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Feasibility of Reintroduction of Anadromous Fish Above or Within the Hells Canyon Complex

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Editor

Technical Report
Appendix E.3.1-2

Hells Canyon Complex
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History of the Hells Canyon Complex

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Chapter 2

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1. INTRODUCTION

This chapter describes administrative and political processes that led to construction of the three-dam Hells Canyon Complex (HCC) by Idaho Power Company (IPC). The experimental measures adopted to maintain anadromous fish native to areas upstream of and within the HCC are summarized, and fish abundance and effects of the HCC on populations of salmon and steelhead are described. The chapter spans pre-construction planning for fish preservation, the failure of measures designed to collect and pass juvenile migrants, declines in fall chinook abundance, and decisions to transfer stocks to hatcheries in tributaries downstream of the HCC.

2. CONTROVERSY OVER CONSTRUCTION OF THE HCC

2.1. Public versus Private Power Interests

In 1958, with completion of the 92-m-high Brownlee Dam, IPC created the first of three HCC reservoirs, 92-km-long Brownlee Reservoir. A 600-ft-high Hells Canyon federal dam was first proposed by both the Bureau of Reclamation and the Corps of Engineers. A long and often virulent competition between public and private power interests marked the period before the completion of Brownlee Dam.

There were other dam proposals for Hells Canyon in addition to the three-dam HCC. Pacific Northwest Power Company proposed Mountain Sheep and Pleasant Valley projects downstream of the present site of Hells Canyon Dam. Another proposal by a group of Washington public utility districts was for a 700-ft-high dam downstream of the Salmon River confluence with the Snake River (Stacy 1991).

Political forces strongly favored either public or private power. Cries of “monopoly” and “creeping socialism,” and other protests were heard. Opponents of the IPC projects included labor organizations, public power groups, Rural Electrification Administration (REA) cooperatives, farmers’ organizations, Lewis County Public Utility District in Washington, and seven other public utility districts in that state.

Evidence of attitudes toward dams in Hells Canyon can be found in Senate testimony concerning High Hells Canyon Dam (U.S. Senate Committee on Interior and Insular Affairs 1957):

> Construction of a high dam at Hells Canyon would be an outstanding contribution to the problems of providing wildlife conservation and outdoor recreation facilities in the Northwest. It would have little effect on migratory fish, because the Snake River above Weiser, Idaho, was long ago blocked to runs of salmon and steelhead, and only a very few still penetrate beyond the high dam site…. The effect of wildlife in Hells Canyon

> itself would be minor. Nesting fowl will quickly find new habitats after the reservoir is filled, and game will not be disturbed to any marked extent.[1]

Even conservation writer Ted Trueblood testified that the building of Hells Canyon Dam "would be the greatest possible good fortune that conceivably could befall the sportsmen of this area." The question was whether power would be private or public, not whether or not dams would be built.

2.2. Private Power with Conservation Measures

The Federal Power Commission (FPC), the agency now known as the Federal Energy Regulatory Commission (FERC), heard testimony that amounted to 19,215 transcript pages and 400 exhibits. Following testimony, on August 4, 1955, the FPC issued a license to IPC for one project (originally having three project numbers, 1971, 2132, and 2133, but now having only one, 1971) that included three relatively low dams and resulting reservoirs (FPC 1955, Stacy 1991). Opponents unsuccessfully appealed the issuance of the license. Morrison-Knudsen Company received the construction contract for the project. Construction was to begin with Brownlee Dam. Oxbow Dam[2] and later Hells Canyon Dam, both downstream of Brownlee Dam, would complete the three-dam HCC. Electrical capacities of the three dams would equal 728,000 kW at Brownlee Dam, 220,000 kW at Oxbow Dam, and 450,000 kW at Hells Canyon Dam, for a total of almost 1.4 MW of energy.

The FPC order specified that each of the HCC dams would be rock-filled and would develop 602 ft of head, with Brownlee Dam at 277 ft, Oxbow Dam at 117 ft, and Hells Canyon Dam at 208 ft of head. The FPC (FPC 1955) noted,

> Any power development would adversely affect the fish and wildlife resources of the area, and particularly the anadromous fish…. [M]easures for the conservation of those resources could and would be taken, and…about $5,000,000 would be required for the fishery program….

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1 The Senate Document displays understanding of neither the winter needs of wildlife nor of the presence of a large run of anadromous fish that passed the proposed dam site. That lack of knowledge is puzzling in light of the extensive offerings of the regulatory agencies to the FPC in connection with IPC license applications.

2 A power plant was present at Oxbow Dam site before the HCC was authorized. A map of Pine Ranger District, in Oregon, dated 1949, shows "Oxbow Power Plant" at the site. The plant, built in 1909, produced about 600 kW of energy and operated for 50 years (Brokaw 1921).

2.3. Fish Regulators' Opposition to Dam Construction in Hells Canyon

For agencies responsible for managing and conserving anadromous fish, the HCC license was a daunting prospect. As early as 1953 the Oregon Fish Commission protested to the FPC, stating (OFC 1953):

> The Idaho Power Company has not satisfied the requirements of this Commission regarding the protection of the fish life which can be completely destroyed by the construction of these projects. The proposal of the Idaho Power Company jeopardizes the existing fisheries and planned increases in runs expected as the result of recent management policies of the state fisheries agencies.

IPC apparently had not contacted the fishery agencies by mid-1953 to discuss project options and construction. The Oregon Game Commission (OGC) noted (OGC 1953),

> Hells Canyon, the farthest downstream of the three dams, would be 320 feet in over-all height.… [A]s yet, there is no way known of successfully passing migratory fish both up and down past a barrier of this height. The other two dams are also of a height such as to make the passage of fish doubtful, or impossible.… The State of Oregon will suffer an irreparable loss of and damage to its wildlife resources from the construction and operation of said project….

The several state wildlife agencies of Washington, Oregon, Idaho, along with the U.S. Fish and Wildlife Service (USFWS), joined in a committee (the Committee) to evaluate options for conserving fish despite dam development in Hells Canyon. Committee members initially thought that Mountain Sheep and Pleasant Valley dams would be built. However, their response to the threat of dams probably would have been the same if they had known that the HCC would be completed. The Committee proposed that relocation of the existing fish runs into suitable streams below the projects was a possible solution to maintaining the runs (OGC 1957). Their model for this alternative was the translocation of runs occasioned by the construction of Grand Coulee Dam on the Columbia River and Shasta Dam on the Sacramento River, as well as translocations in Canada and Alaska. They calculated that the systems in the Snake River basin downstream of Hells Canyon were at capacities ranging from 32 to 81%. The Committee based its opinion not only on the degree to which candidate streams were seeded, but also on the numbers of salmon and steelhead to be translocated. They estimated that the following numbers of chinook salmon and steelhead used streams upstream of Hells Canyon dam sites.

Stream	Chinook salmon	Steelhead
Indian Creek		1,000
Wildhorse River		1,000
Pine Creek		3,000
Eagle Creek (Powder River)	1,550	3,700
Weiser River	1,550	5,000
Payette River		1,500
Boise River		1,500
Snake River	4,000	4,000
Totals	**7,100**	**20,700**

The Committee concluded that candidate streams could provide adequate spawning areas for the escapements occurring upstream of Hells Canyon Dam. The numbers above were estimated without the benefit of trapping information that was obtained in 1957 at the electric weir and trap located just below the outlet of the diversion tunnel of the Brownlee Dam construction site. As noted later, that trapping revealed much larger fall chinook populations than the Committee had estimated. Other activities associated with HCC fish studies revealed that Wildhorse River had a chinook salmon population.

The concept of translocation of runs was not rejected as infeasible because of the desire to maintain genetic integrity of the various salmon and steelhead demes. Neither does it appear that the Committee objected to translocation on grounds that the ability of managers to fully seed streams with native stocks could in itself bring production to full potential without the addition of Hells Canyon stocks.

It is worth noting that the Committee did not consider the Malheur, Owyhee, Burnt, or Powder rivers (except for Eagle Creek) as supporting any anadromous fish. That opinion is found repeatedly in other references (Parkhurst 1950a, 1950b; Thompson and Haas 1960; Murray 1964; Fulton 1968, 1970).

3. Fish Runs in Hells Canyon Prior to HCC Construction

Just before IPC constructed the three HCC dams, the anadromous salmonid populations that migrated past the Hells Canyon area included summer steelhead and fall- and spring-run chinook salmon. Adult Snake River steelhead left the ocean and entered the Columbia River in late spring and summer on their spawning migration, reaching the Hells Canyon area either from September through November or during the following February through April. They spawned from March to May in tributaries of the Snake River. Spring chinook entered the Columbia River between March and May and arrived at the Hells Canyon area in late spring, spawning in a few

Snake River tributaries in August and early September. Spring chinook returned 3 to 5 years after their parents spawned; steelhead, 3 to 4 years.

Fall chinook native to the Snake River upstream of the HCC returned to the Columbia River from the sea in late July and August, arriving in the Hells Canyon area from September to November. They spawned in the main Snake River between the HCC and Swan Falls Dam. Fall chinook returned 2, 3, 4, or occasionally 5 years after their parents spawned.

Juvenile steelhead migrated seaward in spring, primarily from April to May, usually after 2 summers of rearing in tributaries, at a mean size of about 175 mm. Spring chinook migrated as juveniles during the same period, but after only one summer of tributary rearing and at a mean size of 80 to 110 mm. Fall chinook juveniles emerged from spawning nests, or redds, in the Snake River in March or April and reared for up to 3 months in the main river, moving toward the sea as they reared, to arrive in the estuary in midsummer at a mean size of 100 to 125 mm. The fall chinook that reached the Hells Canyon area were "upriver bright." "Tules," another type, spawned in tributaries of the main Columbia River, primarily downstream of The Dalles, Oregon.

4. Chronology of Fish Conservation Programs at the HCC

This section provides a chronology of fish conservation programs that IPC implemented at the HCC. Appendix 1 provides a chronology of pertinent fish correspondence from August 12, 1954, through November 17, 1960. Appendix 2 lists meetings on fish problems held from September 9, 1953, through January 21, 1960. Appendix 3 provides the chronology of major events that affected the fish program from June 11, 1956, through March 12, 1961. The time spans covered in these appendices do not imply that actions after early 1961 were unimportant or less worthy of inclusion. Rather, the included periods are of special significance because the fish conservation events that occurred from 1956 to 1961 resulted in anadromous fish passing becoming the primary mitigation tool. The main emphasis by the agencies and by IPC during that period was on successfully passing adult and juvenile salmon and steelhead at the HCC, not on fish hatcheries or translocations of stocks.

4.1. Influences Affecting Fish Passage Measures

Once the FPC issued a permit for construction of the HCC, everything associated with fish passage went on a fast-track schedule. From issuance of permit (August 1955) to closure of Brownlee Dam in May 1958, only about 33 months were available to decide on mitigation techniques and to build the various passage facilities once passage was chosen. This schedule, which in retrospect seems incredibly demanding considering how little was known about fish conservation efforts, must be seen in the context of the "power push" of the 1950s and what one can justifiably term an extension of the concept of manifest destiny. It was indeed a "go-go" decade and is perhaps difficult to understand from the perspective of the environmentally conscious 1990s. Conservation agencies had less powerful constituencies than those that developed after Earth Day, 1969. Commodity production was the main objective, and "development" was imperative. The main issues in the 1950s centered not on whether development and dams in Hells Canyon were desirable, but whether they would occur in the public or private sectors.

4.2. Construction and Operation of Fish Passages

Article 34 of the FPC license required the licensee to make $250,000 available to carry out detailed studies of the project area's fishery resource and to devise means and measures for mitigating losses to that resource. In accord with that requirement, state and federal fishery agencies investigated or considered all known methods for mitigating losses to the anadromous runs (Haas 1965). These methods included passage, translocation, artificial and semi-artificial propagation, and natural redistribution of fish in streams below the projects. Of the methods, fish passage appeared most promising for protecting the resource. It retained the possibility of restoring runs in the historic spawning and rearing areas and focused mitigation on natural production. On June 27, 1956, Secretary of the Interior F. Aandahl sent a studies program and budget to the FPC (Aandahl 1956a), outlining those actions that the fishery agencies deemed necessary for studying the fish resources of the middle Snake River and investigating means of mitigating losses caused by the IPC projects. A letter from the FPC formally authorizing IPC to spend $250,000 on these studies was sent to IPC on July 6, 1956.

On June 11, 1956, construction began on the temporary passage facilities at Brownlee Dam site, and on October 1, the first work began on the Wildhorse holding pond.[3] On October 16, the Snake River was diverted through the diversion tunnel so that work on the dam itself could begin. Despite a setback on October 26, 1956—the upstream section of the lead-in wall at Brownlee's temporary trap collapsed and was repaired by December 7—the Wildhorse holding pond was completed by mid-December.

Although the electric barrier across the Snake River began operating early in 1957, ice flows and flooding disrupted trapping in January and May, respectively. The fish trap at Brownlee Dam was out of operation for four days in September and for other short periods in the fall of that year.[4] Some question arose at various times about the possible movement of adult salmon through the diversion tunnel after the September outage. Murray (1963a) observed fish with distinguishing marks and tags gathered below the outlet for several days. He saw no evidence of breakup of groups or schools. He also pointed out that velocities of the water at the tunnel outlet were more than 20 feet per second (fps). The tunnel was 2,000 ft long. Critical passage velocity

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[3] Wildhorse River spring chinook and steelhead were to be transferred to lower Pine Creek (Weiser River tributary).

[4] Outages of the electrodes or trap at the outlet of the Brownlee diversion tunnel may have led to alternative results in fish passage: 1) adults that reached the site may have dropped back downstream, either to return later or not; 2) adults that passed the site during outages may have died in the diversion tunnel; 3) adults might have passed through the high velocities of the tunnel. These possibilities are further examined in Chapter 6 (Chandler and Chapman 2001), which estimates numbers of adults that arrived at the Brownlee site in 1957 and early 1958.

for steelhead, he noted, is 18 fps, and less for chinook salmon. He concluded that no chinook or steelhead could move upstream through the diversion tunnel.

The diversion tunnel bulkheads closed at Brownlee Dam on May 9, 1958, and by May 13 water spilled over the spillway at Brownlee Dam. The adult trap at Oxbow Dam began operating on May 23, 1958. On July 7, 1958, IPC removed the electrical barrier at Brownlee Dam from service (presumably after the barrier trap had captured any spring chinook and steelhead that had passed the trap site at Oxbow Dam before it was operating).

4.3. The Effects of Lack of Prior Studies and Experience in Passing Fish at High Dams

As late as September 1956, after Brownlee Dam was under construction (construction began late in 1955), Hutchinson (1956), testifying to the FPC, stated there was "…no feasible method of providing adequate protection to the downstream migrants" at lower Columbia River projects. About translocation he said, "…relocation cannot be considered a sound solution for a fishery problem when a run of fish is blocked by a dam. …[A]t high dams…there is, to date, no known method for the safe downstream passage of the seaward migrants."

Haas (1965), in a comprehensive report on fishery problems associated with the HCC, noted that

> Since no previous attempt had been made to preserve runs of migratory fish above reservoir projects of this magnitude and character, major decisions…were required of the agencies. These decisions sometimes were, of necessity, based on hastily collected and inadequate data brought about by the expediency of the dam construction program.

As early as October 1956, the USFWS (Laythe 1956) noted that

> Progress on the construction of Brownlee Dam has made it necessary to reach certain conclusions in regard to the handling of the fish problem without benefit of some of the studies that were originally envisioned…. The Service concurs with the State fish and game agencies in the decision that the least objectionable procedure for handling the fish runs affected by the construction of these dams is to provide both upstream and downstream fish-passage facilities….

Haas (1965) emphasized that the passage policy was adopted with the understanding that fish protective devices and procedures would be experimental. The policy recognized that there would be losses associated with passage and that reservoir waters would inundate production areas on the Snake and Wildhorse rivers. Many of the fish passage facilities had to be developed from "the most elemental stage." The fast-moving construction schedule left the fishery investigations far behind.

On November 27, 1956, the Idaho Department of Fish and Game (IDFG) formally requested upstream and downstream passage facilities at the HCC (Leonard 1956). A similar letter had been sent by the U.S. Department of the Interior (Aandahl 1956b).

In retrospect, one might ask why, in the face of the tight schedule and lack of knowledge, hatcheries were not the preferred alternative. The fact is that water temperature and siting studies had revealed poor options for hatcheries. Artificial spawning channels and incubation channels were being constructed for chinook salmon on the main Columbia River, largely because such facilities had recently proved useful for sockeye and pink salmon in Canada, but their efficacy for application in the Snake River was speculative at best.[5] The agencies stated (FCO and OSGC 1956):

> The maintenance of large runs of summer-run steelhead and spring chinook by means of artificial propagation is not feasible in light of present knowledge. This is due to the unique life history of these fish which brings them into the rivers months before their spawning time and which requires a year's residency in freshwater prior to their journey to the sea.[6]

The agencies apparently regarded hatcheries as a fallback alternative that should be investigated further. However, because of the urgency and tight schedule for developing mitigation methods, the bulk of the article 34 effort was allocated to passage facilities.

The agency regulators preferred to submerge Brownlee Dam penstocks at least 120 ft below minimum forebay level (Hodges 1957). They believed fish did not sound that deep. Deep submergence was to be combined with a surface artificial outlet using pumps—acting like a "gulper"—to collect fish. However, when considered in conjunction with a requirement by the Corps of Engineers for 101 ft of flood-control drawdown, intakes would have had to be 220 ft deep within 277 ft of total head. The engineers calculated that this setup would require a concrete gravity or arch dam. IPC engineering plans had the penstocks submerged only 16 ft at minimum pool, so this method was not used.

4.4. Continuing Efforts Toward Successful Fish Passage Facilities

Failure of the preferred deep submergence concept led to investigation of means of collecting smolts in the reservoir before the fish arrived at the dam, although such upstream collection was not the method preferred by the regulatory agencies (Hodges 1957). IPC developed a mesh-

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[5] Spawning channels were constructed as the mitigation tool of choice at McNary, Priest Rapids, Rocky Reach, and Wells dams to replace spawning areas lost to inundation. None proved successful. Adult chinook salmon did not distribute themselves in the channels, instead concentrating in a very patchy manner. Gravel in the channels accumulated water- and wind-borne fine sediments and could not practically be cleaned. Non-salmonids invaded the channels with incoming river water. McNary channel was abandoned. Priest Rapids channel was used for a time to incubate planted embryos, then was abandoned and later sectioned and used with groundwater as a rearing site for fall chinook juveniles. Rocky Reach and Wells channels were converted to juvenile rearing facilities.

[6] These statements appear somewhat disingenuous. Leavenworth Hatchery, on the Wenatchee River, and Methow Hatchery, on the Methow River, had been operating and producing spring chinook since the early 1940s as part of the Grand Coulee Fish Maintenance Program (Fish and Hanavan 1948). Steelhead hatcheries were operated by the State of Washington.

barrier concept for collection. Outside engineering experts (Tudor Engineering Company, San Francisco) reviewed and approved the concept, which the fishery regulators adopted but with reservations. On October 4, 1957, the Middle Snake River Technical Committee wrote to regulatory agency administrators, stating:

> Confidence in the Brownlee forebay barrier, as outlined in the August 30, 1957 meeting by Idaho Power Company, is limited by engineering soundness, involving not only basic soundness but also maintenance (so-called "acts of God"). Problems such as ice and debris are potentially critical. The forthcoming report by the special board of engineering consultants will undoubtedly influence the thinking of the biologists on the ability of the net to safely pass fingerlings downstream. Since there is no similar prototype net barrier and associated artificial outlets that have yet been tried, the Brownlee-plus-4 other dams problem is forcing the acceptance of this unproven method.[7]

The barrier and accompanying gulpers and fish pumping systems were to be located 1 mi upstream of Brownlee Dam.[8] Smolts captured there were to be trucked first to a point downstream of Brownlee Dam, then downstream of Oxbow Dam. Ultimately, as additional dams were constructed, the concept called for trucking to points downstream of each new structure.

Consideration of fish passage facilities at the IPC projects remained under a cloud of uncertainty because proposals to build high-head dams downstream of Hells Canyon Dam (Hodges 1957) were being discussed. Mitigation efforts upstream depended on what was happening to fish runs downstream. Proposals were afoot to build Nez Perce Dam downstream of the Salmon River confluence, and Mountain Sheep and Pleasant Valley upstream of the Salmon River. Any of these facilities, if built, would have altered thinking about how best to manage mitigation measures for the runs that passed the HCC.

Fish ladders were first visualized by IPC when only one dam was under consideration (Inman 1951). The Fish Commission of Oregon believed that an Oxbow Development (Project No. 1971, which soon evolved into the HCC) would be better for fish than other proposed mid-Snake developments (Veatch 1951).

In August 1954, IPC was asking whether fish ladders or elevators should be constructed to permit adult fish passage, or whether runs should be relocated in other streams (Gale 1954). T. Murray (1954), a consultant to IPC, recommended translocation of all runs that had spawned in the areas upstream of the HCC. He wanted to transfer spring chinook as eyed eggs and fingerlings in the upper Salmon, Clearwater, Grande Ronde, and Imnaha rivers "without overcrowding the present populations." He noted:

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[7] "Brownlee-plus-4 other dams" refers to the three-dam HCC plus Mountain Sheep and Pleasant Valley dams.

[8] While the technical committee was skeptical about engineering, safe passage, and acts of God, they do not appear to have predicted the inability of smolts to find their way through Brownlee Reservoir to the barrier net because of lack of perceptible currents and vertical convergence of deoxygenated, hyperthermic water.

> If there is a surplus…they could be used…to firm up runs in the Columbia River tributaries above The Dalles impoundment. There is room for steelhead trout in any and all of the downstream tributaries entering the Snake River below the mouth of the Imnaha River. The eyed eggs and fingerlings could be planted on an extensive and widespread scale in the headwater streams of the Salmon, Clearwater, Grande Ronde and Imnaha Rivers. Other tributaries downstream to and including the Deschute River on the Columbia could be planted to firm up the present runs without overcrowding the streams. Tributaries to the Columbia above and below McNary Dam could be planted with Snake River steelhead. Coastal streams could be planted with any surplus numbers of fingerlings and eyed eggs.

Murray (1954) also stated that:

> The fall chinook run can be taken care of by placing mature fish from Oxbow in the Salmon River above Whitebird and above Riggins. Sizeable plants of mature fish could be placed in this stretch of the Salmon River. Sizeable plants of mature fall chinooks could be placed in the Clearwater River above the Spalding bridge[,]…in the Grande Ronde River[,]…in the Imnaha.

Murray's ideas for translocation probably derived from the translocation of runs destined for upstream of Grand Coulee Dam into tributaries downstream. He lacked information on genetic adaptation of stocks to conditions in individual tributaries, as did others in the early 1950s. Nor did he examine why fall chinook had not already colonized the main Salmon, Imnaha, or Grande Ronde rivers.

As late as spring 1956, experts on electrical barriers as a means of blocking adult salmon were cautioning against optimism that this proposed means of stopping and guiding adults at the Brownlee Dam diversion tunnel would succeed (Andrew 1956, Burrows 1956).

On March 6, 1957, options for permanent adult collection or passage at the HCC were the following (Perry 1957a):

1. Permanent collection at Oxbow Dam. Adults would be obtained at the lowermost dam in the Middle Snake River series and transported to the river or forebay between Hells Canyon Dam and Oxbow. This would permit them to sort themselves to Pine Creek, Indian Creek, and other tributaries.[9]

2. A "sorting pond" located near the mouth of Pine Creek. Fish would be collected at the lowermost dam and hauled to the sorting pond where they would choose Pine Creek or Snake River water. Fish that chose Pine Creek would continue their upstream migration

[9] The disadvantage of this approach would be doubled handling and transport for fish destined to pass upstream of Oxbow and Brownlee dams. It is interesting that no proposals were made to build fishways or a fish elevator system at Hells Canyon Dam. Such a system would have eliminated trapping and hauling fish twice and would have permitted fish to seek out Pine and Indian creeks.

into Pine Creek, while those that chose Snake River water would be hauled upstream of Brownlee Dam.

3. Trapping at Oxbow Dam. Trapping would continue only until another downstream dam stopped the adults downstream. All adults captured at the downstream dam would be hauled upstream to Brownlee Reservoir, with no sorting of Pine Creek (or Indian Creek) fish.

IPC considered the runs to Pine and Indian creeks “small,” “relatively minor,” and “minor,” and believed these runs contained “comparatively few fish” (Inman 1959 cited in IPC 1959), as item 3 above suggests. However, subsequent jumps in the steelhead count when trapping moved from Oxbow Dam to Hells Canyon Dam suggest a run of almost 3,000 steelhead to Pine and Indian creeks (potential runs may have been larger). The potential cost of mitigation efforts for Pine and Indian creeks appears to have strongly influenced IPC (Barclay 1959a) to minimize the significance of those runs. Another related concern was that downstream migrant traps would have had to be constructed and operated either in the Hells Canyon Dam forebay or in Pine and Indian creeks. Although such facilities in tributaries would be likely to operate effectively in fall, when presmolts move toward overwintering sites, successful operation in spring freshets would be another matter (a problem that continues to influence thinking about reestablishing anadromous fish in tributaries upstream of the HCC). In any event, as of September 18, 1959, the fish agencies were still proposing passage of adults at Hells Canyon Dam and collection of juveniles in the Hells Canyon Dam forebay (Perry 1959).

At a hearing before the FPC held from early December 1959 to late January 1960, the regulatory agencies argued for fish passage at Hells Canyon Dam, combined with downstream migrant collection in Hells Canyon Reservoir to capture juveniles produced in Pine and Indian creeks. IPC argued for trapping all returning adults at Hells Canyon Dam and transporting them to Brownlee Reservoir, with juvenile collection in Brownlee Reservoir only. IPC intended to make provisions within the IPC proposal for trapping juveniles in Pine Creek for transfer to Catherine Creek, a Grande Ronde River tributary, and for capturing and transferring Indian Creek juveniles to Rapid River, a tributary of the Little Salmon River. (These proposals later became moot when fish conservation began emphasizing hatchery production rather than passage.)

The net barrier at Brownlee Dam received *de facto* approval on October 10, 1957, during a meeting of the Middle Snake River Administrative Committee (Perry 1957b). The following decisions were made at the meeting:

1. Fish passage would be the primary conservation measure.

2. The forebay net barrier was acceptable.

3. Agencies would prepare an overall program for the FPC, including operation.

4. Agencies would state their preference about who would operate facilities.

5. The forebay net barrier would be modeled as recommended by an engineering consultant.

The decision by the agencies to pass fish at the HCC did not receive unanimous approbation. T. Murray, consultant to IPC and an advocate of translocating the runs in a program similar to that of the Grand Coulee Fish Maintenance Project, wrote (Murray 1957):

> …I can make this type of a program [translocation] work and it would be infinitely better, and much cheaper in the long run, than the presently proposed schemes that are based on an unrealistic stubborn determination on the part of some fisheries biologists to try to maintain the present runs into the present spawning areas…. This suggested solution to our knotty spring chinook fisheries problem is too advanced and far-fetched to be appreciated or accepted by the fisheries biologists of the several states and the U.S. Fish and Wildlife Service…. My proposal…would also offer an approach to the problem of handling the steelhead…. The fall run chinook salmon can be handled like domestic cows or sheep.[10]

IPC, concerned about the costs of what it considered an untried system for passage of downstream migrants, did not believe itself to be fully liable for operations and maintenance (O&M) costs. The fish agencies disagreed (Fisheries Administrative Committee 1957). Within the week, the OGC made its expectation clear that IPC would pay all O&M costs (Schneider 1957a).[11] IDFG followed with a similar letter, also noting that it expected the IPC to operate the fish facilities (Leonard 1957a).

The question of full payment of O&M costs by IPC was finally settled in a conference among IPC, the regulatory agencies, and the FPC on September 18, 1958 (FPC 1958).

IPC, in a document dated January 26, 1961, summarized Brownlee Dam fish collection facilities then completed and operative, noting that they were constructed with the approval of the regulatory agencies:

- Skimmer/barrier method was used at Brownlee Dam facilities to capture fish.
- The skimmer/barrier was constructed of a plastic mesh net 2,800 ft by 120 ft deep intended to prevent fish from continuing downstream.
- The skimmer/barrier was equipped with 3 skimmers that attracted fingerlings with pump-created currents.

[10] Reluctance of the agencies to accept translocation probably stemmed from at least two sources: One was the knowledge that the runs in the candidate tributaries targeted for translocated HCC fish could be brought to full production without translocation, with appropriate escapements and management. Another was reluctance to lose access to known productive habitat like the main Snake River, Pine Creek, Weiser River (although degraded), and Eagle Creek.

[11] Suggestions by IPC that it was not fully responsible for O&M costs for fish passage at the HCC may have been part of attempts to keep the agencies aware of the cost of fish passage or to clarify that the facilities for passage were experimental and that the Company did not take responsibility for failure of the biological components of the designs.

- A rubber pipeline pumped fish from skimmers to the truck-loading station.
- Seven custom tank trucks with oxygen and aeration hauled fingerlings around Brownlee and Oxbow dams.
- Two upstream traps were placed at Oxbow Dam.
- A diversion-tunnel ladder and trap transferred adults captured at the Oxbow Dam traps to custom-built trucks.
- An Oregon spillway ladder and trap at Oxbow Dam transferred adults to trucks equipped with oxygen and aeration, which hauled adults 15 mi upstream around Oxbow and Brownlee dams for release in Brownlee Reservoir.

Because IPC constructed first Oxbow Dam, and then Hells Canyon Dam, adult traps were required at each dam as the project developed. The first of these traps was an electric barrier and trap located just downstream of the outlet to the Brownlee diversion tunnel. That barrier and trap collected adults for upstream transport until the traps at Oxbow Dam began to operate (May 23, 1958). The trapping system made counting fish possible from late 1956 through July 7, 1958. Trucks hauled the trapped fish to points within Brownlee Reservoir.

Investigators tagged and released adult fall chinook salmon 0.5 mi upstream of the Brownlee Dam barrier net and at the upper end of Brownlee Reservoir, near Weiser. They then compared recoveries of the released fish at the respective spawning grounds. Recovery rates did not differ between the two release points. This finding reflected the broader effects of adult trap-and-haul operations associated with Brownlee Dam itself; the adult migration at Brownlee Dam succeeded. Adult spring chinook and steelhead also were hauled successfully to a point 1.5 mi upstream of the dam from 1956 to 1964.

Brownlee Dam closed on May 9, 1958. Adult trapping moved in early spring 1958 from the Brownlee Dam diversion tunnel to a temporary trap located on the Oregon shore, downstream of the Oxbow Dam diversion tunnel.[12] The temporary trap operated for 35 months and was replaced in spring 1961 with a permanent facility at the Oregon shore spillway.

4.5. The "Oxbow Incident"

The "Oxbow Incident" occurred at the Oxbow Dam project in late summer 1958. Water flow at the downstream end of the Oxbow Dam diversion tunnel undermined the foundation of the temporary facility. The main concrete wall at the trap failed, and the diversion tunnel and dam had to be dewatered for repairs. This forced the cofferdam to be breached on September 3, 1958, sending the river flow over the cofferdam and through the oxbow. The timing of this incident was unfortunate. Fall chinook and some summer steelhead were migrating upstream while

[12] The diversion tunnel carried the entire Snake River flow from a point upstream of a cofferdam at the upper end of the oxbow to a point downstream of the Oxbow, permitting construction work within the dewatered oxbow.

workers were repairing the damaged facility. This meant that adult fish entered the oxbow. Most could not pass the high-velocity flows at the breached cofferdam and were trapped in the oxbow when the river was diverted once again through the tunnel. Many adults failed to find their way downstream out of the oxbow as the water level dropped. The adults stranded in the oxbow began to suffer from oxygen deprivation. Efforts to salvage fish were extensive and dedicated, but several thousand salmon and steelhead perished. The official estimate was 3,497 fall chinook and 771 steelhead. This loss made up about 20% of the adult fall chinook run that arrived at Oxbow Dam trap and 15% of the steelhead run for the 1958 to 1959 brood.

The Oxbow Dam event in 1958 may have reduced spawning success in the Snake River upstream of Brownlee Dam. When Richards (1959) calculated the number of adult fish per redd in the spawning years 1957, 1958, and 1959, he reported 3.8, 12.6, and 8.2 adults per redd in the respective years. Haas (1965:66, Table 6) estimated that one-half of the fish that were passed above Brownlee and Oxbow dams did not reach the spawning grounds in the Snake River upstream of Brownlee Dam.

While the Oxbow Incident probably was not a long-term biological disaster for fall chinook salmon[13], it was indeed a disaster for public relations. Blame was variously attributed to the contractors, IPC, and fishery agency personnel. Communications of the agencies and IPC reveal considerable finger-pointing (IDFG 1958, USFWS 1958). The State of Oregon filed a complaint on October 15, 1962, with the FPC requesting damages be assessed against IPC for losses associated with the Oxbow Incident. The complaint was dismissed on grounds that the Commission was an improper venue for the complaint.

With the exception of the Oxbow Incident, upstream passage of adult salmon and steelhead at the HCC succeeded. However, the juvenile passage phase of mitigation was a failure from the very beginning.

4.6. The Net Barrier System

The net barrier, installed to prevent downstream migrants from reaching Brownlee Dam and to collect juveniles for transportation, consisted of an 8-mesh/inch saran net measuring 0.5 mi long and 140 ft deep. The net was suspended from pontoons at each bank and lay in a long concave curve. The netting only curtained off 120 ft vertically, the lowest 20 ft extending horizontally upstream in an approximately flat "floor." This floor was thought to discourage fish from swimming under the barrier. Three "gulpers," with openings 14 ft by 14 ft and powered by pumps, moved smolts to the shoreline in rubberized pipes. The currents created by the gulpers attracted the fish. The water velocity increased to 8 fps as the fish progressed into the throat of the trap. Fine-mesh screening removed most of the water. At the shore, an inclined screen separated fish from water.

[13] The IDFG (IDFG 1958) stated that the Oxbow losses "will be reflected for several generations to come in reduced numbers of these species." However, no information was available on optimum escapement of fall chinook or steelhead to spawning areas. Vagaries of environment and biological compensation would have to enter into an evaluation of subsequent effects of the Oxbow Incident losses on population dynamics.

Problems with the net barrier developed early (Haas 1965). Clips that held the net panels together failed during installation, causing holes. Flows into the gulpers initially failed to reach discharge of 100 cfs, as designed.

Bell (1958) reported on the condition of the net barrier at Brownlee Dam after a diving inspection on November 20 and 21, 1958. The divers found evidence of many repairs to the screen. The wing nets curved differently from the main net, creating a considerable bag effect. Divers found a 6-inch gap between a hose on the fish transfer pipe and the right bank barge site. They also found several breaks in the backing cloth, some over 20 ft long. Many wire ties extended through the plastic mesh in such a way that any repositioning of the net would tear the mesh. The bottom 40 ft of the wing and main nets were not fish-tight and could not be repaired without major changes (although the upper 100 ft of net was fish-tight). Bell recommended reporting the net as nonfunctional. IPC maintained a full-time crew of four divers to inspect and repair the barrier. In spite of those efforts, difficulties continued.

In winter 1959, an artificial outlet barge (part of the net barrier system) sank on the Oregon side. Wind storms in April and July 1962 caused extensive net damage. Divers found many holes in the net curtain. The physical difficulties outpaced the efforts of the IPC divers. Haas (1965) noted that the net probably never remained fish-tight for long.

However, by fall 1960, an inspection of the barrier found the main barrier net fish-tight down to 120 ft. Wing nets were fish-tight to a depth of 60 ft, with a few exceptions. Attachments between the main and wing nets were also fish-tight. Shaver (1960) reported: "Based on the reports of the divers making the inspection, the main net can be considered fish-tight down to the bottom, a depth of 120 feet, and the wing nets can be made fish-tight to a depth of 60 feet with a few minor repairs."

Barrier net catches were abysmally low. Some fish swam under the net or passed through holes in the net. Of 15,881 juvenile fall chinook trapped and marked in spring 1962, only 0.85% were recovered at the net barrier. Of 2,898 spring chinook and 1,188 steelhead smolts marked at a trap in the lower Weiser River in the same year, 10.4% and 0.17%, respectively, eventually appeared in the collection facility at the barrier net. For 9,235 and 7,272 spring chinook presmolts marked at a louver trap in Eagle Creek (Powder River) in fall 1961 and 1962, respectively, 6.8% and 4.7% were recaptured at the Brownlee Dam barrier. Haas (1965) concluded that spring chinook salmon migrated through the reservoir with somewhat greater success than either fall chinook or steelhead. Many recovered fall chinook and steelhead had remained in the reservoir and left one year later than was normal.

Total juvenile chinook numbers captured at the barrier net were 130,559 in 1959; 49,485 in 1960; 19,767 in 1961; and 13,675 in 1962. Steelhead numbers totaled 18,250; 2,570; 2,143; and 1,531 in the same respective years.

Some impressions of the types of problems associated with the fish passage facilities can be obtained by examining minutes and memoranda of the Middle Snake River Administrative and Technical Committees, comprised of state and federal administrators and biologists. For example, a memo on January 31, 1960 (Perry 1960), noted that currents were unexpectedly strong along the edges of the reservoir. New backing was required for the wing nets. Five divers were then working continuously on net repairs. The collectors required alteration. Suggestions were made to add guiding nets at the entrance of the collection barges. Test releases of juvenile fall chinook upstream and downstream of the barrier net revealed that fish could move through or beneath the net. Graban (1964) noted:

> It is believed that, from the beginning, the barrier net never constituted a complete barrier…. It is likely that fish passed through holes in the net and, also, with favorable temperature and oxygen conditions, passed beneath it…. It must be concluded…that the barrier net is a failure as a method of collecting downstream migrating salmon and steelhead in Brownlee Reservoir…. Research to develop methods of collecting downstream migrating salmonids from streams prior to their entry into long, deep reservoirs should be accelerated.

Unfortunately, the condition of the barrier net was not the most critical factor in the failure of the net to capture large numbers of juvenile salmon and steelhead. Water temperature, dissolved oxygen levels, and failure of fish to find their way through the reservoir had become more important factors.

4.7. Water Conditions

In summer, when delayed subyearling fall chinook might have been expected to move downstream, high water temperatures in the reservoir may have forced subyearlings to a depth below the barrier net. The result, beyond poor net catches, was more fish passing through turbines and, accordingly, higher mortality rates in passage (Minutes of meeting on downstream passage problems at Brownlee Dam, dated August 18, 1959).

Limnological conditions in Brownlee Reservoir appear to have been poor for salmonids in summer. High surface temperatures and low dissolved oxygen at depth forced fish to an ever-narrowing vertical stratum of suitable water conditions or eliminated livable conditions entirely (Ebel and Koski 1964). However, environmental conditions in spring, winter, and fall were suitable if not ideal. Ebel and Koski (1964) noted that current velocities in the reservoir significantly affected movement of salmonids, with a drawn-down reservoir providing fastest currents and best movement of fish.

Predator populations expanded rapidly in the reservoir and water conditions made their effect on salmonid populations more significant. By August of most years, the livable depth strata for salmonids collapsed as vertical zones of high surface-water temperatures and low dissolved oxygen levels compressed fish into a narrow vertical band (Webb 1961a, 1961b). Haas (1965) mentioned industrial wastes from a sugar processing plant at Nyssa, wastes from a potato processing plant, and chemical nutrients from agricultural fertilization as factors contributing to low oxygen content. Additionally, blue-green algae blooms decomposed each summer, a process demanding oxygen. Current velocity in the reservoir in most years was slight, and juvenile chinook salmon and steelhead apparently did not find their way downstream through the reservoir.

4.8. Rumblings of Failure

As early as January 7, 1959, fishery agency personnel openly speculated that the forebay collection system—the net barrier and trucking facilities—at Brownlee Dam could be a complete failure. They felt that the fishery agencies should have a plan for artificial production somewhere below Hells Canyon Dam for as many of the affected fish runs as possible (Minutes of meeting of Middle Snake River Technical Committee, dated January 7, 1959). Barclay (1959b), referring to the same meeting, noted that investigations of supplemental production of fish "have been quite limited to date. The Committee appointed Mssrs Hauck, Campbell and Gunsolus to carry the investigations further and prepare a proposal on the matter." The regulatory agencies noted that loss of Pine and Indian creeks—a feature of proposals that would trap adults at Hells Canyon Dam and transport them to Brownlee Reservoir—would make it necessary to stock runs artificially, perhaps using hatcheries (Day et al. 1959).

First significant discussion of conversion from passage to hatchery operations appears to have occurred in a meeting of IPC and representatives of the regulatory agencies in late August 1960. A pilot program was discussed for a hatchery that could accommodate 200 adult fall chinook and the expected half-million resulting eggs. A concept was discussed in which the hatchery, suggested for Oxbow Dam site, would be moved downstream as successive dams were built (Moore 1960).

Milo Moore (1960a), Director of the Washington Department of Fisheries, was blunt about fish passage in the HCC. He noted on July 15, 1960, that the barrier net had not operated efficiently and that fish runs in Hells Canyon "are all being badly mauled by inadequate facilities." He proposed a program of translocation and hatchery production. Moore (1960b) stated on November 1, 1960, that "the Brownlee-Oxbow facilities have failed. To continue putting a major portion of the anadromous fish runs above this project for study purposes is tragic." The Department of the Interior did not agree with Moore (Aandahl 1960). It was not ready to abandon passage, felt the studies underway to evaluate the passage facilities were very important[14], and wanted to construct incubation channels in the Pine Creek and Clearwater River areas.

Seaton (1960) recommended that IPC install hatchery facilities for fall chinook. Recommended trial facilities included holding facilities for about 2,000 adult salmon near Oxbow Dam, troughs or trays to care for the eggs until eyed, and incubation channels in the Clearwater River basin and Oxbow Dam, in the vicinity of Pine Creek or Snake River.

Meanwhile, juvenile passage remained unsatisfactory and adult passage proceeded reasonably well. Tagging experiments with fall chinook compared releases at the usual site 4 mi upstream of Brownlee Dam with releases at Weiser near the head of Brownlee Reservoir. They showed no significant differences between recoveries of the two groups on the spawning grounds (Hauck 1961).

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[14] The regulatory agencies, particularly the USFWS, faced proposals for other high dams in the Snake, Clearwater, and Salmon rivers. It is likely that they considered the experimental approaches underway at the HCC critical to future passage decisions, hence maintained passage longer than they might otherwise have sustained it.

A few spring chinook still used Pine Creek in 1960 and 1961. Smith (1961a) thought it unlikely that escapements in either year exceeded 100 salmon. He also thought that spring chinook might divert from the Snake River into Pine Creek when faced with the Oxbow Dam spillway trap. He noted that two tagged salmon, taken from the Oxbow Dam spillway trap and released 3 mi downstream at Homestead, migrated into and were recovered in Pine Creek. He suggested that this tagged fish recovery proved that fish diverted into Pine Creek. However, these fish may have proved that some Pine Creek fish entered the trap at Oxbow Dam, could not exit it, and, when tagged, were considered “Snake River” fish. This problem of wanderers that enter traps and cannot exit them confounds many “homing” studies. Murray (1963b) reported that spring chinook fingerlings were showing up in traps at irrigation diversion screens with increasing frequency each fall from 1959 to 1963. This observation supports Smith’s (1961a) opinion.

By 1962 it had become apparent that the barrier net concept would not work (Smith 1962a, Smith 1963a). Proposals were afoot to convert fall chinook conservation efforts from fish passage to hatcheries and to translocate spring chinook and steelhead to suitable tributaries downstream of the HCC. Smith (1962a) suggested that a proposal for removal of the barrier net should be accompanied by the following options:

1. No passage over Brownlee Dam, with translocation of steelhead and spring chinook into tributaries that enter the Snake River downstream of the HCC.

2. Passage of all spring chinook and steelhead and some fall chinook (with the remaining fall chinook taken to an incubation facility at Oxbow), with no facility for capturing and counting downstream migrants. Removal of the barrier net and periodic flushing of the reservoir over the spillway during the downstream migration between March 1 and June 15.

3. Passage as in option 2 above, with collection of downstream migrants by scoop traps, as used experimentally in the 1962 study program, installed in both the Snake River above the reservoir and the Powder River.

4. Passage as in option 2 above, with collection of downstream migrants in a louver system above the reservoir.

Smith’s (1962a) proposals appear to have been aimed at promoting option 1 above.

A memorandum from Murray (1963c), a consultant to IPC, may provide insight into changes in fishery agency attitudes over time and perhaps to certain attitudes within IPC:

> Fisheries agencies personnel viewpoints and attitudes have gone through a transformation during construction period at Brownlee and Oxbow. Their fund of knowledge has increased. Their beliefs have been shaken in abilities to find answers to fish behaviors. They seem to be looking for some avenue to follow where the view is better and the stopovers are in sight. They told us what to do at Brownlee and it has not worked at barrier net. At Oxbow they modified their demands for a trap at powerhouse and acquiesced to giving a try at picking up fish with trap at Oregon spillway by means of a water flow around the Oxbow. As a stop gap they agreed to eying (sic) station and hatching channel at Oxbow for fall chinook.

> The tenor of present conversations points in the direction of wanting more experimentation above Brownlee, if and when barrier net is deactivated. The thinking is still in the direction of insisting on keeping steelhead in Pine Creek and Indian Creek without knowing how to pass fingerlings through Hells Canyon and High Mountain Sheep[15] backwaters.
>
> Time has taken care of some who would project the impossible for Hells Canyon, if the interim period can be extended. Inactivation of the net, with no strings attached, and a start on High Mountain Sheep by private interests would solve upstream fish passage problems. It is my belief, based on years of contacts with fisheries agencies people, that fish passage above High Mountain Sheep Dam will be indefensible in the light of experience at Brownlee. They will be ready for a program below High Mountain Sheep Dam."[16]

Agency positions when fish passage ended at the HCC did not preclude reestablishment of passage at some later date. A statement by the Fish Commission of Oregon on June 2, 1965, noted that passage should be reinstituted once viable means of collecting and passing downstream migrants are developed.

Under the FPC order of February 12, 1958, the IDFG operated a weir at Wildhorse River (tributary to Oxbow Reservoir) to relocate runs of anadromous fish from Wildhorse River to the Weiser River. In a June 1, 1960, letter to IPC, the IDFG reported that an average of about 10,000 downstream migrants had been trapped and transported to the Weiser River each year. The IDFG noted that many fish escaped the facilities when river flows exceeded the capacity of the trap. The IDFG deemed the transfer impossible to complete successfully and was terminated about July 1, 1960. In September 1960, the FPC issued an order to terminate the operation.

An FPC order called for IPC to install holding and incubation facilities for about 2,000 adult fall chinook salmon near Oxbow Dam and facilities for propagation of progeny on a trial basis (FPC 1960).

4.9. Controversy over Fish Handling at Hells Canyon Dam

Controversy erupted in 1960 over handling of runs of fish that spawned in Pine and Indian creeks, tributaries that flow into Hells Canyon Reservoir. The regulatory agencies desired to provide adult passage at Hells Canyon Dam, while IPC did not. The agencies felt that the runs of anadromous fish into Pine and Indian creeks were substantial and should not be transferred to other sites. Fish trapped at Hells Canyon Dam would, under the agency proposal, be released into Hells Canyon Reservoir so that the Pine Creek and Indian Creek runs could sort themselves out

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[15] High Mountain Sheep Dam was to have been constructed just upstream of the mouth of the Salmon River. Other options for dams included Low Mountain Sheep (just upstream of the Imnaha River), Appaloosa (a short distance upstream of Low Mountain Sheep), and Pleasant Valley (near Pittsburg Landing) sites.

[16] This communication probably was intended for personnel within the administration of IPC.

from the adults traveling to tributaries upstream of Brownlee Dam. These adults would be trapped again at Oxbow Dam and transported upstream of Brownlee Dam so that they could continue their migration to spawning sites. IPC (Roach 1960) proposed to trap migrants in Pine and Indian creeks and to transfer downstream migrants “from these two small streams to other suitable locations.” That transfer never occurred. Seaton (1960) reiterated the views of the regulatory agencies, stating that fish passage to the area between Hells Canyon and Oxbow dams should be provided.

Proposals to build Mountain Sheep Dam downstream of Hells Canyon Dam further complicated fish conservation efforts in the Hells Canyon area. Wendell Smith, a biologist hired by IPC in 1959, thought that Mountain Sheep construction would require that spring chinook and steelhead runs that arrived at the site be transferred to other suitable tributaries downstream of the Mountain Sheep site. In a letter dated August 3, 1960, directed to A. C. Inman, Vice President of IPC, Smith (1960) proposed transfer of the spring chinook and steelhead runs to the Clearwater River. He thought fall chinook should be trapped and their embryos incubated in facilities near Oxbow Dam, for release as fry into the Snake River, presumably downstream of the proposed Mountain Sheep Dam.

5. Effects of the HCC on Anadromous Fish

5.1. Fall Chinook

The completion of the Brownlee Dam project greatly reduced survival of fall chinook juveniles produced upstream of the HCC and their abundance as seaward migrants that successfully passed the HCC. The effects of the HCC on adult fish that reached the HCC cannot explain the time-related decline in the number of fall chinook; rather, the effects of the HCC on juvenile fish explain the decline. The reservoir upstream of Brownlee Dam was an extremely hostile environment for juvenile fall chinook. The Brownlee dam and reservoir essentially extirpated fall chinook upstream of the HCC. These effects appear in adult numbers beginning in 1960 and continuing from then on. Hatchery production failed to sustain the run.

The dams constructed in the Hells Canyon reach of the Snake River retarded fall cooling of the Snake River downstream of the projects, especially in the reach upstream of the Salmon River. In a letter dated January 6, 1961, to L. Perry, of the USFWS, W. Smith (1961b) pointed out that temperatures at Oxbow Reservoir were less suitable in September and October because of the retarded cooling. However, December through January temperatures were improved (“improved” meant warmer incubation temperatures during winter).

Smith (1967a) indicated that redd counts between the Salmon River and Hells Canyon Dam had increased somewhat over previous years. He suggested that the increase stemmed from drop-back spawning (spawning that takes place when fish encounter an obstacle such as a dam, and, instead of trying to continue to their spawning grounds, the fish spawn downstream of the obstacle).

5.2. Spring Chinook

The HCC can be said to have eliminated wild runs of spring chinook that spawned upstream of the HCC in the habitats that were available when HCC construction began (that is, Weiser River, Wildhorse River, Eagle Creek, and Pine Creek). The HCC can also be said to have increased the abundance of spring chinook demes that formerly spawned upstream of the complex. This apparent contradiction derives from the successful transfer of all spring chinook to the Rapid River Hatchery and the substantial increase in their numbers following the transfer. Total return rates to the hatchery for the 1964 and 1965 broods were 0.8 and 0.9%, respectively. Catches in the lower Columbia River increased returns to the mouth of the river to well over 1.0%. Return rates at the hatchery in the following four broods averaged 0.5 to 0.6%. Brood-year return rates declined beginning with the 1970 brood (return years 1973 to 1975) and subsequently remained below 0.2%.

The genetic characteristics of the present Rapid River spring chinook stock have probably changed in some measure as a result of about ten generations of artificial culture. The long-term significance of those probable changes for potentially reestablishing spring chinook salmon upstream of the HCC is unknown. Surplus production from Rapid River Hatchery has been used by fishery managers to stock many streams in the Clearwater, Salmon, Imnaha, and Grande Ronde rivers. Fish of Rapid River origin also were used in trapping broodstock at Sawtooth Hatchery (IPC 1982). Returns of salmon to Clear Creek and Dworshak hatcheries on the Clearwater River came from transfers of Rapid River spring chinook to Clear Creek.

Spring chinook were better able to pass through Brownlee Reservoir than subyearling fall chinook or steelhead. Smith (1967b) attributed this to two factors: 1) Spring chinook juveniles entering Brownlee Reservoir were usually 4 to 5 in long, and therefore survived better than the much smaller fall chinook. 2) The primary source for spring chinook was the Powder River—specifically Eagle Creek—which enters the reservoir 10 mi from Brownlee Dam, while juvenile fall chinook and Weiser River steelhead had to pass almost 60 mi of reservoir.

Raleigh and Ebel (1968) estimated survival of spring chinook juveniles from the Weiser River and Eagle Creek (combined) at 17% in 1963 and 51% in 1964. (It was infeasible to determine separate survivals of smolts from the two drainages for either year.)

5.3. Steelhead

A pattern similar to that identified above for spring chinook would pertain to summer steelhead that formerly passed the HCC to spawn in tributaries. The number of summer steelhead adults that originate from smolts produced at hatcheries supported by IPC (Niagara Springs and Pahsimeroi hatcheries) exceeds the number that existed at the time of HCC construction (Tables 20 and 21 in Abbott and Stute 2001). Again, the long-term significance of possible hatchery-induced genetic changes is unknown. Steelhead with genetics traceable to the HCC have been released and returned to sites throughout the Salmon River (except the Middle Fork and South Fork Salmon River and Chamberlain Creek).

Releases of steelhead smolts produced at Niagara Springs Hatchery into the Snake River downstream of Hells Canyon Dam continue to result in adult returns to the Hells Canyon Dam trap. From 1987 through 1997, steelhead returns to the trap averaged 2,024 (Moore 1998). Trap catches have been lower since 1991 than in the first four years of the data series. Occasional naturally produced steelhead are taken in the trap (mean = 27/yr).

6. Other Conditions Affecting Fish Migration

6.1. Conditions in the Columbia and Snake Rivers in 1955

Two mainstem Columbia River dams were operating in the mid-1950s below the mouth of the Snake River: Bonneville Dam (completed in 1938 at river mile [RM] 146) and McNary Dam (completed in 1953 at RM 292). Upriver storage projects, such as Dworshak, Mica, Libby, and Hungry Horse dams, had not been built. Swan Falls Dam (built from 1901 to 1909 at Snake RM 458), above Marsing, Idaho, was the most-downstream dam on the Snake River. Flows and the fishway at Swan Falls Dam constrained adult upstream migrations. A few steelhead probably passed the Swan Falls facility in spring until C.J. Strike Dam was completed.

The Snake River was warm in mid- to late summer. The spring chinook and steelhead had adapted to these conditions by using tributaries during that time of year. Adult fall chinook did not enter the main Snake River from the cooler Columbia River in quantity until the end of August, and juveniles left before summer. September was the peak month of passage of adult fall chinook at McNary Dam. Counts in September are useful in regression analyses because they minimize inclusion in the data of summer-run chinook salmon produced in the Columbia River and its tributaries upstream of the mouth of the Snake River.

6.2. Downriver Dams

Bonneville and McNary dams were equipped with adequate fishways, but lacked protective features, such as turbine intake screens and collection facilities for transporting downstream migrants in the mid-1950s. However, spill rates were high at both dams in late spring and early summer as powerhouse capacity was inadequate to pass all the river flow through turbine intakes. Juvenile fish that passed through Kaplan turbine intakes probably suffered about 11% mortality in each turbine passage, but less than 1% loss in spill passage (Schoeneman et al. 1961). Adult fall chinook salmon and steelhead that migrated in late summer and early fall probably suffered about 5% loss in passage at each of the mainstem dams, although loss may have been higher in some years, depending on flow level. Some interdam loss may have been caused by the dams, while some may have been caused by the delayed effects of fishing or other injury.

By comparing the number of HCC fall chinook that arrived at the mouth of the Columbia River with the number that arrived at the HCC, we estimated a 5% loss of adults per dam project as they moved upstream. Thus, when two dams were present, the project loss would be about 9.8%;

when three dams present, 14.2%; four dams, 18.5%; five dams, 22.6%; and six dams, 26.5%. In Chapter 6 (Chapman and Chandler 2001), we estimated abundance of adult salmon at HCC traps and at various downstream points.

6.3. The Dalles Dam and Flooding of Fishing Sites near and at Celilo Falls

The Dalles Dam (RM 192), completed in 1957, flooded Native American fishing sites at Celilo Falls near The Dalles and drift-gill net sites downstream of the falls. Salmon and steelhead escapements (fishway counts) at McNary Dam immediately increased sharply. Native Americans had fished from wooden platforms constructed over the cascades at Celilo Falls for hundreds of years. Their catches were sporadically and inadequately recorded, and fish were sold both at the riverbank and through commercial marketing channels. Fall chinook were more vulnerable to the Celilo Falls fishery than spring- and summer-run chinook; river flows were lower in August when the fall chinook passed than in spring and early summer when spring- and summer-run chinook moved through the area. Summer chinook also were more vulnerable to the fishery than spring chinook.

The Native American fishery, located upstream of Bonneville Dam, did not resume fishing with any intensity until 1963, when catches with gill nets began increasing. (Gill nets were of the set type, meaning they were anchored to the bottom.) Catches were modest from 1963 through 1966.

The elimination of the fishery near and at Celilo Falls had a major effect on fish counts at McNary Dam and upstream points. The effect on escapements must be considered as one examines temporal changes in fall chinook numbers at the HCC.

7. Fish Counts at the HCC

7.1. Estimates of Fall Chinook from 1953 to 1956

Counts of fish passage at Bonneville and McNary dams and estimated harvest counts provide estimates of fall chinook abundance for the mid-1950s. These estimates are tentative for two reasons. First, some adult salmon fell back over spillways and reascended fishways, which inflated fish counts to an unknown degree. Fallback and the subsequent count inflation is a minor problem for fall chinook because spill fractions were lower by August and early September than fractions in spring and early summer. Second, and more significantly, the data on harvest in the mid-1950s were incomplete, especially in the fishery between Bonneville and McNary dams. Catches were more carefully monitored in the commercial fisheries downstream of Bonneville Dam.

Fishway counts at McNary Dam and escapement counts taken from status reports on Columbia River fish stocks are useful in evaluating information on fall chinook abundance. The data reveal that the small September counts of fall chinook at McNary Dam from 1954 to 1956 made up only 18.3% of upriver bright escapement (that is, the upriver run minus the catch downstream of Bonneville, minus any fish trapped and retained at Bonneville Dam, minus the catch between Bonneville and McNary dams). In the same years, the September count at McNary Dam made up only 6.4% of the Bonneville Dam counts. From 1957 to 1961, the McNary count rose to 43.7% of the upriver bright escapement, and to 30.3% of the Bonneville fishway counts. Given that as soon as Celilo Falls flooded, the McNary count jumped sharply as a fraction of total escapement and of the Bonneville fishway count, it seems likely that catch in Zone[17] 6 was underestimated for 1954 to 1956. It might be argued that a portion of the increase at McNary Dam could be attributed to fall chinook whose mainstem spawning areas in The Dalles Reservoir were flooded. However, those fish had access to the lower Deschutes River, lower John Day River, and over 75 mi of potential mainstem spawning areas between the upper end of The Dalles Reservoir and McNary Dam.

7.2. Escapement of Fall Chinook Salmon at the HCC in 1957

Trap catches at the HCC can be used to estimate how many fall chinook use the area upstream of the complex. The counts from such catches are useful, but they are affected by several downriver circumstances. For example, the number of fish caught at the fishery downstream of Bonneville Dam (Zones 1 through 5) varied from year to year and affected the number of fish arriving at the HCC. Then, the flooding of Celilo Falls and its fishery resulted in a significant change in counts at the HCC. In addition, the total interdam loss of adults changed as other dams came on line (The Dalles in 1957, Ice Harbor in 1961, John Day in1968, Lower Monumental in1969, Little Goose in1970, and Lower Granite in 1975). And the offshore fisheries in Washington, British Columbia, and Alaska also influenced adult numbers that reached the HCC.

Tags were placed on 1,144 fall chinook salmon at McNary Dam between August 25 and September 28, 1957. Recoveries totaled 291—or 25%—at the HCC trap (an electric barrier and adjoining trap downstream of the exit of the Brownlee Dam diversion tunnel). The barrier and trap collected chinook for transport to a site upstream, and largely prevented adults from attempting to migrate through the high velocities in the diversion tunnel. Twenty-five percent recovery is the best and only estimate for the HCC fraction of the Columbia River fall chinook run at McNary Dam.

7.3. Decline in Fall Chinook at the HCC from 1957 to 1971

Numbers of fall chinook that arrived at the HCC declined from about 15,000 in 1957 (counted at the electric barrier and trap at the Brownlee Dam diversion tunnel) and nearly 18,000 fish in 1958 (counted at permanent traps at Oxbow Dam), to less than 10 fish by 1971 (counted at temporary traps at Hells Canyon Dam). Beginning at the HCC and working downstream, we used fish counts at fisheries and across dams to the Columbia River mouth to estimate HCC fish

[17] Zone 1 begins at the mouth of the Columbia River. Zones 1 through 5 lie downstream of Bonneville Dam. Zone 6 lies upstream of Bonneville Dam.

numbers as follows: 35,000 in 1957; 28,000 in 1958; 20,000 in 1959; 14,000 in 1960 and 1961; 6,400 in 1962; 2,000 in 1963; 3,500 in 1964; 4,600 in 1965; 8,100 in 1966; 3,300 in 1967; declining sharply to 13 fish in 1971. We estimated fish numbers from 1954 through 1956 using a regression of HCC numbers on McNary fishway counts. To account for the effects of Zone 6 catch on McNary counts, we also used the 1957 through 1961 ratio of McNary count to upriver bright escapement to adjust upward the 1954 through 1956 estimate. Our estimates of HCC fall chinook at the mouth of the Columbia River from 1954 through 1956 are 7,700, 6,800, and 5,400, respectively.

Because trap counts of fall chinook at the HCC from 1957 to 1971 are based on fish actually trapped and handled, the counts discussed previously appear reasonably accurate. However, some fall chinook might have passed the barrier during occasional outages (the barrier was inoperative about 11% of the time between August 17 and October 19, 1957). Additionally, in 1958, a number of adults that would have been trapped were killed by hypoxia and stress in the oxbow near the Oxbow Dam site (section 4.5). The trap count in 1958 was adjusted upward based on the estimated kill of fall chinook in the oxbow.

7.4. Spring and Summer Chinook Abundance at the HCC in the 1950s and Subsequently

Even with the flooding of Celilo Falls, spring chinook abundance at the HCC equaled just 761, 1,250, 2,631, and 2,047 in 1958, 1959, 1960, and 1961, respectively. The first year in which the effects of the HCC on spring chinook counts became apparent was 1961. Brownlee Reservoir began to fill on May 9, 1958, after most spring chinook had passed downstream. Thus, the effects of the HCC on the 1959 smolts began returning to appear two and three years later, in 1961 and 1962, with respective returns of 2,047 and 1,050. Subsequent returns dropped to an average of 624 for 1963 through 1965. The trap at Hells Canyon began to operate after the spring chinook return of 1965, and counts at the trap increased to 1,955 and 1,177 in 1966 and 1967, respectively (Appendix 4). These counts might have been affected by capture of some fish destined for return to Pine Creek. Jack chinook salmon (precocious males that have spent one year in the ocean) returns in 1967 were the first counts affected by transfer of 1964 brood spring chinook to Rapid River. Counts in 1968 and later were affected by 2-ocean returns (fish that have spent two years in the ocean) from Rapid River releases to Rapid River, rather than to the HCC.

7.5. Steelhead Abundance at the HCC in the 1950s and Subsequently

On a brood-year basis, steelhead returns to the HCC were 4,414 and 4,557 in 1958 and 1959, respectively. The effects of the HCC on adult returns became evident in 1960 (for 1-ocean fish) and 1961, when adult numbers were 1,971 and 1,798 fish, respectively. Subsequent Oxbow counts dropped to 806 and 779 in the 1963 and 1964 broods, respectively. When IPC moved trapping facilities downstream to Hells Canyon Dam in 1965, the steelhead return for the 1965 to

1966 and 1966 to 1967 brood years, respectively, increased to 4,195 and 5,092, possibly because of the capture of fish destined to enter Pine and Indian creeks (Appendix 4).

7.6. Sockeye Abundance from 1953 through 1956

Sockeye, native to Big Payette Lake in the Payette River drainage, were extinct in the area upstream of the HCC by the mid-1920s. Black Canyon Dam on the Payette River lacked fish passage facilities; therefore, no sockeye were present when the HCC was constructed.

8. CAUSES OF DECLINE IN ANADROMOUS FISH UPSTREAM OF THE HCC

8.1. Fall Chinook

The foregoing report sections should be kept in mind when analyzing changes in numbers of HCC fall chinook that returned to the Columbia River. We regressed adult numbers (the dependent variable) on independent variables in several analyses. The abundance of fall chinook in the HCC regresses positively for escapement past Zone 6 and negatively for time, beginning in 1954 and ending in 1971. The year-of-return variable contributed more to the regressions than did other variates. We calculated an R^2 of 0.90 for a regression of square-root transformed HCC counts on McNary escapement and year, with year contributing most of the variation. Using numbers of HCC fish at the Columbia River mouth from 1954 through 1971 (the first year that HCC counts numbered fewer than 10 fish), and regressing on time, we found a significant negative regression at $P = 0.0001$, $R^2 = 0.63$. Neither John Day Dam (RM 216) nor Ice Harbor Dam (RM 334) completion (in 1968 and 1961, respectively) explains the temporal decline in HCC fish.

The fall chinook run to the Snake River upstream of the HCC declined over time whether or not one adjusts for incomplete catch recording in the fishery upstream of Bonneville Dam. The most likely time-related factor is the influence of the HCC projects, specifically the Brownlee Dam project. The Brownlee Dam project greatly reduced the proportion and numbers of juvenile fall chinook that safely passed the HCC. Brownlee Dam began filling on May 9, 1958, and juvenile passage declined greatly thereafter. The reservoir upstream of Brownlee Dam became warm, and oxygen content declined in the summer months, constraining juvenile fall chinook to a very limited vertical zone of reservoir water. Currents through the reservoir were insufficient for juveniles to find their way through the project. At the same time, predator populations expanded rapidly in the reservoir.

The barrier net at Brownlee Dam failed to capture juvenile fall chinook in quantities necessary to protect the fish from the effects of the reservoir and dam. Evaluations in 1962 suggest that the barrier net captured a total of 0.8% of the subyearling fall chinook that entered the upper end of Brownlee Reservoir, 0.2% as subyearlings and 0.6% as yearlings. Thus, the barrier net captured only 0.8% of the juvenile fall chinook that entered the reservoir from redds in the Snake River. Estimates place efficiency of the barrier net at about 14 to 17%, meaning the percentage of fish that arrived at the net and were guided and collected. Many juveniles perished in the reservoir or in passing through turbines. Survival rates for juveniles moving from the upper end of Brownlee Reservoir to the barrier net are estimated as only about 5.2% for subyearling and yearling fall chinook combined, which represents a loss of 95% of the cohort passing through this stretch. The remaining 5% exited the reservoir through turbine intakes or any available spill.

The first return year in which fall chinook numbers partially reflect the effects of poor survival through the reservoir is 1959, when precocious males returned from the 1957 spawning. We say “partially” because in 1958 the reservoir was not full in spring and early summer. The first year a full reservoir affected adult returns was 1960. The effects of the reservoir on adult returns probably worsened from 1959 on, as predator populations expanded.

8.2. Spring Chinook

The first spring chinook translocation occurred in 1964, from the HCC to Rapid River Hatchery on Rapid River (Appendix 5), a tributary of the Little Salmon River. Thus, adult returns in 1967 (jacks) and 1968 (2-ocean adults) reflect the effects of the translocation. The first year in which significant project-related effects on spring chinook returns appeared was 1961. Although a significant number of the 1960 brood moved through Brownlee Reservoir in 1958 as smolts, that movement actually occurred both in fall 1957 (as presmolts that overwintered in the Snake River) and April 1958 (as smolts), before the diversion tunnel closed on May 9, 1958. The 1961 brood migrated through a filled Brownlee Reservoir in 1959 as smolts. The presence of 3-ocean adults and downriver fisheries might have masked the effects of that passage to some degree. The adult returns of 1962 to 1964, averaging 739 fish (Smith 1969), probably reflect the effects of Brownlee Dam on the downstream migrations of 1960 through 1962. Except for a single increase in the HCC count in 1966, escapements remained low (Appendix 4).

For smolt migration years 1960 through 1964, Junge (1964) found a positive correlation between the number of Oxbow-trapped spring chinook as a percentage of Ice Harbor Dam counts (dependent variable) and the sum of average monthly spillway releases at Brownlee Dam from March 1 through June 30 (independent variable) ($R^2 = 0.84$, $p < 0.05$, $n = 5$). The percentage ranged from a low of about 12% to a high of about 55%. Spring chinook juveniles found their way through Brownlee Reservoir somewhat more effectively than fall chinook subyearlings or steelhead (Graban 1964), and they appear to have benefited from spill at Brownlee Dam. Although yearling migrants found their way through the reservoir more effectively than did subyearlings (Haas 1965), survival was low. Raleigh and Ebel (1968) estimated that only 17 and 51% of yearling migrants that entered Brownlee Reservoir in 1963 and 1964, respectively, reached the Brownlee Dam tailrace.

By June 5, 1966, 1,600 spring chinook salmon taken at the HCC traps were delivered to Rapid River Hatchery. The fishery agencies specified to IPC that any fish collected after June 5 be released to other Snake River tributaries. The first preferred release site was the Wallowa River, where 80 adults and 25 jacks were placed. However, because of road conditions or excessive heating in tanker containers, “a substantial number” of fish were released into

Lick Creek, a tributary of the Imnaha River (Smith 1966a). This release into Lick Creek totaled 101 adults and 18 jack salmon. After July 15, fish were taken to Summit Creek, a tributary of the South Fork Salmon River, in Idaho. The releases to Summit Creek totaled 43 adults and 7 jacks. In 1966, all arrivals at the HCC between July 15 and appearance of the earliest fall chinook were delivered to Summit Creek. Smith (1968) summarized adult transfers to Rapid River from brood years 1964 through 1967, and smolt releases, as follows:

- 1964: 360 adults and 600,000 smolts
- 1965: 408 adults and 470,000 smolts
- 1966: 1,511 adults and 1.4 million smolts
- 1967: 974 adults and 900,000 smolts

With one exception, no literature or record indicates that spring chinook from streams or hatcheries other than tributaries upstream of the HCC contributed to spring chinook broodstock at Rapid River Hatchery, suggesting the transfer was successful. The exception is the probable contribution of wild spring and summer chinook of Rapid River itself. In the 1960s and 1970s, not all hatchery-reared smolts were marked or otherwise identifiable upon return to hatchery racks at Rapid River. Thus, wild chinook salmon (considered “summer chinook”) produced upstream of the hatchery almost certainly contributed to broodstock at Rapid River.

8.3. Steelhead

First translocations of steelhead from the HCC began with the 1964 brood (migrants that reached the HCC in fall 1964 and spring 1965), from which 288,000 eggs were split between the Lemhi incubation channel and the Hagerman Hatchery (Appendix 6). In 1966, 55,000 smolts were released in the Lemhi River and another 55,000 in the Pahsimeroi River. Large egg takes began with the 1965 brood, with 1,645,000 smolts released in the Pahsimeroi River and 750,000 liberated in the Snake River below the HCC. Thus, counts beginning in 1966 reflect some effects of translocation.

Another complication in examination of HCC counts is that in 1965, trapping moved to Hells Canyon Dam, thus incorporating escapements destined for Pine and Indian creeks. This means that beginning in 1965, the escapements include survivors of smolt passage through the HCC plus adults returning to two additional streams. However, HCC steelhead counts for the 1960 brood probably fully incorporate the effects of Brownlee Dam on smolts that left the Snake River in 1959. The 1959 brood of steelhead came from presmolts that overwintered in the Snake River in fall and winter 1957, smolts that departed the system in spring 1958 before dam closure, and some smolts that passed in spill after Brownlee Reservoir filled to the spillway level.

Full transfer of adult steelhead from the HCC to other streams took many years. Although spring chinook were fully transferred by 1966 to 1967, some adult steelhead continued to reach Hells Canyon through the mid-1970s. Translocation was slowed by the continued release of some steelhead into the Snake River downstream of Hells Canyon to support a sport fishery in the Snake River. Such releases consisted of wholesale release of about 750,000 smolts annually and release of culls from Niagara Springs Hatchery, which provided rainbow trout to the fishery downstream of Hells Canyon Dam. Some of the surviving culled fish may have gone to sea after they reached sufficient size.

9. Degree to Which Declines in Anadromous Fish Were Anticipated

When reviewing the actions of both the regulators and IPC during construction of the HCC, it is important to remember that very little was known then about methods for fish passage at high-head dams as large as Brownlee Dam. Almost no empirical experience was available. It was known that adults could be trapped and hauled successfully. Fish ladders were known to pass fish reasonably well at dams. “Gulper” traps were known to collect juvenile fish at certain dams in the Pacific Northwest, most notably at Baker Dam in the Skagit River system. As early as fall 1953, a barrier net and gulper system was visualized as a means of passing juvenile fish (Marriage 1953). But how to pass juvenile salmon successfully through a deep, still reservoir, such as Brownlee Reservoir, was not known. A committee of fish agency experts developed fish passage facilities that were adopted by the FPC, with the acquiescence of IPC.

It was generally assumed that power development in the Hells Canyon reach of the Snake River would adversely affect anadromous fish (FPC 1955). However, the regulatory agencies and the various committees did not fully anticipate the combined effects of severe oxygen depression, temperature elevation, and the inability of juveniles to find their way through the reservoir. Neither did regulators fully anticipate the physical problems that would attend installation and maintenance of the Brownlee Dam barrier net. Even later, when Hells Canyon Dam was under construction, agency regulators were still proposing to pass adults upstream through Hells Canyon and Oxbow dams to retain habitat in tributaries that lay between the HCC dams. Neither IPC nor the regulators predicted the one-decade demise of fall chinook in the HCC.

This is not to say that regulators were unaware of the potential for run decimation. They were. Regulators conveyed their worry to IPC and to the FPC and Congress. In 1951, even a low Oxbow Dam, a precursor in planning to the HCC, was noted as causing losses to anadromous fish (Murray 1951). It can be fairly said that regulators were forced to attempt to preserve the runs by the pressure of politics and a perceived need for electrical energy, often stated by proponents of dams in Hells Canyon.

10. MOVING FROM NATURAL PRODUCTION TO HATCHERIES

On December 7, 1956, the regulatory agencies (IDFG et al. 1956) prepared a program for the FPC, outlining studies necessary to developing a conservation program that would respond to fish and wildlife problems caused by the HCC. One of the studies involved hatchery feasibility and temperature investigations. One option was to develop artificial spawning areas, beginning with an evaluation of the spawning channel already in place at McNary Dam, at a cost of $10,000. Another $36,000 was allocated to a full-time fishery research biologist, consulting limnologist, 6 thermographs, and operational costs. The budget noted that "If pilot hatchery studies are necessary, an additional $28,800 would be required."[18] As late as the end of December 1957, hatcheries were considered an alternative, should fish passage prove unsuccessful (Hodges 1957).

On August 30, 1957, IPC denied that it was considering a hatchery below Mountain Sheep Dam (Minutes of Middle Snake River Administrative Committee, with Idaho and Pacific Northwest Power companies, dated August 30, 1957). On December 13, 1957, IPC wrote to the FPC (Inman 1957) and provided a budget for fish mitigation that totaled $8.5 million capital cost and $1.5 million annual cost for anadromous fish, with a comment that the fisheries agencies estimated annual value of the runs upstream of the HCC at only $1 million. Included in the budgets were $1.5 million for construction of hatchery facilities and $330,000 for annual operation of the facilities. The IDFG and OGC quickly countered that hatcheries were an alternative to unsuccessful fish passage, and thus annual costs should not be included in the total budget (Leonard 1957b, Schneider 1957b). The letter from Oregon also noted that the value stated for the fisheries upstream of the HCC was out of date.

Fall 1960 marked the first effort to acquire and incubate fall chinook eggs. Haas (1965) notes that Heath incubators were temporarily installed in the Brownlee Powerhouse. In spring 1961, 1,500 fall chinook fry were released in a pond near the mouth of Wildhorse River. This effort was largely experimental, with 132,000 eggs taken, of which 40,000 went to Eagle Hatchery for an evaluation study, 12,000 to the Snake River and Pine Creek for incubation tests, and 41,000 to Clearwater River incubation. Known egg mortality was over 20,000. Haas shows 205 fish held for artificial propagation, but no information on the number of females.

An IPC letter dated March 21, 1961, addressed to the directors of the several fishery regulatory agencies, responded to an FPC order dated November 17, 1960, requiring IPC to install "appropriate and adequate facilities, including holding facilities, for about 2000 adult salmon near Oxbow dam; troughs or trays to care for the eggs until eyed; and incubation channels in the Clearwater River basin and below Oxbow dam in the vicinity of Pine Creek or Snake River, for the artificial propagation of fall chinook from the Oxbow dam on a trial basis. Should the Licensee and the fishery agencies be unable to agree upon the terms of the program, the

[18] In another program phase, stream candidates for run relocation would be investigated in funded cooperation with the Pacific Northwest Power Company (PNPC), which hoped to construct Mountain Sheep and Pleasant Valley dams. The reason for the cooperative effort was that the same streams would be candidates for relocation of runs affected by PNPC and IPC dams.

Commission reserves the right to determine the same….” Possible sites for the experimental facilities included the confluence of the Snake River and Pine Creek, the mouth of Indian Creek, and the Wildhorse River. The facility would be for fall chinook only. However, the IPC letter noted that W. Smith, IPC biologist, believed that the Wildhorse facility would also be “suitable for spring chinook and steelhead on at least an experimental basis. It is also his opinion that the Oxbow pond (reservoir) would be as good an area for release of free swimming fall chinook fry, or for residence for a year for spring chinook and steelhead, as can be found, since it should be relatively predator free.”[19]

By August 1965, the fisheries agencies had adopted a non-passage mode. To a letter from the USFWS, Perry (1965) attached the adopted policy, called “Policy for the perpetuation and management of anadromous fish in Snake River drainage upstream of Salmon River.” Anadromous fish populations were to be restored to levels not less than the maximum counts recorded at Oxbow and Brownlee dams plus the number of fish utilizing the drainage from the High Mountain Sheep damsite to Brownlee Dam.[20] Future reestablishment of upriver runs was retained as an option. The policy stated: “If determined by the agencies that the fish runs will be reestablished, upriver production areas now blocked by existing dams or currently rendered unusable because of other water uses shall be made accessible and/or productive as early as possible through the provision of passage facilities, pollution abatement, and releases of water from storage to augment quantities and improve qualities of the flows to satisfy migration, spawning, incubation, and rearing requirements.”

An FPC order dated January 28, 1966, required that fish conservation efforts associated with the HCC be confined to artificial propagation.

10.1. Fall Chinook

Pilot hatchery facilities for fall chinook began to operate in fall 1961, after returns of fall chinook dropped sharply in 1960. Oxbow Hatchery operations began with collection of 2,000 adults in 1961. Adults captured at the Oxbow Dam fish trap were hauled by truck to the Oxbow holding pond. In this and other years, severe prespawning mortality reduced hatchery efficiency. In 1962, 602,000 juveniles were released into the Snake River (Appendix 7) (Smith 1969). Juveniles exited the Oxbow incubation facility through an 8-inch pipe that led to the Snake River. The first

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[19] The presumption that fall chinook fry and rearing spring chinook and steelhead could prosper in Oxbow Reservoir *and find their way safely through the project* is surprising today, but indicates the state of knowledge about fish passage and environmental requirements in 1961. Not only would juveniles have had to pass through Oxbow Dam, but, ultimately, through the Hells Canyon dam and reservoir. Data attached to the March 21, 1961, letter indicate Brownlee tailrace and Oxbow fish trap temperatures of 21.1 °C in August. Also, predator populations developed quickly in Oxbow Reservoir. IPC was already aware of this problem; an IPC summary of fish facilities dated January 26, 1961, noted that “[p]redatory species in (Brownlee) reservoir may be eating fingerlings.”

[20] The policy statement did not mention downriver fisheries or dams as influences on the numbers of fish reaching the area upstream of the High Mountain Sheep site above the Salmon River. These factors could certainly affect the ability of managers to restore the maximum counts recorded at Oxbow and Brownlee dams.

return of these fish was in 1963, with greater numbers in 1964 and 1965. About 1.1 million fingerlings were released in 1963, and their impact should have appeared from 1964 to 1966. Releases subsequently ranged from 496,000 in 1964 to 1.47 million in 1967, but the number of returning adults continued to decline. Smith (1974) ascribed failure of the fall chinook hatchery at Oxbow to two conditions: 1) Stored water in Brownlee Reservoir retained summer heat into the fall and provided inadequate temperatures for normal spawning that occurs in early November. 2) Half the fall chinook adults that arrived at IPC collection facilities were debilitated by *Columnaris* because of increased susceptibility following the strain of the summer trip from the sea, a trip that included passage over five federal dams.[21] The combination of an increase in predators in the Snake River downstream of the release point and readily available food sources provided by the reservoir(s) (for instance, prey that passed through turbine runners or collected around fish ladders) probably contributed to poor survival for fall chinook, from fingerling to returning adult. And the development of dams downstream may also have contributed to poor survival rates; however, we cannot attribute the extirpation of fall chinook that formerly spawned in the Snake River upstream of the HCC to the development of downstream dams.

Regulatory policy (Perry 1965) stated that, beginning in 1965, all fall chinook adults arriving at Hells Canyon Dam would be collected and transferred to artificial propagation facilities. Fingerlings from the 1965 and 1966 runs would be released into the Snake River downstream of Oxbow Dam. After 1966, and until final closure at High Mountain Sheep Dam, fingerlings would be released downstream of Hells Canyon Dam. The final step in the policy called for release of fingerlings downstream of High Mountain Sheep Dam. The regulators were optimistic that hatchery production could sustain the fall chinook run. Not until the late 1960s did it become obvious that survival rates for hatchery-produced fish were far too low to sustain the run.

Prespawning losses in fall chinook were a continuing problem at Oxbow Hatchery. One fish examination report for October 20 and 22, 1965, noted that most of the mortalities had been caused by injuries, although not recent ones. Pathogens increased as the fall progressed and as fish became more debilitated. *Ceratomyxa* sp., *Aeromonas salmonicida*, and *A. pseudomonas* were endemic in mortalities. A fish examination report for November 1 and 3, 1965, noted a 66% prespawning mortality among the 414 females received at Oxbow Hatchery. This report suggested using Pine Creek water to hold maturing fish to reduce bacterial infections.

Water quality for incubation was poor at Oxbow Hatchery (Woodworth 1968). Of 812,000 fall chinook eggs taken at Oxbow Hatchery in fall 1967, only 282,000 fry survived until the end of February 1968. Woodworth (1968) attributed the losses to high temperatures in the early incubation stages and to higher levels of plankton coming in with the Snake River water, after Hells Canyon Reservoir filled. Woodworth requested that 180 gallons of well water per minute be provided for egg incubation.

[21] The second explanation has been shown incorrect by the persistence of fall chinook in the Snake River between Lower Granite Dam and the HCC. These fish must pass eight dams, not five.

10.2. Spring Chinook

First mention of a proposal to rear spring chinook and steelhead in a pilot program is found in a letter from IPC to fishery regulators (Moore 1961). Moore noted that W. Smith, IPC biologist, suggested that holding and incubation facilities, if constructed at the mouth of Wildhorse River for fall chinook, could be suitable for spring chinook and steelhead "on at least an experimental basis." In March 1962, Smith (1962b) recommended that "Procedures be formulated to commence immediately the transplantation of a portion of the spring chinook and steelhead stocks arriving at the present Oxbow spillway trap facilities. Introduce these stocks into the Clearwater and Salmon River watersheds of Idaho and similarly suitable sites in Northeastern Oregon."

In April 1963, Smith (1963b) prepared an outline of a proposed fish conservation program for the Middle Snake River. The second item of the outline was "Commence construction of Rapid River (or other nearby location) spring chinook and steelhead spawning channel, with ultimate capacity for 2500 spawners, for operation in spring of 1964." Item 5 called for transplantation of spring chinook and steelhead entering the trap at Oxbow Dam or the temporary trap at Hells Canyon Dam to Rapid River, Clearwater River, Grande Ronde River, or other suitable nearby location. Not everyone agreed with the move toward hatcheries proposed by Smith. One protest, dated July 12, 1963, came from the Idaho Wildlife Federation. It objected to an IPC proposal to terminate passage of anadromous fish at the HCC. It noted that ending passage would make it impossible to reestablish salmon and steelhead in tributaries upstream of the HCC, where they had formerly spawned and reared. In response, Wendell Smith (1963c) noted:

> 1) No fisheries biologist can look realistically to re-establishment of historical runs above Swan Falls Dam in the Snake River or in any tributaries where runs were eliminated long before construction of the Brownlee Dam complex. Present water-use programs and contemplated uses in the future negate possibilities for successful rehabilitation in all these areas. Furthermore, no stocks of fish are available for re-introduction therein.[22]
>
> 2) Fisheries agency people are already agreed that fish passage of fall chinook (the most abundant race of fish in the Brownlee Dam complex area) should be discontinued in favor of below-dam artificial spawning and rearing facilities.
>
> 3) Should fish-passage be maintained for spring chinook and steelhead (which limits, then, the productive spawning and rearing areas to the Weiser River in Idaho and Eagle Creek in Oregon), extensive truck hauling of the migrants will be required. Following construction of High Mountain Sheep dam this haul distance may exceed 250 miles.

[22] Only the last sentence of this quotation might be incorrect today. The Rapid River and Niagara Springs hatcheries would provide a logical source for reestablishment of anadromous fish in tributaries of the HCC. Smith's comment about habitat remains at least as accurate, and probably more accurate, today.

On December 11, 1963, the FPC issued an order (FPC 1963, summarized in Haas [1965]) that IPC abandon net installation at Brownlee Dam, purchase the necessary land in lower Rapid River basin, and construct a hatchery. It also ordered that IPC transport 300 adult spring chinook and steelhead, or their eggs (but not more than 15% of the adult steelhead trapped at Oxbow), to the Rapid River Hatchery. Additionally, Idaho Power was ordered to continue the fall chinook incubation program at Oxbow Hatchery and to spill water at Brownlee Reservoir to facilitate fish migration.

The first egg take of spring chinook—captured at the HCC in 1964 and transferred to the Rapid River holding ponds—was 887,000 eggs (Smith 1969). The egg take in 1965 was 603,000. All surviving progeny were released into the Rapid River. The program was meant to be experimental and was accordingly designed to accommodate only 300 to 400 adults. The policy statement (Perry 1965) required all spring chinook to be transferred to Rapid River Hatchery beginning in 1966. Therefore, in 1966, before the return of any adults from the initial releases of smolts, the fishery agencies requested that the FPC order IPC to discontinue fish passage at the HCC and switch to a major hatchery program (Smith 1968). Rapid River Hatchery capacity doubled in 1966 and later expanded to accommodate 2,700 adult salmon and their eggs and the presmolt progeny of 1,500 adults. Later, the capacity again increased to handle the progeny of 2,700 adults. Subsequent egg takes exceeded 2 million in 1966 and 1967 and 6.6 and 5.2 million in 1968 and 1969, respectively. The first return of juveniles produced in the hatchery and released into the Rapid River were jack salmon in 1967 and 2-ocean adults in 1968. This means that, beginning in 1968, spring chinook counts at the HCC were decreased by the transfer of adults to Rapid River Hatchery.

The FPC order also determined the fish conservation efforts at High Mountain Sheep Dam. It required temporary passage facilities to pass all adult spring chinook over the dam until final dam closure. Following closure, all spring chinook were to be collected at the dam and transferred to the Imnaha River. For two years prior to final closure at High Mountain Sheep Dam, all downstream migrants from the Imnaha River were to be collected upstream of the maximum pool level of High Mountain Sheep Reservoir and released into the Snake River downstream of the dam. Thus, the FPC visualized a mitigation program at High Mountain Sheep Dam that collected spring chinook smolts from the Imnaha River and transported returning adults to the Imnaha River. That program was never implemented because High Mountain Sheep Dam was never built.

A small run of spring and summer chinook existed in Rapid River when Rapid River Hatchery began operating. For example, 180 spring and summer chinook (considered “summer chinook” by managers) arrived in spring 1966 (Ainsworth 1966).

Prespawning mortality rates for spring chinook adults hauled from the HCC were 20%, 25%, 18%, and 11%, in 1964, 1965, 1966, and 1967, respectively (Smith 1966b, Ainsworth 1967). The figure for 1967 may be too low, as Ainsworth (1967) reported total mortality of about 40%. He also reported spawning of 518 females from 616 received, suggesting a loss of 16%.

Ainsworth (1968) reported that, in 1968, some spring chinook salmon were transferred from Rapid River trap to other locations: 100 adults and 6 jacks to McCall Hatchery, 408 adults and 17 jacks to the Stolle Meadows holding pond, 478 adult and 207 jacks to Hard Creek, 337 jacks to the Little Salmon River, and 57 adults to Summit Creek. These translocations were the first of many that used surplus spring chinook salmon from Rapid River Hatchery. For example, embryos were delivered to a Clearwater River hatching channel in 1968 and to Clear Creek Hatchery (on the Clearwater River) in 1969. Smith (1977) indicates that 504,000 eggs were traded to Minnesota for walleye eggs in 1973, and 1.6 million and 262,000 eggs were delivered to Mullan and Sandpoint hatcheries, respectively, in 1976.

For the first several years of hatchery operation, return counts of adults from smolt releases into the Rapid River were high. Survival rates for brood years 1964 through 1970 were 0.78%, 0.75%, 0.69%, 0.79%, 0.79%, 0.79%, and 0.79%, respectively (Smith 1970). These return rates do not take into account ocean or downriver fisheries or interdam losses downriver.

10.3. Steelhead

The first take of steelhead eggs came from HCC adults in spring 1965. The egg take was 288,000 (Smith 1969)[23]. Surviving progeny were released in 1966—55,000 in the Lemhi River and 55,000 in the Pahsimeroi River. The FPC Order (Perry 1965) required all adult steelhead to be collected at Hells Canyon Dam and transported to holding facilities. The run was to be transferred "to a suitable drainage or drainages, such as the Salmon River." Following closure of High Mountain Sheep Dam, adult steelhead that arrived there were to be collected and transported to the Imnaha River. For two years prior to final closure at High Mountain Sheep Dam, all downstream migrant steelhead were to be collected from the Imnaha River and released downstream of High Mountain Sheep Dam.

In the 1965 to 1966 brood year, 3.64 million eggs were collected at Oxbow Hatchery. Destinations of the eggs included Hagerman State Hatchery (994,840 eggs), Hagerman National Hatchery (54,540 eggs), Eagle State Hatchery (927,724 eggs), Big Springs (Lemhi) incubation channel (143,990 eggs), and Enterprise Hatchery (464,100 eggs) (Craig 1966).

In the 1966 to 1967 brood year, 8.2 million steelhead eggs were taken (Craig 1967), some to the OGC facilities (4.36 million eggs) and some to Niagara Springs and the Lemhi River incubation channel (a combined total of 3.74 million eggs). A total of 1.65 million smolts were released into the Pahsimeroi River in 1967. Subsequent egg takes through 1969 were obtained either at the HCC or the Pahsimeroi Hatchery. Adults from the 1965 egg take first returned in 1967 as 1-ocean adults. Thus, counts of steelhead at the HCC began to decline in 1967 because of the transfer of runs to other sites.

[23] The numbers in Smith (1969) for steelhead egg takes differ in at least two instances from numbers shown in Craig (1966, 1967). The differences do not affect the description of hatchery operations, genetic consequences, or any other factors. Where differences were found, the text uses numbers from Craig (1966, 1967).

Transfer of summer steelhead adults from Oxbow trap to Rapid River (and the holding of adults at Rapid River until they were ripe) on an experimental basis was unsuccessful (IPC 1966). High prespawning mortality (33%) was reported, with the highest mortality rates occurring in fish transported in the fall (Smith 1966c).

Examination of steelhead smolts released in the first years of hatchery operations revealed that many smolts were in poor condition (Reingold 1967). Fish that were transported from Hagerman State Fish Hatchery and released in the Pahsimeroi River were thin and had eroded dorsal and ventral fins. Because of this unsuccessful transportation, Niagara Springs Hatchery was to become the most important facility for artificial propagation of HCC steelhead. By fall 1966, all steelhead rearing was transferred to Niagara Springs Hatchery (Smith 1966b).

In 1967, about 1.29 million juvenile steelhead reared at Niagara Springs were released in the Pahsimeroi River. About 558,000 left the river in spring 1967. Another complement of juveniles left the river that fall. By the end of the year, about 929,000 juveniles had left the river. The fall migrants were in very poor condition and were unlikely to survive seaward migration the following spring (Reingold 1968). In 1968, about 1.23 million hatchery steelhead—from a release of 1.48 million—left the Pahsimeroi River. Again, fall migrants were in very poor condition (Reingold 1969).

The failure of many juvenile steelhead to leave the Pahsimeroi River was obvious again in 1969. Only 600,000 juveniles emigrated—or 37% of a release of 1.645 million hatchery-produced fish. Again, fish that remained in the river all summer were in poor condition by fall (Reingold 1969).

Schneider and Schoning (1968) requested supplemental hatchery production to compensate for loss of Pine and Indian creeks. They suggested that up to 6,000 steelhead may have been produced by Pine Creek in maximum years, but they were willing to accept compensatory production equivalent to 5,000 adult steelhead.

10.4. Coho Salmon

No coho salmon are known to have used streams upstream of the HCC. However, about 200 coho returned to the HCC in fall 1965. These fish were presumed to be survivors of an experimental release of 375,000 yearling coho from the 1962 brood year. These coho were released about 3 mi downstream of the Oxbow Powerhouse by the Fish Passage Research program of the Bureau of Commercial Fisheries. The smolt-to-adult returns for these fish equaled about 0.05%. The adults arrived mostly in November and early December, when water temperatures in tributary streams were too cold to provide suitable spawning. The only area with suitable temperatures was the main Snake River. No spawning fish were found in the Oxbow area, although observations were hampered by water depth and turbidity (Smith 1965).

11. A Look Back

Development, energy for economic growth, and the issue of public vs. private power dominated the decision-making processes of the 1950s. The two decades following World War II—the last years relatively unfettered by legislation designed to protect natural, aquatic, and terrestrial communities and habitats—can perhaps now be seen as the last in the 200-year march toward "manifest destiny" in resource exploitation.

We cannot overemphasize the importance of the evolving environmental ethos in this retrospective. Nor can we ignore the relatively primitive ecological understandings that regulators and the public faced in the mid-1900s, when managers had to decide how to deal with anadromous fish in relation to hydropower dam construction. To a very considerable degree, fish biologists mostly observed, counted, and described biological phenomena. Mechanistic research had only begun, and we had limited understanding of fish genetics, behavior, and ecology.

In short, the mid-1950s were not conducive to regulators being able to ignore the societal forces that insisted on development at a rapid pace. However, we suggest that, even if agency personnel and developers had faced a more moderate pace of development, fish passage at the HCC still would have been impractical because of the scant knowledge of fish and mitigation tools available at the time.

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Appendix 1. Chronological list of pertinent fish correspondence.

August 12, 1954	Letter from IPC to the USFWS posing questions about the type of fish handling program that would be required.
January 27, 1956	Memorandum agreement between the USFWS and IPC signed and first payment made for studies.
April 11, 1956	Letter from IPC to the fishery agencies submitting preliminary drawings of the Brownlee temporary facilities for agency approval.
April 25, 1956	Letter from the USFWS to IPC indicating conditional approval of Brownlee temporary facilities.
September 24, 1956	Letter from IPC to the Department of the Interior requesting procedure for transferring article 34 funds.
October 10, 1956	Letter from the USFWS to IPC stating the concurrence of state and federal fisheries agencies to provide both upstream and downstream fish passage facilities.
November 8, 1956	Letter from the Department of the Interior to the FPC containing preliminary recommendations for the fish conservation program.
December 3, 1956	Letter from the USFS to IPC appointing Dr. Perry coordinator for fish and wildlife activities for Middle Snake.
January 16, 1957	Letter from IPC to the FPC commenting on the Department of the Interior's letter of November 8 requesting no action until studies of the Task Force are completed.
July 1, 1957	Letter from the Department of the Interior to the FPC recommending facilities to implement a fish passage program.
July 12, 1957	Letter from the USFWS to IPC indicating general agreement on the criteria for Oxbow fish facilities.
July 19, 1957	Letter from IPC to the fishery agencies submitting preliminary plans for the Brownlee barrier.
August 2, 1957	Letter from the USFWS to IPC indicating conditional approval of the Brownlee barrier.
September 5, 1957	Letter from IPC to the FPC requesting a conference to review the proposed fish conservation program.
September 9, 1957	Letter from IPC to the fishery agencies submitting plans for Wildhorse facilities.
September 12, 1957	Letter from the USFWS to IPC indicating conditional approval of the Wildhorse River trap.
September 19, 1957	Letter from IPC to the fishery agencies submitting for approval drawings of temporary facilities at Oxbow.
September 23, 1957	Letter from Tudor to Roach reporting on the condition of the floating barrier.
October 29, 1957	Letter from the USFWS to IPC indicating conditional approval of Oxbow diversion tunnel facilities.
December 3, 1957	Letter from Perry to directors of the states' fishery agencies containing the December 1 draft of the overall fish and wildlife plans for the IPC Snake River dams.
December 4, 1957	Letter from IPC to the fishery agencies submitting for approval drawings of the Oxbow spillway temporary trap.
December 9, 1957	Letter from the Department of the Interior to the FPC requesting an order to construct the Brownlee barrier.
December 10, 1957	Letter from IPC to fishery agencies transmitting general drawings for the Brownlee and Oxbow facilities.
December 13, 1957	Letter from IPC to the FPC submitting details of the facilities proposed for Brownlee and Oxbow and requesting a determination as to the feasibility of such a program.

Appendix 1. (Cont.)

December 16, 1957	Letter from the USFWS to IPC indicating conditional approval of the temporary fish facilities at the Oxbow spillway.
December 24, 1957	Letter from FPC to the Idaho and Oregon Commissions and the Secretary of the Interior requesting comments on plans submitted by IPC on December 13, 1957.
January 6, 1958	Letter from IPC to the fishery agencies submitting revised drawings for the Oxbow spillway temporary facilities.
January 10, 1958	Letter from the USFWS to IPC indicating conditional approval of the changes in the Oxbow spillway temporary facilities.
February 5, 1958	Letter from the Department of the Interior to the FPC approving general plans of facilities submitted by IPC on December 13.
February 8, 1958	Letter from IPC to the fishery agencies submitting a program to the FPC for filling Brownlee Reservoir and installing downstream facilities at Brownlee.
February 12, 1958	FPC order prescribing fish facilities.
March 20, 1958	Application from IPC to the FPC for an order to allow filling Brownlee Reservoir.
April.10, 1958	FPC order authorizing filling of the Brownlee Reservoir.
June 16, 1958	Letter from IPC to directors of the states' fisheries agencies transmitting general drawings of the Oxbow spillway permanent facilities.
August 13, 1958	Wire from IPC to the FPC requesting permission to operate the first unit at Brownlee before completion of the net barrier.
August 26, 1958	FPC order providing for operation of the first unit at Brownlee without the net barrier in position.
September 10, 1958	Wire from IPC to the FPC stating that the net barrier will be completed and in position by September 14 and requesting permission to continue operation of Brownlee Unit No. 1.
January 5, 1959	Letter from Perry to IPC approving the Oxbow spillway permanent fish facilities.
March 11, 1959	Letter from Perry to the fishery agencies submitting the final draft of the Hells Canyon fish passage proposal.
April 22, 1959	Letter from IPC to the FPC regarding facilities at Oxbow and Hells Canyon, proposing to build the Hells Canyon diversion tunnel and trap fish at that point, and requesting a conference.
May 11, 1959	Letter from state agencies to the FPC opposing proposed IPC plan for facilities at Oxbow and Hells Canyon.
May 14, 1959	Letter from Perry to IPC stating that fishery agencies oppose IPC Hells Canyon proposal.
September 4, 1959	Letter from IPC to the FPC requesting a hearing on facilities for Oxbow and Hells Canyon.
October 15, 1959	Letter from IPC to the FPC requesting a supplemental order prescribing fish facilities.
October 28, 1959	FPC order setting a hearing.
November 2, 1959	Letter from the Department of the Interior to the FPC opposing the IPC plan and recommending proceeding with the original program.
December 1, 1959	Letter from IPC to the FPC submitting revised exhibits to its application for a supplemental order prescribing fish facilities.
January 15, 1960	Letter from the Department of the Interior to the FPC setting forth the Department of the Interior's position on the fish passage program.
November 17, 1960	FPC order omitting the intermediate decision procedure and modifying the order of February 12, 1958, prescribing fish facilities.

Appendix 2. Chronological list of meetings pertaining to fish problems.

September 9, 1953	Meeting (Portland) with Oregon agencies to acquaint them with the Hells Canyon Project.
October 5, 1953	Meeting (Portland) of state and federal agencies to discuss a fishery program for the Snake River.
November 4, 1953	Meeting (Boise) with the state and federal fisheries agencies to discuss the Hells Canyon Development and the studies necessary to recommend a program for fish and wildlife.
July 23, 1954	Meeting (Seattle) with the Washington agencies to discuss a fish program for the Snake River.
August 5, 1954	Meeting (Portland) with the Oregon agencies to discuss a fish program for the Snake River.
August 6, 1954	Meeting (Portland) with the USFWS to discuss a fish program for the Snake River.
September,24, 1954	Meeting (Portland) with the state and federal fisheries agencies to develop a plan for studies of fishery problems. (A Memorandum of Understanding was developed.)
June 10, 1955	Meeting (Portland) with state and federal agencies to discuss an integrated study program with Pacific Northwest Power Company.
September 27, 1955	Meeting (Boise) with the state and federal agencies to further consider a coordinated fishery program for the Hells Canyon area.
December 13, 1955	Meeting (Boise) with the state and federal fisheries agencies to discuss a proposed study program of fish and wildlife problems in connection with the Hells Canyon Projects.
January 9, 1956	First meeting (Boise) with USFWS to discuss Brownlee temporary facilities.
January 23, 1956	Meeting (Portland) with state and federal agencies to discuss Brownlee temporary fish facilities.
January 31, 1956	Trip to Brownlee and meeting with the USFWS to discuss temporary facilities.
February 9, 1956	Meeting (Boise) with Pacific Northwest Power Company to discuss mutual fisheries problems.
February 20 & 21, 1956	Meeting (Boise) with the USFWS to discuss the Brownlee temporary facilities.
April 13, 1956	Meeting (Portland) with state and federal agencies to discuss article 34 of the license, particularly the amount of money and the procedure by which these funds were to be made available.
April 26, 1956	Meeting (Boise) with the USFWS to discuss the electric barrier.
May 19, 1956	Meeting (Pullman, WA) with state and federal agencies to review progress on the Brownlee temporary facilities and to observe the Brownlee hydraulic model tests.
July 12, 1956	Meeting (Washington, DC) with the USFWS to discuss distribution of funds under article 34.
September 14, 1956	Meeting (Pullman, WA) with state and federal agencies to view the Brownlee model.
December 29, 1956	Meeting (Boise) with the Idaho Commission to discuss the general fish problem.
January 2, 1957	Meeting (Boise) of the Administrative Committee to determine how to solve fishery problems.
January 3, 1957	Meeting (Boise) of the Technical Committee, which appointed a Task Force to work on the fishery problem.

Appendix 2. (Cont.)

January 10 & 11, 1957	Meeting (Portland) of the Task Force to study the fish passage program.
January 17 & 18, 1957	Meeting (Portland) of the Task Force to study the fish passage program.
January 24, 1957	Meeting (Portland) of the Technical Committee to discuss a program of fish handling prepared by the Task Force.
January 30 & 31, 1957	Meeting (Seattle) of the Task Force to continue the study of passage facilities.
February 6 & 7, 1957	Meeting (San Francisco) with the International Engineering Company to discuss a fish facilities design program.
February 13, 1957	Meeting (Portland) of the Task Force to continue work on passage facilities.
February 14, 1957	Meeting (Portland) of the Technical Committee to review work of the Task Force.
February 22, 1957	Meeting (Boise) of Task Force to continue work on, passage facilities.
February 28 & March 1, 1957	Meeting (San Francisco) of the Task Force to continue work on passage facilities.
March 19, 1957	Meeting (Washington, DC) with the USFWS to discuss progress of the Snake River fishery program.
March 22, 1957	Meeting (Boise) with Idaho and Oregon agencies to discuss sports fishery.
March 25, 1957	Meeting (Vancouver, BC) of the Task Force to discuss fishery problems with Canadian biologists.
March 27 & 28, 1957	Meeting (San Francisco) of the Task Force to continue work on fish passage facilities.
March 29, 1957	Meeting (Boise) of the Technical Committee to review the work of the Task Force.
April 18 & 19, 1957	Meeting (San Francisco) of the Task Force to continue work on passage facilities.
May 10, 1957	Meeting (Boise) of the Technical Committee to discuss the Brownlee floating barrier.
June 14, 1957	Meeting (Portland) of the Task Force to review the engineering of passage facilities.
August 9, 1957	Meeting (Pullman, WA) of the Technical Committee to observe Oxbow model studies and discuss fishery problems.
August 30, 1957	Meeting (Portland) of the Administrative and Technical Committees to discuss fishery problems. Fisheries Agencies requested an independent engineering review of the floating barrier.
October 10, 1957	Meeting (Portland) of the Administrative and Technical Committees to review Tudor’s report on the barrier and other problems of the fish passage program.
November 14, 1957	Meeting (Pullman, WA) of the Technical Committee to observe the Oxbow model and to discuss the overall program.
December 12, 1957	Meeting (Portland) of the Task Force to discuss the details of facilities.
January 14, 1958	Meeting (Pullman, WA) of the Technical Committee to view the Brownlee barrier model.
February 12, 1958	Meeting (Pullman, WA) of the Technical Committee to view the Brownlee barrier model.
February 19, 1958	Meeting (San Francisco) of the International Engineering Company and IPC to review designs for the Brownlee barrier.
April 1, 1958	Meeting (Portland) of state and federal agencies to outline a program for migrant passage during 1958.

Appendix 2. (Cont.)

June 2, 1958	Meeting (Portland) of the Technical Committee to review various fish problems.
September 10, 1958	Meeting (Portland) of the Technical Committee to review plans for repairing Oxbow trap.
September 18, 1958	Meeting (Washington, DC) with state and federal fisheries agencies and the FPC to discuss the Oxbow problem and the appropriation of the remaining article 34 funds.
October 2, 1958	Meeting (Brownlee) of USFWS and IPC to discuss procedures and reclosure of the Oxbow cofferdam.
December 10, 1958	Meeting (Portland) of the Task Force to discuss Oxbow Hells Canyon facilities.
January 7, 1959	Meeting (Seattle) of the Technical Committee to discuss the fish passage proposal outline for the Hells Canyon Project.
April 15, 1959	Meeting (Portland) of the Technical Committee to discuss operating problems at Oxbow and Brownlee.
May 6, 1959	Meeting (Portland) of the Administrative Committee to discuss the proposal presented in IPC letter to the FPC dated April 22.
July 9, 1959	Meeting (Portland) with the Administrative Committee to discuss Hells Canyon and the Oxbow fish passage proposals.
July 15, 1959	Meeting (Boise) of the Task Force to discuss Hells Canyon Oxbow facilities.
August 18, 1959	Meeting (Boise) of the Technical Committee to discuss downstream passage problems at Brownlee.
December 8, 1959, to January 21, 1960	Hearings (Washington, DC) on IPC's application for supplemental order prescribing facilities.
January 21, 1960	Meeting (Washington, DC) to discuss fishery problems.

Appendix 3. Chronological list of major events affecting the fish program.

June 11, 1956	Construction of the Brownlee temporary facilities began.
October 1, 1956	Construction of the Wildhorse holding pond began.
October 16, 1956	The river at Brownlee Dam was diverted and the temporary trap and barrier began operating.
October 26, 1956	The upstream section of the wooden lead-in wall at the Brownlee temporary trap collapsed.
December 7, 1956	The damaged section of the lead-in wall at the Brownlee temporary trap was replaced with a steel wall.
December 14, 1956	The Wildhorse holding pond was completed.
January 27, 1957	Ice flows dislocated electrodes at the Brownlee temporary trap.
February 25, 1957	The cofferdams at Brownlee were breached and the electronics building flooded.
April 6, 1957	The electric barrier at Brownlee was restored to operation.
May 15, 1957	Flooding required that sandbags be used at the electronics house at the Brownlee temporary trap.
May 16, 1957	The remaining part of the wooden lead-in wall at the Brownlee fish trap collapsed.
May 22, 1957	Electrodes at the Brownlee temporary trap had to be removed because of flooding.
July 2, 1957	The Brownlee temporary trap began operating again.
July 4, 1957	The river was rediverted at Brownlee.
September 19, 1957	The Brownlee fish trap stopped operating until September 23, 1957, because of pump failure.
November 22, 1957	The contract to model the Brownlee fish barrier was signed.
December 1, 1957	Work began on the Oxbow diversion tunnel facility.
December 27, 1957	The Wildhorse transfer weir was activated.
February 17, 1958	Flooding displaced electrodes at the Brownlee temporary trap.
February 19, 1958	Two upstream sections of the lead-in wall at the Brownlee temporary trap collapsed because of rock fall and flood.
March 7, 1958	Two upstream sections of the lead-in wall were replaced.
March 10, 1958	Construction of the Brownlee barrier began.
April 4, 1958	Two upstream sections of the lead-in wall at the Brownlee temporary trap collapsed and the trap pump turned off.
April. 12, 1958	The pump was restored to operation at the Brownlee temporary trap.
April 18, 1958	Metal pipe on the outside of the Brownlee temporary trap washed away and the pump turned off.
April 24, 1958	The wall of the upstream pump compartment of the Brownlee temporary trap washed away.
April 30, 1958	The pump and trap began operating again at the Brownlee temporary facilities.
May 9, 1958	The diversion tunnel bulkheads closed at Brownlee.
May 13, 1958	Water spilled over the spillway at Brownlee.
May 23, 1958	The Oxbow trap began operating.

Appendix 3. (Cont.)

June 27, 1958	The Oxbow cofferdam was closed between June 27 and 29.
July 3, 1958	The closure of the Brownlee diversion tunnel began.
July 7, 1958	Operations at the Brownlee diversion tunnel trap stopped.
August 23, 1958	Work to repair the damage to the Oxbow tunnel facility began.
August 27, 1958	Brownlee Unit No. 4 began operating.
September 3, 1958	The Oxbow cofferdam was breached and repairs were made to the tunnel outlet facility.
September 24, 1958	The temporary trap at the Oxbow cofferdam was activated.
October 3, 1958	Brownlee Unit No. 3 began operating.
October 6, 1958	Brownlee barrier floating traps began initial operation.
October 7, 1958	The Oxbow cofferdam was closed.
October 9, 1958	The trap at Oxbow diversion tunnel was reactivated.
October 10, 1958	Work started on the Oxbow spillway trap.
November 17, 1958	The first fish were trapped at the Brownlee barrier.
December 17, 1958	Brownlee Unit No. 2 began operating.
January 5, 1959	The fish trap and fish lock at Brownlee barrier sunk.
January 22, 1959	Brownlee Unit No. 1 began operating.
July 22, 1959	The Oxbow fuse plug was tested.
July 1, 1960	The Wildhorse transfer operation was terminated.
March 12, 1961	The Oxbow diversion tunnel was closed and spillway trap was activated.

Appendix 4. Annual salmon and steelhead counts at Hells Canyon Complex, from 1958 to 1974. These numbers reflect collections at the Brownlee temporary trap until July 1954, at the Oxbow temporary traps from July 1958, to August 1, 1965, and at the Hells Canyon trap thereafter. Hatchery transfers to other drainages are reflected in adult returns as follows: spring chinook beginning in 1968, steelhead beginning in 1966, fall chinook to minor degree in 1964 and 1965.

Years	Spring chinook	Steelhead + Oxbow mortalities	Fall Chinook + Oxbow mortalities
1957	Nc	3,911	15,160
1958	761	4,414 + 771	14,351 + 3,497
1959	1,250	4,557	11,825
1960	2,631	1,971	5,191
1961	2,047	1,798	6,659
1962	1,050	1,140	2,402
1963	339	806	945
1964	829	779	1,503
1965	705	4,195	1,584
1966	1,645	5,092	3,612
1967	1,177	1,593	1,249
1968	835	1,496	412
1969	940	443	48
1970	6	260	48
1971	0	696	4
1972	0	464	6
1973	1	121	2
1974	0		0

Note: Count years for steelhead in this table are shown as the year in which the fall run arrives. That is, the count for 1958 includes the fall arrivals of 1958 and the spring arrivals of 1959. In other tables specific to steelhead, the trap year refers to the year in which steelhead spawned, that is, the year of arrival of the spring portion of the summer steelhead run.

Appendix 5. Spring chinook salmon egg takes, egg and fry distribution, number of smolts released, and locations of smolt releases for hatchery operations associated with the Hells Canyon Complex (from Smith 1969).

Year	Egg take	Egg-fry distribution	Smolts released	Release location
64	887,000	Rapid River Hatchery raceways		
65	603,000	Rapid River Hatchery raceways		
66	2,297,000	Rapid River Hatchery raceways and rear pond	580,000 (1964)	Rapid River Hatchery
67	2,055,000	Rapid River Hatchery raceways and rear pond	479,000 (1965)	Rapid River Hatchery
68	6,641,000	757,000 Clearwater River hatch channel	1,400,000 (1966)	Rapid River Hatchery
		5,612,000 Rapid River Hatchery raceways and rear pond		
69	5,172,000	500,000 Clearwater River Clear Creek Hatchery	900,000 (1967)	Rapid River Hatchery
		4,500,000 Rapid River Hatchery raceways and rear pond		

Appendix 6. Steelhead egg takes, egg and fry distribution, number of smolts released, and locations of smolt releases for hatchery operations associated with the Hells Canyon Complex (from Smith 1969).

Year	Egg take	Egg-fry distribution	Smolts released	Release location
65	144,000 Oxbow Hatchery	Lemhi River channel		
	144,000	IDFG Hagerman Hatchery		
66	528,000 Oxbow Hatchery	Lemhi River channel	55,000 (1965)	Lemhi River
	2,605,000 Oxbow Hatchery	Niagara Springs Hatchery	55,000 (1965)	Pahsimeroi River
	3,003,000 Oxbow Hatchery	Grande Ronde Channel		
	1,360,000 Oxbow Hatchery	Oregon Game Comm. Hatchery		
67	3,216,000 Oxbow Hatchery	Niagara Springs Hatchery	1,645,000 (1966)	Pahsimeroi River
			750,000 (1967)	Snake River < Hells Canyon
68	2,470,000 Oxbow Hatchery	Niagara Springs Hatchery	1,664,000 (1967)	Pahsimeroi River
			350,000 (1968)	Hayden Creek Lemhi
			342,000 (1968)	Snake River < Hells Canyon
69	1,361,000 Pahsimeroi River Hatchery	Niagara Springs Hatchery	758,000 (1969)	Snake River < Hells Canyon
	1,928,000 Oxbow Hatchery	Niagara Springs Hatchery	1,600,000 (1969)	For Pahsimeroi River release in 1970

Appendix 7. Fall chinook salmon egg takes, egg and fry distribution, number of smolts released, and locations of smolt releases for hatchery operations associated with the Hells Canyon Complex (from Smith 1969).

Year	Egg take	Egg-fry distribution	Smolts released	Release location
61	1,669,000	250,000 Clearwater River		
		78,750 Eagle Hatchery		
		1,137,000 Oxbow channel		
62	2,015,000	400,000 Clearwater River		
		75,000 Eagle Hatchery		
		1,437,000 Oxbow channel	602,000 (1961)	Snake River Oxbow
63	774,000	498,000 Oxbow Hatchery raceways	1,100,000 (1962)	Snake River Oxbow
64	779,000 24,000 (Rapid River)	674,000 Oxbow Hatchery raceways	496,000 (1963)	Snake River Oxbow
65	545,000	217,000 Oxbow Hatchery raceways	650,000 (1964)	Snake River Oxbow
66	1,691,000	1,000,000 Oxbow channel	214,000 (1965)	Snake River Oxbow
		500,000 Oxbow Hatchery raceways		
67	822,000	282,000 Oxbow Hatchery raceways	1,474,000 (1966)	Snake River Oxbow
68	274,000	263,000 Oxbow Hatchery raceways	202,000 (1967)	Snake River < Hells Canyon
69			256,000 (1968)	Snake River < Hells Canyon

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