The Federal Role in Fish Passage at Hydropower Facilities

5

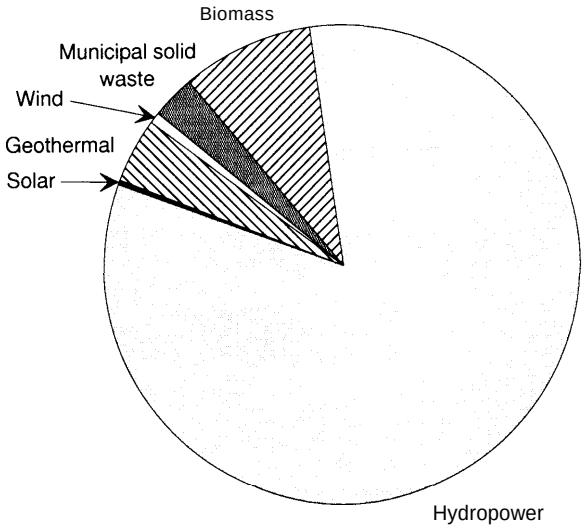
Hydroelectricity provides over 10 percent of the electricity in the United States and is by far the largest developed renewable energy resource in the nation (figure 5-1). At least 25 million Americans depend on hydropower for their electricity needs. Conventional hydropower plants total nearly 74,000 megawatts (MW) of capacity at roughly 2,400 plants. Pumped storage provides an additional 18,000 MW of capacity at about 40 plants. The undeveloped hydropower resource potential in this country is significant. The Federal Energy Regulatory Commission estimates that approximately 71,000 MW of conventional capacity remains undeveloped (81,82).

History has shown that hydropower development can, and generally does result in changes in the abundance and composition of migratory and riverine fish populations. Dams impede fish movements up and down rivers, delaying them, blocking them altogether and sometimes killing them directly (e.g., turbine mortality) or indirectly (e.g., predation at points of delay) (37). However, specific data on population changes attributable to hydropower development are difficult to come by and other factors also have had adverse impacts (e.g., habitat destruction, water pollution, over-harvest). To what degree each of these factors contributes to the overall decline of North American fisheries remains unclear.

This chapter examines the federal role in fish passage and protection at hydropower facilities (box 5-1). Federal involvement in managing nonfederal hydropower issues includes: licensing, monitoring, and enforcement; identifying mitigation plans for hydropower facilities; and conducting research on and development of fish protection technologies. The Federal Energy Regulatory Commission (FERC) is responsible for the licensing, monitoring, and enforcement of license conditions for nonfederal hydropower facilities. Explicit in FERC's authority is the responsibility for balancing the developmental and nondevelopmental values of hydropower development in the licensing process.

The National Marine Fisheries Service (NMFS), the U.S. Fish and Wildlife Service (FWS), and, in certain cases, U.S. federal land management agencies prescribe mandatory fish passage conditions for inclusion in hydropower licenses. In addition, these agencies and state resource agencies also may make nonbinding recommendations for additional mitigation to promote fish protection.

FIGURE 5-1: Relative Contribution of Various Renewable Energy Sources



SOURCE: "Renewable Resources in the U.S. Electric Supply, " Table 4, February 1993,

Mitigation technologies to reduce the adverse effect of hydropower on the nation's fish resources exist and have been employed, although not uniformly, since the early part of this century. These techniques can be costly and their effectiveness is often poorly understood (242). Yet, in a review of 16 case studies, the majority demonstrated positive results stemming from technology implementation (242). The high cost of installing or retrofitting fish protection or passage facilities relative to the perceived benefit derived generates some tension between resource agencies and the hydropower industry. Yet, few studies have attempted to describe the full range of benefits and costs of fish passage mitigation over the long-term. [1]

LICENSING OF NONFEDERAL HYDROPOWER PLANTS

Federal licensing of nonfederal hydropower plants on navigable waterways is the responsibility of the Federal Energy Regulatory Commission (previously the Federal Power Commission (FPC) under the Federal Power Act of 1920).[2] In the 1930s, FPC's role was expanded to include rate regulation and other matters related to wholesale, interstate sales of electricity and natural gas (1935 FPA and 1938 Natural Gas Act). The 1977 Department of Energy Organization Act created the Federal Energy Regulatory Commission (FERC) and transferred FPC's energy jurisdiction to the agency as well as jurisdiction over oil pipeline transportation rates and practices. Today, FERC has exclusive authority to license nonfederal hydropower facilities on navigable waterways and federal lands (approximately 1,825 dams); regulate the electric utility and interstate natural gas pipeline industries at the wholesale level (including reviewing electric utility mergers and supervising/authorizing hydropower and gas pipeline construction); and regulate oil pipeline transportation (74).

The initial mandate of the agency was the regulation of energy production, distribution, and availability; and the promotion of hydropower, particularly for the Northeast and Northwest regions of the United States. Environmental concerns were largely addressed through a number of laws that were enacted to protect natural resources and the environment, including: the National Environmental Policy Act (NEPA), Fish and Wildlife Coordination Act, National Historic Preservation Act, Endangered Species Act, Federal Water Pollution Control Act (Clean Water Act), and the Wild and Scenic Rivers Act (box 5-2).

1 Hydroelectric licenses run from 30 to 50 years. Economic comparisions of the costs of installing or retrofitting facilities and the revenue flow from plant operation over the license period might clarify this debate, however, the information does not currently exist.

2 Under section 23(b) of the Federal Power Act, FERC has jurisdiction to license nonfederal hydroelectric projects that are on navigable U.S. waters; are on non-navigable U.S. waters over which Congress has "Commerce Clause" jurisdiction, were constructed after 1935, and affect interstate or foreign commerce; are on public lands or reservations; or use surplus water or water power from any federal dam (49).

BOX 5-1: Chapter Findings—Federal Role

- The Federal Energy Regulatory Commission (FERC) has exclusive authority to license nonfederal hydroelectric facilities on navigable waterways and federal lands, which includes conditioning of licenses to require operators' adoption of fish protection measures.
- Section 18 of the Federal Power Act (FPA) gives the federal resource agencies authority to prescribe mandatory fish passage conditions to be included in FERC license orders. Section 10(j) recommendations relate to additional mitigation for rehabilitating damages resulting from hydropower development or to address broader fish and wildlife needs (e.g., minimum flow requirements). Yet, these recommendations are subject to FERC approval.
- FERC's hydroelectric licensing process has been criticized as lengthy and can be costly for applicants and participating government agencies. In some cases, the cost of implementing fish protection mitigations from the utility perspective may render a project uneconomical.
- FERC uses benefit-cost analyses in its final hydroelectric licensing decisions; yet economic methods for valuing habitat and/or natural resources are not well established and many economists feel that they fit poorly in traditional benefit-cost analysis.
- There is no comprehensive system for monitoring and enforcing resource agency fish passage prescriptions. FERC's monitoring and enforcement authority has been used infrequently, and only recently, to fulfill its mandate to adequately and equitably protect, mitigate damages to, and enhance fish and wildlife (including related spawning grounds and habitat) affected by the development, operation, and management of hydroelectric projects.
- Parties must perceive a need to negotiate in the FERC hydropower licensing process, beyond the regulatory requirements of applicants and agencies, in order to achieve success. FERC must be seen as a neutral party to motivate participants to find mutually acceptable agreements in accommodating the need for power production and resource protection. If FERC is perceived to favor certain interests, the need to negotiate is diminished or eliminated.
- There are no clearly defined overall goals for North American fishery management and Congress has not clearly articulated goals for management of fishery resources and/or priorities for resource allocation.
- Fish protection and hydropower licensing issues return repeatedly to the congressional agenda. The 1920 FPA was designed to eliminate controversy between private hydropower developers and conservation groups opposed to unregulated use of the nation's waterways. Greater consideration of fisheries and other "nondevelopmental" values was called for in the Electric Consumers Protection Act of 1986 (ECPA) and oversight on these issues continued with the passage of the Energy Policy Act of 1992. In the 104th Congress, efforts continue to address power production (e.g., sale of PMA's; BPA debt restructuring) and developing sustainable fisheries (e.g., Magnuson Act amendments; Striped Bass Conservation Act).

SOURCE: Office of Technology Assessment, 1995.

In addition, section 18 of the FPA gave the Secretaries of Commerce and Interior authority to prescribe fishways at FERC-licensed hydropower projects. Section 4(e) allows federal land management agencies to issue mandatory conditions to protect the purposes for which their lands are held in trust. If the purposes of the lands include fish and wildlife, then section 4(e) may be used to issue mandatory fish protection conditions. Section 30 applies primarily to conduit exemptions: projects that use the hydroelectric potential of a conduit that is operated for the distribution of water for agricultural, municipal, or industrial consumption and not primarily hydropower. In these cases, FERC must include in the exemption the terms and conditions that NMFS,

BOX 5-2: Environmental Laws Affecting the FERC Licensing Process

A number of laws beyond the FPA influence environmental protection in the FERC hydropower licensing process. These laws continue to affect the licensing process, although some of the intent contained in them has been reiterated and directly applied to FERC through ECPA.

- *National Environmental Policy Act*—requires preparation of an Environmental Assessment (EA) or an Environmental Impact Statement (EIS).
- *Fish and Wildlife Coordination Act*—requires FERC to give full consideration to the recommendations of the U.S. Fish and Wildlife Service (FWS), National Marine Fisheries Service (NMFS), and state resource agencies on the wildlife aspects of a project.
- *National Historic Preservation Act*—requires FERC to give the Advisory Council on Historic Preservation reasonable opportunity to comment on a license issuance involving an historic resource.
- *Endangered Species Act*—requires FERC to consult with FWS and NMFS to determine if action is likely to jeopardize the continued existence of any endangered or threatened species or adversely affect critical habitat.
- *Federal Water Pollution Control Act (Clean Water Act; CWA)*—requires applicants to confer with the "certifying agency" (U.S. Army Corps of Engineers (COE) or the Environmental Protection Agency (EPA)) and verify compliance with the CWA (National Pollutant Discharge Elimination System permit [NPDES], S401 water quality certificate, or S404 dredge and fill permit).
- *Wild and Scenic Rivers Act*—FERC is prohibited from licensing projects on or directly affecting a wild and scenic river as established by an act of Congress or State Legislatures.

SOURCE: Office of Technology Assessment, 1995.

FWS, and state resource agencies determine are appropriate to prevent loss or damage of the affected fish and wildlife resources. Under the broad scope of section 30 language, fish passage could be included, if appropriate. Sections 4(e), 18, and 30 have provided these specific authorities to protect fish and wildlife resources since the inception of the FPA in 1920 (123,150).

In 1986, Congress passed the Electric Consumers Protection Act (ECPA)(PL 99-495), a series of amendments to the FPA, which was designed to alter FERC's tendency to place power over fish in licensing decisions. The FPA, as amended by ECPA, establishes principles that guide FERC in the issuance of hydropower licenses. FERC is directed to give equal consideration[3] to the full range of purposes related to the potential value of a stream or river, to include: hydropower development; energy conservation; fish and wildlife resources, including spawning grounds and habitat; recreational opportunities; other aspects of environmental quality; irrigation; flood control; and water supply (1,74,123).

Although mandatory fish passage authority rested with the federal resource agencies since the early part of this century,[4] ECPA was instrumental in elevating the importance of nondevelopmental values in and increasing FERC's accountability for licensing decisions (1,240).

[3] *Equal consideration* does not mean treating all potential purposes equally or requiring that an equal amount of money be spent on each resource value, but it does mean that all values must be given the same level of reflection and thorough evaluation in determining that the project licensed is best adapted. In balancing developmental and nondevelopmental objectives, FERC will consider the relative value of the existing power generation, flood control, and other potential developmental objectives in relation to present and future needs for improved water quality, recreation, fish, wildlife, and other aspects of environmental quality (74).

[4] Since the early part of this century, the authority for issuing fishway prescriptions rested with the Department of Commerce and the Department of the Interior (DOI). Prior to the passage of the Federal Power Act in 1920, the Secretary of Commerce held primary responsibility for fish passage facilities at federally licensed projects (An Act to Regulate the Construction of Dams Across Navigable Waters, 1906) (P.L. 262). In 1939, DOI acquired concurrent authority. The Departments now share responsibility for developing fishway prescriptions (257).

Through the addition of section 10(j), federal and state resource agencies may recommend conditions to protect, enhance, or mitigate for damages to fish and wildlife resources under the FPA:

> Section 10(j) (U.S.C.§803(j)) stipulates that: in order to adequately and equitably protect, mitigate damages to, and enhance fish and wildlife (including related spawning grounds and habitat) affected by the development, operation, and management of the project, each license issued under this subchapter [16 U.S.C. §§ 792-828c] shall include conditions for such protection, mitigation, and enhancement....[S]uch conditions shall be based on recommendations received pursuant to the Fish and Wildlife Coordination Act (16 U.S.C. 661 et. seq.) from the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and State fish and wildlife agencies.
>
> Whenever the Commission believes that any recommendation referred to in paragraph (1) may be inconsistent with the purposes and requirements of this subchapter or other applicable law, the Commission and the agencies referred to in paragraph (1) shall attempt to resolve any such inconsistency, giving due weight to the recommendations, expertise, and statutory responsibilities of such agencies. If, after such attempt, the Commission does not adopt in whole or in part a recommendation of any such agency, the Commission shall publish each of the following findings (together with a statement of the basis for each of the findings): 1) a finding that adoption of such recommendation is inconsistent with the purposes and requirements of this Part or with other applicable provisions of the law, and 2) a finding that the conditions selected by the Commission comply with the requirements of paragraph (1).

The authority given to the resource agencies is a little more restricted than it may appear. Section 4(e), which allows federal land management agencies (e.g., Forest Service, Bureau of Land Management, etc.) to issue mandatory terms and conditions to protect the purposes for which their lands are held in trust, including fish passage where appropriate, applies to FERC-licensed hydropower plants on federal reservation lands.[5] Fish and wildlife recommendations made by federal and state resource agencies under section 10(j) are limited to those designed to protect, mitigate damages to, or enhance fish and wildlife, including related breeding or spawning grounds and habitats; but they are not mandatory.[6] FERC must meet with the pertinent agencies to discuss alternatives and new information or to demonstrate the recommendations' inconsistency with other applicable legislation in order to alter or decline section 10(j) recommendations. Nevertheless, this issue is at the core of one of the larger "balancing" debates. Section 18 fishway prescriptions developed by the federal resource agencies are mandatory, although of narrower scope than recommendations allowed under section 10(j).

FERC is not primarily an environmental agency, yet has the ability to enforce environmental requirements through conditioning authority, power to investigate, and penalty and revocation authority (43). FERC can specify conditions for a license approval, such as minimum flow, fishway requirements, etc. Once the conditioned license is accepted, the conditions become enforceable by FERC. Indeed, FERC is able to exact civil penalties of up to $10,000 per day in enforcement. In one case, a hydropower licensee that was found to have violated "run of the river" and minimum stream flow requirements was assessed a $19,000 civil penalty (43). Revocation authority—whereby the agency can halt a project found in non-compliance—is another important FERC enforcement tool. Yet, revocation also faces great constraints to use since it may not result in correcting the damage. In one such instance where revocation might have been

[5] Federal reservation lands include national forests, wilderness areas, Indian reservations, and other federal public lands reserved for specific purposes and withdrawn from private disposition.

[6] Additional recommendations related to broad-reaching efforts such as rehabilitation of damages, habitat, management considerations, and general enhancements for fish and wildife populations may be made under section 10(a); also subject to FERC approval.

employed, FERC chose not to revoke the license, but to examine possibilities for mitigation requirements and penalties instead (43).

Hydropower Licensing Procedure

The licensing (or re-licensing) procedure is a seven-step process occurring in three stages and culminating in a licensing decision (box 5-3) (74). Prospective licensees must notify FERC of the intent to relicense as early as five and a half years, but no later than five years, prior to license expiration. The application must be filed with FERC at least two years prior to expiration. Prior to application filing, prospective licensees must confer with the appropriate resource agencies. Pre-filing consultation stages include:

Stage 1: The applicant must provide the agencies with basic information about the project and any proposed changes. The agencies respond with recommendations for studies.

Stage 2: The applicant completes all reasonable and necessary studies, obtains all reasonable and necessary information required by resource agencies, and prepares the draft application.

Stage 3: The applicant provides the agencies with a copy of the application, including agency correspondence regarding the project, and copies of relevant certifications (e.g., section 401 CWA permit).

FERC staff conduct the environmental analysis required for the project by the National Environmental Protection Act and produce an Environmental Assessment or an Environmental Impact Statement, as appropriate. Finally, the Director of the Office of Hydropower Licensing (by delegated authority) or the Commission determines whether or not to issue the license and includes the conditions recommended by the agencies and found consistent by FERC, as well as conditions recommended by FERC staff in the environmental analysis.

A large number of FERC licenses have recently expired and many more are due for renewal by the year 2010. This situation provides a significant opportunity to consider the adequacy of fish passage at these sites. As of July 1995, FERC had relicensed 65 of the 167 projects in the "class of 1993." An additional 97 facilities will need relicensing between now and the year 2010 (49).

The Federal Resource Agencies

The Department of Commerce, acting through the National Marine Fisheries Service (NMFS), and the Department of the Interior, acting through the Fish and Wildlife Service (FWS), are the federal agencies primarily responsible for the conservation and management of the nation's fish and wildlife resources. Together, these agencies share a mandate to conserve, protect, enhance, and restore fish populations and habitat for commercial, recreational, and tribal fisheries.

FWS has broad-delegated responsibilities to protect and enhance fish and wildlife and related public resources and interests under authorities granted by the Fish and Wildlife Act of 1956; the Fish and Wildlife Coordination Act (FWCA); the National Environmental Policy Act (NEPA); the Migratory Bird Treaty Act; and the Endangered Species Act of 1973 (ESA). NMFS is entrusted with federal jurisdiction over marine, estuarine, and anadromous fishery resources under various laws, including the FWCA, NEPA, ESA, and the Magnuson Fishery Conservation and Management Act.

FWS and NMFS have expertise and responsibility for fishery resources which are germane to FERC's hydropower licensing decisions. Prior to licensing, FERC has an affirmative duty to consult with FWS and NMFS pursuant to the FWCA and the FPA to determine measures to protect, mitigate damages to, and enhance fishery resources, including related spawning grounds and habitat. FWS and NMFS recommend license conditions to achieve these goals and prescribe mandatory conditions for the construction, operation, and maintenance of fishways (150).

Consultation with prospective hydropower licensees and development of fish passage mitigation plans are the responsibility of these federal resource agencies and their state counterparts. NMFS and FWS develop fish passage prescriptions under section 18 of FPA for inclusion in the FERC license order. Broader mitigation recom-

BOX 5-3: Procedural Steps in Hydropower Licensing

- Applicant submits an application to FERC along with the background information on the project, economic, environmental, proposed benefits, etc. The background information may include as much as eight to nine volumes of information.
- FERC reviews the application and the supporting information and determines the need for additional studies or information. FERC sends Deficiency Statements to the applicant describing the types of information or studies that will be required to continue the application process.
- Additional information requests may be submitted by FERC after reviewing the new information submitted by the applicant in response to the Deficiency Statements.
- Upon receipt of all of the required information, FERC identifies the project as "Ready for Environmental Analysis." This is the starting point for the resource agencies, which have 45 days to develop and determine the need for fish protection mitigation under sections 10(j) and 18 of the Federal Power Act. The agencies may file for an extension if this cannot be completed within the 45-day period.
- Based on the information provided by the applicant and resource agencies, FERC develops Scoping Document I that investigates whether to undertake an Environmental Assessment (EA) or an Environmental Impact Statement (EIS) in compliance with the National Environmental Policy Act (NEPA).
- Scoping Document I is submitted for general public comment. Based on the review comments, FERC produces Scoping Document II, which is in essence a blueprint for the EA or EIS.
- The draft EA or EIS is produced and submitted for general public comment. Based on review, the final EA or EIS is produced.
- FERC develops a License Order for the project and submits this and the environmental document to the Commission for final determination for licensing.

SOURCE: Office of Technology Assessment, 1995.

mendations are made by the federal and state resource agencies under section 10(j) of the FPA.

Federal land management agencies (e.g., U.S. Forest Service, Bureau of Land Management, Bureau of Reclamation) have authority to issue section 4(e) conditions for hydropower facilities on public lands under their jurisdiction. Facilities on U.S. Forest Service lands represent nearly 15 percent of all FERC-licensed hydropower plants, or at least 240 facilities. The Forest Service (FS) currently is facing approximately 50 applications for relicensing and another 60 applications for new projects. In an effort to streamline its process and improve certainty for prospective licensees, the FS has recently outlined a proposed policy with regard to issuing section 4(e) conditions.[7]

Although the FERC licensing process is not integrated with the fishway prescription process, it drives the latter. Resource agency prescriptions and recommendations must be submitted when FERC rules that the project is ready to undertake the required environmental studies (EA or EIS). In some instances, FERC makes this decision before the resource agencies have the information they believe is needed to make meaningful fish and wildlife recommendations that can be supported by substantial evidence.

[7] In the proposed policy, it is stated that 4(e) recommendations would not try to achieve "preconstruction" conditions. This harmonizes with FERC's approach to environmental assessment documents. A second alteration involves the relinquishing of FS's unilateral "reopener" for special-use permits. At present, FS may revise special-use authorization conditions at specified intervals to reflect changing environmental conditions if the terms of the authorization exceed 30 years. This enables FS to re-open the permit to ameliorate negative impacts at a site without waiting up to 50 years for a license to expire.

Issues in Hydropower Licensing

The licensing and relicensing of hydropower projects under the jurisdiction of FERC provides a unique opportunity to restore, rehabilitate, and protect river systems for the license term, often a 30- to 50-year time frame. However, relicensing is a highly controversial issue among the many stakeholders involved in the process. State and federal resource agencies, the hydropower industry, special interest groups (e.g., environmental), Native Americans, individual owner/operators, and the public at large are all involved. Balancing of all of the competing interests in hydropower licensing is a complex process, generating much dispute among the participants (112). Key issues include: adequate balancing of developmental and nondevelopmental values; defining the baseline goal for mitigation; process timeliness; reopening license orders; and dam decommissioning.

Adequate Balancing

The need for balance of developmental and nondevelopmental values in hydropower licensing decisions was underscored by ECPA in 1986. Yet, resource agencies contend that despite existing authority identifying their role and expertise in the hydropower licensing process, insufficient weight is given to their recommendations in final balancing decisions. Some observers note that FERC's role in balancing competing interests in hydropower licensing has become increasingly difficult because of the many mandatory license conditions possible in the licensing process (e.g., resource agencies, states) (112). Others point to the need for this broad level of input to ensure all factors are considered in FERC's balancing role.

Federal and state resource agencies and environmental groups note that the nonbinding nature of the section 10(j) recommendations is a significant problem. If FERC finds that 10(j) recommendations are inconsistent with other applicable law, they may be altered or excluded. FERC must meet with relevant agencies to alter or decline section 10(j) recommendations and section 10(j)(2) requires that FERC give "due weight to the recommendations, expertise, and statutory responsibilities" of federal and state resource agencies. In some instances where disputes are settled on the basis of FERC professional judgment, the resource agencies feel that their views and expertise have not been adequately considered or have been supplanted by FERC expertise. Thus, FERC has been criticized for rejecting or modifying recommendations—in some cases nullifying the recommendations' impacts (91). On the other hand, GAO found that FERC accepts a higher proportion of environmental recommendations without modification now than it did before ECPA, i.e., three-fourths versus two-thirds in the cases studied (123,240,241). However, given the nature of balancing, recommendations that are unlikely to affect a hydropower project's economic viability may be more likely to be approved than those that directly affect power production.

States may also enter into the balancing process in other venues. Where FERC's jurisdiction is exclusive it may preempt state environmental requirements. For example, in *California* v. *FERC*, 495 U.S. 490 (1990), FERC successfully defeated a proposal by the California State Water Resources Control Board to increase minimum streamflow requirements for a previously licensed hydropower plant. The licensee demonstrated to FERC that this increase would adversely affect the economic viability of the project (43).

Yet, FERC's authority to preempt state requirements recently was limited by the U.S. Supreme Court in *Jefferson County* v. *Washington Dept. of Ecology*. The case clarified that states could require minimum instream flows as a condition of a federally issued permit, such as a FERC license. Under the Clean Water Act's section 401, all applications for a federally issued permit must include a certification from the state that the proposed permit is consistent with achieving the state's water quality goals. The State's Department of Ecology argued that minimum flows were necessary to maintain the quality of the riverine systems for fisheries management, and refused to grant a certification

unless the permit required those flows. The Supreme Court found that a state's responsibility for achieving water quality goals gave it the authority to mandate release of flows by FERC-licensed projects and to enforce other standards (136).

Critics of the ruling in *Jefferson County* argue that the intent of the Clean Water Act is to restore and maintain water quality, not to interfere with water quantity issues (113). Proponents of the decision say the Supreme Court was correct in saying that water quantity was an integral part of the Clean Water Act's intent to "restore the chemical, physical and biological integrity of the nation's waters" (Clean Water Act §101(a), 33 U.S.C. §1251(a)). The *Jefferson County* decision has created substantial controversy within the hydropower sector and is likely to be a continuing point of contention. In the 104th Congress, legislation has been introduced that would alter the effect of the decision.

Defining Baseline for Mitigation

Defining the baseline to be used in determining the goal for mitigation is perhaps one of the more hotly disputed issues. This is particularly significant in re-licensing decisions since existing hydropower plants may not have been previously required to mitigate for environmental impacts. Further, lack of historical baseline environmental data hinders identification of pre-construction conditions.[8] The question also arises as to the potential for achieving pre-construction conditions, given that the alterations to the environment may have occurred decades ago.

Operators sometimes feel that they are being asked to mitigate for conditions not of their making. Many view relicensing as a continuation of the status quo, and thus, existing conditions become the starting point for environmental studies. On the other hand, critics state that relicensing is not just a continuation of the status quo but a federal recommitment of public resources for a lengthy period of time (30 to 50 years). The environmental community points to the relative time sequence of past and present decisionmaking criteria and the significant advances made in environmental law and mitigation measures since the mid 1900s. Thus, efforts to achieve pre-construction conditions in certain riverine systems might be considered properly managing the resource for the public interest. In any event, there clearly is a need for close collaboration among FERC staff (or their surrogates) and the state and federal resource agencies in the development of the Environmental Impact Statement (EIS) and Environmental Assessment (EA) for hydropower projects.

Process Timeliness

Relicensing has not been a timely process, creating uncertainty for prospective licensees and resource managers. Licensees are concerned about uncertainty and costs in increasingly competitive energy markets. Delays due to multiple processes at both the state and federal levels may expose licensees to the risks of duplicative study efforts and inefficiency. Resource managers are concerned about preserving and conserving resources at risk. Delays in the licensing process slow the implementation of mandatory fish passage prescriptions. In the current "class of '93" situation, the process has been especially prolonged. Some blame licensing delays on the lack of cooperation among stakeholders, resulting in revisiting issues over the course of the process to ensure that all sides are fairly heard.

Delay may also be perpetuated by the timetables set by FERC's licensing regulations. For some projects, especially those involving multiple developments, the timeframe may be unrealistically short. Resource agencies contend that one to two years is inadequate to complete the required studies to give decisionmakers reliable information (150). Similarly, linking multiple facilities in the licensing process may lead to delays in implementing resource protection mitigation at several facilities due to difficulties at a

[8] Preconstruction conditions refers to the environmental conditions that existed prior to the placement of the hydroelectric facility.

single site. For example, several Bangor Hydroelectric Company facilities on the Penobscot River in Maine are linked in the licensing process. A single, controversial new project proposal has delayed the licensing process, leaving the other existing projects operating under annual licenses and delaying decisions on the need for fish protection mitigation at these sites (21).

Decommissioning and Dam Removal

Decommissioning and/or removal of existing dam facilities as an alternative to relicensing has been raised more frequently since the "class of 1993" and as part of the movement toward greater scrutiny of the adverse impacts of hydropower plants on certain fish populations. Dam removal options are faced by a number of very real environmental, economic, and political constraints and, thus, are infrequently considered as alternatives to fish passage development.

A recent FERC policy statement (RM93-23) identifies the Commission's authority to order decommissioning of hydropower plants at licensee expense as an alternative to relicensing. FERC would hear the cases individually rather than developing a generic decommissioning program. If the policy is actively pursued, a need exists to incorporate planning and budgeting for decommissioning and dam removal in the licensing procedure so that applicants are aware from the start of the costs and possibilities.

The Bureau of Reclamation is examining possibilities for removal of Savage Rapids Dam on the Rogue River in Oregon; the operator asked for removal rather than fishway installation. Removal of the dam would eliminate salmon and steelhead passage problems although recreational value would be curtailed. Demolition of the dam and construction of the plants is estimated to take five years and cost $13.3 million. To retain the dam and install fish protection has been estimated to cost $21.3 million (115).

License Reopeners

Reopening of licenses prior to expiration has also been the subject of much debate. FERC can use reopeners to require projects to mitigate cumulative impacts in multi-project basins. Placeholder clauses allow revisiting of license conditions after a specified event occurs. For example, an upstream facility license could contain a placeholder clause that would require development of fish passage mitigation at such time as a facility downstream completed relicensing to include fish passage, e.g., when fish populations were physically able to proceed to the upstream facility.

Resource agencies and other participants in the process may request that FERC reopen a license for various causes. However, this is not a unilateral decision and must be accomplished through a hearing process. Understandably, industry may be less inclined to support reopening when the potential for additional mitigation costs may result from the activity and thus affect project economics. Consequently, the resource agencies have been criticized for attempting to solve larger fishery management problems through the prescription process. The agencies respond that the long license period and lack of reopening authority means that they must develop mitigation plans with a vision toward meeting future as well as present needs through their recommendations, terms and conditions, and prescriptions.

Improving Hydropower Licensing

Not surprisingly, the level of controversy generated by hydropower licensing has led to a number of efforts to improve the process and bring adversarial parties together. Some of these efforts show promise, although in certain cases they have been bogged down by the very debate they intended to address. Primarily, efforts have attempted to make the process transparent and improve discussion among the participants.

Settlement Agreements

The FERC licensing process requires that prospective licensees consult with resource agencies and others in the first stage of licensing. Yet, many licensees are learning that even earlier coordination and outreach is needed. Agreements

between parties with opposing interests are commonly used in other resource protection venues, and now appear more often than before in FERC proceedings. For parties advocating fish protection, a settlement agreement involves negotiating with the licensing party to obtain the protective measures deemed necessary. Tradeoffs in the usual fixed positions of the two parties can be made to obtain better mitigation than is usually attainable through the FERC process. Holistic viewpoints can be developed and maintained, and decisions can be reached at a local rather than exclusively federal level.

Parties must perceive a need to negotiate in the FERC hydropower licensing process, beyond the regulatory requirements of applicants and agencies, in order to achieve success. FERC must be seen as a neutral party to motivate participants to find mutually acceptable agreements in accommodating the need for power production and resource protection. If FERC is perceived to favor certain interests, the need to negotiate is diminished or eliminated. Requirements for successful use of settlement agreements are: skilled negotiators, technical specialists and lawyers skilled in FERC issues; and a shared goal to resolve differences. Commitment to conflict resolution on the part of negotiating parties is essential for success. Necessary tradeoffs can then be made to resolve difficult negotiating points.

Conceptual agreements may be reached fairly early in the process without involvement of legal expertise, but this expertise may be essential when it comes to drafting the actual language of the agreement. Successful settlement agreements also depend on consensus on a single position among resource agencies outside the negotiating room. Since different agencies have their own agendas and missions, which sometimes clash, this can be problematic. Significant agency concessions may be needed to satisfy the interests/missions of each.

The Michigan Department of Natural Resources has realized many of its goals for fish protection through settlement agreements on relicensing projects with Consumers Power Company and a new license project with Wolverine Supply Cooperative. Issues resolved in these agreements were largely accepted by FERC and incorporated in the licenses for these projects.

NMFS/FWS Advanced Notice of Proposed Rulemaking (ANOPR)

Some licensees feel the licensing process is unpredictable because of the lack of universal standards to be used in the fish passage prescription process. Neither NMFS nor FWS has published standards and criteria that a licensee can use to judge if a fishway is likely to be prescribed, and if so, what sort. However, licensees can expect that passage will be an issue if their project has blocked or will block fish movement and access to historic habitat.

In an effort to address this concern, FWS and NMFS solicited comments on the benefits of a proposed rule to harmonize and codify their existing practices for prescribing fishways under section 18 of the FPA (233). An extensive review and comment period generated a number of issues to be resolved, one of which is the need for such a rule or if a policy statement is sufficient.

Hydropower Reform Coalition

The Hydropower Reform Coalition (HRC) is a coalition of conservation groups with an interest in river protection. In its review of the hydropower licensing process, HRC found FERC's existing hydropower regulatory structure to be better than any of the suggested alternatives.[9] However, HRC feels FERC regulation of hydropower's effects on nonpower values of river systems is inadequate and suggests several options to rectify the problem, including:

[9] Some of the suggested alternatives included: 1) placing regulatory authority at the state level and 2) exempting small dams from FERC authority. The first alternative was criticized for increasing the fragmentation of the licensing process and the latter was for failing to recognize that adverse environmental impact is not necessarily proportionate to facility size.

- FERC should examine an entire river system when evaluating and mitigating adverse environmental effects from hydropower development;
- FERC should synchronize license expiration dates so projects in a basin can be reviewed simultaneously; and
- FERC should include headwater storage reservoirs more consistently within regulatory control.

HRC supports FERC deference to state CWA section 401 rulings and favors adopting resource agency section 10(j) recommendations.

HRC and National Hydropower Association (NHA) entered into negotiations to determine if it would be possible to collaborate in developing a proposal to resolve many of the difficulties in the licensing process. Issues included ensuring compensation for private use of public goods by setting up decommissioning funds, establishing mitigation and restoration funds, and requiring licensees to reimburse resource agencies for study of license recommendations (113). Negotiations broke off, however, and NHA developed its own proposal and requested a FERC rulemaking proceeding. HRC opposed the rulemaking as unnecessary and a distraction to the relicensing process.

MITIGATION COSTS AND BENEFITS[10]

Quantifying fish passage system capital costs is fairly simple and largely a question of accounting. Determining which costs are rightly attributable to fish protection or passage may pose the largest difficulty. For example, damaged turbines at the Conowingo Plants required replacement to continue generating power at the facility. These new turbines provided acceptable downstream passage for juvenile American Shad as well as reduced turbine mortality rates compared to the older models (177). What, if any, part of the new turbines and installation expenses should be counted as fish protection costs, given that the turbines were needed for power generation in any event?

Quantifying operating costs related to fish passage is more difficult since it frequently involves costs related to revenue loss from lost power generation potential due to spillflows or other water management practices that are required for proper fish passage operation. For example, the high annual cost of downstream protection at the Lower Monumental Plant (table 5-1) is largely costs for the power that will not be produced.

Determining the benefits of fish protection and passage is more difficult. As a first step, it is imperative to examine the multiple values assigned to the resource. Some of these values are difficult if not impossible to describe economically (e.g., cultural, ecological) and thus fit poorly into traditional benefit-cost analyses. Nevertheless, they must be weighed in decisionmaking.

Costs and benefits are not directly proportionate. For example, "X" dollars for constructing and operating a fish passage/protection system does not necessarily result in an "X" amount change in the number of fish passing a barrier. Other life-cycle factors that affect a species also affect passage rates. Availability and quantity of spawning habitat, downstream passage success, ocean catch levels, and drought may directly affect population success.

Mitigation costs vary considerably depending on the type and scale of the mitigation measure. Scale is driven by a site's physical features (e.g., water flow, dam size, and configuration) and finding similarities between two plants can be difficult (table 5-2). For example, the Wadhams plant, with its 0.56 megawatt capacity and 214 cubic feet per second (cfs) average water flows,

[10] This section is drawn from J. Francfort, Idaho National Engineering Laboratory, "Synthesis of the Department of Energy's Fish Passage and Protection Report, Vol.II," unpublished contractor paper prepared for the Office of Technology Assessment, U.S. Congress, June 1995.

TABLE 5-1: Downstream Fish Passage/Protection Mitigation Benefits Over 20 Years (Levelized Annual Costs in 1993 Dollars)

Plant	Mitigation type	Agency objective	Mitigation benefit	Annual cost[a] (20-year average)
Arbuckle Mountain	Cylindrical, wedgewire screens	Prevent fish entrainment (chinook salmon, steelhead, rainbow trout)	No anadromous fish present. Drought restricted monitoring.	$7,900
Brunswick	Steel bypass pipe	Reduce mortality for downstream migrating fish (American shad, alewife)	No established monitoring program.	46,500
Jim Boyd	Perforated steel screen	"No induced mortality" standard	Reportedly achieves agency standard. Visual observations performed.	51,000
Kern River No. 3	Fixed barrier screens	Protect "put-and-take" rainbow trout fishery	No established monitoring program.	7,700
Leaburg	"V" wire screens and bypass	"No net loss" standard	Meets agency standards.	381,200
Little Falls	Wire mesh screens and bypass	Protect downstream migrating blueback herring	Less than 1% turbine entrainment (>100,000 passed each season).	123,400
Lowell	Bypass sluice	Pass American shad and Atlantic salmon	No established monitoring program but existing sluice is considered ineffective.	52,850
Lower Monumental	Submerged, traveling screens	Prevent turbine entrainment (salmon and steelhead)	Not yet monitored.	4,812,000
T.W. Sullivan	Eicher screen and conduit	Decrease turbine entrainment	Bypass efficiency between 77 and 95%.	713,000
Twin Falls	Inclined wedgewire screens	"No induced turbine mortality" standard	Reportedly effective.	75,850
Wadhams	Angled trash racks and bypass sluice	Protect downstream-moving Atlantic salmon from turbine mortality	1987 study; 8% entrainment.	2,420
Wells	Hydrocombine bypass	Goal: "no induced mortality"; present agency criteria: (passage efficiency): spring – 80% efficiency summer – 70% efficiency	Passage efficiency exceeds agency criteria.	1,756,000
West Enfield	Steel bypass pipe	Protect downstream migrating Atlantic salmon and alewife	Efficiency: 1990—18% 1991—62% (with attraction lighting). Mortality in bypass greater than in turbines.	61,000

[a] Some of these annual costs include costs due to loss of power generation capacity resulting from spillflows and other water management practices.

SOURCE: U.S. Department of Energy, *Environmental Mitigation at Hydroelectric Projects, Volume II: Benefits and Costs of Fish Passage and Protection*, Idaho Field Office, DOE/ID-10360(V2), January 1994.

TABLE 5-2: Case Studies General Information

Plant name	Capacity (MW)	Annual energy production (MWh)	Diversion height (ft.)	Average site flow (cfs)	State	Upstream mitigation	Downstream mitigation	Mitigation cost (mils/kWh)[a]
Arbuckle Mountain	0.4	904	12	50	California	Y	Y	12.9
Brunswick	19.7	105,200	34	6,480	Maine	Y	Y	3.7
Buchanan	4.1	21,270	15	3,636	Michigan	Y	N	10.6
Conowingo	512	1,738,000	105	45,000	Maryland	Y	N	0.9
Jim Boyd	1.2	4,230	3.5	556	Oregon	Y	Y	21.1
Kern River No. 3	36.8	188,922	20	357	California	Y	Y	0.09
Leaburg	15	97,300	20	4,780	Oregon	Y	Y	5.2
Little Falls	13.6	49,400	6	n/a	New York	N[b]	Y	2.8
Lowell	15	84,500	15	6,450	Massachusetts	Y	Y	5.5
Lower Monumental	810	2,856,000	100	48,950	Washington	Y	Y	2.3
Potter Valley	9.2	57,700	63	331	California	Y	Y	n/a
T.W. Sullivan	16.6	122,832	45	23,810	Oregon	N[c]	Y	5.8
Twin Falls	24	80,000	10	325	Oregon	N	Y	0.9
Wadhams	0.56	2,000	7	214	New York	N	Y	1.2
Wells	840	4,097,851	185	80,000	Washington	Y	Y	1.0
West Enfield	13	96,000	45	12,000	Maine	Y	Y	3.9

[a]Costs are in 1993 dollars, per kilowatt-hour of generation, based on 20-year averages. All upstream and downstream mitigation-related costs are included.

[b]Upstream passage occurs through New York Department of Transportation Barge Lock Number 17.

[c]Upstream passage occurs through Oregon Department of Fish and Wildlife maintained fish ladder at Willamette Falls.

KEY: n/a = not available.

SOURCE: U.S. Department of Energy, *Environmental Mitigation at Hydroelectric Projects, Volume II: Benefits and Costs of Fish Passage and Protection*, Idaho Field Office, DOE/ID-10360(V2), January 1994.

has annual downstream mitigation costs of $2,420. The Lower Monumental plant, with 810 MW capacity and average flows of 48,950 cfs, has an average annual cost of $2.4 million (table 5-1). Although these are poor summaries of both plants' costs, it illustrates the disparity despite their identical objectives to safely pass downstream migrants. A summary based on averages for such diverse costs would be, if not erroneous, at least misleading.

Alternatively, costs could be summarized based on a factor such as fish ladder construction costs per foot of design head; the design head implies the vertical elevation that a ladder must pass adults. Yet, it can also be misleading to assume that the hydraulic design head is approximately the same as the required height for a fish ladder. For example, the Kern River No. 3 plant has an 880-foot head, but the ladder is used at an upstream diversion that is only 20 feet high.

In the same vein, quantifying the benefits of fish passage mitigation is plagued with problems stemming from the inadequacy of traditional economic analyses in resource valuation. The examination of the DOE case studies that have implemented fish passage measures reveals that several plants have been successful in increasing the passage rates or survival of anadromous fish (i.e., the Conowingo, Leaburg, Lower Monumental, Wells, Buchanan, and T. W. Sullivan plants). Six other plants show encouraging pre-

liminary results; they have not been adequately studied to determine the long-term impacts on fish populations (i.e., Brunswick, Jim Boyd, Little Falls, Lowell, Twin Falls, and Wadhams). Only one of the case studies (West Enfield) appears to have failed in the attempt to enhance fish populations, but for some the benefits are unclear. In some cases, benefits could be expressed only in terms of the numbers of individual fish that were transported around the dam or protected from entrainment. Missing, however, is the assessment of the long-term effects of these mitigation measures on fish population levels.

"How much are additional fish worth?" In some cases, the fish are commercially caught and determining value may be simplified. It is slightly more difficult to determine the revenue stream from fish caught recreationally. It becomes even more difficult to attach a price tag to fish caught as part of a traditional cultural activity. For example, Native American fishing rights at usual and customary locations as guaranteed by U.S. treaty is recognized as a significant cultural event. If hydropower development depletes historic stocks to the point where this activity can no longer be pursued, then how much is a fish worth? Clearly, fish have a variety of values depending on their ultimate use and the role that fishing plays in human activities.

If price tags are not available, how can the value of fish be estimated? Resource economics has developed two types of methods for estimating the values of natural resources, including recreational fish. The *direct method* is to ask people their valuations of particular resources through surveys constructed to eliminate a number of potential biases. The *indirect method* relies on the fact that to consume part of a natural resource, which has no price tag, a fisherman must spend some of his or her money (and time) on goods which are sold in markets. Travel costs, including the value of time as well as out-of-pocket costs and any entry fees at restricted fishing sites, amount to the effective, or implicit, price which fishermen pay for their recreational fish. This information can be used to construct a demand curve to estimate the recreational value of fish at a specific site and time—the marginal value.

Use and nonuse values in natural resource valuation have become prominent in public, scientific debates in the past several years, however, they are subject to theoretical and methodological concerns. The *use value* is the value someone will pay to consume a natural resource, whether that consumption act is catching a fish and eating it, catching a fish and releasing it, or looking at a mountain in a national park. The consumer of the natural resource is actively involved in the act of consumption and somewhere in the act of consumption pays out some real resources—money, time, wear and tear on a vehicle—for that consumption.

Nonuse value is how much it is worth to a person simply to know that a natural resource exists, even though he or she has no intention of ever directly consuming it (e.g., hunting or catching it, walking through it, or even viewing it). Nonuse value is more difficult—if not impossible—to observe, and its measurement is restricted to the direct method survey.

The estimated marginal values of recreational fish vary considerably, even within a single state, primarily according to the accessibility of the site to a population of fishermen and, of course, according to species. Fish at sites which are accessible to larger numbers of fishermen will be valued by more people, which drives up their marginal values. Table 5-3, which shows marginal values for steelhead trout on 21 rivers in Oregon in 1977 (in 1993 prices), reveals this effect quite clearly. Table 5-4 shows marginal values of trout and salmon (1978 values at 1993 prices) in 11 counties along the Lake Michigan shoreline in Wisconsin, with a range of values from $10.56 to $87.37, an eight-fold difference. The values in these two tables clearly demonstrate variation in value between sites, and the transfer of fish value estimates from one site to another is a subject of active study. The principal rule of thumb emerging so far is that values are more transferable to nearby sites than to sites farther away, although measures of "near" and "far" are still rough.

This brief review of the various methods used in determining the value of a fish points out the

TABLE 5-3: Marginal Values of Steelhead Trout in Oregon Rivers, 1977 (in 1993 prices)

River	Marginal value (in $)	River	Marginal value (in $)
Alsea	$31.48	Rogue	$114.95
Chetco	30.11	Salmon	243.59
Clackamas	240.86	Sandy	157.38
Columbia	190.22	Santiam	253.17
Coquille	46.53	Siletz	87.58
Coos	24.63	Siuslaw	90.32
Descutes	109.48	Trask	184.75
Hood	168.33	Umpqua	134.11
John Day	56.11	Willamette	455.71
Nehalem	183.54	Wilson	172.43
Nestucca	143.69		

SOURCE: Loomis, 1989, table 1, in U.S. Department of Energy, *Environmental Mitigation at Hydroelectric Projects, Volume II: Benefits and Costs of Fish Passage and Protection*, Idaho Field Office, DOE/ID-10360(V2), January 1994.

complex and subjective nature of this issue. Determining the value of a natural resource such as a fish is not an exact science. Research and discussion continue in the attempt to develop a methodology to determine natural resource values that would be universally acceptable. How this ultimately will affect the development of new hydropower sites, the relicensing of developed sites, and any affiliated mitigation requirements is unknown.

RESEARCH AND DEVELOPMENT: FEDERAL INVOLVEMENT

Many federal agencies are involved in research and development efforts related to fish passage and protection technologies. Below is an overview of certain institutions and activities relevant to improving fish protection.

Northwest Fisheries Science Center

The NMFS Northwest Fisheries Science Center (NWFSC) is the research center serving the Northwest Regional NMFS Office and provides scientific and technical support for management, conservation, and development of fishery resources. Research is performed in conjunction with federal, state, and local resource agencies, universities, and other fishery groups. The mission of the NWFSC includes a focus on the following research areas:

- understanding and mitigating the impacts of hydropower dams on salmon and performing ecological and genetic research on salmon in support of the ESA;
- evaluating the effects of marine pollutants on coastal ecosystems in the United States;
- enhancing the quality, safety, and value of fishery products; and
- developing methodologies for marine aquaculture and salmon enhancement.

Coastal Zone and Estuarine Studies

The Coastal Zone and Estuarine Studies (CZES) Division of NMFS defines its scientific mission as to develop information leading to conservation, enhancement, and balanced use of marine and anadromous resources of the Pacific Northwest (235). Research of the CZES Division focuses on the Columbia River Basin and Puget Sound and the salmonid populations in these regions. Four research programs exist in CZES: Ecological Effects of Dams, Habitat Investigations, Fisheries Enhancement, and Conservation Biology. Projects within these programs are undertaken collaboratively with other appropriate agencies (e.g., COE, FWS). CZES maintains

TABLE 5–4: Marginal Values of Trout and Salmon in Eleven Wisconsin Counties Bordering Lake Michigan, 1978

County	1	2	3	4	5	6	7	8	9	10	11
Marginal value of fish in dollars	12.42	18.37	11.50	36.52	86.37	10.56	12.01	15.17	87.37	16.23	42.63

NOTE: Unweighted averages in 1993 dollars.

SOURCE: Samples and Bishop, 1985, Table 2, p. 69, pp. 70–71, in U.S. Department of Energy, *Environmental Mitigation at Hydroelectric Projects, Volume II: Benefits and Costs of Fish Passage and Protection*, Idaho Field Office, DOE/ID-10360(V2), January 1994.

two field stations for research on the Columbia River at Pasco, Washington, and Hammond, Oregon.

The Ecological Effects of Dams Program engages in applied research relating to the migration of anadromous fish. Studies include: 1) the adaptability of juvenile salmonids to changing environments created by dams, 2) collection and transportation of juvenile salmonids, 3) migrant passage at dams, and 4) enhancement and redistribution of stocks. Habitat Investigation Program projects focus on the Columbia River estuary and emphasize environmental background studies, impacts of dredging and dredge-disposal studies, impacts of discharged materials or heat studies, and estuarine salmonid studies. The Fisheries Enhancement Program provides regional leadership in research on improving the production of aquatic organisms for commercial and recreational use and conservation of endangered populations. The Conservation Biology Program has responsibility for providing scientific bases for decisions on listing anadromous Pacific salmonids under the Endangered Species Act.

Conte Anadromous Fish Research Center

The National Biological Survey (NBS) operates the Conte Anadromous Fish Research Center in Turner's Falls, Massachusetts, and conducts cooperative research with a number of federal agencies. Conte is the sole center for applied fish passage research in the country. The lab is relatively new, having opened its doors in 1991, and is staffed and funded by FWS and NBS. The facility's size, and financial and personnel resources, limits the number of projects that can be conducted at any one time, and often joint efforts are forged with private research organizations or utilities that can provide an area of expertise or funding. As a result, the Conte staff tends to select studies that have the potential for generic applicability in the field, as opposed to those that might be more site- or project-specific. Thus, research results have the potential to be broadly applicable to practitioners in the field.

Conte's laboratory resources are allocated to projects that address questions concerning fish passage from *hydraulic*, *biological*, and *behavioral* perspectives. Staff engage in a constant exchange of data and results to help support research in the complementary area. Below are sketches of research areas the lab is currently engaged in:

Hydraulic Lab: The Hydraulic Lab conducts hydraulic modeling to answer specific research questions. Current projects include evaluation of a new passage technology, gathering basic data on the operation of Denil and Alaska steeppass fishways at various slopes and flows, and development of a fish passage design for Little Falls Dam on the Potomac River. Some investigatory work at Cabot Station on the Connecticut River is also underway.

Fish Behavior Lab: The fish behavior lab at Conte addresses fish passage research questions from a biological perspective. The lab has developed cooperative relationships with universities who share graduate students and funding. This program is an extension of the Fish and Wildlife Research Units that came into existence in the 1960s to enable university-supported fisheries

research. The lab has also established relationships with state resource agencies and hydro project operators interested in improving and developing fish passage technologies for application at specific sites.

Project Improvements for Endangered Species

Under the direction and supervision of the Secretary of the Army, through the Assistant Secretary of the Army (Civil Works), the Commander of the Army Corps of Engineers (COE) has responsibility for investigating, developing and maintaining the nation's water and related environmental resources; constructing and operating projects for navigation, flood control, major drainage, shore and beach restoration and protection, related hydropower development, water supply, water quality control, fish and wildlife conservation and enhancement, and outdoor recreation; responding to emergency relief activities directed by other federal agencies; and administering laws for the protection and preservation of navigable waters, for emergency flood control, and for shore protection.

The COE has coordinated with other agencies and other regional interests in establishing programs to lessen the impacts of those projects on fish. The Portland District has developed a program that covers 19 activities under one umbrella called Project Improvements for Endangered Species (PIES). PIES, and its mission to improve salmon passage, has been endorsed by NMFS. The projects cover a wide range of issues and costs and are financed through Operations and Maintenance funding to the tune of $14 million. The COE also has a regionally funded research program known as the Fish Passage Development and Evaluation Program (FPDEP) which has numerous studies underway on juvenile bypass and transportation, adult fish passage, and related issues such as spill effectiveness and dissolved gas effects.

Waterways Experiment Station

The Waterways Experiment Station (WES) in Vicksburg, Mississippi, is a COE research compound complete with six laboratories: Hydraulics, Coastal Engineering, Geotechnical, Structures, Environmental and Information Technology. At WES, working models of dams in the northwest are used to assist engineers and biologists in finding ways to increase anadromous fish survival rates. The facility was established in 1929 with the mission of developing flood control plans for the Mississippi River. Today, its mission is a bit different.

In the Hydraulics Lab, most of the work is focused on fish passage issues. Research techniques are used on models (built 1 ft to 80 ft, or 1 ft to 100 ft) of the Columbia and Snake River projects (231). The models are used to analyze flow conditions, and scientists can evaluate the hydraulic conditions that salmon may encounter as they pass various projects in an effort to determine the range of on-site tests that might be needed when investigating passage needs. There are also sectional models at WES which focus on specific portions of projects and are generally constructed at a larger scale (1 ft to 25 ft). The sectional models are used to answer more localized and specific fish passage questions.[11] The models also help answer questions about drawdown operations by tracking changing flow patterns. WES personnel are also involved in passage research to develop and evaluate alternative behavioral guidance methods. At the Richard B. Russell Pumped Storage Project, an ultrasonic and light system have been tested for many years (chapter 1).

System Configuration Study

The COE's System Configuration Study (SCS) is examining various alternatives for physically altering the lower Snake and Columbia River dams to improve salmon passage conditions. The focus is mainly on restoration of the Snake River.

[11] Sectional models currently being used include three-bay turbine intake sections of Lower Granite, the Lower Granite Spillway, McNary, Bonneville, and the Dalles.

Preliminary findings of the study indicate that passage would only improve if the Snake River were returned to its natural condition (232). Other options under consideration in the study include constructing bypasses to route the river around the dams, creating a controlled breach through each dam, or removing the four lower dams.[12] The study also concluded that a year-round river drawdown would adversely affect power production, navigation, irrigation and recreation benefits, and would result in short-term loss of fish and wildlife habitat during construction and re-establishment of habitat (232).

Fish Passage Research Center

The Bonneville Power Administration (BPA) has responsibility to mitigate for wildlife and wildlife habitat affected by federal hydropower dams and reservoirs in the Columbia River Basin under the 1980 Pacific Northwest Electric Power Planning and Conservation Act.[13] The Northwest Power Planning Council was established by the 1980 Act and was charged with developing a program to "protect, mitigate, and enhance fish and wildlife" and their habitats. Under section 4(h)(10)(A) of the Act, Congress directed BPA to use its funds and legal resources to implement the program and to fund many of the program measures to offset effects of development and operation of hydropower projects in the Columbia River Basin. Many of the recommendations for fish and wildlife protection, mitigation, and enhancement come from resource agencies and Tribes, utilities, and the public. The Fish Passage Research Center in Portland was established in large part to monitor the effectiveness of programs undertaken in response to the 1980 Act.

One of the Center's main responsibilities is to monitor smolt passage on the Snake and Columbia Rivers. Hydrologic and hydraulic data, as well as temperature and gas concentration data, are collected at all trap sites in the tailraces of the lower Columbia and Snake River projects.[14] The smolt monitoring program provides data on the passage of fish through the basin's dams and reservoirs and also provides data about the physiological status of the fish. This information can be helpful in making operational management decisions relative to flow and spill which correlates to determinations and recommendations regarding the status of the smolt passage program and what improvements might be made to increase its success.

Surface Collector

BPA and COE are jointly supporting the development of a surface collection system for transporting downmigrating salmonids around dams. The idea behind surface collection is to present a flow stimulus to downstream migrants that will take advantage of their natural outmigration behavior. Juvenile migrants, typically oriented in the upper levels of a reservoir water column, are drawn into the system by the attraction flow at the surface and are collected for transport or directed to a bypass around the dam (40). NMFS and the Northwest Power Planning Council have endorsed the research effort. Hydroacoustic techniques will be used to monitor and evaluate the effectiveness of the system.

Research at the Wells Dam in the Douglas County Public Utility District indicated that juvenile passage could be improved using surface collection techniques. Hydrocombine units used at Wells Dam are a unique design for hydropower where the spill bays are located directly over the turbine units. Between 1984 and 1993, modifications to the spill bays at Wells Dam along with operational changes achieved at least 90 percent passage of smolts. Wells Dam

[12] The four dams on the lower Snake River are Lower Granite, Little Goose, Lower Monumental, and Ice Harbor.

[13] COE owns and operates many of the dams in the Columbia River Basin, whereas BPA is responsible for generation and distribution of the power generated at those dams. COE engages in its own research efforts; BPA and COE jointly fund and support research and development of fish passage mitigation methods and managing techniques.

[14] Data are collected at trap sites at the four dams on the lower Columbia (Bonneville, The Dalles, John Day, McNary) and at two Snake River dams (Lower Granite, Little Goose); data are then downloaded to the Fish Passage Center for analysis.

has become a model for downstream migrant passage using the surface collection concept, and an adaptation of this design, which is suitable for conventional hydropower configuration, is in place at Rocky Reach Dam (40).

COE hopes that the four-year $90-million-dollar program will provide a new means of passing juvenile salmon and steelhead around hydro projects at lower cost, and with improved efficiency over conventional fish passage. COE has placed great emphasis on this effort, as it represents an attempt to link the sciences of fish behavior and engineering (77). Plans call for system prototypes to be installed at a number of dams on the Columbia over the next few years, beginning with Lower Granite Dam in 1997. Additional prototypes will be installed at The Dalles and Bonneville dams in 1998.

Bureau of Reclamation Research Facility

The Bureau of Reclamation (BuRec) has been the nation's pre-eminent western water resource development agency for decades. The agency has increasingly focused on environment and water resource management as the need for large construction projects decreased. Today, BuRec helps to fund and participates in research and development of fish passage technologies to protect anadromous species in California and the Pacific Northwest.

BuRec's research facility in Denver offers technical support on fish passage issues to the Northwest and California regional offices. The facility is used in part to experiment with hydraulic models of parts of the Columbia River hydropower system, and various projects on the Sacramento River in California. This capability gives scientists the opportunity to laboratory test fish passage technologies under a range of potential hydraulic conditions which reflect field possibilities. The facility also evaluates prototypes of fish passage technologies (e.g., various screening technologies, downstream surface collector system) and conducts research on monitoring downmigrating salmonids on the Sacramento River.

Central Valley Project

In 1992, the Central Valley Project Improvement Act (CVPIA) directed BuRec to improve the management practices of the Central Valley Project (CVP) to address fish protection concerns.[15] The CVP is a federally funded water project on the Sacramento and San Joaquin Rivers and Delta in California and is essential to the distribution of water in California. The CVPIA expands the purposes of the CVP to mandate the protection of fish, wildlife, and associated habitat, and to work toward achieving a balance among competing demands for water.

The streams and rivers of the Central Valley are host to a multitude of diverters—federal, state, and private—which range in size and flow. In all, there are 3,000 outlets, most of which serve agricultural uses. More than 2,000 of the CVP diversions are unscreened and implicated in the decline of species in the river system. Although part of the CVPIA budget is allocated for fish protection through a diversion screening program, BuRec is not required to install physical barrier screens at diversions along the rivers and Delta. Whether it should is a point of considerable debate because of the high cost of the screens.

The resource agencies, NMFS, FWS, and the California Department of Fish and Game, favor positive-exclusion devices over alternative behavioral techniques that rely on sound, light,

[15] The Central Valley Project Improvement Act was passed in 1992 as part of an extensive piece of legislation known as the Reclamation Projects Authorization and Adjustment Act of 1992. Some of the Act's titles authorized water projects; however, the CVPIA (title 34) took a step toward conservation in mandating fish and wildlife protection.

and electric barriers.[16,17] The presence of endangered and threatened species in the CVP has heightened the concern over experimentation and use of behavioral guidance technologies particularly at sites where positive-exclusion barriers are feasible and where fish that are entrained in irrigation diversions have no chance at survival.

CONCLUSIONS

The incomplete state of knowledge regarding fish population dynamics; the impacts of hydropower development on fish; the need for mitigation in various contexts; and the protection/passage effectiveness of available mitigation technologies exacerbate the already adversarial relationship between hydropower and environmental interests. This situation is unlikely to be alleviated unless a solid, science-based process for mutual understanding and rational decisionmaking can be developed (box 5-4).

A combination of academic, government, and industry expertise is needed in a concerted effort to focus science and technology resources on the question of hydropower development effects on fish population sustainability, and on the assessment of available and developing fish protection technologies at dams.

Technologies

Technologies for upstream passage are more advanced than for downstream passage but both need more work and evaluation. Upstream passage failure tends to result from less than optimal design criteria based on physical, hydrologic, and behavioral information, or lack of adequate attention to operation and maintenance of facilities. Downstream fish passage technology is complicated by the limited swimming ability of many downmigrating juvenile species and unfavorable hydrologic conditions. There is no single solution for designing up- and downstream passageways. Effective fish passage design for a specific site requires good communication between engineers and biologists and thorough understanding of site characteristics.

Downstream passage of fish and protective measures to reduce turbine mortality are probably the areas most in need of research. The most fundamental test of downstream mitigation effectiveness—that the measure should yield better survival than downstream passage through turbines—rarely has been rigorously examined. When research and demonstration is carried out, results can be dramatic.

Varied technical fish passage knowledge among participants in the debate results in unsubstantiated claims and arguments. Moreover, some experimental results contradict others. Ambiguous or equivocal results of many fish passage studies have caused concern as to whether certain technologies are effective or generally useful. The variability of results may reflect site variability; uncontrolled environmental conditions in field studies; or incomplete knowledge of fish behavior. Thus, certain proposed solutions to the problem may be based on incomplete assessments. Advocates on both sides of the fish/power issue can select from a diverse body of scientifically unproven information to substantiate their points of view. Care must be taken in interpreting much published information on fish protection, arguments drawn from it, and conclusions reached.

Hydropower Licensing

Controversy abounds in the FERC hydropower licensing process. In part, this may be a result of the lack of clearly identified *goals* to be achieved through mitigation. Although *objectives* exist in the legislative language of the FPA, as amended, these lend themselves more to a philosophy than to hard goals that describe numbers, timeframes,

[16] A positive exclusion device is a barrier that physically blocks fish from entering diversions or water intakes; its effectiveness is not dependent on the swimming ability of the fish.

[17] NMFS supports research efforts on behavioral guidance technologies but guards against implementation prior to performance criteria being met.

BOX 5-4: Development of Fish Passage Technologies: Research Needs

There are no "sure things" in the world of fish passage technology. The technologies themselves, which are based on hydraulic engineering and biological science, can be designed to accommodate a wide range of environmental conditions and behavioral concerns, but in the real riverine world *anything* can happen.

Upstream and downstream fish passage problems differ considerably and both present a range of obstacles and challenges for researchers and practitioners. Despite these differences, common considerations in design and application exist, including: hydraulics in the fishway, accommodating the biology and behavior of the target fish, and considering the potential range of hydrologic conditions in the waterway that the passage technology must accommodate. Engineers and biologists in the Northeast and Northwest are collaborating in a number of research programs designed to improve understanding of the swimming ability and behavior of target fish. Understanding how fish respond to different stimuli, and why, is critical to improving passage methods.

Using a scientific approach to explore as many scenarios as possible, and collecting data in a careful manner, can improve researchers' abilities to design improved technologies. In addition, producing information that all parties can acknowledge as credible is key to the successful advancement of fish passage technologies. A sound scientific approach to developing, executing, and evaluating a field study is critical to the successful advancement of fish passage technologies. The elements of a good test include the establishment of clear objectives, agreement among all parties to the study design, and a protocol that lends itself to repeatability. In addition, there must be a proper accounting of environmental variability, documentation of all assumptions, and sufficient replications to support findings. Regular communication among stakeholders and peer-reviewed research results are key requirements.

Employing a process of this type could increase the potential for information transfer between sites. That information might include data regarding the response of the device to hydraulic parameters (e.g., flow/acoustical response), fish response to stimuli under hydraulic parameters, and basic biological information within species. Agreement on performance criteria and standards prior to study will avoid lack of acceptance of data and recommendations in the long term.

SOURCE: Office of Technology Assessment, 1995.

and methods for achieving and measuring the stated goal. Clearly defined goals for protection and restoration of fish resources might refer to numbers or percentages of fish expected to successfully pass a barrier and/or projected population sizes. Since resource management goals are rarely articulated, mitigation and enhancement measures are judged on a case-by-case basis with no means for assessment or comparison.

The lack of clear goals is, in part, reflected in the disjunction between section 18 prescriptions and section 10(j) recommendations of the FPA. Section 18 fish passage prescriptions are mandatory; however, section 10(j) recommendations may be altered based on consistency with other applicable laws or the goals for the river (e.g., whitewater rafting/recreation, power production needs). Yet, the recommendations made under section 10(j) may be critical to maintaining habitat for fish populations or promoting timely migrations for certain species. FERC, as the final authority for balancing developmental and nondevelopmental values, is not specifically charged with sustaining fish populations. Without clear identification of the goal for mitigation, monitoring and evaluation become less meaningful and fail to become critical to the process.

Monitoring and evaluation conditions for hydropower licenses are infrequently enforced, resulting in little information on how effective available mitigation technologies are in improving fish passage and survival at hydropower plants. Operation and maintenance failures have been implicated in poor efficiency of fishways. Forty percent of nonfederal hydropower projects with upstream fish passage mitigation have no

performance monitoring requirements (242). Those that do generally only quantify passage rates, without regard to how many fish arrive at and fail to pass hydropower facilities. Moreover, most monitoring has dealt with anadromous salmonids or clupeids; much less is known about the effectiveness of mitigation measures for "less-valued" or riverine fish. Research is needed to determine whether river blockage is even negatively affecting riverine species.

Relicensing decisions often are not based on river-wide planning and cumulative analysis. FERC is required to review existing river management plans to assure that the project will not interfere with the stated goals (pursuant to section 10(a) of the FPA). Yet, comprehensive river basin planning is fragmented. Synchronizing license terms on river basins could improve the relicensing process and promote cumulative impact analyses. Terms could be adjusted to meet the ecological needs of the basin and to provide timeliness and predictability for licensees. Under such a plan, multiple sites could be relicensed simultaneously, although operators may be unlikely to respond positively to undergoing the relicensing process "early." On the other hand, consolidation could yield benefits, allowing licensees to develop integrated management plans to maximize the energy and capacity values of their projects; making it easier for all involved parties to view the projects and their impacts in their totality; and facilitating understanding of cause and effect relationships.

There is a need for further research on cumulative fish passage impacts of multiple projects; and for consideration of fish needs at the watershed level. In several northeastern states, cooperative agreements between resource agencies and hydropower companies have generated successful approaches to basin-wide planning for fish protection. Carefully planned sequential construction and operation of fish passages could provide significant opportunities for restoring historic fish runs. In the western states, watersheds in National Forests provide about one-half of the remaining spawning and rearing habitat for anadromous fish in the United States. Ecosystem or watershed management in these areas could have immediate and long-term impacts on fish populations (e.g., PACFISH).