EFFECTS OF HYDROELECTRIC PROJECTS ON FISH POPULATIONS

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There are currently over 1,500 reservoirs in the United States larger than 500 surface acres. Many of the largest of these are formed by hydroelectric dams.

The majority of these reservoirs are located on watersheds that would be classified as containing mainly warmwater fishes such as bass, bluegills, crappies, shad, carp, suckers, freshwater drum, and catfish. However, several large hydroelectric dams, particularly in the Pacific Northwest, are located in drainages that contained mainly coldwater species; primarily salmonids. The impacts of hydroelectric projects on the two types of fish populations (warmwater vs. coldwater) are substantially different particularly when impacts on warmwater populations are compared with the anadromous portion of the salmonid population (Table 17-1).

The degree or amount of impact of a project on fish populations varies and is dependent mainly on size of the reservoir (retention time), the height, and turbine capacity of the dam, and whether fishways are provided for adult passage.

In general, the overall effect of hydroelectric projects that are placed on streams containing warmwater fish is to increase the total population and standing crop over that which was present in the free flowing stream, but species composition and abundance is usually changed. An example of these effects is shown by examination of pre- and post-impoundment catch rates (Table 17-2) and species changes that occurred at the Rough River, Kentucky Project (Turner 1971). Catch per unit of effort increased as well as number of fish caught per surface acre, but species composition changed from the dominant game species (rock bass, spotted bass, and small mouth bass) to crappies, sunfish, and bluegill. Studies of fish populations in several reservoirs containing warmwater fish have shown that the most important factor controlling production of warmwater fishes (particularly bass) in reservoirs is water level fluctuation (Jenkins 1975). Production can be substantially enhanced if reservoir level can be optimized during the spawning period of the game fishes.

The best example of the effect of hydroelectric dams on a coldwater fishery is the Columbia River. Figure 17-1 shows the dams currently in operation on the Columbia River. These dams have caused a major reduction in the production of salmon and steelhead particularly among the upriver stocks (Raymond 1979). For example, chinook salmon runs destined for the Snake River (a tributary of the Columbia River) declined from average runs of 120,000 to 50,000 in 1974 (Ebel 1978).

Research done by the National Marine Fisheries Service (Raymond 1979) has shown that the main cause of this reduction has been the loss of juveniles during their seaward migration (Figure 17-2a and 17-2b). This research has also

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TABLE 17-1—General Effects of Hydroelectric Dams on Cold and Warmwatei Fish Populations

COLDWATER FISH (Mainly Salmonids)	WARMWATER FISH (Centrarchids, Cyprinoids, Cluepeids)
1. Decreased survival of juveniles	1. Change in species composition
2. Decreased survival of adults	2. Increased survival of both adults and juveniles (some species)
3. Decreased reproduction	3. Decreased survival of both adults and juveniles (some species)
4. Changes in species composition	4. Decreased reproduction of some species; increased reproduction of others
5. Increased incidence of disease	
6. Overall decrease in salmonid populations	5. Overall increase in mixed warmwater fish population

TABLE 17-2.—Pre and Post Impoundment Catch Rate (Creeled Fish) Rough River, Kentucky (from Turner 1971)

	Pre Impoundment	Post Impoundment
C/PUE[1]	0.53	1.06 – 0.81 5th year
No. of fish per surface acre	12.00	50.00

CHANGES IN SPECIES COMPOSITION

	Pre Impoundment	Post Impoundme
Large mouth bass	Common	Common
Spotted bass	Common	Common
Small mouth bass	Common	Absent
Rock bass	Abundant	Absent
Crappie	Few	Abundant
Sun fish	"	"
Bluegill	"	"
Channel cat	Abundant	Abundant
Bullheads	Rare	"
Redhorse sucker	Abundant	Few
Spotted sucker	"	"

[1] Catch per man hour of fishing.

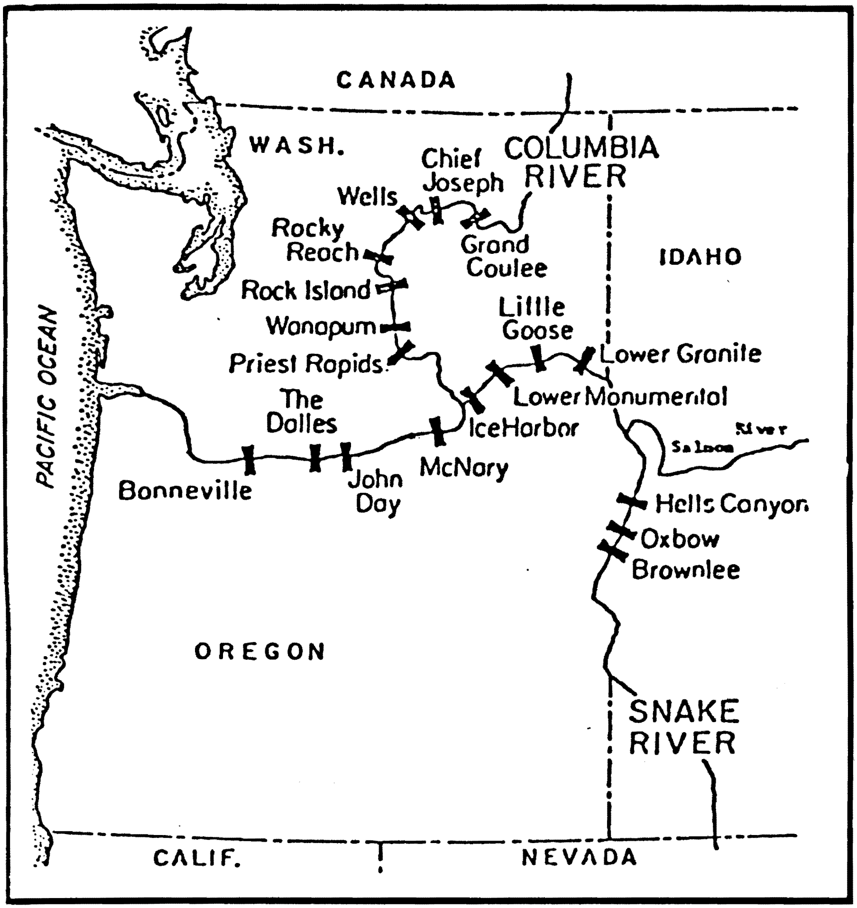
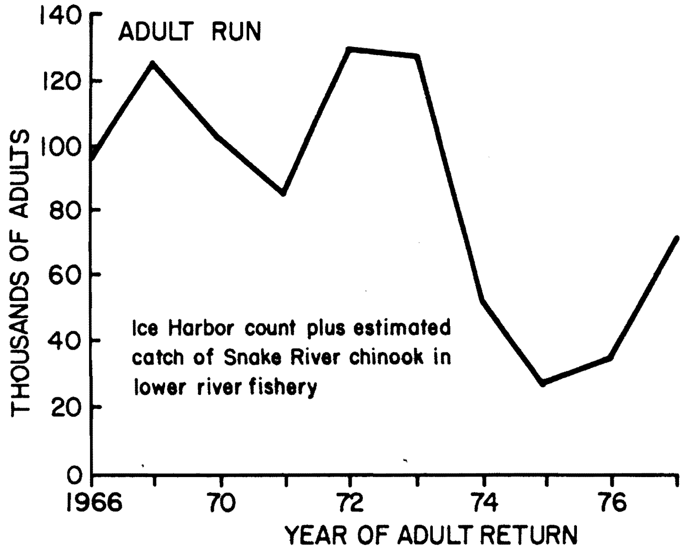


FIGURE 17-1—Main Stem Dams in the Columbia River Basin

CHINOOK SALMON



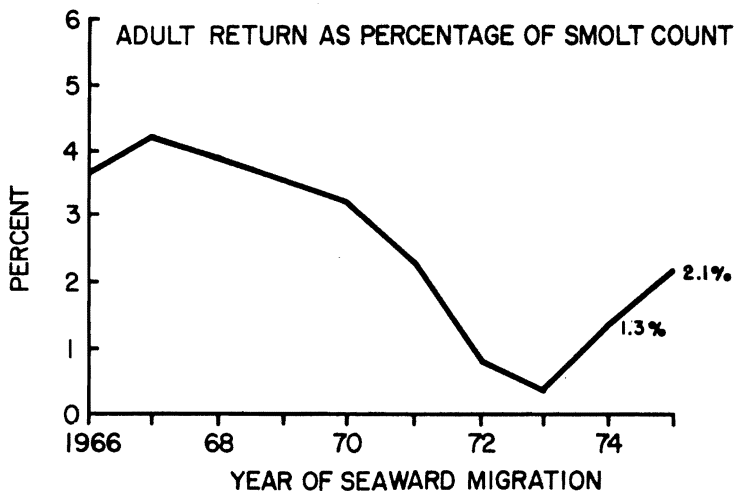
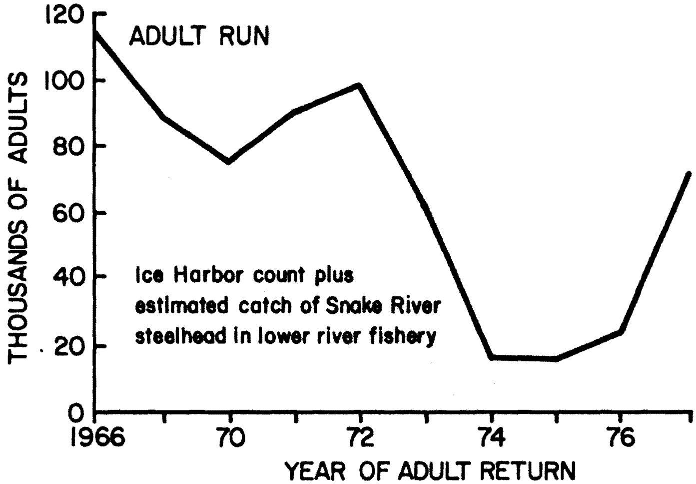


FIGURE 17-2a—Trends in Abundance of Adult Chinook Salmon and Steelhead Trout to the Snake River Expressed in Terms of Year of Adult Return and Percent Return in Relation to Year of Smolt Seaward Migration Continued

STEELHEAD TROUT



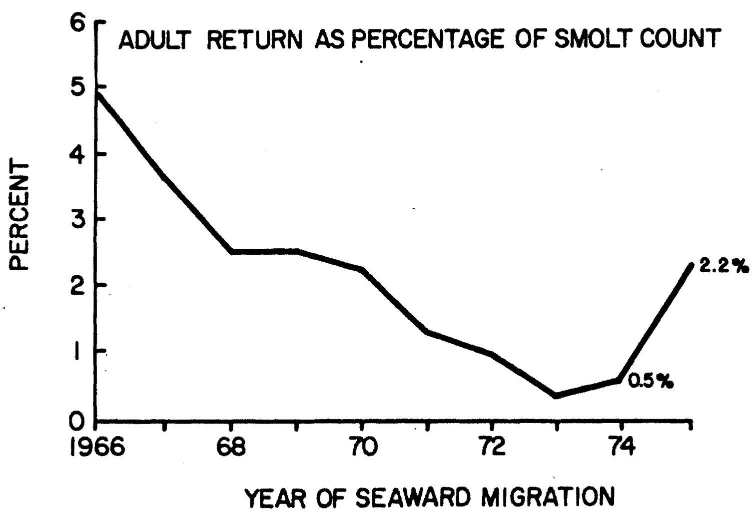


FIGURE 17-2b—Trends in Abundance of Adult Chinook Salmon and Steelhead Trout to the Snake River Expressed in Terms of Year of Adult Return and Percent Return in Relation to Year of Smolt Seaward Migration

shown that the main factors causing the losses are: (1) mortality of juveniles passing through turbines; (2) delay in migration; (3) increased predation; (4) gas bubble disease caused by supersaturation of atmospheric gas; and (5) loss of spawning habitat (Raymond 1979, Chaney and Perry 1976, Ebel and Raymond 1976). Solutions: Recent cooperative effort by NMFS, Corps of Engineers, and several state agencies has been centered on research designed to find methods of reducing the effect of these factors.

This research has resulted in:

(1) Development of diversion screens and bypass systems to divert salmon from turbine intakes.

(2) Development of collection and transportation systems.

(3) Manipulation of turbine and spillway operations for optimizing passage.

(4) Development of spillway deflectors to reduce gas supersaturation.

The diversion screens are capable of diverting 70-80% of all migrants entering the turbine intake and at this time are considered sufficiently perfected for operational use.

The transportation research (Ebel 1973 *et al.* and Ebel 1980) has also shown that both juvenile salmon and steelhead can be transported from collector dams to locations downstream without significant loss of homing ability in returning adults and that survival can be increased from 10 to 1,500% depending on river conditions.

Use of scanning sonar at dams has also been shown to be an excellent method of monitoring movement and abundance of juvenile migrants. It was discovered in 1977 that by sequentially shutting down turbines and subsequently opening the spillway at John Day Dam, concentrations of juvenile fish could be passed in a 2-hour period.

Spillway deflectors are now installed on the most critical of the dams producing dangerous levels of supersaturation of atmospheric gas, and at this time the problem of supersaturation and gas bubble disease is considered to be solved.

Loss of spawning habitat and subsequent loss of reproduction has been partially replaced by mitigation hatcheries.

As a result of the above research, fishery people in the Northwest believe that runs in the upper Columbia River can be restored to their former level by implementing the above solutions as long as critical spawning areas still available are maintained and adequate instream flows are maintained to transport the fish through the rivers and reservoirs. However, it should be pointed out that the dams where these measures appear to be effective are lowhead dams (100 ft or less) and adult passage (fishways) are provided. There are several highhead dams around the country where these measures probably would not be effective because the reservoirs formed by these highhead dams are usually very large, and insufficient currents are present to move migrating juvenile through the reservoir. In addition, most high dams constructed in the U.S. do not have fishways. Anadromous fish populations formerly abundant above many of these are now completely absent, and resident salmonid populations have been substituted by making annual hatchery plants or the fishery has completely changed from coldwater to warmwater species or mixed cold and warmwater species.

In summary, the research data available indicate that hydroelectric projects generally result in increased production of warmwater fishes, particularly if water levels are controlled during critical spawning periods, but changes in species combinations do occur. Coldwater fish populations generally decline, particularly if the species are mainly anadromous, but solutions to the problems causing the decline are available for lowhead dams like those constructed in the Columbia River. Coldwater fisheries in reservoirs formed by highhead dams can be continued by periodically stocking from hatcheries if limnological conditions are favorable, but the anadromous portion of the fishery is generally lost upstream from the dam.

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