rate of juvenile fish migrating downstream and the number of returning adults.

Numerous studies have been conducted of existing traveling-screen bypasses at Corps dams on the Columbia and Snake Rivers. These studies have dealt with how many fish are being guided into the bypass and the condition of the fish after using the bypass. However, Corps, National Marine Fisheries Service, and U.S. Fish and Wildlife Service

officials could identify only two studies that have been done that directly compare at the same dam the survival of salmon using the various routes to get by a particular dam. Neither study has so far produced conclusive evidence that bypasses enhance the survival rate for juvenile fish. A study at Lower Granite Dam indicated a lower survival rate for fish using the traveling-screen bypass than for fish using other means to get by the dam, such as the spillway or turbines. Preliminary results from an ongoing study at Bonneville Dam have shown a higher survival rate for juvenile fish going through the turbines than for juvenile fish using the traveling-screen bypass.

Lower Granite Dam Study

To determine the survival of the juvenile spring chinook salmon, the Corps funded a study in 1986 at Lower Granite Dam. The objective of the study, which was conducted by the National Marine Fisheries Service, was to estimate the short-term survival and condition of (1) juvenile spring chinook salmon after passing through either the spillway, the turbines, or the traveling-screen bypass and (2) a control group released below the dam. Unfortunately, the number of recovered marked fish was insufficient for complete analysis. However, the researchers' report made the following observations:

- The survival of the fish released in the lower turbine area was approximately equal to the control group released below the dam.
- Fish released into the traveling-screen bypass system appeared to have sustained the highest mortality of all groups.

Bonneville Dam Study

Corps and fish and wildlife officials stated that no studies have been completed on the survival effectiveness of the traveling screen in increasing adult salmon and steelhead returns. However, one study is currently ongoing at one of Bonneville's two powerhouses. Begun in 1987, this is an 8-year study composed of 3 years of juvenile fall chinook salmon releases followed by a 5-year adult recovery period. The study used hatchery fish that were released in the summer. The principal National Marine Fisheries Service biologist stated that preliminary data on returning adults will be available in March 1990 and each year thereafter until the recovery period has been completed.

In 1987 there were four release points: the upper and lower turbine intakes, the traveling-screen bypass, and 2.5 kilometers downstream from Bonneville's second powerhouse. In 1988 and 1989 an additional release point was made just below the dam. Short-term comparative

juvenile survival analyses were then made on the basis of juvenile salmon recoveries 167 kilometers downstream from Bonneville dam.

Combined recovery data for all 3 years showed a statistically significant decreased survival rate for juveniles released into the traveling-screen bypasses compared to those going through the turbines. There was a 9 percent difference between the turbines and bypass. The actual impact on adult returns, however, will not be known until adult return data are available and the analysis is completed.

The Corps made several inspections of the traveling-screen bypasses in 1987 and 1988 and found no major physical problems with them. The principal National Marine Fisheries Service biologist on the study advised us that the reasons for the low traveling-screen bypass survival rate could be problems in the bypass itself; the location where the bypass returns the fish to the river, allowing predator fish to eat a large number of juveniles; or downstream mortality because of predators and increased stress from going through the bypass. He believed the problem is probably predation resulting from a problem in the bypass that affects the fish downstream. He also cautioned that the results could be different for other species with different release dates.

The National Marine Fisheries Service has proposed a 1-year study to identify the reason for the problem. The Corps has approved funding for the study and expects it to begin in 1990.

Conclusions

The controversy surrounding the need to build additional traveling-screen bypasses at the Corps' dams could be repeated in the absence of a specific Corps mitigation objective for the remaining unmitigated damages to anadromous fish populations in the Columbia and Snake Rivers. Without a mitigation objective, the Corps and Congress cannot (1) determine the budgetary needs for additional mitigation projects or (2) know which measures provide the most cost-effective assistance to downstream fish migration.

Recommendations

We recommend that the Secretary of the Army direct the Chief, Corps of Engineers, in consultation with the Council, fish and wildlife agencies, Indian tribes, and other interested parties, to (1) establish a mitigation objective for damage to anadromous fish populations in the Snake and Columbia Rivers and (2) determine which measures, such as bypass

facilities, are necessary to meet this objective. The objective should be specific in terms of how the fish populations will be measured.

Options for Consideration by the Congress

Establishing a mitigation objective would not necessarily result in a conclusion to construct bypasses at The Dalles and Ice Harbor Dams. Rather, under the incremental analysis approach called for in Corps engineering regulations, a decision in favor of the traveling-screen bypasses would depend on determining that they are among the most cost-effective measures needed to meet the objective. This determination is made more complex by the lack of data as to whether fish bypasses actually produce benefits at their anticipated level. As discussed in this chapter, studies to date have not established that the bypasses are effective in increasing the numbers of surviving juvenile fish migrating downstream, and thus the numbers of returning adult fish.

In light of these findings, the Congress appears to have three main options with regard to considering bypass facilities at Lower Monumental, The Dalles, and Ice Harbor Dams.

1. Directing the Corps to proceed with planning and constructing the traveling-screen bypasses as currently authorized, irrespective of a specific mitigation objective or further study of bypass effectiveness. This option could result in completing design and/or construction of the bypasses before the final results are available from the current bypass-effectiveness study at Bonneville Dam; thus, it carries the risk that substantial sums may be spent to plan and build bypasses that are subsequently found to be ineffective. Further, a specific mitigation objective and incremental analysis could conclude that not all of the bypasses are warranted.
2. Directing the Corps not to proceed with planning and constructing the traveling-screen bypasses until the Corps has established an agreed-upon mitigation objective and, through incremental analysis, determined that the bypasses are cost effective. This option, unlike the first, would provide assurance that the bypasses were needed to mitigate losses caused by the Corps dams. However, like the first option, it carries the risk that substantial sums may be spent to plan and build facilities that later are found not to be as effective as other alternatives.
3. Directing the Corps to postpone construction of the traveling-screen bypasses until completion of (1) the mitigation study and (2) additional research on the effectiveness of bypasses and other factors that affect

juvenile fish passage and survival. This additional research could include the ongoing Bonneville Dam study and, if deemed necessary, other studies examining bypass effectiveness. If a mitigation study concludes that additional mitigation is not warranted, this option would avoid unnecessary expenditure of funds. If further mitigation is warranted and the bypass research is conclusive, this option would help to ensure that funds expended for the bypasses would best aid downstream migration of juvenile fish. However, if the research is not conclusive, this option carries with it the risk that, after several years' delay, the Congress could face the same decision with little or no additional information. In addition, further delay could adversely affect stocks in a critical condition. As noted in chapter 2, groups have petitioned the Fish and Wildlife Service to place several species of Snake and Columbia River fish on the list of endangered and threatened species.

Consolidation of Fish and Wildlife Agencies', Indian Tribes', and the Council's Concerns; Corps' Responses; And GAO's Observations

This appendix contains detailed concerns raised by the Council, fish and wildlife agencies, and Indian tribes, about various aspects of the Corps' consideration of traveling screen bypasses. Those concerns were expressed in correspondence among the Chairman of the House Committee on Energy and Commerce, the Council, fish and wildlife agencies, Indian tribes, BPA, and the Corps. We discussed this consolidated list of concerns with the groups and agencies expressing the comments to ensure that it accurately reflected their views.

The Corps' responses were obtained from discussions with North Pacific Division (Division) officials which they, officials from the Portland and Walla Walla Districts, and headquarters officials subsequently reviewed. All changes suggested by Corps officials have been incorporated into the responses. Our observations are based on our analysis of Corps' reports and other documents, and discussions with our consultant and officials from the Corps, the Council, BPA, and the University of Washington.

Concern 1: Compliance With the Spirit of the Act

The Corps is at odds with the spirit, if not the letter, of the Northwest Planning Act.

Corps Response: The Corps is required to comply with the act "to the fullest extent practicable." The Corps believes it has done that.

GAO Observation: The Corps must consider the program adopted by the Council under the Northwest Planning Act "to the fullest extent practicable" in the decision-making process. The Corps has not accepted the Council's interim goal of doubling the fish runs or any part of that goal as its mitigation objective. The Corps maintains that it will provide measures for the improved passage of fish at individual dams if the measures can be justified through its studies.

Concern 2: Delays

The Corps has had a history of delays in implementing fish improvements even though the Northwest Planning Act specifically provides for improved survival of fish at hydroelectric facilities. The following are examples of concerns about delays.

Concern 2a

The conflict between Corps headquarters and the Division over the Goals Report (final report dated April 4, 1988) caused a delay in the allocation of appropriated funds for Corps-supported projects at Little Goose, McNary, Lower Granite, and Lower Monumental Dams in fiscal years 1988 and 1989. Also, any delay in spending authorized design

funds for The Dalles and Ice Harbor Dams will further delay actual construction of bypass facilities.

Corps Response: There was no conflict between Corps headquarters and the Division. Congressional funding was delayed as a result of differing interpretations of congressional committee language. Since that difference was resolved by the administration and the Congress, design funds have been spent at all the projects in accordance with congressional language.

Concern 2b

All juvenile fish bypass systems currently in place on the Snake and Columbia Rivers were constructed or approved before the Council adopted its first Fish and Wildlife Program in 1982. The April 1988 chartering of an Army team to review the Corps' fish bypass program occurred 3-1/2 years after the Council's 1984 Fish and Wildlife Program required the development, testing, and installation of bypass systems and 14 months after the Council's 1987 Program Amendment, which added a specific schedule, based on Corps input, for bypass development. The Corps did not request adequate funds in its budget for planning and design of needed juvenile fish bypass facilities in fiscal years 1986-90.

Corps Response: The Corps has supported making improvements for the survival of fish at hydroelectric facilities when its benefit and cost analysis showed such improvements were justified. When such improvements were not justified on this basis, the Corps did not recommend them for funding. Any perceived delays on the Corps' part are because of differences in the Corps' and others' ideas about what is sufficient information to justify funding for projects. The Corps had, in fact, carried out most of the mitigation required for its dams before the Council was established. The justification for the remaining measures is much less certain.

Concern 3: Coordination
With Interested Parties

Regional parties have not been adequately involved, as is required by Corps planning engineering regulations, in the Corps' economic analysis prepared for the (1) Goals Report and (2) The Dalles Report.

Corps Response: For Corps planning studies, the interested parties, the public, and other government agencies are involved from the beginning. Some of the Corps' studies on bypass improvements were internal budgetary documents and were not considered part of the normal planning process. Consequently, the Corps was not required to coordinate with

other parties. Also, the Corps did not have much time to coordinate because of deadlines. The Dalles study, however, was a general letter report and was coordinated to some extent, but not to the full extent, with other parties from the beginning.

GAO Observation: A Corps Engineering Regulation (ER-1105-2-50) provides that state and local participation in addressing fish and wildlife resources shall be encouraged throughout the Corps' planning process. The Corps' decision that it was not obligated to include other parties in its studies leading to its decision against building bypasses at The Dalles and Ice Harbor Dams added to the concerns raised by local agencies, tribes, and others. The Corps did ask for and receive comments on The Dalles draft report.

Concern 4: Benefit-to-Cost Analyses

Benefit-to-cost analysis should not be the criterion for fish and wildlife mitigation decisions. The Congress, in enacting the Northwest Planning Act, specifically considered and rejected the use of benefit/cost analyses as a prerequisite for mitigation measures. (16 U.S.C. Section 839 (h)(6)(C).) Also, the Water Resources Development Act, P.L. 99-662, 33 U.S.C.A. Section 2284 (1987), expressly deems the benefits of fisheries mitigation measures to be equal to their cost. Congress took this extraordinary step because of frustration that benefit/cost analyses were being used to thwart fish and wildlife and related mitigation. The Corps' Water Resources Council's Principles and Guidelines are not applicable to the analyses of bypass system economic considerations. Mechanical fish bypass facilities are measures to mitigate the impacts of water resource projects and are not themselves water resource projects.

Corps Response: A positive economic benefit-to-cost ratio is not required for justification of all increments to a water resource project. What is required is incremental justification of each element. Incremental justification means that the benefits (both monetary and nonmonetary) of a project increment exceed the costs (both monetary and nonmonetary) of adding that increment to the plan.

The Corps recognizes that all benefits of a project may not be easily quantifiable in economic terms, and this should be considered in an incremental justification. But each increment to be included in a plan must be incrementally justified on a monetary and/or nonmonetary basis.

The Goals Report identified the monetary costs and benefits associated with each of the proposed bypass measures. This was done by identifying the incremental monetary benefits and costs of each measure; therefore, it could be considered a limited incremental justification as discussed above. The shortcomings of this incremental analysis were that it did not include the nonmonetary benefits because they were not easily identifiable, and it did not include the mitigation planning objective. The Corps is responsible for identifying the adverse effects which may be caused by the construction and operation of its dams. The Corps, however, is not required to mitigate all adverse effects resulting from completed projects, and the Council's fish and wildlife program is not binding on the Corps.

GAO Observation: P.L. 99-662, 33 U.S.C., states that in the evaluation of a water resources project,

... the benefits attributable to measures included in a project for the purpose of environmental quality, including improvement of the environment and fish and wildlife enhancement, shall be deemed to be at least equal to the costs of such measures.

Corps engineering regulations require incremental analysis for mitigation-related projects rather than benefit and cost analysis. These Corps engineering regulations, however, do require that the monetary and non-monetary benefits of an individual mitigation increment exceed the costs of adding that increment to the plan. Increments are added to the plan until the mitigation planning objective has been achieved or until increments become too costly. Incremental analysis provides that those increments with the lowest cost should be implemented first, providing they obtain the same objective. However, the Corps is not precluded from using a benefit and cost analysis.

Concern 5: Who Pays for Bypass Activities?

The Corps' analysis does not recognize that, since BPA will repay most of the fish bypass costs, they are not really a cost to the federal government.

Corps Response: The bypass activities are a cost to the federal government. The design and construction funds come from the federal Treasury. Northwest ratepayers repay the Treasury over a long period of time. Only if the ratepayers paid for the bypasses up front would there be no federal cost.

GAO Observation: Bypass funding is a cost to the federal government. As long as the Corps incurs costs for mitigation purposes, regional rate-payers through BPA will reimburse the U.S. Treasury. According to a BPA financial analyst, BPA must repay the Treasury with interest at a rate current at the time of the loan. In April 1990, current Treasury rates were between 9 and 10 percent. The length of time to repay depends upon how many years remain of the dam's expected 50-year life.

Concern 6: The FISHPASS Model

The Corps consulted with fish agencies and tribes in the early development of the FISHPASS model that was subsequently used in the economic analysis for the Goals and Dalles reports, but did not resolve or incorporate their concerns and recommendations.

Corps Response: FISHPASS was the best available analytical tool at the time. Because of the need to meet deadlines, the Corps was unable to make many changes at the time of the analysis. The Corps received a number of fish agencies' and tribes' concerns and recommendations during the development of FISHPASS through the Council's Mainstem Passage Advisory Committee. Some recommendations were not adopted, such as the recommendation that the Corps not use computer modeling or not use the results.

GAO Observation: The Corps attempted to coordinate its input parameters with the Mainstem Passage Advisory Committee. According to the former Chairman, the Mainstem Passage Advisory Committee was established by the Council to obtain agreement among parties in the region on parameter values to be used for modeling purposes to analyze spill. However, they did not all agree to the parameter values.

The following are examples of other modeling concerns.

Concern 6a

The Corps did not have a peer validation of the model.

Corps Response: The Corps is working with BPA and the University of Washington in a peer review of FISHPASS. The University of Washington review will not validate/test the model against nature; it is not a reality check.

GAO Observation: The Corps did not have the model independently reviewed or calibrated, that is, results checked against the actual numbers of fish present in the rivers. BPA contracted with the University of Washington for the review of both the Corps' and BPA's versions of

FISHPASS. However, the work did not include the portion of the Corps' model dealing with returning adult fish, since the ocean survival portion was based on scanty data.

Concern 6b

(i) The FISHPASS model is an overly simplified abstract of a very complex natural system. Because of the limitations of available data, many assumptions were made in constructing FISHPASS that add a great deal of uncertainty to the model outputs. The model may be useful in identifying information gaps or making gross comparisons or rankings of alternatives, but it is wholly inadequate as a predictive model for estimating the actual fish benefits of alternative bypass actions.

(ii) FISHPASS uses point estimates for a number of parameters that vary within a very large range. Some of this variation reflects changes that occur in response to environmental factors or interaction with other parameters, and some reflect the precision (or lack thereof) of the methods of estimation. Given this weakness in basic model parameters, the model should not be relied on to predict fishery benefits because of a large uncertainty associated with the output results.

(iii) The sensitivity analysis in the Goals Report does not address this fundamental weakness of the FISHPASS model. Instead, it assumes the predicted fishery benefits provided by FISHPASS are accurate and then evaluates the sensitivity of the analysis, using FISHPASS output, that was conducted for this report.

Corps Response: (i) FISHPASS is useful for ranking alternatives. However, it is incorrect to say that FISHPASS is wholly inadequate as a predictive model for estimating the actual fish benefits of alternative bypass actions because FISHPASS ranks the alternatives according to estimated benefits.

(ii) The whole point of using FISHPASS is to attempt to have the model rank alternatives, not make the decision.

(iii) FISHPASS is a deterministic model; specific points, rather than ranges, are used in the model. A probabilistic model should be used, but there is none currently available to do this.

GAO Observation: (i) According to University of Washington researchers, FISHPASS, as used by the Corps to evaluate bypass improvements, was the best available analytical tool at the time. As such, using the model to

rank alternatives based on relative survival estimates was an appropriate way to analyze its results. However, we agree that FISHPASS does not estimate the "actual fish benefits" of bypass actions. Rather, the ranking of model results only suggests which alternatives might be better or worse than others. The estimated fish benefits cannot be interpreted as exact.

(ii) While the Corps' response states that the whole point of using FISHPASS was to rank alternatives and not make the decision, that appears to have been how the Corps' decision makers used the modeling results—to justify its decision not to recommend bypasses at The Dalles and Ice Harbor Dams for further federal funding. FISHPASS results alone are insufficient support for the decision not to pursue bypasses at these two locations.

(iii) Both using "point estimates" for parameters in a deterministic modeling approach or "ranges" for parameter values in a probabilistic modeling approach have merit. More important, however, the Corps did not indicate how reliable, or close to reality, the results were from the method it chose to use. The Corps performed sensitivity analysis, but that type of analysis cannot determine the reliability of a model.

Concern 6c

The Corps' method for calculating system survival estimates has not been agreed to by the fishery agencies and Indian tribes.

Corps Response: The statement is true.

GAO Observation: The Corps is not required to obtain agreement on a method for calculating system survival estimates. However, doing so would have helped to resolve the bypass controversy.

Concern 6d

Analysis does not include noneconomic factors or regional economic multiplier effects. Noneconomic factors would include (1) Indian treaty fishing rights; (2) U.S./Canada Pacific Salmon Treaty; and (3) Indians' ceremonial, cultural, and religious significance of salmon and steelhead trout. Regional effects include the economic development and quality-of-life benefits of maintaining healthy fisheries.

Corps Response: The Goals Report does mention that these noneconomic factors should be considered in any decision on whether or not the bypasses should be constructed. They were not included in the economic analysis because there was no reliable way to place a value on them.

GAO Observation: The Corps' analysis does not include noneconomic factors. Corps engineering regulations require that project analysis identify and, to the fullest extent practicable, take into consideration noneconomic factors, such as environmental effects. The Goals Report analysis ignored noneconomic considerations because, according to Corps officials, the Division was directed by headquarters to perform an analysis that was limited to economic considerations.

GAO believes the Corps could have done more to consider noneconomic values in its analysis, even if attaching a dollar value to all noneconomic effects was not feasible. For example, the estimate of project effects could have focused on particular fish stocks where nonmonetary values might be quite high.

Concern 6e

The Corps' analysis does not incorporate the real benefits of increased juvenile survival. A life-cycle analysis would show that small improvements in juvenile survival can result in substantial increases in run sizes over time. For example, a constant 3.5 percent increase in survival could result in doubling the population in 20 years. The model incorrectly assumes a constant production population of all stocks of salmon and steelhead for all studies and water conditions.

Corps Response: The FISHPASS model used in the Goals Report had assumed doubling the run had already occurred and the population was stable so life-cycle modeling would have been appropriate.

The model is very optimistic on the issue of whether the population of all stocks of salmon and steelhead will remain constant. This assumption yields the highest possible benefits for the bypasses because a large number of fish are assumed to arrive at each project.

The fishery agency and tribe concept of life-cycle modeling for bypass alternatives assumes that the fish populations are affected only by the Corps' dams. This is untrue; the effects of other factors are much greater. The impact of ocean survival and production (hatchery capacity) make life-cycle modeling largely useless in determining the effects of the dams.

GAO Observation: FISHPASS is not a full life-cycle model. FISHPASS simulates one generation from the time juvenile fish migrate downstream to when adults are harvested. A life-cycle model ideally would provide more information about longer term effects on the fish population. However,

more research and data are needed to produce a reliable life-cycle model.

FISHPASS (as used in the Goals Report) assumed a fish population for 1995 based on completion of the Corps' Lower Snake River Compensation Plan and state and regional initiatives, regardless of decisions made by the Corps on bypasses. Based on estimates from the fish agencies, the Corps assumed there would be more than a doubling of the 1987 number of natural and hatchery fish migrating downstream in 1995 (56 million in 1987 and 130 million in 1995).

Concern 6f

The Corps' analysis considers only total numbers of fish rather than individual stocks of fish, such as natural stocks entering the Snake or Columbia Rivers below transportation collection points. BPA has identified at least four natural stocks of fish that could be significantly affected. In addition, a disproportionate number of fish not collected and transported are wild or natural smolts which migrate before and after the bulk of hatchery migrants. Lastly, the importance of genetic diversity is not included.

Corps Response: The total number of fish at specific collection points is considered in the model. The impact on individual stocks could be considered in future models. Transportation in the model does not affect wild or natural juvenile fish any differently than hatchery juveniles.

GAO Observation: The Corps' analysis does not study individual stocks or the importance of genetic diversity. As used by the Corps, FISHPASS considers spring and fall chinook, salmon, and steelhead trout. Including stocks in addition to species would be a more accurate way of reflecting the fish population status because it could show adverse effects on individual stocks of fish.

Concern 6g

The Corps' analysis assumes a homogeneity of fish stocks that does not exist. No value is placed on fish necessary for reproduction, especially those necessary for rebuilding depleted stocks.

Corps Response: The Corps assumed stocks were already at a stable level.

GAO Observation: By not distinguishing among fish stocks, the Corps' analysis values them equally. Also, the Corps' analysis does not place a value on fish necessary for reproduction or for rebuilding depleted stocks.

Concern 6h

The model ignores the cumulative effect of turbine passage by several dams on survival and assumes that turbine and reservoir mortality are independent. Mortality resulting from increased susceptibility to disease or increased vulnerability to predators caused by injury or stress from turbine passage through one dam or a series of dams is considered reservoir mortality in FISHPASS, not turbine mortality.

Corps Response: FISHPASS is a system model; it looks at survival of fish entering above the Corps' complex of dams and tracks survival to below Bonneville Dam. These numbers are then converted to adult returns for economic purposes. FISHPASS does assume that the chance of survival remains unchanged as the fish migrate through the system. For example, a fish safely passing through a turbine or spillway is assumed to have the same probability of surviving through the next dam. At least one study has found that fish surviving through a turbine have the same chance of returning to spawn as fish that were bypassed. There may be a long-term effect on fish passing through spill over a dam, but the Corps is unaware of any data on this.

GAO Observation: FISHPASS does not account for possible cumulative debilitating effects on fish health such as injury, descaling, or stress from passing by several dams. However, as the Corps stated, we are not aware of any data on this.

Concern 6i

The number of projected fish used in the model for 1987 and 1995 is not accurate. For example, the model used 5.5 million steelhead for 1987. However, according to juvenile monitoring statistics, 9.47 million hatchery steelhead were released in 1987, including several million more natural steelhead.

Corps Response: The numbers refer to the Dalles Report; all of the numbers used in this report have been revised.

GAO Observation: An appendix to The Dalles Report incorporated revised estimates of the number of juvenile fish projected to be in the river. We did not evaluate the accuracy of these estimates. While the numbers of hatchery fish are predictable, data on natural and wild juvenile fish are less certain.

Concern 6j

The 30- to 40-percent cumulative reservoir mortality estimate for juvenile fish is unsupported by research data. At the very least, a sensitivity analysis using a reasonable range of reservoir mortality estimates

should be conducted and model output should be a range, not point estimates.

Corps Response: Reservoir mortalities estimates generated by FISHPASS were based on existing research. They are a function of water flow (representing the speed at which fish travel through a reservoir) and distance (how far fish have to travel per reservoir). The weaker the flow, or the larger the reservoir, the more fish are estimated to die. Reservoir mortalities also differ by species or age of fish.

The 30- to 40-percent cumulative reservoir mortality is a conservative estimate mentioned in the Goals Report to roughly illustrate the extent of reservoir mortality. In a sensitivity analysis of bypass options using FISHPASS, reservoir mortalities varied greatly per reservoir and in total depending on the different conditions assumed. In FISHPASS, the calculations are based on the best available research.

GAO Observation: The draft report from the University of Washington's review of FISHPASS indicates that the model's predictions are very sensitive to reservoir survival conditions and that such predictions would be "most improved" by more study of this parameter.

Predation has been identified as a major cause of fish mortality in the John Day reservoir. Predator fish at John Day reservoir are estimated to kill 7 to 61 percent of juvenile salmon and steelhead trout that enter the reservoir. According to a Corps official, the best data on reservoir mortality and predation are from the John Day study. Mortality rates and predation at places other than John Day reservoir have not been tested to the same extent.

Concern 6k

Fish guidance efficiency values are in some cases undocumented and appear overly optimistic, especially with the use of gate raises and lowered submersible traveling screens. For example, at Lower Granite Dam, yearling fish guidance efficiency increases from 53 to 77 percent (a 45 percent increase) via gate raises alone, and then to 88 percent from extending submersible traveling screens. The group with this concern was unaware of research to support this level.

Corps Response: Because of a lack of data with regard to fish guidance efficiencies at some dams for some species—expressed as a percent of fish passing by a dam which are guided into the collection channel of its bypass system—judgment is involved in using any numbers for analytical purposes. The Corps had to use a point estimate because FISHPASS is

a deterministic model. The research data show a range for fish guidance efficiency; the Corps had to pick the most likely point that it believed representative.

GAO Observation: We did not evaluate the accuracy of fish guidance efficiencies. Research to test the fish guidance efficiencies of extended traveling-screen bypasses, where the screens are 40 feet long rather than the standard 20 feet, have been based on prototypes rather than actual installation. Therefore, the high fish guidance efficiencies for this type of screen are estimates.

Concern 6l

(i) The Corps' Goals Report stresses the benefit and value of using the ice and trash sluiceways at Ice Harbor, The Dalles, and Bonneville Dams. However, it fails to present the wide range in the data gathered from sluiceway effectiveness studies, nor does it state that point estimates made from hydroacoustics studies are lacking error bounds. Further, the fishery agencies and tribes have repeatedly disputed the Corps' choice of the highest value for sluiceway effectiveness at Ice Harbor.

(ii) Existing long-term spill agreement levels were not included. Spill is needed in the interim, until bypass systems are installed, to achieve comparable levels of survival for all migrating juvenile salmon and steelheads. Including the cost savings from not having to spill would increase the benefit-to-cost ratio up to 1.46 for Ice Harbor and 1.04 for The Dalles, using willingness-to-pay economic values. However, using willingness-to-sell values would increase the benefit-to-cost ratios to 2.4 for Ice Harbor and 1.4 for The Dalles Dam.

Corps Response: (i) The 40- to 50-percent sluiceway efficiencies in the model are based on the best available data.

(ii) The statement that existing long-term spill agreement levels were not included in the model parameters is true. The spill agreement was not in place when the Corps prepared the Goals Report. Further, the Corps has consistently stated that spill is so cost-ineffective that it is not reasonable to use spill to justify bypass construction.

GAO Observation: (i) The Corps used the Mainstem Passage Advisory Committee sluiceway estimates of 51 percent at Ice Harbor and 40 percent at The Dalles for analyzing bypass alternatives with FISHPASS. However, the Chairman, Mainstem Passage Advisory Committee, said these numbers were controversial estimates. He indicated that research shows sluiceway efficiency can range from 30 to 70 percent.

(ii) At GAO's request, the Corps incorporated spill into the benefit and cost analysis. By changing this assumption, the analysis showed the benefits of submerged traveling-screen bypass facilities at The Dalles and Ice Harbor Dams would exceed the costs when spill was included.

Concern 6m

Point estimates for turbine survival in the Goals Report are not documented.

Corps Response: The turbine survival figures were jointly agreed to by the region through the Mainstem Passage Committee of the Council.

GAO Observation: The Goals Report does not document point estimates for turbine survival used in FISHPASS. The Corps has stated that FISHPASS assumes that 85 percent of fish going through a turbine survive. According to one of the researchers, preliminary results from the University of Washington review of the model confirm the survival estimate, and conclude that it is reasonable given the evaluation of existing research. The Corps' estimate is the same as the Mainstem Passage Advisory Committee's. However, the Chairman of the committee said there was no regional agreement on the estimates.

As discussed in chapter 3, only two studies have been conducted comparing, at the same dam, the survival of fish using the bypass with other routes to get by the dam. The ongoing study at Bonneville's second powerhouse has shown that more fish survive going through the turbines than through the bypass system.

Concern 6n

The high 97.6 percent dam passage survival estimate without any spill at McNary Dam used in FISHPASS should be justified.

Corps Response: Dam passage survival represents the percent of fish surviving all the possible routes by a dam: through the turbine, the bypass system, the sluiceway, or over the spillway. Given all the possible ways of surviving passage at McNary Dam, the Corps believes that 97.6 percent is possible.

GAO Observation: The McNary Dam passage survival of 97.6 percent, assuming no spill, is an estimate. The estimate might be more likely assuming spill. Additional research is needed to know what the actual dam passage survival is with extended submersible travel screens because none have been permanently installed.

Concern 6o

The assumptions used in the FISHPASS model are not clearly stated. For example, escapement levels or harvest rates are not documented. This biological information is critical to a credible biological evaluation.

Corps Response: All of the assumptions of FISHPASS may not be clearly stated in the Goals and Dalles Reports. However, a FISHPASS User Manual does describe these assumptions.

GAO Observation: The assumptions used in the model are not all clearly stated in the Corps' reports and sometimes not even in the FISHPASS User Manual (1988). The User Manual, however, does document the FISHPASS assumptions about the levels of escapement (the number of returning adult fish that are allowed to remain free for spawning purposes) and harvest (the number of returning adult fish that are caught for commercial or sport purposes).

The model assumes set escapement levels for the three types of fish considered in FISHPASS—spring chinook, fall chinook, and steelhead trout. Harvest levels, on the other hand, were variable. The Corps assumed 50,100 spring chinook, 71,900 fall chinook, and 174,300 steelhead would have to escape for spawning each year. Harvest levels were then calculated as the number of returning fish above and beyond these amounts.

Concern 6p

Transport benefit ratios for transported versus nontransported spring chinook of 4.5 to 1 from the two Snake River collection points should be closer to 2 to 1. (The transport benefit ratio is probably even lower from McNary Dam.) Also, an analysis by the Columbia Fish and Wildlife Authority indicates that significant mortality is occurring after release from the barges.

Corps Response: Transport benefit ratios as stated in the concern were not used in FISHPASS. The Corps represented survival differences for transported versus nontransported fish in another way because of how the model calculates survival.

Research by the National Marine Fisheries Service shows a low level of fish mortality after release from transport barges. FISHPASS includes this in its calculations of adult fish returning from the ocean.

GAO Observation: We did not evaluate how FISHPASS transportation mortality calculations compare to statistics on transport benefit ratios.

Concern 6q

Improved survival may not result for transported fish from John Day Dam as proposed.

Corps Response: Studies would be needed to prove this one way or the other. The Corps has proposed research on transport from John Day Dam but it has not been supported by fish agencies.

GAO Observation: Since the Corps, as of May 1990, does not transport fish from John Day Dam, research would be needed to show the effects of transportation from this location.

Concern 6r

Transportation will not meet the same biological objectives as the installation of mechanical bypass screens. For example, until further research can be concluded and agreement on benefits achieved, transportation of spring and summer chinook salmon should be undertaken only as called for by the region's fish and wildlife agencies and Indian tribes. Regional fisheries biologists have four principal concerns with transportation of spring and summer chinook. They are

- homing impairment and straying problems;
- cumulative stressful conditions encountered at collection facilities;
- increased exposure to diseases in barges, trucks, and collection facilities; or
- potential for accidents involving large fish kills in transportation program.

Corps Response: The problem with spring chinook may be bacterial kidney disease. Research is currently ongoing to address this issue. If this hypothesis is correct, it can readily be argued that additional bypass systems would provide little benefit to these fish. With the disease, these fish do not survive acclimation to seawater whether they are transported or migrate in-river. Bypass systems do not correct this problem.

Transportation of spring and summer chinook is being included in the FISHPASS analysis because it represents what is actually happening at those projects.

GAO Observation: As agreed with the fish and wildlife agencies and Indian tribes, the Corps does not transport spring chinook in average and greater-than-average water flow years. Also, research by the National Marine Fisheries Service has indicated that fall chinook and steelhead benefit from transportation, but spring and summer chinook

do not transport well. On the other hand, researchers at the University of Washington in their draft report on FISHPASS suggest that all study results on transportation are "questionable."

Concern 6s

The Corps' preferred alternative (maximum juvenile transportation) understates and excludes costs. Total capital costs of \$5 million should be \$28 million (levelized to \$2.5 million annually at 8.875 percent) and annual operations and maintenance costs should be \$1.8 million. Adding the levelized annual capital cost to the annual operations and maintenance cost gives a total annual cost of about \$4.3 million.

Corps Response: The incremental costs for transportation and bypass were included on a yearly basis.

GAO Observation: We did not evaluate transportation costs. Therefore, we have no basis on which to make an observation about the accuracy of the "total annual cost" for transportation. However, in an incremental analysis, total annual costs would include new but not previous expenditures, such as the costs of existing transportation barges and facilities.

Concern 6t

The draft Dalles Report underestimates the fishery benefits derived from a fish collection-bypass facility at The Dalles Dam. The number of fish arriving at the project was based on a projection of fish production for 1992. The Northwest Power Planning Council has estimated that 5 to 11 million salmon and steelhead were lost due to hydropower development and operation. A tripling of current production would be required to achieve mitigation at the low end of this range and much of this production would not occur until after 1992. The Council has set an interim goal of doubling the existing salmon and steelhead runs. The benefit-to-cost ratio analysis is very sensitive to the number of fish arriving at the project and should use an estimate of fish arriving at the project when full mitigation is achieved. Higher production levels would increase fishery benefits from the collection-bypass system.

Corps Response: The numbers used in The Dalles Report were revised to represent 1995 expected numbers. This represents the 5 million fish interim goal set by the Council.

GAO Observation: We disagree with the Corps' response. The Dalles Report shows that the Corps based its recommendations on an analysis assuming 1992 rather than 1995 conditions. In the report, the Corps' benefit and cost analysis is sensitive to the number of juvenile fish

assumed to be in the river. Increasing the number of fish would alter overall benefits. According to a Corps official, had 1995 rather than 1992 conditions been assumed, more fish would have been projected to be in the system. As demonstrated in an appendix to the report using 1995 conditions and the no-head-loss assumption, the benefits would have exceeded the costs for a bypass at The Dalles Dam under partial transportation conditions. On that basis, the Corps could have recommended construction of a bypass at The Dalles Dam.

As previously stated, we did not evaluate the accuracy of estimates of juvenile fish projected to be in the river. While the numbers of hatchery fish are predictable, data on natural and wild juvenile fish are less certain.

Concern 6u

The Corps' economic analysis incorrectly "assumes that the value of Indian tribal fisheries is the same as sport fisheries."

Corps Response: The model does assume that the value of Indian tribal fish is the same as sport and commercial fish. A report prepared for the Rock Island Project, of Chelan Public Utility District, says that tribal fish is best valued as a commercial fishery because this is basically what the Indians do—sell the fish.

GAO Observation: Indian tribes maintain that fish have more than just commercial value. According to the Director of the Columbia River Intertribal Fish Commission, this additional value or benefit to Indian tribes would be noneconomic. The value chosen for Indian tribal fish demonstrates how the Corps did not consider noneconomic benefits.

Concern 6v

The Corps uses a "willingness to pay" value for determining the benefit of harvestable adult fish. However, under Corps criteria, they should have used a "willingness to sell" value, which would economically justify bypass facilities at John Day and The Dalles.

Corps Response: Corps engineering regulations allow for using a "willingness to pay" rather than a willingness to sell value for fish. Corps policy and guidelines for National Economic Development evaluation require that if actions are considered restorative or mitigative, then a willingness to sell value should be used to determine the benefits. However, the policy and guidelines also state that for cases when there is no reliable empirical method for estimating willingness to sell (also referred to as "willingness to accept compensation for losses"), then a willingness to pay value should be used.

Appendix I
Consolidation of Fish and Wildlife Agencies',
Indian Tribes', and the Council's Concerns;
Corps' Responses; And GAO's Observations

GAO Observation: The applicable Corps engineering regulation, ER 1105-2-40, Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, Change 2, July 9, 1983, states that using a "willingness to pay" value was permissible.

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