HABITAT APPENDIX TO THE
FISHERY MANAGEMENT PLAN FOR
COMMERCIAL AND RECREATIONAL SALMON
FISHERIES OFF THE COASTS OF WASHINGTON,
OREGON, AND CALIFORNIA COMMENCING IN 1978

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INTRODUCTION

Pacific salmon habitat spans ocean, estuarine, and freshwater environments. Each habitat can be critical at different stages of the salmon life cycle, and each poses unique challenges to salmon survival. Although physiologically equipped to withstand changes in their environment consistent with their migration from freshwater to seawater and back again, within any of these zones salmon have exacting environmental requirements and limited tolerance for change.

The ocean environment provides salmon with a fairly stable habitat for feeding, growth, maturation, and migration. It is typified by physical and chemical equilibrium and an abundant food supply. Occasional disruptions occur in the ocean, however, such as El Nino events, which are large-scale shifts in water temperature that can severely affect fishery resources through disruption of the food chain and displacement of food organisms.

By contrast, estuaries, where salmon feed and acclimate to shifts in salinity, are sites of complex and changeable water quality and quantity. Estuaries can also trap and accumulate contaminants from point and nonpoint source discharges, potentially posing a threat to salmon or the organisms upon which salmon rely for food.

The freshwater environment of Pacific salmon, where their life cycle begins and ends, is characterized by cool, swift-running streams typical of the areas from central California north through Oregon, Washington, and Idaho. Salmonid reproduction and survival in freshwater is dependent upon barrier-free streams, good water quality, abundant spawning gravel, resting pools and cover, sufficient food supply, and adequate and stable stream flow.

The availability and quality of salmon habitat are key determinants of the health and abundance of salmon populations. The destruction and degradation of significant areas of estuarine and freshwater habitat, along with overfishing of stocks, have been responsible over time for drastically reducing salmon populations. Maintaining current production, much less rebuilding salmon populations, requires integrated management decisions, policies, and programs that reflect the fundamental relationship between habitat and harvest.

LIFE HISTORY

The salmon life cycle begins with the deposition and fertilization of eggs in nests (redds) dug in the streambed by spawning adults. The eggs incubate in the gravel before hatching. After hatching, the alevins remain in the gravel, nourished by the egg yolk sac, for several weeks before emerging as swimming, feeding fry. Depending on the species and the location of the natal stream, the fry either migrate directly to sea, or rear one to two years in freshwater before migrating downstream as smolts. In the ocean, salmon may migrate thousands of miles before returning to their natal stream to spawn one to five years later.

Juvenile salmon feed on aquatic and terrestrial insects, annelid worms, crustaceans, and mollusks. Once in the ocean, young salmon feed on zooplankton, but after developing strong jaws and teeth, salmon feed voraciously on marine species such as crustaceans, herring, pilchards, and anchovies.

Salmon are food for a variety of predators in the freshwater and ocean. While in freshwater, fry are fed upon by larger fish, birds, and reptiles. Saltwater predators include larger fish and various marine mammals.

Descriptions of the Pacific salmon species that occur within the management area of the Council are provided below (Beauchamp et al., 1983; Bell, 1973; Clemens and Wilby, 1949; Fry, 1979; Netboy, 1974 and 1980; Scott and Crossman, 1973). Table 1 summarizes the biological data for Pacific salmon on the west coast of North America.

Chinook Salmon

Chinook salmon occur from central California through northwestern Alaska mainly in larger rivers. Different stocks spawn at different times of the year, from summer through fall, and into the winter. Chinook have been known to migrate up to 1,200 miles inland to reach their spawning grounds. Young chinook remain in freshwater for up to two years before beginning their seaward migration; generally, outmigration occurs earlier in the southern portion of chinook range, with freshwater residence times longer in the northern portion. Chinook usually reach maturity between their third and fifth year. At maturity, they usually weigh between 10 and 50 pounds, with an average weight of about 18 pounds, and are approximately 2 to 3 feet long, although chinook are known to occur in excess of 100 pounds and over four feet in length. Chinook can be highly migratory during the oceanic phase of their life cycle. Food of chinook in saltwater consists chiefly of herring and sand lance and smaller quantities of other small fishes, crustaceans, and squid.

Coho Salmon

Coho salmon are common throughout the waters of northern California to northwestern Alaska. Spawning normally occurs at three years, from November through February, in smaller streams and tributaries of large streams. Two-year (jacks) or four-year or older coho may also spawn. Coho fry migrate to the sea after approximately one year of rearing in fresh water. At maturity, coho usually weigh around 10 pounds, but can occur up to 30 pounds and 3 feet long. Coho feed largely on herring, pilchards, sand lance, small fishes, squid, and assorted crustaceans.

Pink Salmon

Pink salmon are common from Puget Sound northward with small runs occurring incidentally south of Puget Sound. Pinks reach maturity at age two with no overlap in generations and occur almost exclusively in odd-numbered years south of the Fraser River. As spawning approaches, male pinks develop a pronounced hump on their back and a hooked snout. Pinks spawn from June to September in small streams, in tributaries as well as larger rivers, and in the intertidal gravels near freshwater discharges. Upon emergence, the young do not remain in streams but will linger in estuaries before proceeding to sea. The smallest of the Pacific salmon species, pinks grow to an average of three to five pounds in weight and less than two feet in length. Pink salmon feed almost exclusively on small crustaceans.

TABLE 1: BIOLOGICAL DATA FOR PACIFIC SALMON IN THE WESTERN UNITED STATES

	CHINOOK	*COHO*	*PINK*	*CHUM*	*SOCKEYE*
Length of stay in freshwater after emergence	days to 2 yrs	1–2 yrs	few days	few days	days to 3 yrs
Length of stay in ocean	1–5 yrs	0.5–1.5 yrs	1.3 yrs	0.5–4 yrs	0.5–4 yrs
Average age at maturity	3–5 yrs	2–3 yrs	2 yrs	2–5 yrs	3–4 yrs
Average length at maturity	33–36"	18–26"	17–19"	25"	24–28"
Average weight at maturity	17–20 lbs	7–12 lbs	3–5 lbs	10–15 lbs	5–8 lbs
Principal spawning months	Aug–Oct	Sept–Dec	July–Sept	Sept–Nov	July–Sept
Average fecundity (# of eggs)	5000	3500	2000	3000	4000

Chum Salmon

The range of chum salmon is from northern California to northwestern Alaska, but they occur in abundance north of the Puget Sound. They usually spawn in the lower reaches of rivers, often just upstream from brackish water or tide flats during late summer and fall. However, in the Yukon River, chum migrate hundreds of miles upriver. Chum fry proceed to saltwater soon after emerging from the gravel with an extended rearing period in estuarine and nearshore waters. Chum reach maturity in their second to fifth year, reaching average weights of 10 to 15 pounds and average lengths of 2 feet. Plankton and small crustaceans constitute the bulk of the chum diet.

Sockeye Salmon

The range of sockeye salmon extends from the Columbia River to Bristol Bay, Alaska. Sockeye spawn mainly in streams associated with lakes or on lake shoals. Upon hatching, fry move directly into the lake where they rear for usually one year, but up to three before migrating to the ocean. Sockeye usually reach maturity at three or four years, although some stocks have a significant five year old component. Sockeye generally range between five and eight pounds and two feet in length. In the ocean, sockeye feed mainly on crustaceans (mostly euphausiids), while in freshwater they feed primarily on other plankton. Some sockeye, called kokanees, spend their entire life cycle in lakes, returning to the natal stream to spawn. Kokanee rarely exceed 20 inches or three pounds.

HABITAT REQUIREMENTS

Ecosystems include all of the biological and nonbiological components of the environment and their highly complex interactions. Changes in the physical and chemical components of habitat can fundamentally alter the biological components, as clearly seen in salmon habitat and salmon populations.

Key physical factors in salmon streams are migration routes; streamflow; temperature; riparian vegetation; stable, appropriately sized spawning gravel; cover availability; sediments; and water depth and velocity. Key chemical factors in streams include dissolved oxygen, phosphate, and nitrate concentrations. Some of these factors are closely interrelated. An alteration in one parameter can affect the others and ultimately salmon abundance and productivity.

Migration Routes

The successful passage of adult salmon to upstream spawning areas depends on a barrier-free migration route. Waterfalls, debris jams, dams, diversions, culverts, excessive water velocities, and reduced flows can impede or prevent salmon movement in streams.

Migration barriers can frequently be modified to allow salmon passage. Dams have been equipped with fish ladders, lifts, or bypass systems. Falls have been altered or fish ladders have been installed to allow salmon access to previously inaccessible areas, increasing available spawning and rearing habitat. Debris jams can be removed; however, since instream debris is important as cover for salmon, such jams should be carefully evaluated and removed only if they constitute a barrier.

Streamflow

Streamflow affects the availability of riparian and instream cover, dissolved oxygen, temperature, pool areas for rearing of juveniles and resting adult migrants, channel morphology, and sediment transport (Chevalier et al., 1984). The effects of streamflow fluctuation depend on its duration and timing. Low flow during spawning season can inhibit reproduction by crowding the fish or by forcing them into areas less suitable for spawning. Low flow in the summer results in increased water temperatures, and in the winter can result in the freezing of interstitial water. In both instances, direct mortality to eggs and juvenile salmon can occur. High streamflow increases water velocity, scouring the substrate and washing away eggs, fry, and gravel suitable for incubation and cover. When high water recedes, adults and fry can be stranded and die as a result of high temperature, freezing, desiccation, or oxygen depletion.

Temperature

Stream temperature is a key determinant in the suitability of habitat for salmonid production. It is influenced by a combination of factors, including riparian shading, altitude, and climate. Since it is common for salmonid streamflows to emanate from a storage reservoir, dam design also can significantly affect stream temperatures, depending on whether multilevel outlets are included.

The salmonid life cycle is dependent on temperature to stimulate physiological changes required for survival. For example, eggs mature at various rates depending upon temperature of incubation with hatching timed to coincide with the availability of food organisms. Higher temperatures can increase the rate of egg development but decrease food production, resulting in an inadequate food source for the fry and starvation after emergence (Chevalier et al., 1984). High temperatures can be acutely lethal to eggs, fry, and adults. Table 2 shows normal spawning and incubation temperature ranges for Pacific salmon.

Adverse water temperatures induce direct mortality; can inhibit plankton growth; influence dissolved oxygen levels and nutrient concentrations; and affect the growth, condition, and behavior of fish. Prolonged temperature alteration can change the species composition of a stream and foster the growth of predatory fish and undesirable microorganisms, including pathogens. For example, the myxobacteria _Columnaris_ becomes a serious pathogen when water temperature rises above 18°C and may cause heavy mortality (Macy, 1954). Similarly, when outbreaks of bacterial kidney disease occur in waters with elevated temperatures, high mortality occurs (Earp et al., 1953). Increased temperature may lower the resistance of salmon to disease, and in addition may intensify the toxicity of pollutants (Sylvester, 1971).

In general, tolerance to temperature fluctuation is greater in adults than in eggs and young. Spring chinook and coho probably suffer least under conditions of prolonged exposure to increased temperature, whereas pink and chum are the most sensitive (Brett, et al., 1958).

TABLE 2: RECOMMENDED TEMPERATURE RANGES FOR SPAWNING AND INCUBATION OF SALMON

(From Reiser & Bjornn, 1979, as adapted from Bell, 1973)

SPECIES	SPAWNING TEMPERATURE (degrees Fahrenheit)	INCUBATION TEMPERATURE (degrees Fahrenheit)
Fall Chinook	42 – 57	41 – 58
Spring Chinook	42 – 57	41 – 58
Summer Chinook	42 – 57	41 – 58
Coho	40 – 49	40 – 56
Pink	45 – 55	40 – 56
Chum	45 – 55	40 – 56
Sockeye	51 – 54	40 – 56

Riparian Vegetation and Instream Cover

Riparian vegetation stabilizes stream banks and helps regulate stream temperature by providing shade. It serves the important function of filtering nutrients from run-off, preventing overenrichment of the stream, while also providing a source of organic matter and insects. Studies have shown that plant materials are important sources of food for juvenile salmonids and aquatic invertebrates (Sekulich and Bjornn, 1977). Riparian vegetation can also serve as a barrier to the transport of large debris into streams from steep-sloped areas. Debris can form jams, creating barriers to fish migration. Overhanging riparian vegetation, as well as undercut banks and submerged vegetation, provides hiding and resting cover for fish in streams.

Substrate

The porous gravel substrate of salmon streams is crucial to salmon reproduction. Eggs incubate in the gravel, where alevins remain after hatching until their yolk sac is absorbed. When alevins emerge as swimming fry, the gravel substrate interstices provide protective cover from predators.

Circulation of interstitial water carries dissolved oxygen to and metabolic wastes away from incubating eggs. Reduced velocity of circulating interstitial water can result in reduced size at hatching (Silver et al., 1963) or death of eggs or alevins in extreme cases. Large percentages of very fine materials in the gravel is the usual cause of poor interstitial water flow.

Dissolved Oxygen

Salmon require high levels of dissolved oxygen for their physiological processes. Oxygen concentrations in salmon streams are generally near saturation, unless affected by logging, instream construction, or waste discharge. Low levels of dissolved oxygen can block migration, impair motility, reduce growth, or cause the death of salmon. Oxygen levels of at least 80 percent saturation are desirable for spawning salmon with temporary levels no lower than 5.0 mg/l (Reiser and Bjornn, 1979). These levels should also be suitable for migrating fish.

Laboratory research indicates a relationship between dissolved oxygen, water velocity, and the size of fry at hatching. At higher oxygen concentrations and velocities, emergent fry are larger (Silver et al., 1963). Other research has concluded that while low oxygen concentrations early in the incubation period can increase biological defects and delay hatching, low oxygen concentrations in the later stages can stimulate premature hatching (Alderdice et al., 1958). In either instance, low oxygen concentrations result in fry that are smaller and weaker than those incubated under conditions of higher oxygen concentrations (Silver et al., 1963; Shumway et al., 1964). These smaller and weaker fry almost certainly suffer higher mortality than normal fish.

Inorganic Nutrients

Although dissolved oxygen is a critical factor determining the community found in a habitat, phosphates and nitrates are also important (Chevalier et al., 1984). Increased phosphate and nitrate concentrations can increase primary production (plant growth), which increases the biochemical oxygen demand of a stream (through decay of organic matter), decreasing levels of dissolved oxygen, and eventually leading to eutrophication. This process is frequently observed in sluggish bodies of warm water, or in waters receiving high levels of phosphorus and/or nitrogen-containing wastes.

Sediments

Sediments that remain in the water column contribute to the turbidity of a stream. Increased turbidity can reduce light penetration and productivity of a stream and abrade salmon gill surfaces, disrupting respiration. In general, prolonged exposure to turbidities of 200 to 300 ppm and greater is lethal (Gibbons and Salo, 1973). Shorter exposures to turbidities of 90 ppm and greater may also reduce survival when accompanied by other stresses (Gibbons and Salo, 1973). Turbidity in excess of 4,000 ppm will cause salmon to cease movement (Reiser and Bjornn, 1979). Studies indicate that high turbidity may induce a thermal barrier to migration as well, since turbid water absorbs more heat (radiation) than clear water (Reiser and Bjornn, 1979). There is some evidence that smolts exposed to high levels of suspended sediment in freshwater are less capable of surviving the osmoregulatory changes that occur when they migrate to sea (Ross 1982).

Sediments that settle out of the water column (bedload sediments) cause comparatively more damage to salmon than suspended sediments. Bedload sediments fill gravel interstices, decreasing oxygen exchange in interstitial waters. The result is reduced oxygen available to incubating eggs which can be smothered. Bedload sediments can prevent fry from emerging and can increase the instability of the substrate, reducing invertebrate diversity and abundance, thereby reducing food available to fry, if they are able to emerge. Or, silt can harden as it becomes packed into gravel interstices, making spawning difficult or impossible.

Research indicates that the lethal effects of sediment are greatest during the developmental stages of salmon, since once hatching and emergence occur, the physical environment becomes secondary in importance to the availability of food (Gibbons and Salo, 1973). It has also been suggested that the indirect effects of increased sedimentation cause more damage to fish populations than direct lethal effects. Eggs, alevins, and salmonid food organisms may be more vulnerable to lethal effects of sedimentation at much lower levels than adult fish (Cordone and Kelley, 1961).

SIGNIFICANT ADVERSE HABITAT ALTERATION

Habitat loss and alteration have reduced and continue to threaten salmon populations in California, Oregon, Washington, and Idaho. Major losses of salmonid habitat have occurred as a result of the effects of resource development and urbanization. The NPPC estimates that such activities in the Columbia River Basin, for example, have reduced naturally spawning salmon runs from historical averages of between 9 and 15 million fish, to the current average run size (natural spawners and hatchery fish) of 2.5 million fish. This constitutes a production loss of between 75 and 85 percent, most of which has been attributed to hydropower development (NPPC, 1986b).

Natural events can also adversely affect habitat and salmon populations. The impact of these relatively rare occurrences is certainly less significant than habitat damage inflicted by human activities. However, in light of the declines in stocks and the fragility of certain runs, a natural event can act in synergy with other forms of habitat alteration and have a more serious impact on the resource than would have otherwise occurred.

Habitat alteration can impose significant socio-economic impacts to the salmon industry and local businesses. Habitat loss or destruction results in reduced salmon populations which lowers the income of fishermen, processors, and others directly related to the fishery. Likewise, local retail, wholesale, housing, or other service businesses are indirectly affected via loss of income due to reduction of general purchases. Because of the mixed-stock nature of the ocean fishery, reduced abundance of one critical salmon stock due to habitat degradation can cause a multiplicative reduction in ocean harvest. This occurs because the maximum harvest rate in the ocean is based on assuring an adequate escapement of the weakest critical stock. All other stocks are harvested at a lesser rate than that required to meet their ocean escapements. Thus there is a direct loss of harvest of the stock suffering habitat degradation, plus the loss of harvest of many fish of other stocks as well. Income generated by the salmon fisheries of California, Oregon, and Washington are summarized in Table 3.

The following sections discuss the major sources of habitat alteration which potentially threaten salmon populations and associated fisheries and related industries of the west coast of the continental United States.

Dams and Impoundments

Dams usually have detrimental effects on salmon and their habitat. The transformation of a river from its natural free-flowing state to an impoundment fundamentally alters that environment, and, as mentioned, major declines of salmon runs in affected river basins have resulted.

Dams are a significant barrier to migration and have probably caused the greatest loss of salmon habitat. The construction of dams without fish passage facilities has blocked salmon from thousands of miles of mainstem and tributary stream spawning grounds in the Columbia River Basin, Sacramento-San Joaquin system, and other streams throughout the western United States. For example, over 3,000 miles of the Columbia-Snake system are no longer accessible to salmon, a decrease of approximately 50 percent. Estimates place remaining spawning grounds in the Sacramento-San Joaquin system at 900 miles of the original 6,000 miles of available spawning habitat (Council, 1979).

Dependence upon technology to provide passage around dams has not always been successful. Where upstream fish passage facilities have been provided migration delays and increased mortality of adults persist. Fishway design and flow are very important to attract and guide adult salmon into passage facilities. Poorly designed fishways can inhibit movement of adults upstream, causing migration delays, increased prespawning mortality, and reduced

TABLE 3: LOCAL PERSONAL INCOME GENERATED BY SALMON OCEAN TROLL AND RECREATIONAL FISHERIES IN CALIFORNIA, OREGON, AND WASHINGTON (1976–85 AVERAGES)

	OCEAN TROLL	RECREATIONAL
CALIFORNIA	$41,410,890	$ 9,567,204
OREGON	$16,321,039	$13,103,737
WASHINGTON	$17,836,115	$17,117,159
TOTAL	$75,568,044	$39,788,100

reproductive success of the fish that eventually reach their spawning grounds (Bureau of Reclamation, 1985; Hallock et al., 1982). Sacramento River winter run chinook adults delayed during their migration by Red Bluff Diversion Dam try to spawn below the dam where water temperatures are usually too high for successful reproduction.

Dams also present an obstacle to downstream passage of juveniles. Changes in current patterns and reduced water velocities in impoundments result in substantial delays in the downstream migration of juveniles. Some of these salmon lose the urge to migrate as a result of prolonged delay. Mortality can be high when juveniles move from the upstream impoundment through the turbine intake at high velocity and are expelled at the base of the dam. Impact with turbine blades, rough surfaces, or solid objects can cause death or injury. Changes in pressure within turbines or over spillways result in hemorrhage; missing, ruptured, or bulging eyes; scale loss; or mutilation of body parts. Juveniles, frequently stunned and disoriented as they are expelled at the base of the dam, are particularly vulnerable to predation.

Losses of juvenile fish due to passage mortalities are estimated at 11 to 15 percent per dam for those passing through turbines, compared to one to two percent or more for those going over spillways or through bypasses. This mortality is cumulative along the course of a river on which a number of dams are built. On the Columbia River, where some stocks have as many as eight or nine dams to pass, cumulative juvenile passage mortality can routinely exceed 75 percent. In low flow years, this loss can approach 100 percent; for example, in 1977, loss of chinook salmon between Lower Granite and The Dalles dams was estimated at 98 percent (Sims and Ossiander, 1981).

Dams can also cause water to become supersaturated with atmospheric gases when air trapped by large volumes of spilling water is forced into solution under hydrostatic pressure. Dissolved gas supersaturation can lead to a condition lethal in fish. This condition, gas bubble disease, occurs when high levels of dissolved gases from surrounding supersaturated water are taken up in the bloodstream of fish and then in body tissues, causing embolism and frequently death. Mortalities from gas bubble disease increase in years of high flow and high spill (NPPC, 1976). The severity and outcome of gas bubble disease depends on the level of dissolved gas supersaturation; duration of exposure to supersaturated water; water temperature (warmer water can hold less gas, and can therefore become supersaturated at lower pressures); health and condition of the fish; and swimming depth of fish (Ebel and Raymond, 1976).

Dams can also cause temperature alterations in streams with potentially significant effects on salmon populations. For example, California's Trinity Dam releases water too cold for the hatchery at its base, while Shasta Dam sometimes releases water too warm to sustain natural production.

Other alterations in the stream environment caused by dams and impoundments include siltation in the reservoir above the dam and scouring of substrate below the dam from the force of spilled water, blockage of gravel recruitment, inundation of spawning grounds, and narrowing of the genetic base of a salmon stock as upstream fish populations decline. Reduced flow can dewater redds and strand juveniles. The reservoir environment can be favorable to increased populations of salmon predators. Streambanks fortified by riprap for flood protection reduce available rearing habitat for juveniles, as they prefer non-riprapped areas (Schaffter et al., 1983; Michny and Hampton, 1984) and create plentiful hiding places from which predators can prey upon passing juvenile salmon. Riprap or other streambank stabilization devices can also reduce or eliminate recruitment of crucial spawning gravel by eliminating lateral erosion (as has occurred in the Sacramento River). Diversion and exportation of 90 percent of the water available at Trinity Dam has resulted in sedimentation, riparian encroachment, abrading of the channel, and loss of most of the salmon production potential of the Trinity River.

Agricultural Practices

The use of irrigation in agriculture has grown rapidly in the Pacific Northwest and in California's Central Valley. The current rate of growth in irrigated lands has been estimated at 53,000 acres per year (Dillard, 1985).

The impacts of irrigation withdrawals are varied. Irrigation dams can block or delay salmon migrations. Withdrawal of water results in water level fluctuations and flow alterations which can dewater eggs, strand fry, trap alevins, increase stream temperature, and delay migrations, all resulting in significant mortalities. Low flows can concentrate fish, rendering juveniles more vulnerable to predation (Stober et al., 1979).

Irrigation return flow also often degrades water quality in salmon streams by elevating temperature, increasing sediment loads and levels of phosphates, nitrates, selenium and other metals, and may contain chemical pesticide and fertilizer residues (see discussion on forest chemicals) and harmful parasites and bacteria (NPPC, 1986a). These changes in water quality can cause ecosystem alterations which affect spawning, survival, food supply, and the health of salmon (Stober et al., 1979; NPPC, 1986a).

Major losses of salmon can occur in irrigated fields by their entry into unscreened or inadequately screened irrigation systems. The screening of irrigation systems was slow to develop; few diversions in the State of Washington were screened before the 1930s and some major Oregon and Idaho intakes were unscreened until the 1960s to 1970s (Delarm and Wold, 1985; Easterbrook, 1985). Salmon mortalities continue in these states due to remaining unscreened and poorly-designed fish screens.

On California's Sacramento River, there are about 140 metered diversions and an unknown number of riparian water rights holders, which collectively divert over three million acre feet. Only the three largest diversions (responsible for about one-half of the total water diverted) are equipped with some sort of fish screen. Two of these have major problems. Under existing California law, the CDFG is responsible for providing screens on existing diversions less than 250 cfs. Without concomitant funding, it has been difficult to meet this responsibility (Central Valley Task Force, 1986).

Other effects of agriculture are those associated with channelization of streams and removal of stream corridor vegetation. Impacts include erosion, sedimentation, chemical contamination from herbicide and pesticide use, and loss of riparian vegetation that stabilizes banks, filters nutrients, and supplies organic matter and nutrients to the stream (see Section III discussion of riparian vegetation and instream cover).

Grazing of livestock also results in the degradation of aquatic habitat. As soil is compacted and vegetation eradicated by grazing herds, the ability of the soil to absorb water decreases, and surface run-off increases, smothering salmon spawning grounds and rearing habitats, and lowering stream productivity (Platts, 1981).

Forest Practices

There are a number of forest practice activities that can impact salmon habitat; including road construction and maintenance, use of forest chemicals, and logging itself. These activities increase bedload and suspended sediments, alter streamflow, introduce debris, create migration barriers, increase streambank erosion, cause soil avalanches, alter temperature regimes, and have toxic effects on biota. Figure 1 illustrates the relationship of forest harvesting to changes in fishery habitat and resources.

Forest roads can destabilize slopes and increase erosion and sedimentation. In fact, forest roads have been described as the major source of erosion caused by human activities (Gibbons and Salo, 1973). This erosion occurs in two forms, as mass soil movement (i.e., avalanche) and surface erosion (Yee and Roelofs, 1980). These types of erosion can introduce large amounts of debris and sediment into adjacent streams, up to years following initial construction, and are most severe where poor construction practices are followed, inadequate attention is paid to drainage, and construction continues in inclement weather. In California's Trinity River Basin, as well as in the region of the Idaho Batholith, forest roads have acted in conjunction with natural formations of highly decomposed granite to create devastating loads of granitic sand which have smothered spawning gravels.

Culverts are often installed during road construction as an economical alternative to bridges, although bridges are preferable in salmon streams because they are generally less disruptive to the stream environment. Culverts are a serious threat to salmon unless specifically designed, installed, and maintained to accommodate fish passage.

Culverts can create a barrier to salmon migration if:

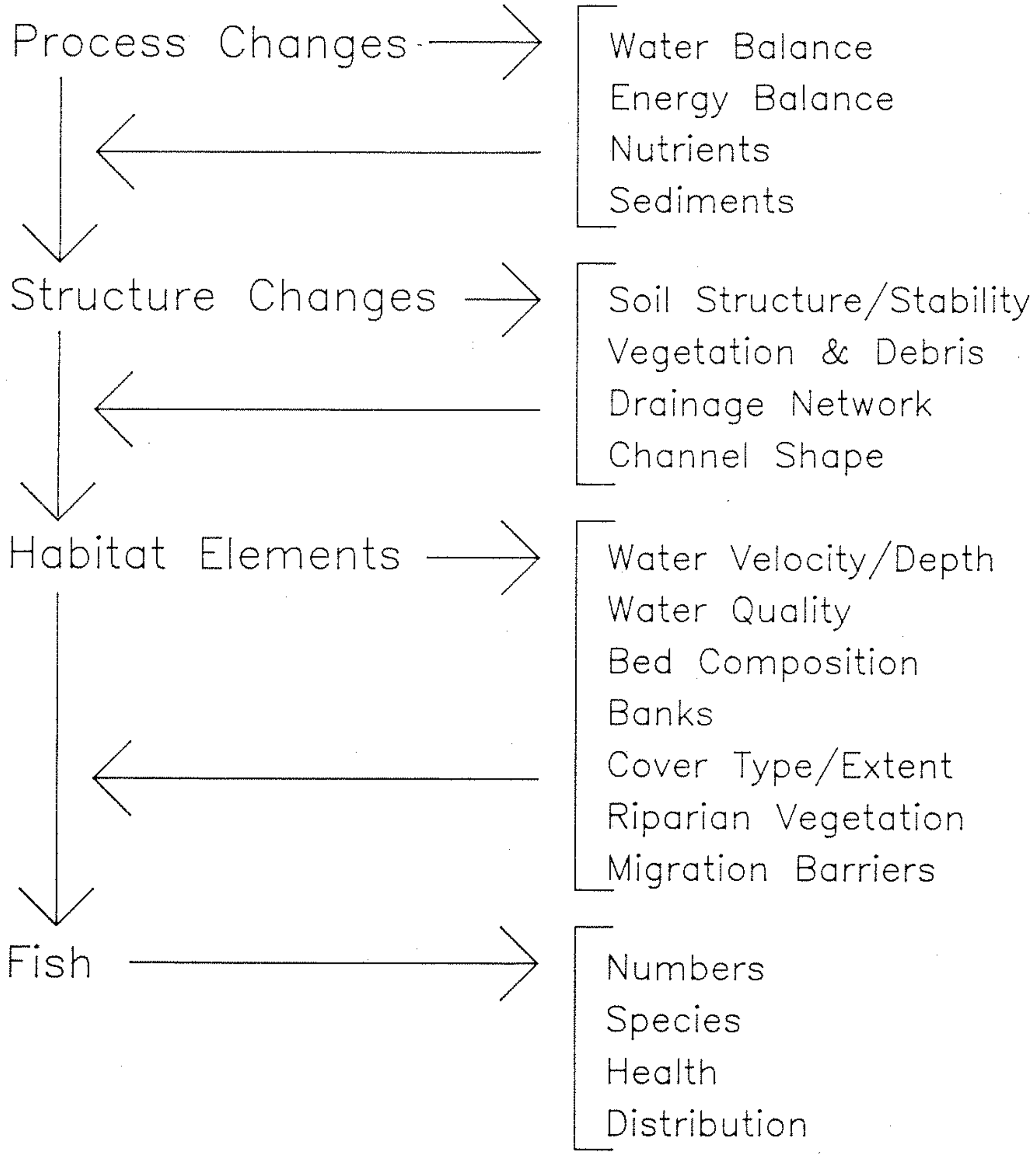
- water velocity through the culvert is excessive
- water depth in the culvert is too shallow
- the culvert is positioned too high for salmon access
- no resting pool is provided below the culvert
- the culvert becomes plugged by debris

The most common culvert installed on western forest roads is standard corrugated metal pipe. It is also the type least desirable for fish passage (Yee and Roelofs, 1980). The culvert is usually much narrower than the stream channel, causing a velocity differential, and it is likely to be installed with the outfall above the tailwater, causing an outfall barrier.

Tree harvest eliminates substantial absorptive surface area (leaves and roots) increasing run-off and elevating soil-water content. The elevated soil-water content reduces soil strength, destabilizing slopes, and influencing mass soil

FIGURE 1: RELATIONS OF FOREST HARVESTING TO FISH

(Chamberlin, 1982)



movement (O'Loughlin, 1972; Swanston, 1974). ODFW surveys indicate that 95 percent of slides in forested areas are attributable largely to logging and related activities (Johnson, 1983).

Increased run-off and removal of streamside vegetation during logging operations can result in ruinous flash freshets which can silt in streams or introduce debris. While some debris may create valuable habitat, too much debris can create debris jams which may block fish movement. (Hall and Lantz, 1969).

The effects of timber harvest can be dramatic and sustained. Salmon productivity can be diminished as turbidity increases and dissolved oxygen decreases; migration can be blocked by logjams, spawning gravel compacted by sediment, and eggs and alevins washed away or smothered. Benthic algae and insects important as food sources can be reduced by gravel movement and the scouring of streambeds (Yee and Roelofs, 1980; Hall and Lantz, 1969).

Chemicals are used in forestry to control insects and undergrowth, promote tree growth, and inhibit fire. Although the use of chemicals in forests is just a fraction of the amount used in agriculture, the contribution of run-off from forest lands to streams is much greater than agricultural lands (Norris et al., 1983).

The effect on anadromous fish from the use of forest chemicals may be direct or indirect. The potential for direct effects exists when chemicals enter a forest stream via direct application, atmospheric drift, or run-off (Norris et al., 1983). Among these three routes, direct application introduces the highest concentrations of chemicals into streams and thus holds the greatest potential for causing acute toxicity in nontarget organisms. Dilution in the atmosphere and absorption by soil result in the introduction of comparatively smaller concentrations of chemicals by drift and run-off.

Indirect effects of chemical use in forests arise from the modification of habitat rather than the interaction between the fish and a chemical. Indirect effects are those that alter the abundance and diversity of vegetation, which in turn can affect the availability of aquatic insects that are food for anadromous fish. The removal of riparian vegetation is also an indirect effect that can impact anadromous fish by the resultant increase in stream temperature, loss of food source, and reduction in habitat complexity.

Mining

Hydraulic mining for gold began in 1852 and by the 1880s was the most important industry in the Pacific Northwest. The effects of gold mining were disastrous; it has been estimated that the intense salmon fishery conducted between 1864 and 1882 in California had less effect on salmon runs than gold mining activities (Netboy, 1974). Extremely heavy siltation, to the point of filling streams, was a by-product of gold mining. Dredging altered the streambed and destroyed riparian vegetation.

Fortunately, the devastating effects of previous mining practices have been largely brought under control. Current mining activities are primarily limited to sand and gravel extraction operations, with only a minimal amount of metal mining occurring in watersheds supporting anadromous fish. In the

Columbia River Basin, however, sand and gravel mining continues to disrupt salmon habitat, particularly in the Willamette River (NPPC, 1986a). In California, where dams block gravel recruitment on some major streams, gravel mining in salmon streams is coming under increased scrutiny because of concerns about poor gravel recruitment. The impact of recreational dredging for gold in streams is unknown. These activities are generally limited to times of the year when salmon nests are empty (Ashbaker, 1987).

Urbanization and Pollution

Urbanization has a pronounced effect on coastal ecosystems through drastic modification of the hydrography, biology, and chemistry of rivers, lakes, bays, and estuaries. Inwater construction, dredging, filling, diking, draining, run-off, and waste discharge can degrade water quality, reduce biological productivity, or alter sedimentation patterns.

The removal and relocation of river, harbor, and coastal sediments is often conducted for maintenance of channels for navigation and port facilities. Sediment excavated in maintenance dredging may be contaminated with a wide variety of wastes, notably heavy metals, that have been spilled, discharged, or otherwise have entered the waterway (Kester et al., 1983).

Dredging results in increased turbidity, with the effects being dependent on the type of substrate being dredged, on currents or tides, on preventive measures, and type of dredge employed by the contractor. As discussed in Section III, excessive turbidity can clog or abrade gill tissue, lower dissolved oxygen concentrations, and smother eggs and alevins in gravel beds. While these effects can be temporary, long-term habitat degradation can result when dredging resuspends pollutants that had settled in the sediment, from disruption of benthic communities, or loss of shallow water habitat.

Filling occurs as part of dredging operations, as well as for residential, industrial, and agricultural purposes. Reclamation by filling, diking, or draining of stream side channels, sloughs, and other inland and estuarine wetland areas has resulted in major losses of important salmon habitat. Nearly 90 percent of wetland losses in California, Oregon, and Washington are due to agricultural reclamation and channelization, which decrease the quality and diversity of instream habitat and may destroy riparian habitat as well. Significant losses also have occurred in Washington and California through the filling of coastal freshwater and saltwater wetlands to create open water, unvegetated areas for port, and marine expansion. Extensive wetland losses due to filling have had a great impact in reducing the productivity of the San Francisco Bay Delta Estuary by eliminating significant areas used as nursery, rearing, and spawning habitats for many estuarine and coastal species, including juvenile salmonids (Wolcott, 1986).

The inland freshwater and coastal wetland areas that have been and continue to be filled, drained, or otherwise modified are areas of widespread ecological significance. In addition to providing valuable spawning, rearing, and food production areas for salmon, wetlands store run-off, thereby reducing floodpeak; filter nutrients and pollutants from run-off; and reduce shoreline erosion due to presence of stabilizing vegetation. Their conversion has had severe impacts on fisheries as well as other species dependent on wetland areas.

Prior to the strengthening of environmental controls in the 1960s, rivers, streams, lakes, and estuaries were the receiving waters for vast volumes of untreated organic and industrial wastes. The major forms of pollution affecting Pacific salmon included raw sewage, pulp mill effluents, aluminum plant discharge, and acid and metal wastes. Severe environmental damage from uncontrolled waste discharge was evidenced by fish kills, oxygen depletion, massive blooms of nuisance algae, and public health problems. Regulation of municipal and industrial discharges have improved the situation, but impacts of urbanization and pollution remain a threat to anadromous fish.

As discussed in previous sections, the introduction of foreign materials into waterways causes serious habitat degradation. Nutrients and other oxygen-demanding materials reduce oxygen levels and can create oxygen-poor zones which delay or block migration of salmonids. Sewage, wood processing wastes, and agricultural run-off can impose an extremely high oxygen demand in waterways causing such oxygen blocks. Heavy metals, petroleum hydrocarbons, chlorinated hydrocarbons, and other chemical wastes can be toxic to salmonids, or their food, or inhibit their movement in streams. There is growing evidence that organic compounds used in marine antifouling paints are extremely toxic to salmon (Short and Thrower, 1986). Mining operations and aluminum smelters produce heavy metals as waste products. Aluminum plant waste streams also contain fluoride and hydrocarbons. There is evidence that these substances may modify the movement of salmon causing migration delays (Damaker and Dey, 1985).

MAINTENANCE OF PRODUCTIVE CAPACITY

Habitat now remaining for salmon migration, spawning, and rearing is essential to maintain a healthy salmon fishery and associated industries. The remaining habitat continues to be threatened, however, by pressures from a variety of competing land and water uses. The cumulative impacts of water resource developments on the Pacific salmon resource, in the Columbia and Sacramento river basins in particular, have been devastating. This experience highlights the need for coordinated and comprehensive water management planning that balances competing purposes and reflects equitable treatment of fisheries with other project purposes.

As has been demonstrated, the degree to which water is managed for fishery purposes unavoidably affects the survival of salmon stocks. The ability of fishery agencies to influence water management decisions, however, is constrained by their lack of direct authority over water resources. For example, federal construction agencies are not bound by the recommendations of fisheries agencies when planning or operating a project, but are required by the Fish and Wildlife Coordination Act only to give full consideration to fisheries concerns. This has resulted in situations in which the actions of one federal agency jeopardize or preempt the mission of another federal agency, for example, the siting of a hydropower project in a river basin where considerable investment had been made to restore salmon resources. Project features that mitigate losses are often controversial because the benefits are sometimes difficult to quantify and costs can be high.

Therefore, it is incumbent upon fishery managers to participate actively and effectively with agencies holding direct water management authority in project planning and review to ensure that the habitat needs of salmon receive equal treatment with other water management purposes. Approaches fisheries managers should take to influence water management decisions include (among others) negotiation for water flows for salmon spawning, rearing, and migration; filings of intervention in hydroelectric licensing procedures; vigorous review of land management agency plans; oversight of dam operations and fish passage; designation of critical habitats as protected areas; or other forms of mitigation. Federal court rulings have supported efforts by fisheries interests to gain standing for fishery resources in water management decisions.

Another approach to achieve equitable treatment for salmon in water management decision making is the identification of nondamaging project alternatives. The concept of "no-impact development" is becoming increasingly endorsed by fisheries interests. Fisheries agencies and tribes in the Northwest have identified hydroelectric sites in the region which would have insignificant impact on fishery resources if developed. The State of Oregon passed legislation in 1985 (House Bill 2990) which mandates that hydroelectric projects shall have no adverse impact on anadromous fish resources.

Maintaining the productive capacity of salmon habitat is the goal for a number of state and federal laws that regulate activities in anadromous fish watersheds. In many instances, these laws have reduced impacts on salmon habitat quality and quantity by controlling or curtailing activities that formerly had substantial adverse impacts on such habitat. However, in other cases, weak enforcement or inadequate implementation has allowed damaging activities to persist. The following sections describe significant programs and measures regulating activities in anadromous fish watersheds, as well as the respective roles of the implementing agencies, fisheries agencies, and tribes.

Hydropower Licensing

Over the years, the protection afforded to anadromous fishery resources in hydropower licensing decisions has been disappointing. Despite laws requiring the protection and enhancement of fisheries, anadromous resources often suffer from minimal or inadequate consideration in these decisions. Further, such decisions have frequently been at odds with recommendations made by fisheries agencies and Indian tribes, especially in regard to selection of less damaging alternative sites, analysis of cumulative impacts, and fish resource mitigation features. In sum, licenses and exemptions from licenses are often issued with inadequate conditions to protect, restore, or enhance fishery resources. This frequently leaves fishery agencies and Indian tribes in the undesirable and costly position of having to litigate to obtain license conditions more favorable for fishery resources.

The situation described above is particularly alarming in light of the increased number of small hydropower project proposals prompted by tax incentives and a requirement that utilities purchase the power regardless of need. To illustrate, nine preliminary permits for small hydroelectric projects were issued in 1977. By 1981, the number of preliminary permits issued jumped to 1,548. Since then, the number has moderated to an average of about 500 per year through 1985.

Many of these new hydroelectric projects are sited in tributaries--areas vital as salmon spawning and rearing habitat. Multiple hydroelectric projects are proposed for many river basins, threatening not only significant cumulative impacts to valuable fishery resources but also impacting restoration plans and associated investments. For example, in the Salmon River Basin in Idaho, there are proposals for over 40 small hydroelectric projects. The NPPC, meanwhile, has listed 16 areas of that basin as candidates for habitat enhancement funding under the Columbia Basin Fish and Wildlife Program. The cost of the habitat enhancement projects would be borne by the same electricity rate payers who would buy the power from the small hydroelectric projects.

The FPA as amended authorizes the FERC to issue licenses and license exemptions as appropriate to nonfederal hydroelectric projects. The fisheries agencies and Indian tribes regularly intervene in FERC hydropower authorization proceedings that may potentially affect valuable anadromous fish resources. These organizations provide FERC with a description of the affected fishery resource, potential project impacts on the resource, information on restoration efforts and past mitigation efforts, and other relevant matters. Where appropriate, the filings identify deficiencies regarding fishery features of the proposed project and identify studies which the project applicant must undertake to assure full understanding of project impacts and potential mitigation. In the case of license applications, filings recommend conditions which should be included in any license issued to protect, mitigate, and enhance anadromous fishery resources. NMFS is becoming increasingly active in setting binding criteria for adult and juvenile passage facility licenses under Section 18 of the FPA. Similarly, in the case of small hydroelectric exemptions, NMFS, the U.S. Fish and Wildlife Service, and state fishery agency filings specify binding terms and conditions under the Public Utility Regulatory Policies Act and the Energy Security Act to prevent loss of or damage to anadromous fishery resources.

Federal Construction

Federal dams are proposed, designed, constructed, and operated by the Corps and the Bureau of Reclamation. Dams are authorized and funded by Congress specifying one or more public interest purposes. Often these purposes include hydropower generation, flood control, navigation, and irrigation. In some cases, fish enhancement is an authorized but often secondary purpose. In most cases, however, salmon resources suffer from losses due to operations designed for other project purposes.

Efforts to achieve consideration for fisheries in Corps and Bureau of Reclamation activities began with the FWCA, which directs all federal agencies involved with water resource development to preserve and enhance fish and wildlife. Whenever the Corps or Bureau of Reclamation propose to impound, divert, control, or otherwise modify any stream for any purpose, the FWCA directs that the appropriate state and federal fisheries agencies be consulted. The fisheries agencies are responsible for recommending measures that conserve, mitigate, or compensate for fishery losses suffered as a result of the project. However, as previously mentioned, the construction agencies are not bound by the recommendations of the fisheries agencies but are required by the FWCA only to give them "full consideration."

In 1978, President Carter directed all appropriate agency heads to see that the FWCA was vigorously implemented. Over the next five years a series of landmark judicial, legislative, and administrative events occurred that contributed significantly to improving interagency cooperation in protecting and restoring anadromous fish runs. Federal construction agencies have made significant strides in increasing protection for fish in both the design and operation of their projects. Still, progress toward achieving equitable treatment for fish was slow. Fisheries groups and federal construction agencies must push for measures that protect fish, such as appropriate water releases for migration and temperature control, timing of channel maintenance, adequate by pass facilities, etc.

Permits

Federal agencies issue permits for a variety of activities in navigable waters and on federal lands. Permits for construction or placement of structures in waterways are regulated by Section 10 of the Rivers and Harbors Act. Dredge and fill permits are issued under Section 404 of the Clean Water Act. Both permit programs are administered by the Corps, which solicits comments on permit applications from fish and wildlife agencies and affected Indian tribes.

The Corps makes permit decisions based on a public interest determination, which is supposed to weigh resource issues with other project concerns. Although the activities allowed by Section 10 and 404 permits are potentially harmful to salmon habitat, the Corps permit review criteria and procedures generally prevent permanent loss or reduction of large amounts of anadromous fish habitat. However, a vast number of permits are issued each year, and subtle, cumulative impacts in watersheds occur over time.

Activities on federal lands are regulated by the Bureau of Land Management and the U.S. Forest Service through the issuance of special use permits. These permits are required for road construction or use, logging, mining, hydropower development, or resort construction and operation. Special use permits are generally effective in reducing disturbances to anadromous fish habitat, particularly in those areas where the Bureau of Land Management or U.S. Forest Service offices have fishery biologists on staff to review permit applications.

Resource Management

Logging, mining, grazing, and water withdrawals continue to degrade salmon habitat, although regulations controlling stream corridor use have curtailed many of the most severe abuses. The use of technology and habitat management methods allow these activities to be conducted with reduced impacts, however, the success of these methods are a function of the extent to which they are employed or enforced.

Forest Management

Improvements in forest management practices have successfully reduced, although not eliminated, many adverse effects of logging. The success of improved forest management practices in reducing adverse effects of logging is directly related to the degree to which such practices are observed or employed prior to, during, and subsequent to logging operations.

Methods to reduce impacts of logging include leaving buffer strips next to streams to preserve riparian vegetation, suspension logging to protect riparian vegetation and streambeds by moving logs across streams while elevated instead of dragging them across, helicopter and balloon logging in areas susceptible to mass soil movement, replacement of unsuitable culverts, and proper construction and maintenance of roads.

In attempting to meet water quality standards during logging operations, foresters have emphasized water quality monitoring, i.e., temperature and turbidity. However, federal agencies are now encouraging the monitoring of additional parameters that more accurately describe habitat quality, such as concentrations of fine sediments, pool-riffle ratios, instream debris, etc.

The States of California, Oregon, Washington, and Idaho have all implemented forest practices legislation governing logging on state and private lands. These laws differ in the stringency of required practices and extent of enforcement, thus, salmon habitat is afforded varying levels of protection among these states. Where forest practices measures that preserve habitat quality are weak or not enforced salmon habitat continues to be degraded from the adverse effects of logging.

Mining

The adverse effects of mining are controlled through state and federal water quality standards which restrict mine discharges, sand and gravel operations, and other mining activities that affect water quality. The most severe forms of habitat degradation from mining have been brought under control, although residual impacts from former mining may linger in the most heavily impacted areas. Again, effective laws regulating stream corridor use, and their enforcement, are essential to protecting salmon habitat where mining operations are still conducted.

Grazing

The U.S. Forest Service and the Bureau of Land Management have been largely responsible for implementing measures to reduce the adverse effects of grazing on public lands. Management measures to rehabilitate rangeland and stabilize soil include livestock control practices, fencing, revegetation, and expanded fire protection (NPPC, 1986a). The problem of cattle congregating in stream bottoms during summer months continues to degrade salmon habitat. While measures to solve this problem are readily available, a funding commitment to do so is not.

Water Withdrawals

The withdrawal of water for irrigation in river basins continues to increase. Water in many areas is overappropriated, particularly during summer months, resulting in flow depletion, lost production, and salmon mortalities. Minimum stream flow designations are needed to protect salmon resources, but these measures have not been implemented effectively in most areas.

Pollution Control

State and federal implementation of the Clean Water Act has been directly responsible for significant improvement of water quality in degraded salmon habitats, the Willamette River in the Columbia River Basin and the San Francisco Bay Estuary being notable examples.

States are being urged by the U.S. Environmental Protection Agency to adopt antidegradation criteria. These criteria protect waterways of good to exceptional water quality from activities which would reduce that quality. In some instances, water bodies of exceptional quality or of special ecological value would become protected areas. The U.S. Environmental Protection Agency is also advocating the linkage of water quality criteria with habitat criteria so that beneficial uses of a waterway; i.e., fish production; are adequately protected by applicable water quality standards.

In the Puget Sound, a major multi-agency effort to address water quality has been undertaken. The Puget Sound Water Quality Management Plan is a comprehensive program developed and administered by the Puget Sound Water Quality Authority to protect Puget Sound from nonpoint source pollution, municipal and industrial discharges, contaminated sediments and dredging, stormwater and combined sewer overflows, and oil spills. The plan also includes programs for habitat and wetlands protection. The plan is administered by the Puget Sound Water Quality Authority, established by the Washington State Legislature on the finding that the large number of governmental entities that affect Puget Sound water quality have diverse interests and limited jurisdictions which can not adequately address the cumulative, wide-ranging impacts which contribute to the degradation of Puget Sound (Puget Sound Water Quality Authority, 1986).

RESTORATION OF PRODUCTIVE CAPACITY

Although the term enhancement is commonly used in relation to increasing production in the salmon fishery, frequently "enhancement" programs and activities are more accurately restoration of populations dramatically depleted due to habitat alteration. It is in all likelihood impossible to truly enhance salmon runs, i.e., increase them beyond historical levels, due to widespread habitat destruction and degradation. However, restoration holds significant potential for increasing natural salmon production, perhaps by as much as 30 percent by the year 2,000 (Council, 1979). Without such efforts, production declines are likely to continue.

Restoration activities include resource or habitat management measures whereby relief is sought from spawning and rearing habitat loss, blocked or impaired fish passage, inadequate flow releases, or other operational regimes detrimental to fish. Such measures are generally achieved through negotiation between fisheries interests and project operators; FERC relicensing procedures; litigation; or through federal, state, and local restoration programs.

Habitat restoration alone, however, is not sufficient to increase or even maintain natural production. Adequate spawning escapement is also required. In 1978, a Council salmonid task force cited the need for a 40 percent coastwide increase in spawning escapements to fully use available habitat (Council, 1979). More recent work indicates that Pacific coast rivers consistently fall short of escapement goals by 500,000 fish per year. Some stocks are up to 70 percent underescaped (Fraidenburg and Lincoln, 1985). Thus, enhancement investments must be accompanied by vigorous efforts to achieve spawning escapement goals. Several examples of enhancement efforts are discussed below.

Columbia Basin Fish and Wildlife Program

The Pacific Northwest Electric Power Planning and Conservation Act of 1980 established the NPPC and directed it to develop a fish and wildlife program to protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat on the Columbia River and its tributaries. The objectives specified by the act are to improve anadromous fish survival at hydroelectric facilities and provide sufficient flows to improve survival between such facilities. The fish provisions of the act constituted a major advance because fish were, for the first time, explicitly included as a purpose, co-equal with power, for which the federal and nonfederal hydroelectric facilities on the Columbia River and its tributaries are to be managed, operated, and regulated.

In practice, the success of the fish and wildlife program in accomplishing specified objectives of the act has been mixed. NMFS recently reviewed initiatives to improve juvenile fish survival on the mainstem Columbia and Snake rivers for the period immediately prior to and since passage of the Northwest Power Act (NMFS, 1986). The review concludes that there has been no substantive improvement in flows compared with conditions prior to enactment of the act. In the case of spill for fish passage and juvenile bypass facility development, the review revealed both some progress and backsliding. The review also noted little improvement in the status of fishery agencies and tribes relative to the power interests in system planning or operations.

On the other hand, the NPPC has provided strong support for a number of initiatives supported by the fishery agencies and tribes to improve fish survival. The NMFS report points out that the value of both the act and fish and wildlife program as basic tools to improve fish survival should not be underestimated.

Trinity River Restoration Plan

The Trinity River Restoration Plan is a $50 million, 10 year program designed to rehabilitate fish and wildlife populations in California's Trinity River Basin to compensate for losses over the past few decades from habitat alteration and degradation.

Authorized in 1984 by federal legislation, the major fishery goals of the plan are to (1) provide artificial (hatchery) production as compensation for salmon spawning and rearing areas lost due to migration blockage of the Trinity River by the Lewiston Dam, (2) restore full natural salmon production in the Trinity River and its tributaries downstream from Lewiston Dam, and (3) make fishery management recommendations that are compatible with the goal of restoring full natural salmon production in the Trinity River and its tributaries downstream from Lewiston Dam. Corrective measures in the Trinity River Basin will include barrier removal, sediment control, construction of holding and nursery areas, screening of water diversions, streambank stabilization, and spawning area rehabilitation. Monitoring of escapements, production, and management measures will be provided on a year-round basis.

Lower Snake River Fish and Wildlife Compensation Plan

The Lower Snake River Compensation Plan is a program to compensate for fish and wildlife losses caused by the construction of four dams on the lower Snake River in Washington and Idaho. The objective of the plan is to return anadromous fish runs to preproject levels through construction of fish hatcheries and associated satellite facilities for juvenile releases and to trap and hold spawning stock.

The focus of the plan on hatchery rearing and release does not address the need for project operational modifications to compensate and restore the lower Snake River fish runs. Hatchery supplementation under the plan, the costly passage facilities constructed at the dams, and the program to transport juveniles around the dams are of little value unless water release at the dams is sufficient to permit the juveniles to move through the reservoirs or reach the collection facilities.

Salmon and Steelhead Conservation and Enhancement Act

Designed to complement the Northwest Power Act, the Salmon and Steelhead Conservation and Enhancement Act was enacted in 1980. The act established the Salmon and Steelhead Advisory Commission which recommended a new structure to (1) improve management and enhancement planning and coordination in Washington and Oregon, (2) facilitate resolution of disputes between management entities concerned with stocks of common interest, (3) prepare comprehensive resource production and management plans, and (4) coordinate enforcement efforts.

The Salmon and Steelhead Advisory Commission's 1984 report containing the above recommendations was not approved by the Secretary of Commerce. The recommendations put forward by the commission to accomplish its mandate under the act have, therefore, not been fulfilled or implemented, nor have any benefits to the resource from this potentially valuable enhancement tool been realized.

Local Restoration Effort

Local fishing and community groups; frustrated by controversies over harvest levels, harvest allocations, and questions about hatchery propagation while salmon runs continued to decline; have shifted their attention to salmon habitat enhancement in some areas. These efforts include nurturing juveniles in hatchboxes in streams, replanting riparian vegetation, removing logjams, and clearing streams of slash and debris.

California has numerous salmon restoration programs designed to encourage and support local involvement. Annual appropriations of approximately $700,000 are provided by the legislature, and in 1984 the Fish and Wildlife Habitat Enhancement Act was passed (Proposition 19) that provides $10,000,000 over five years for stream improvement. California trollers supported legislation for a salmon stamp which annually provides between $400,000 and $1,000,000, depending upon pounds of salmon landed. The trollers also supported legislation to provide a one-time allocation of $10,000,000 to be used to correct damages caused by past water development projects, much of which is for anadromous salmonids. The state also funds an annual $1,000,000 CDFG-California Conservation Corps program for north coast stream restoration. Most of the projects including habitat restoration and fish production operations are conducted by private contractors, local government, and Indian tribes under contract with the CDFG. Many of these projects include local volunteers from conservation and fishing organizations. CDFG also has an active fish screening and habitat restoration program.

Oregon's Salmon and Trout Enhancement Program is funded by the state legislature and staffed with a statewide coordinator and fishery biologists. Oregon's Salmon and Trout Enhancement Program projects have been granted status by the legislature over private salmon ranches to receive the surplus hatchery eggs needed to carry out their enhancement work.

In Washington, the Salmon Tributary Enhancement for Puget Sound group is promoting streamside hatchboxes in the fishing community. An enhancement program administered by WDF has authorized nearly 100 enhancement projects, ranging from individual hatchboxes to small tribal hatchery operations. Long Live the Kings is a private, nonprofit group working in Washington to rebuild self-sustaining levels in targeted watersheds. It is a cooperative effort that includes key constituencies of the salmon industry and the general public. The approach being taken is temporary intervention in the spawning process and coordination of work to restore and maintain habitats in watersheds that will support wild salmon.

Although the contribution of these grass-roots restoration efforts to a regionwide increase in salmon production may not be large, their role should not be underestimated. The work of restoration advocates also promotes an awareness of salmon habitat problems and a sensitivity to those activities that threaten it. Loss of salmon habitat is not something that occurred only in the past, it is continuing--perhaps even accelerating. The threat of small hydroelectric development, logging, irrigation, etc., could cancel the gains made by both local and large-scale restoration programs; the end result being the further endangerment of already depleted salmon runs. The involvement of local groups in restoration efforts builds a constituency with political strength devoted to averting these threats.

SUMMARY

No Pacific salmon population remains undisturbed by the effects of human activities. Habitat loss has been the most pronounced in the Columbia and Sacramento-San Joaquin river systems due to the construction of numerous mainstem dams. Coastal streams in California, Oregon, and Washington have fewer dams constructed on them, and, accordingly, have had somewhat less loss of habitat due to physical blockage. Smaller rivers, such as coastal streams or headwater areas, less impacted by hydropower development to date, are now threatened by large numbers of proposed new projects which could cause significant additional decline in rearing and spawning habitat.

Salmon populations in river systems where dams interrupt major migration routes have experienced drastic declines. Reductions in salmon populations have occurred in all areas due to habitat degradation from logging, road-building, irrigation, agriculture, urban growth, mining, and other activities.

Salmon production is directly related to salmon habitat quality and quantity which, in turn, directly affects allowable harvest in the commercial, recreational, and native fisheries. Thus, harvest and habitat management are inextricably related. While harvest management is the responsibility of fisheries agencies, habitat management is usually the responsibility of land and water management agencies. Therefore a two-way commitment must exist among the agencies to preserve salmon resources through appropriate habitat and harvest management.

The Pacific salmon fishery contributes to the food supply, economy and health of the nation, and provides recreational opportunities. The fishery is dependent upon the survival and optimal production of salmon resources, which can only be assured by wise management of all aspects of salmon habitat. Increased productivity of salmon stocks is not possible without habitat restoration.

COUNCIL POLICY

The Council, under the authorities and guidelines of the MFCMA and NMFS Habitat Conservation Policy, makes the following policy statements concerning the conservation and protection of Pacific salmon habitat.

The Council will be guided by the principle that there should be no net loss of the productive capacity of marine, estuarine, and freshwater habitats which sustain commercial, recreational, and native salmon fisheries beneficial to the nation. Within this policy, the Council will assume an aggressive role in the protection and enhancement of anadromous fish habitat and work toward achieving the following habitat.

1. The Council will work to assure that Pacific salmon, along with other fish and wildlife resources, receive equal treatment with other purposes of water and land resource development.

2. The Council will support efforts to restore Pacific salmon stocks and their habitat through vigorous implementation of federal and state programs.

3. The Council will work with fishery agencies, tribes, land management agencies, and water management agencies to assess habitat conditions and develop comprehensive restoration plans.

4. The Council will support diligent application and enforcement of regulations governing ocean oil exploration and development, timber harvest, mining, water withdrawals, agriculture, or other stream corridor uses by local, state, and federal authorities. It is Council policy that approved and permitted activities employ the best management practices available to protect salmon and their habitat from adverse effects of contamination from domestic and industrial wastes, pesticides, dredged material disposal, and radioactive wastes.

5. Where existing authorities and regulations are inadequate, the Council will encourage users to seek legislative remedies as potential means to conserve, protect, and restore salmon populations and their habitat.

6. The Council will promote agreements between fisheries agencies and land and water management agencies for the benefit of fishery resources and to preserve biological diversity.

7. The Council will strive to assure that the standard operation of existing hydropower and water diversion projects will protect and enhance salmon productivity.

8. The Council supports efforts to identify and avoid cumulative or synergistic impacts in drainages where Pacific salmon spawn and rear. The Council will assist in the coordination and accomplishment of comprehensive plans to provide basinwide review of proposed hydropower development and other water use projects. The Council encourages the identification of no-impact alternatives for all water resource development.

9. The Council will support and encourage efforts to determine the net economic value of conservation by identifying the economic value of fish production under present habitat conditions and expected economic value under improved habitat conditions.

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