Feature

# Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington

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ABSTRACT

The American Fisheries Society herein provides a list of depleted Pacific salmon, steelhead, and sea-run cutthroat stocks from California, Oregon, Idaho, and Washington, to accompany the list of rare inland fishes reported by Williams et al. (1989). The list includes 214 native naturally-spawning stocks: 101 at high risk of extinction, 58 at moderate risk of extinction, 54 of special concern, and one classified as threatened under the Endangered Species Act of 1973 and as endangered by the state of California. The decline in native salmon, steelhead, and sea-run cutthroat populations has resulted from habitat loss and damage, and inadequate passage and flows caused by hydropower, agriculture, logging, and other developments; overfishing, primarily of weaker stocks in mixed-stock fisheries; and negative interactions with other fishes, including nonnative hatchery salmon and steelhead. While some attempts at remedying these threats have been made, they have not been enough to prevent the broad decline of stocks along the West Coast. A new paradigm that advances habitat restoration and ecosystem function rather than hatchery production is needed for many of these stocks to survive and prosper into the next century.

That part of the industry dependent on the Columbia River salmon run has expressed alarm at the possibility of disastrous effects upon the fish through the erection of the tremendous dams at Bonneville and the Grand Coulee.. Aside from the fish ladders and elevators contemplated, there is a program for artificial propagation set up which may be put into effect if the fish-passing devices fail to meet expectations. No possibilities, either biological or engineering, have been overlooked in devising a means to assure perpetuation of the Columbia River salmon.

—M. C. James, Report of the Division of Commercial Fishing presented at the 67th Annual Meeting of the American Fisheries Society, August 1937.

## Introduction

During the 1930s, society had little appreciation of the complexity of adaptations of stocks to local conditions, their differing life history requirements, or the number of distinct stocks that composed the salmon fisheries. Maintenance of salmon appeared deceptively easy.

In the 1990s, native anadromous Pacific salmonids (*Oncorhynchus* spp.) are at a crossroads, the habitats of these once wide-ranging fishes are severely curtailed, many stocks are extinct, and many remaining stocks face a variety of threats. Since the 1850s, development activities such as hydropower, fishing, logging, mining, agriculture, and urban growth have caused extensive losses in salmon and steelhead populations and habitats. In most cases, enough of the native resource remains to allow a variety of remedial actions. If the salmon and their habitat continue to diminish, however, available options for present and future generations will diminish or disappear. The challenge for the 1990s is to take maximum advantage of technical, legal, and management avenues available to us now.

The task ahead is critically important. Salmon and steelhead are a cornerstone of West Coast industry, recreation, and culture. Native stocks are needed and will be needed in the future to (1) maintain natural genetic diversity within and among fish stocks needed to respond to major ecological and climatic changes, (2) provide the basis for re-establishing natural stocks where opportunities occur, (3) optimize natural production in streams, (4) support natural ecosystem function, (5) re-establish genetic variability in existing hatchery stocks, and (6) provide the basis for new hatchery stocks. While much progress has been made in artificially producing these fish, artificial production in itself cannot sustain them, and may contribute to the decline of native populations (Goodman 1990).

We identify 214 native naturally-spawning Pacific salmon and steelhead stocks in California, Oregon, Washington, and Idaho that appear to be facing a high or moderate risk of extinction, or are of special concern. The American Fisheries Society (AFS) Endangered Species Committee recently identified vanishing inland fish species and subspecies (Williams et al. 1989). The Committee inventoried inland fishes that were endangered, threatened, or of special concern, updating the decade-old Deacon et al. (1979) report. The present paper is intended to complement Williams et al. (1989) by reporting on declining anadromous fish stocks.

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About 60 copies of the manuscript were distributed for review, and about 25 agencies, tribes, and individuals responded. Most reviewers offered additional information on stocks included in our draft list, and suggestions for additional stocks; the list presented here generally reflects that information. Although every effort was made to take the comments of the reviewers into account, the AFS Endangered Species Committee is responsible for the opinions expressed herein.

Interpretation of the limited data is hindered because concepts of stocks, thresholds for endangerment, and the role of artificial production are still being developed. Additional work on the fundamental concepts of stock identification is needed.

## *The Stock Concept*

Anadromous salmonid species comprise populations that originate from specific watersheds as juveniles and generally return to their natal streams to spawn. This life cycle results in a large degree of reproductive isolation of interbreeding individuals or stocks (Ricker 1972). Because Pacific salmon species comprise stocks adapted to local environmental conditions, the loss of stocks is more likely to lead to changes in genetic composition and reduction in genetic diversity in Pacific salmon than in species not stock-structured (Thorpe et al. 1981). This suggests that stocks are the basic building blocks of the Pacific salmon species. It is at the stock level that conservation and rehabilitation of salmon, if it is to be successful, will take place (Rich 1939).

The term "stock" was adopted 51 years ago (McIntyre 1983) shortly after the first attempts to describe stocks of Pacific salmon and discuss their importance to management of the species. Willis Rich was one of the earliest proponents of management based on the stock concept. After reviewing the results of early marking experiments, Rich (1939) concluded that Pacific salmon were divided into many local populations or what we now refer to as stocks (Ricker 1972). In reaching that conclusion Rich offered the following advice:

> In the conservation of any natural, biological resource it may, I believe, be considered self-evident that the population must be the unit to be treated. By population I mean an effectively isolated, self-perpetuating group of organisms of the same species regardless of whether they may or may not display distinguishing characters and regardless of whether these distinguishing characters, if present, be genetic or environmental in origin. Given a species that is broken up into a number of such isolated groups or populations, it is obvious that the conservation of the species as a whole resolves into the conservation of every one of the component groups; that the success of efforts to conserve the species will depend, not only upon the results attained with any one population, but upon the fraction of the total number of individuals in the species that is contained within the populations affected by the conservation measures.
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> —W. M. Rich (1939, p. 45). Contribution No. 1, Oregon Fish Commission.

Rich's views were not shared by all biologists at the time. Fish culturists generally ignored stock differences in the operation of hatcheries (Lichatowich and McIntyre 1987) and biologists disputed the hereditary basis of stock differences (Ricker 1972). Ricker (1972) responded to the challenge to show hereditary differences in stocks and published his comprehensive survey that has been followed by Howell et al. (1985) for the Columbia Basin salmon and steelhead stocks and Nicholas and Hankin (1988) for Oregon coastal chinook stocks. These compendia of stock characteristics have given greater meaning and emphasis to Rich's concern for stock conservation. In addition to the surveys of life history differences in stocks, biochemical studies of the genetic structure of salmon and steelhead (Kristiansson and McIntyre 1976; Reisenbichler and Phelps 1987, 1989; Utter et al. 1989) also have accumulated evidence supporting the stock concept in Pacific salmon and steelhead.

In Pacific salmon, adaptation to local environments builds into a stock a set of unique characteristics that increase fitness in the local environment (Mayr 1971). Reduced survival of coho salmon transplanted to foreign streams (Reisenbichler 1988) is a practical demonstration of fitness imparted by local adaptation. An obvious adaptation which improves fitness is resistance to disease; Buchanan et al. (1982) demonstrated stock differences in susceptibility of steelhead to *Ceratomyxa shasta*, and Wade (1986) showed that crosses of resistant (to *C. shasta*) and nonresistant stocks of steelhead were intermediate in susceptibility. Wade (1986) also reported observations made in the Nehalem River in Oregon that suggest reduced resistance of coho salmon to *C. shasta* following several years of introductions of nonresistant hatchery stocks.

The Fraser River in British Columbia contained up to 40 separate stocks of sockeye salmon (Ricker 1972). Among the many differences between the remaining stocks of Fraser River sockeye salmon is the unique migratory behavior of juvenile sockeye from lake outlet and tributary spawning stocks. Progeny of sockeye that spawned in outlet streams migrate upstream to reach the lake and progeny from sockeye that spawn in the tributaries migrate downstream to reach the lake. The direction of migration was shown to be under genetic control (Brannon 1967).

Oregon coastal chinook stocks show variation in ocean migration. Some stocks migrate north, some migrate south, and one stock has a mixed north and south ocean migration (Nicholas and Hankin 1988). In addition, Nicholas and Hankin (1988) showed stock variation in Oregon coastal chinook for duration of juvenile rearing, size and date of ocean entrance, timing of adult return and spawning, age composition of spawners, fecundity, and egg size.

Adaptation to local environments can be expressed as variation in life histories within a stock. Reimers (1973) and Schlucter and Lichatowich (1977) used scale analysis to demonstrate life history variation within stocks of Oregon coastal chinook salmon. Carl and Healey (1984) showed that within-stock variation of life history of the Nanaimo River (British Columbia) chinook salmon was a genetic adaptation to local rearing environments. Three juvenile life histories (age at seaward migration) had biochemical and morphological differences that were linked to increased fitness in different rearing habitats (Carl and Healey 1984).

Some stocks have unique characteristics for which the adaptive significance is not obvious, such as the half-pounder life history trait in the Rogue River (Oregon) stock of summer steelhead. The Dungeness River in Washington supports two stocks of pink salmon: one of the stocks is a unique upriver and early-spawning stock; the other stock is a typical lower river, late-spawning stock (Brown 1982). Both stocks developed in a relatively small river with a main stem passable to anadromous salmonids for only 17 miles.

The existence of stocks as defined by Ricker (1972) is no longer in doubt. At the conclusion of the International Symposium on the Stock Concept (STOCS) in 1981, Spangler et al. (1981, p. 1909) said, "It is no longer necessary to question whether freshwater fish of management concern (including cultured species) are comprised of discrete stocks; henceforth this will be a management assumption." MacLean and Evans (1981) argued at the STOCS symposium that a specific definition of stocks was less important than the development of a stock concept and the incorporation of a genetic perspective into fishery management. The subdivision of a species into local populations which possess genetic differences that are adaptive is the fundamental basis of the stock concept, and it is this concept that must be incorporated into management if fishery resources are to be restored and maintained (MacLean and Evans 1981). We recognize that many instances will arise where there is doubt about the existence of a stock and insufficient evidence to remove the doubt. In those cases, we believe the prudent manager will recognize the stock in question until such time that enough evidence is collected to show otherwise. Since the loss of a stock is an irreversible loss, its existence should be given the benefit of any doubt.

## *Application of the Endangered Species Act*

The Endangered Species Act (ESA) is the most powerful single tool to prevent extinction of anadromous fish stocks. Once a species is listed as endangered or threatened pursuant to the ESA, it is protected from take (although certain exceptions may be granted for those species listed as threatened), and federal agencies are required to insure that their actions do not jeopardize the continued existence of a listed species or result in the destruction of or adversely modify officially defined critical habitat. For anadromous fishes, the basis for determining whether a species is to be listed is the responsibility of the secretary of commerce through the National Marine Fisheries Service (NMFS). Once such a determination has been made by NMFS, the Fish and Wildlife Service adds the species to the List of Endangered and Threatened Wildlife.

A report on the biological criteria for endangered and threatened status of Pacific salmon and steelhead relative to the ESA has been prepared for NMFS (Bjornn and Horner 1980a). This report defines an endangered population as one with a persistent negative production rate (i.e., less than one adult returning to spawn per spawner), with no return to a higher rate envisioned. A threatened population is defined as one with a declining production rate, a ratio of approximately one adult returning to spawn per spawner, and little likelihood of an increasing adult production rate under existing conditions (Bjornn and Horner 1980a).

Application of the Endangered Species Act to the protection of anadromous fish populations also requires understanding the genetic discreteness of the fish stocks. The term "species" is defined in Section 3 of the ESA to include "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." According to this definition, individual fish stocks as defined by Ricker (1972) could qualify for protection under the ESA. The strong homing tendencies present among anadromous salmonids have provided for formation of numerous discrete populations. It also is important, however, to characterize genetic variation within the group and distinct genetic qualities that are reflected in allozyme data or special life history adaptations (Utter 1981).

The first anadromous salmonid population to be protected under the ESA was the Sacramento River winter chinook of California's Central Valley. The California-Nevada Chapter of AFS first petitioned NMFS to list the Sacramento River winter chinook as a threatened species on 7 November 1985. NMFS initially found that the winter chinook of the Sacramento River did not warrant listing. It was not until the 1989 run returned at a historically low population count of 550 adults over the Red Bluff Diversion Dam and artificial propagation efforts failed that NMFS changed its opinion. From 1967 to 1969, the winter chinook run averaged 86,509 adults past the Red Bluff facility. The low 1989 count prompted NMFS to publish an emergency rule listing the winter run as a threatened species on 4 August 1989. Emergency rules provide protection for only 240 days. A proposed rule for long-term protection was published on 20 March 1990 and was followed by a second emergency rule on 2 April (NMFS 1990a, b). On 5 November 1990, NMFS (1990c) issued a final listing of the Sacramento River winter chinook as a threatened species.

The listing includes special regulations that allow for take of Sacramento River winter chinook if the fish are lawfully taken in accordance with California state law or regulations under the Magnuson Fisheries Conservation and Management Act. These regulations allow continued sport and commercial catch of winter chinook, although the California Fish and Game Commission has instituted a fishing closure on the Sacramento River when spawning adult winter chinook are present. Habitat loss and modification in the Sacramento River system, rather than overfishing, have been the primary causes of the decline (Williams and Williams 1991).

NMFS presently is reviewing petitions to list several Columbia River salmon populations pursuant to the Endangered Species Act. On 21 March 1990, the Shoshone-Bannock Tribes submitted to NMFS a petition to list Snake River sockeye, which has been reduced to a single population in Redfish Lake. This population has declined from adult counts of 55 to 4400 in the 1950s, to 2 adults in 1989, and 1 in 1990. The run was already substantially reduced by the 1950s because of a dam that blocked nearly all upstream migration from 1913 to 1934. Petitioners cite mainstem passage mortalities at Columbia and Snake river dams, overutilization in commercial fisheries, and habitat modification as the major threats to the population.

On 7 June 1990, conservation organizations and the Idaho and Oregon Chapters of AFS submitted to NMFS a petition to list Snake River spring, summer, and fall chinook, and lower Columbia River coho. The petitioners documented the declining status of these stocks and cite passage mortalities at mainstem Columbia and Snake river dams, loss and destruction of habitat, overharvest in mixed-stock fisheries, and detrimental impacts of hatchery programs as the major threats to these stocks.

### *Effects of Small Population Size*

If the decline of a stock is unchecked, a threshold is reached at which the probability of extinction from genetic, demographic, or environmental stochasticity increases sharply. Habitat destruction or overharvesting can reduce a population to a point where extinction from a stochastic event, such as drought or random variation in sex ratio, is virtually inevitable (Soule and Simberloff 1986).

The threshold at which a stock is no longer able to maintain viability when subjected to such random events will vary substantially depending on characteristics of the population. Many of these events establish feedback loops, or "extinction vortices," that increase the likelihood that other stochastic variables will cause population failure (Gilpin and Soule 1986). A drought, for example, that caused substantial mortality to eggs or juvenile salmonids would result in a much smaller number of adult fish returning to spawn the next generation. The smaller number of spawning adults might then be vulnerable to increases in genetic drift or inbreeding, or depensatory mortality.

The consequences of environmental stochasticity are illustrated by the decline of the Sacramento River winter chinook. The 1976-77 drought caused substantial mortality to eggs because of elevated water temperatures. As a result, the 1976 and 1977 runs of 35,096 and 17,214 spawners produced adult runs of 2,364 and 1,156 (Williams and Williams 1989). More recently, run size has been near 500 fish, a level even more vulnerable to environmental stochasticity.

Little information is available on the size of anadromous salmonid populations necessary to prevent deleterious effects of genetic stochasticity. At a minimum, an effective population size of at least 50 fish is necessary to minimize problems associated with inbreeding (Nelson and Soule 1987). Because the effective population size is defined as one in which each spawner contributes equally to the subsequent generation (which requires equal sex ratios and equal spawning success among all individuals), the equivalent census population of a wild stock may be at least twice that of the effective population size. Also, particular life history characteristics of each population, e.g., sex ratio of spawners and the percentage of overlapping generations at each spawning, should be considered in any assessment of small population size (Waples and Tee1 1990). NMFS (1987) stated that 200 adult Sacramento River winter chinook were needed to avoid irretrievable genetic loss.

## Methods

This paper addresses seven species of anadromous salmonids: *Oncorhynchus tshawytscha, 0. kisutch, 0. nerka, 0. keta, 0. gorbuscha, 0. mykiss, 0. clarki;* chinook, coho, sockeye, chum, and pink salmon, steelhead, and sea-run cutthroat trout, respectively. Sea-run Dolly Varden *(Salvelinus malma)* were not included; small populations exist in Washington streams north of Grays Harbor (Sam Wright, Washington Department of Fisheries, personal communication).

### *Stocks*

We use the word "stock" in the sense of Ricker (1972) to describe the fish that spawn in a particular river system (or portion of it) at a particular season, and that do not interbreed to any substantial degree with any group spawning in a different place, or in the same place at a different season. Ricker acknowledged that what constitutes "a substantial degree" is open to investigation, but clarified that he did not mean to exclude *all* exchange of genetic material between stocks. Our identification of stock units does not necessarily imply that all these stocks are synonymous with "distinct populations" as provided for in the Endangered Species Act of 1973. In some cases, we may have aggregated more than one population within a drainage because existing data were inadequate to separate them.

Native (descended from original stocks present prior to development), naturally-spawning anadromous fish stocks are found in a variety of circumstances, ranging from stocks having no known interactions with nonnative fish to those that coexist with nonnative hatchery stocks in the same stream. Potential interbreeding with nonnative fish did not disqualify a stock from our list because substantial native character may remain. However, in many cases it is not known whether any fish of native or largely native character persist in such mixed populations. Bjornn and Horner (1980b) discussed the role of artificial propagation of Pacific salmon and steelhead in relation to the Endangered Species Act. The National Marine Fisheries Service (NMFS) is presently reviewing the issue in relation to petitions submitted in early 1990 to list Snake River salmon and lower Columbia River coho stocks.

### *Status Descriptors*

Information on the status of salmon and steelhead stocks was obtained from the published literature, fish management agencies, Indian tribes, Oregon and Idaho Chapters of the American Fisheries Society, and sportfishing and conservation groups. We reviewed all available data, e.g., spawning escapements, redd counts, adult counts, recreational catch, dam counts, and anecdotal observations. We relied primarily on spawning escapement data where these were available, but note that these data can be misleading because factors such as changes in methods, environmental and habitat conditions, harvest rates, and personnel can affect the data. More intensive analysis of such factors would be required to confirm population trends.

Based on these data, we then identified native stocks that fell into three categories: (1) at high risk of extinction, (2) at moderate risk of extinction, and (3) of special concern. The status descriptors are based on the NMFS (1980) working policy position papers for biological thresholds of endangerment. The policies are now being reviewed by NMFS as a result of recent petitions for endangered species listing of salmon stocks. New or refined criteria may emerge as a result of this review.

*At high risk of extinction:* Populations whose spawning escapements are declining. Fewer than one adult fish returns to spawn from each parent spawner.

Populations having recent (within the past 1 to 5 years) escapements under 200, in the absence of evidence that they were historically small, also were placed in this category because of the genetic and environmental risks they likely face. NMFS, considering the status of Sacramento River winter chinook, cited the genetic evidence that 200 returning adults per year are needed to avoid irretrievable genetic losses, and recommended that 400- 1,000 is a more realistic minimum for wild fish (NMFS 1987). The minimum number of adults needed depends on the size of the watershed, the extent of gene flow among stocks, and the history of the stock. We apply the "200 adults" threshold, recognizing that it is too stringent in some cases and not stringent enough in others.

A stock in this category, if intensive analysis confirms its population status and identity as a "distinct population segment," has likely reached the threshold for listing as endangered under the Endangered Species Act.

*At moderate risk of extinction:* Populations whose spawning escapements appear to be stable after previously declining more than natural variation would account for, but are above 200. Approximately one adult per spawner is returning to spawn. A stock in this category, if intensive analysis confirms its population status and identity as a "distinct population segment," has likely attained the threshold for listing as threatened under the Endangered Species Act.

In many cases it was difficult to distinguish a declining population from one that has stabilized after a period of decline, because of an insufficient period of record. In these cases, population size was also taken into account. Populations having larger escapements (around 1,000) were more weighted toward the at moderate *risk* category, while those having smaller escapements were weighted toward the at high *risk* category.

*of special concern*: Populations for which:
1. Relatively minor disturbances could threaten them, especially if a specific threat is known.
2. Insufficient information on population trend exists, but available information suggests depletion.
3. There are relatively large ongoing releases of nonnative fish, and the potential for interbreeding with the native population exists.
4. The population is not presently at risk, but requires attention because of a unique character.

Our stock status criteria, which rely primarily on recent trends in escapements, may result in under-representing the number of at-risk stocks. Declines in numbers may not fully show the trend toward extinction. Goodman (1990) pointed out that gene pools are destroyed through means other than declining populations, e.g., introgression of maladaptive genes due to interbreeding with nonnative and hatchery fish, and selection. The population sizes of native stocks may over-represent their genetic resources.

Recent trends may not necessarily tell us whether a stock is headed toward extinction. Jay Nicholas (Oregon Department of Fish and Wildlife, unpublished data) illustrates this point using the example of Columbia River chum landings. Landings during the period from 1960 to 1989 were fairly stable at under 110,000 kg. However, landings during this period scarcely appear at all on a plot of landings from 1938 to 1989, where landings peaked at over 11,000,000 kg in 1944. Long-term records may provide a very different indication of the direction a stock is headed than recent trends alone.

### *Identification of Nature of Threat*

We identified the major factors that threaten these at-risk populations, based on published information and the judgments of those who provided the stock status information. The population of anadromous fish returning to its home stream is the result of complex interactions during an entire life cycle. As one or more of these biological, environmental, or management-related factors changes, the abundance of the returning stock of fish will change (Nicholas and Hankin 1988). Although in nearly all cases several factors are contributing to the depletion of a population, we listed only those that our sources considered to be the most constraining.

The nature of threat refers to current problems, not necessarily the historical cause of the decline. A threat is identified even if efforts have begun to remedy it, if the status of the population has not yet shown improvement. The nature of threat is numerically coded according to the following key:
1. The present or threatened destruction, modification, or curtailment of its habitat or range. (In addition to habitat damage, this category includes mainstem passage and flow problems, and predation during reservoir passage or residence.)
2. Overutilization for commercial, recreational, scientific, or educational purposes. (This category includes overharvest in mixed-stock fisheries.)
3. Disease.
4. Other natural or manmade factors affecting its continued existence (hybridization, introduction of exotic or translocated species, predation not primarily associated with mainstem passage and flow problems, competition). (This category includes negative interactions with hatchery fish, such as hybridization, competition, and disease. Also included here are poor ocean survival conditions.)

## The List

The list of *at high risk* **of** *extinction* **(A),** *at moderate risk of extinction* (B), or *of special concern* (C) salmon, steelhead, and sea-run cutthroat trout stocks is organized by species and race. Stocks that may have become extinct are noted as A+. Stocks on state or federal lists are noted as endangered (E) or threatened (T). Stocks that have been petitioned for listing under the Endangered Species Act of 1973 are noted by an asterisk (*). Native stocks believed to have a high probability of introgression with hatchery stocks are italicized. Numbers indicate the nature of threat as described above.

### Chinook salmon
### *Oncorhynchus tshawytscha*

**Winter race**

1. Sacramento River, T (U.S.), E (California), 1, 4, CA

**Spring/summer race**

1. Sacramento River (including tributaries) (spring race), **B, 1, 2, 4,** CA
2. *Klamath River (spring race),* **A, 1, 2, 4,** *CA*
3. Smith River (spring race), **A,** 1, 2, CA
4. *Yuba River (spring race), B, 1, 2, 4, CA*
5. *Coquille River (spring race), A, 1, 2, 4, OR*
6. *South Umpquu River (spring race), A, 1, 2, 4, OR*
7. Alsea River (spring race), C, 1, 2, OR
8. Siletz River (spring/summer race), C, 1, 2, OR
9. Nehalem River (summer race), C, 1, OR
10. *Willumette River (spring race), C, 1, 2, 4, OR*

11. *Sandy River (spring race), A+, 1, 4, OR*
12. *Hood River (spring race), A, 1, 4, OR*
13. *Klickitat River (spring race), A+, 1, 4, WA*
14. John Day River (spring race), C, 1, OR
15. 'Tucannon River (spring race), A, 1, WA
16. *Asotin Creek (spring race), A, 1, WA
17. **Grande Ronde River (spring race), B, 1, 4, OR, WA*
18. *Imnaha River (spring/summer race), B, 1, OR
19. *Salmon River (summer race), A, 1, ID
20. *Salmon River (spring race), A, 1, ID
21. *Methow River (summer race), B, 1, 4, WA*
22. Okanogan River (summer race), C, 1, WA
23. Wynoochee River (spring race), A, 1, WA
24. Skokomish River, A+, 1, 2, WA
25. Dosewallips River (spring race), A+, 2, WA
26. Dungeness River (spring race), A, 1, WA
27. Elwha River (spring race), A+, 1, WA
28. White River (spring race), B, 1, WA
29. Stillaguamish River (spring race), A+, 1, 2, WA
30. Nooksack River, North Fork, A, 1, 2, WA
31. Nooksack River, South Fork, A, 1, 2, WA

**Fall race**

1. *Shasta River, A, 1, 4, CA*
2. *Scott River, C, 1, 4, CA*
3. San Joaquin River, C, 1, 2, 4, CA
4. Cosumnes River, C, 1, 4, CA
5. Minor Humboldt tributaries, A, 1, 2, CA
6. Lower Klamath tributaries, B, 1, 2, CA
7. Redwood Creek, B, 1, 2, CA
8. Mad River, B, 1, 2, CA
9. Smith River, B, 1, 2, CA
10. Mattole River, A, 1, 2, CA
11. Russian River, A, 1, 2, CA
12. Lower Eel River, B, 1, 2, CA
13. Winchuck River, B, 1, 2, 4, OR
14. Pistol River, B, 1, 2, 4, OR
15. Hunter Creek, A, 1, 2, OR
16. Rogue River (lower tributaries), A, 1, 2, OR
17. *Euchre Creek, A, 1, 2, 4, OR*
18. *Coos River, C, 4, OR*
19. Yachats River, B, 1, OR
20. *Yaquina River, C, 4, OR*
21. *Lower Columbia River (small tributaries), A+, 1, 2, 4, OR, WA*
22. *Cowlitz River, A, 1, 2, 4, WA*
23. Sandy River, A, 1, 2, OR
24. *Washougal River, A +, 1, 2, 4, WA*
25. *White Salmon River, A +, 1, 4, WA*
26. *Hood River, A, 1, 4, OR*
27. **Snake River, A, 1, 2, 4, OR, WA, ID*
28. Duckabush River, A, 2, WA
29. Dosewallips River, A, 2, WA
30. Dungeness River, A, 1, WA
31. Ozette River, A+, 1, WA
32. *Puyallup River, C, 1, 2, 4, WA*

## Coho salmon
### *Oncorhynchus kisutch*

1. California small coastal streams north of San Francisco, B, 1, CA
2. California small coastal streams south of San Francisco, A, 1, CA
3. *Klamath River, C, 1, 4, CA*
4. *Winchuck River, A, 1, 2, 4, OR*
5. *Chetco River, A, 1, 2, 4, OR*
6. *Pistol River, A, 1, 2, 4, OR*
7. *Rogue River, A, 1, 2, 4, OR*
8. *Elk River, A, 1, 2, 4, OR*
9. *Sixes River, A, 1, 2, 4, OR*
10. *Floras Creek, A, 1, 2, 4, OR*
11. *Coquille River, B, 1, 2, 4, OR*
12. *Coos River, B, 1, 2, 4, OR*
13. *Umpqua River, B, 1, 2, 4, OR*
14. *Siuslaw River, B, 1, 2, 4, OR*
15. *Yachats River, B, 1, 2, 4, OR*
16. *Alsea River, B, 1, 2, 4, OR*
17. *Beaver Creek, B, 1, 2, 4, OR*
18. *Siletz River, B, 1, 2, 4, OR*
19. *Salmon River, B, 1, 2, 4, OR*
20. *Nestucca River, B, 1, 2, 4, OR*
21. *Tillamook Bay, B, 1, 2, 4, OR*
22. *Nehalem River, B, 1, 2, 4, OR*
23. *Elk Creek, B, 1, 2, 4, OR*
24. *Necanicum River, B, 1, 2, 4, OR*
25. **Lower Columbia River tributaries, A, 1, 2, 4, OR, WA*
26. *Clackamas River, B, 1, 2, 4, OR*
27. **Sandy River, A, 1, 2, 4, OR*
28. *"Washougal River, A +, 1, 4, WA*
29. *Hood River, A, 1, 2, OR
30. *Willapa Bay, A, 2, 4, WA*
31. *Chambers Creek, A, 1, 2, 4, WA*
32. Lyre River, A, 1, WA
33. *Elwha River, A, 1, 4, WA*
34. Lake Ozette, C, 1, WA
35. *Nooksack River, A+, 1, 2, 4, WA*

## Sockeye salmon
### *Oncorhynchus nerka*

1. Deschutes River, A, 1, OR
2. *Redfish Lake, A+, 1, 2, ID
3. Okanogan River, C, 1, WA
4. Wenatchee River, C, 1, WA
5. Baker River, A, 1, WA
6. Lake Ozette, B, 1, WA

## Chum salmon
### *Oncorhynchus keta*

1. Elk River, A, 1, 2, OR
2. Sixes River, A, 1, 2, OR
3. Coos River, A, 1, 2, OR
4. Umpqua River, A, 1, 2, OR
5. Alsea River, A, 1, 2, OR
6. Yaquina River, A, 1, 2, OR
7. Siletz River, A, 1, 2, OR
8. Netarts River, B, 1, 2, OR
9. Nestucca River, B, 1, 2, OR
10. Tillamook Bay, B, 1, 2, OR
11. Lower Columbia River small tributaries, B, 1, 2, OR, WA
12. Washougal River, A +, 1, WA
13. Duwamish-Green River, A, 1, WA
14. *Hood Canal (early-timed), B, 2, 4, WA*
15. Chambers Creek (early-timed), B, 1, WA
16. Ozette River, A+, 1, WA
17. Elwha River, A +, 1, WA

## Pink salmon
*Oncorhynchus gorbuscha*

1. Russian River, A + , 1, CA
2. Skokomish River, A, 1, WA
3. Dungeness River, B, 1, WA
4. Elwha River, A, 1, WA

## Steelhead trout
*Oncorhynchus mykiss*

Winter race

1. Malibu Creek, A, 1, CA
2. Santa Clara River, A, 1, 4, CA
3. Ventura River, A, 1, CA
4. Santa Ynez River, A, 1, CA
5. Little Sur River, C, 1, CA
6. Big Sur River, C, 1, CA
7. Carmel River, A, 1, CA
8. Salinas River, B, 1, CA
9. Pajaro River, A, 1, CA
10. South San Francisco Bay tributaries, A, 1, CA
11. Sacramento River, A, 1, 4, CA
12. Napa River, A, 1, CA
13. Illinois River, B, 1, OR
14. *Siuslaw River, C, 4, OR*
15. *Big Creek, C, 4, OR*
16. *Tenmile Creek, C, 4, OR*
17. *Yachats River, C, 4, OR*
18. *Alsea River, C, 4, OR*
19. *Yaquina River, C, 4, OR*
20. *Siletz River, C, 4, OR*
21. *Salmon River, C, 4, OR*
22. *Nestucca River, C, 4, OR*
23. *Tillamook Bay, C, 4, OR*
24. *Lower Columbia River small tributaries below Bonneville Dam, B, 1, 4, OR, WA*
25. *Grays River, C, 1, 4, WA*
26. *Elochoman River, C, 1, 4, WA*
27. *Cowlitz River, B, 1, 4, WA*
28. Toutle River, C, 1, WA
29. *Coweeman River, C, 1, 4, WA*
30. *Kalama River, C, 1, 4, WA*
31. *Lewis River, C, 1, 4, WA*
32. *Clackamas River, B, 1, 2, 4, OR*
33. Calapooia River, C, 1, OR
34. *Washougal River, B, 1, 4, WA*
35. Lower Columbia River small tributaries above Bonneville Dam, A, 1, OR, WA
36. Wind River, A, 1, 2, WA
37. *White Salmon River, A, 1, 4, WA*
38. *Hood River, A, 1, 2, 4, OR*
39. Fifteen-Mile Creek, B, 1, 2, OR
40. Klickitat River, A, 1, WA
41. *Dewatto River, A, 1, 2, 4, WA*
42. Lake Washington, B, 4, WA
43. Nooksack River, C, 1, 2, WA
44. Samish River, C, 1, WA
45. *Tahuya River, B, 1, 2, 4, WA*
46. *Skokomish River, C, 1, 4, WA*

Summer race

1. Eel River, B, 1, 2, CA
2. Mad River, A, 1, 2, CA
3. Redwood Creek, A, 1, 2, CA
4. *Klamath River, B, 1, 4, CA*
5. Smith River, A, 2, CA
6. Rogue River, B, 1, 4, OR
7. *Siletz River, B, 4, OR*
8. *Cowlitz River, A, 1, 4, WA*
9. *Lewis River North Fork, A, 1, 4, WA*
10. *Lewis River East Fork, C, 1, 4, WA*
11. *Washougal River, A, 1, 4, WA*
12. Lower Columbia River small tributaries above Bonneville Dam, A, 1, OR, WA
13. *Wind River, B, 1, 4, WA*
14. *White Salmon River, A+, 1, 4, WA*
15. *Hood River, B, 1, 4, OR*
16. *Klickitat River, C, 1, 2, 4, WA*
17. *Walla Walla River, C, 1, 4, OR, WA*
18. *Tucannon River, C, 1, 4, WA*
19. Clearwater River, C, 1, ID
20. Asotin Creek, B, 1, WA
21. Salmon River, C, 1, 2, ID
22. Imnaha River, C, 1, OR
23. *Wenatchee River, C, 1, 2, 4, WA*
24. *Entiat River, A, 1, 4, WA*
25. *Methow River, A, 1, 4, WA*
26. *Okanogan River, A, 1, 4, WA*
27. *Tolt River, A, 1, 2, 4, WA*
28. Stillaguamish River, Deer Creek, A, 1, WA
29. Nooksack River, B, 1, 2, WA

## Sea-run cutthroat trout
*Oncorhynchus clarki*

1. California coastal streams, B, 1, CA
2. *Oregon coastal streams, B, 1, 2, 4, OR*
3. *Lower Columbia River small tributaries below Bonneville Dam, B, 1, 2, 4, OR, WA*
4. *Elochoman River, C, 1, 2, 4, WA*
5. *Cowlitz River, C, 1, 2, 4, WA*
6. *Toutle River, C, 1, 2, 4, WA*
7. *Coweeman River, C, 1, 2, 4, WA*
8. *Kalama River, C, 1, 2, 4, WA*
9. *Washougal River, C, 1, 2, 4, WA*
10. Hood River, A, 1, 2, OR
11. *Rock Creek, A, 1, 2, 4, WA*
12. Washington coastal and Puget Sound tributaries (except Grays Harbor and Hood Canal tributaries), C, 1, 2, WA
13. *Grays Harbor and Hood Canal tributaries, C, 1, 2, 4, WA*

## Summary

We identify 214 native naturally-spawning Pacific salmon and steelhead stocks or groups of stocks in California, Oregon, Washington, and Idaho that met our criteria. Of these, one is classified as threatened under the Endangered Species Act and as endangered by the state of California, 101 are at high risk of extinction, 58 are at moderate risk of extinction, and 54 are of special concern (Table 1). Thirty-nine of the stocks occur in California, 58 on the Oregon coast, 76 in the Columbia River basin, and 41 in the Washington coast/Puget Sound area. About half (104) of the stocks have a high probability of introgression with hatchery stocks.

The list is incomplete and provides only an imperfect snapshot of the status of these fishes. Our investigations often were met with incomplete data, a lack of sufficient

**Table 1. Summary of stock status by geographic area and degree of risk.**

| Status | California | Oregon coast | Columbia basin | Washington coast / Puget Sound | Totals |
|---|---|---|---|---|---|
| Listed as threatened or endangered | 1 | — | — | — | 1 |
| High risk (A, A+) | 20 | 19 | 36 | 26 | 101 |
| Moderate risk (B) | 12 | 24 | 14 | 8 | 58 |
| Of special concern (C) | 6 | 15 | 26 | 7 | 54 |
| Totals | 39 | 58 | 76 | 41 | 214 |

information for most systems, and the lack of a comprehensive picture. Because of variability in the quality and amount of data, some parts of the picture are in sharper focus than others; undoubtedly some important areas are hidden in the background. At best, the list helps outline what the shape of a comprehensive picture might be. For these reasons, we characterize our list as provisional, subject to refinement and focus as additional data become available. Unfortunately, the picture may never be fully in focus, as small populations overlooked in the past may continue to be overlooked and disappear unrecognized.

The stocks on our list represent a range of populations including small creeks (e.g., Asotin Creek, Washington), large rivers (e.g., Snake River in Idaho, Oregon, and Washington), and aggregates of streams (e.g., sea-run cutthroat in Oregon coastal streams). The range of how populations are represented on our list in part reflects the variation in data availability. For example, if data were available to describe each sea-run cutthroat population on Oregon's coast, each might be listed separately.

Columbia River basin stocks are especially well documented because of stock assessments and basin plans developed under the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program (Howell et al. 1985; CBFWA 1990a, b). Oregon coastal chinook stocks are well documented as a result of studies funded by Oregon Department of Fish and Wildlife (Nicholas and Hankin 1988). General information on California fish populations is summarized by Moyle et al. (1989).

Eighteen of the stocks on our list may already be extinct. Some are small wild populations for which spawning has not been observed for some time, e.g., spring chinook in Dosewallips River (Washington) and pink salmon in Russian River (California). In other cases, such as coho in Washougal River (Washington), a hatchery program was established "on top of" a native stock and the continued existence of the native stock is in doubt. The same may be true for any basin in which a hatchery program was established in addition to an existing native population. We included several such examples on our list, but more very likely exist.

When natural escapement is estimated as the aggregate of all fish returning to a basin, a decline in a native stock may be masked by returns of hatchery fish. This has occurred with Nooksack River (Washington) coho, where native stock coexisted with a nonnative hatchery program. Escapement data do not show a decline, but returns to the hatchery mask a decline in native stock escapement; the native stock may have become extinct in the early 1980s. In the Sandy River (Oregon), spring chinook escapements have increased since the mid-1970s (CBFWA 1990a, b). This increase resulted from improvements in habitat and outplants of nonnative hatchery fish, and may mask the decline or extinction of a native stock that was at very low levels when the outplanting program began. There may be other examples in which escapement data do not accurately reflect the status of a native population.

Of the stocks on our list, 104 are believed to have a high probability of introgression with hatchery stocks. This category includes (1) native stocks that coexist with large hatchery programs, such as Willamette River spring chinook; (2) native stocks receiving ongoing supplementation by nonnative fish, such as Methow River summer chinook; and (3) native stocks in streams in areas dominated by hatchery production, such as coho on the Oregon coast. The native character of such stocks may have been affected by introgression with the hatchery stocks. More investigation would be required to determine how extensive the influence of hatchery production on native stocks has been.

Stocks being supplemented by artifically-produced native fish, such as Imnaha River (Oregon) spring/summer chinook, were not identified as hatchery-influenced, nor were stocks that received limited supplementation from nonnative fish in the past. The native character of such stocks is less likely to be altered than the foregoing examples.

To put our inventory in perspective, we reviewed Konkel and McIntyre's (1987) assessment of trends in spawning populations of Pacific salmon and steelhead, including the four states we covered plus Alaska. Konkel and McIntyre (1987) found statistically significant trends in about 30% of 886 populations. Coho and chum salmon trends were predominantly decreasing (ratio of increasing to decreasing trends was 1:3) throughout the five-state area. For chinook, sockeye, and pink salmon, trends were predominantly increasing in Alaska and either lacking or predominantly decreasing in the other states. Konkel and McIntyre (1987) concluded that the status of coho and chum were of greatest concern, because declines occurred throughout the study area. Although chinook, sockeye, and pink salmon had increasing trends in Alaska, Konkel and McIntyre (1987) stated that their status is by no means secure because of widespread declines in the other states, especially declines of chinook in the Columbia River basin. These results suggest that concern is justified not only for a large number of naturally-spawning native populations, but also for these species as a whole.

The relatively good status of Alaska's fisheries is discussed by Royce (1989), who believed that much of the credit belongs to improved fishery management that supports continuation of genetic units, primarily by preventing overfishing.

Each of the stock complexes described below has its own history of factors causing its rarity. The erosion of native naturally-spawning salmon and steelhead populations results primarily from habitat loss and damage, and inadequate passage and flows, due to hydropower, agriculture, logging, and other developments; overfishing, primarily of weaker stocks in mixed-stock ocean and river fisheries; and negative interactions with other fish. Improvements in remedying these threats have been made, but the improvements have not been enough to prevent the overall decline of fish stocks on the West Coast.

In many cases, the decline of a native population is attributable to several detrimental factors. The Grande Ronde River (Oregon) historically supported a run of 2,000 to 4,000 coho (Howell et al. 1985), which was initially affected by habitat degradation from logging, livestock grazing, and agriculture. Construction of Snake River dams during the 1960s and 1970s further reduced the population. Management agencies then concluded that the stock was too weak to warrant protection from overfishing in the mixed-stock fisheries. By 1980, the population was reduced to about 50 fish. An attempt was made to restore the run in 1983 and 1984 using artificial production but by then only a few fish remained in the native broodstock, and the attempt failed because too few fish were available for broodstock (CBFWA 1990b). In other cases, populations have been brought to the brink of extinction by hatchery programs attempting to remedy other forms of damage. For example, the spring chinook in Klickitat River (Washington) originally declined as a result of habitat damage and mainstem passage losses. Although sufficient native fish remained to provide broodstock for artificial production, nonnative hatchery stocks have been used so extensively that the native stock may now be extinct.

## *Chinook*

### *Winter Race*

In 1989 the National Marine Fisheries Service (NMFS) listed Sacramento River (California) winter chinook as a threatened species under the Endangered Species Act, and the state of California listed this stock as endangered (Williams and Williams 1989). This is the only remaining winter chinook population in California, and is the first anadromous fish stock to be protected as a threatened or endangered species. Its decline is attributed to inadequate dam passage for adults; poor water flows and high water temperatures; and pollution and habitat damage from mining, irrigation diversions, river channelization, and bank stabilization.

### *Spring and Summer Races*

Native spring and summer chinook populations from California, the Oregon coast, the Columbia River basin, and Puget Sound appear on our list. The exception is the Washington coast area, where returns of all spring chinook stocks have increased in recent years (Gary Morishima, Quinalt Indian Nation, personal communication).

In California, native spring chinook populations persist in the Sacramento and Klamath river systems, with remnant populations in the Smith and Yuba rivers and perhaps other small rivers (Moyle et al. 1989). In northern California, Klamath and Smith river populations are declining primarily as a result of habitat damage (Moyle et al. 1989). The Klamath River population has undergone a 95% reduction from historical population levels, due to dams, irrigation diversions, mining, timber harvest, and floods. In the Central Valley, chinook stocks have been especially hard-hit by agricultural expansion, including water diversions, improperly screened irrigation facilities, pollution, dams, and alteration of delta flow patterns. Spring chinook in the entire San Joaquin River drainage already have been lost, and only the Sacramento River population, with 850 spawners recorded in 1987, remains in the Central Valley (Moyle et al. 1989).

The five Oregon coast spring chinook stocks that appear on our list are affected primarily by habitat damage from development activities, and overfishing or poaching (Nicholas and Hankin 1988). Five other populations surveyed by them do not qualify for our list. Damage to coastal habitat has resulted from forestry-related activities in headwater areas, agricultural and residential activities in mainstem floodplain areas, and commercial-industrial, residential, and recreational activities in many estuarine areas (Nicholas and Hankin 1988). The Coquille and South Umpqua populations also are threatened by introductions of nonnative hatchery fish (Nicholas and Hankin 1988).

Ten Columbia River basin spring chinook stocks appear on our list. (Native naturally-spawning populations originating in the Yakima, Deschutes, Methow, Entiat, and Wenatchee rivers do not appear to qualify.) Five of these ten populations, those from Grande Ronde, Imnaha, Tucannon, Salmon rivers, and Asotin Creek, compose the native naturally-spawning populations of the Snake River drainage. All have declined to low levels, e.g., Salmon River (Idaho) spring chinook redd counts in some index areas are less than 30% of the 1958-62 period. These stocks are threatened primarily by inadequate mainstem passage and water flows, and habitat damage (CBFWA 1990a, b). NMFS is reviewing the status of Snake River spring, summer, and fall chinook, in response to Endangered Species Act petitions submitted in June 1990 by the conservation group Oregon Trout, the Oregon and Idaho Chapters of the American Fisheries Society, and other cosigners. Oregon Department of Fish and Wildlife (1990) has added Snake River spring chinook populations to its Sensitive Fish Species list.

In the Hood River (Oregon), there are estimated to be fewer than 100 spring chinook spawners annually (CBFWA 1990a, b). This population appears to be near extinction; it is threatened by habitat loss, agricultural diversions, and inadequate dam passage. To help rebuild its numbers, the population is being supplemented with nonnative fish. In Sandy (Oregon) and Klickitat (Washington) rivers, hatchery programs are in place and it is not known whether any native stock persists. In the Willamette River, a system dominated by a very successful hatchery program, natural spawners have decreased from about 25% in 1970 to about 5- 15% today (CBFWA 1990a, b). This population is affected by habitat loss, dam passage, overharvest in fisheries with abundant hatchery fish, and potentially by negative interactions with the hatchery fish. It is unknown whether distinct native stocks remain in the Willamette River. The spring chinook population in John Day River is considered to be of special concern, because though reduced substantially from historic levels, it may be increasing after at least 10 years of declining returns (CBFWA 1990a, b). This population is affected primarily by habitat damage and inadequate mainstem dam passage.

Three of four remaining Columbia River basin summer chinook stocks qualify for our list. Summer chinook populations in the Salmon River, Idaho (Snake River drainage), are at very low levels. Redd counts in some index areas are less than 50% of 1958-62 levels (CBFWA 1990a, b). NMFS is reviewing the status of Snake River summer chinook, in response to the Endangered Species Act petition submitted by Oregon Trout and other cosigners.

Summer chinook populations in the Methow and Okanogan rivers have declined primarily because of inadequate mainstem passage and habitat loss and damage (CBFWA 1990a, b). These stocks, historically very abundant, now average 500 1,000 natural and hatchery spawners (Methow) and 1,000 natural spawners (Okanogan). Summer chinook in Wenatchee River did not qualify for our list.

All Puget Sound spring chinook populations are considered depressed, except for the Skagit River (WDF et al. 1989b). Some of these stocks are at or near extinction, including those from the Stillaguamish, Dungeness, Dosewallips, Wynoochee, Elwha, and Skokomish rivers. Various authorities have attributed the poor status of these populations to overfishing — Skokomish (James 1980) and Dosewallips; dam construction-Skokomish (James 1980), Wynoochee, and Elwha; and habitat damage-Dungeness (Hiss 1987) and Stillaguamish. White River spring chinook, reduced to extremely low levels by dam passage problems, appear to be recovering as the result of a natural stock rehabilitation program. The decline of North and South Fork Nooksack River spring chinook stocks, resulting from habitat degradation and poaching, has not been arrested (Schuett-Hames et al. 1988; Gregg Dunphy, Lummi Fisheries Office, personal communication).

### *Fall Race*

Fall chinook populations from all surveyed areas appear on our list. Native fall chinook stocks are under particular pressure on the Oregon coast, in the Snake River basin, and in the lower Columbia River basin.

Two Klamath basin (California) fall chinook stocks qualified for our list. Populations in Shasta and Scott rivers are affected by excessive water diversions and poor habitat quality, and may be affected by large hatchery programs in the basin (Ron Iverson, Fish and Wildlife Service, personal communication). Small populations in northern California streams (minor Humboldt tributaries, lower Klamath tributaries, Redwood Creek; Mad, Smith, Mattole, Russian and lower Eel rivers) have been depleted primarily by habitat damage and overfishing.

Habitat damage and overfishing are the primary factors affecting the eight Oregon coast fall chinook populations that appear on our list (Nicholas and Hankin 1988). Euchre and Hunter creeks and Pistol River have been especially impacted by logging. Fall chinook escapement in Euchre Creek is estimated at 50 to 200 fish. Populations in lower Rogue River tributaries have been very depressed since the 1970s. Populations in Winchuck and Pistol rivers are also threatened by potential introductions of nonnative fish. Fall chinook populations in Yaquina and Coos rivers are considered to be of special concern because of large releases of nonnative hatchery fish. Fifteen other naturally-spawning fall chinook stocks surveyed by Nicholas and Hankin (1988) did not meet the criteria for our list. Oregon Department of Fish and Wildlife (ODFW 1990) has added fall chinook salmon populations south of Bandon (including Winchuck and Pistol rivers, Rogue River populations downstream of Agness, and Hunter and Euchre creeks) to its Sensitive Fish Species list.

In the Columbia River basin, native upriver fall chinook populations originating in the Hanford reach (Washington) and Deschutes River (Oregon) remain strong. Native naturally-spawning fall chinook populations in the Snake River have declined to very low levels, primarily as a result of inadequate mainstem passage and flows, habitat loss, and overharvest (CBFWA 1990a, b). The status of these stocks is being reviewed by NMFS in reponse to the petition submitted by Oregon Trout and other cosigners. The Snake River stocks in Oregon have been added to the Sensitive Fish Species list for that state (ODFW 1990).

A single strong native lower river population persists in the Lewis River (Washington). A native population in the Sandy River (Oregon) was reduced to remnant levels by overfishing, loss of habitat, and poor tributary dam passage. Natural spawning of native stocks is believed to be low or nonexistent in lower Columbia River areas dominated by hatchery production, such as the Hood (Oregon), Cowlitz, Washougal, and White Salmon (Washington) rivers, and in smaller lower Columbia River tributaries in Oregon and Washington (CBFWA 1990a, b). Major threats for lower Columbia River stocks include habitat loss and damage, tributary dam passage and inadequate water flows, overfishing, and interactions with hatchery fish.

In the Puget Sound (Washington) area, summer/fall chinook stocks in five of six production areas were strong enough to support fisheries in 1989 (WDF et al. 1989a). However, fall chinook in Puyallup River are of special concern because of threats posed by habitat damage from logging and development, overfishing, and large releases of hatchery fish. In the sixth area, Dungeness River escapement has declined to fewer than 50 adults per year for the last 10 years; the decline is attributed to habitat degradation and insufficient water flows. Two other stocks not addressed by WDF et al. (1989a), from Dosewallips and Duckabush rivers, also have declined to escapements of less than 100, which some authorities have attributed to overfishing and habitat damage. The Ozette River fall chinook population probably is extinct as a result of overfishing in the 1940s and 1950s, and extensive logging in the watershed.

## *Coho*

Native coho populations are most at risk at the southern and eastern portions of their range, largely as a by-product of successful hatchery programs. Native populations in California and on the Oregon coast appear on our list. Columbia River coho stocks above Bonneville Dam have been nearly eliminated, and are at very low levels below Bonneville Dam.

In California, small native coho populations exist as far south as the San Lorenzo River (Shapovalov and Taft 1954; Hassler et al. 1988; Pacific Fishery Management Council 1990). The short-run populations appear to be at very low levels and are threatened by habitat damage from poor stream and watershed management, especially logging (Moyle et al. 1989). Populations from longer rivers, such as the Klamath River, are also threatened by interactions with hatchery fish from large-scale hatchery programs.

Oregon coastal coho stocks are dominated by hatchery programs. Many native coho stocks on the southern Oregon coast have declined from historical levels of about 2,000 spawners to fewer than 100, which has resulted in ODFW (1990) adding these populations to their Sensitive Fish Species list. Dam counts of native naturally-spawning Rogue River coho declined from an average of 2,300 before 1964 to about 200 between 1964 and 1976, as a result of habitat loss and habitat damage from dams and other factors (ODFW 1989). A hatchery program began releasing fish in 1976, and returns of wild fish to the area above the hatchery are believed to have been low since then. A pre-1970 decline in coho populations on the north and central Oregon coast appears to have stabilized in subsequent years; these stocks generally are in better condition than those farther south. Oregon coastal coho stocks are threatened primarily by overharvest, habitat damage, and interactions with hatchery fish.

Native coho stocks that once ranged into Snake River and mid-Columbia tributaries of the Columbia River basin are now extinct above Bonneville Dam, with the exception of a remnant population in the Hood River (CBFWA 1990a, b). The loss of these populations is attributed primarily to mainstem passage problems, habitat damage, overharvest, and interactions with hatchery fish. The latter two factors resulted from management emphasis on the successful hatchery program, causing the eradication of wild stocks (CBFWA 1990b). Native coho populations in the lower Columbia River (including Hood River and Sandy River [Oregon], Washougal River [Washington] and small tributaries) have decreased to less than one spawning fish per mile in small tributaries primarily because of overharvest, interactions with hatchery fish, and habitat damage (CBFWA 1990a, b). The status of these stocks is being reviewed by NMFS in response to a petition submitted by Oregon Trout and other cosigners in June 1990. Clackamas River coho, a native stock that remains fairly strong, is considered to be of special concern because it is the last substantial remaining native coho stock in the Columbia River basin. The state of Oregon (ODFW 1990) has included all of its Columbia River coho populations on the Sensitive Fish Species list.

In the Washington coast/Puget Sound area, coho populations in the Elwha and Lyre rivers are at levels below 200 spawners (WDF et al. 1989c); the low levels are attributed to habitat damage and loss. A coho population in the Ozette River is believed to be stable at low levels but no data are available; the Ozette system has been severely damaged due to logging of 90% of the watershed. In Willapa Bay, a hatchery-dominated system, natural escapement has declined from an average of about 4,800 in 1976-80 to very few fish today (Pacific Fishery Management Council 1990), owing to overharvest and interactions with hatchery fish. Natural escapement to Chambers Creek, a hatchery-dominated system, has ranged from 100 to 800 since 1979, and may be declining due to habitat degradation, interactions with hatchery fish, and overfishing. Most or all of these fish are believed to be hatchery strays. In the Nooksack River, total natural escapement (native and hatchery fish) has remained stable, but native stock escapements are believed to be very low or nonexistent due to overfishing, interactions with the hatchery fish, and habitat damage (Mark Schuler, Washington Department of Fisheries, personal communication).

### *Chum*

Chum are in jeopardy in Oregon and the Columbia River basin, near the southern end of their range. The poor condition of these chum populations is attributed to their sensitivity to degraded water quality, incidental overharvest, and competition with hatchery fish in streams.

Numerous early records exist for chum salmon in California as far south as the Salinas River (Evermann and Clark 1931). Moyle (1976) considered them to be strays from rivers north of that state, but small spawning runs (now extinct) probably occurred at least in the Klamath and Sacramento rivers (Snyder 1931; Hallock and Fry 1967). On the southern Oregon coast, historically small chum stocks are nearly extinct as a result of overfishing and habitat damage. Chum populations on Oregon's north coast appear to have been stable at low levels for several years. All chum populations in Oregon are included on that state's Sensitive Fish Species list (ODFW 1990).

In the Columbia River basin, historically large chum stocks in the lower river have declined to about 0.5% (total escapement about 2,000 fish) of their historic level, but appear to be stable at this very low level (CBFWA 1990a, b). These chum populations have been reduced primarily by habitat degradation from forest and agricultural practices, urbanization, pollution, and overharvest in mainstem fisheries directed at coho and fall chinook.

In the Washington coast/Puget Sound area, chum populations in the Duwamish-Green and Elwha rivers are very small or extinct due to habitat loss and degradation. Natural escapement of Hood Canal early chum has declined from over 40,000 in 1968 to less than 5,000 since 1979. Chambers Creek early chum escapement is at low levels (under 100 several times since 1979), but appears to be rebuilding (5,235 in 1988).

### *Sockeye*

Sockeye in the Columbia River basin have been heavily impacted by loss of an estimated 96% of their habitat (Northwest Power Planning Council 1986). The Snake River sockeye is now considered to be functionally extinct; two fish were reported at Lower Granite Dam in 1989 and one in 1990 (CBFWA 1990a, b). Today production is limited to Redfish Lake in the Stanley Basin, Salmon River headwaters, Idaho. Production has declined, and mortality primarily during juvenile migration has increased. Overall, stock productivity is poor. NMFS is reviewing the status of Snake River sockeye in response to a petition submitted by the Shoshone-Bannock Tribes in March 1990. Sockeye in the Deschutes River (Oregon) were largely eradicated by dam construction, but incidental passage of smolts from a resident kokanee population maintains a small anadromous run. The two remaining substantial sockeye stocks in the Columbia River basin, originating in Okanogan and Wenatchee rivers, did not meet expectations in 1990, and are considered to be of special concern.

In the Puget Sound (Washington) area, the Baker River sockeye population has declined from an average escapement of about 3,000 in 1967-78, to an average of about 650 since 1979. The decline has been attributed to upstream and downstream passage problems as a result of dam construction. The other sockeye stock in Puget Sound, Lake Washington, did not qualify for our list. The Lake Ozette sockeye run on the Washington coast has declined from 30,000 historically to about 1,000 during the past year because of logging and overfishing during the 1940s and 1950s.

### *Pink*

In the survey area, pink salmon occur in Washington and as far south as the Salinas River in California (Snyder 1931). There are few spawning records for pink salmon in California; many recent sightings of adults may be strays produced from rivers to the north. Early records indicate that small spawning runs formerly occurred at least in the Klamath, Russian, and Sacramento rivers (Evermann and Clark 1931; Snyder 1931). The last documented spawning of pink salmon in California was from the Russian River in 1955 (Fry 1967; Moyle et al. 1989). We include the Russian River pink salmon in our list, consider the Klamath and Sacramento populations extinct, and do not include other California stocks because of a lack of spawning records.

In the Puget Sound (Washington) area, pink salmon stocks in the Elwha and Skokomish rivers have declined to escapements of 100 or fewer due to dam construction and habitat damage. The Dungeness River population had decreased by 90% of its historical level by 1981, due to insufficient flows and habitat degradation. Six major Puget Sound pink salmon production areas did not qualify for our list.

### *Steelhead*

#### *Winter Race*

Many winter steelhead populations are at very low levels. In California, winter steelhead populations have declined in nearly all streams in central and southern California. The situation is critical in four streams: Ventura (Moore 1980), Santa Clara (Hubbs 1946; Moore 1981), and Santa Ynez (Curtis 1937; Shapovalov 1944) rivers and Malibu Creek (Franklin and Dobush 1989) all have spawning escapements of 100 or fewer. Before 1920, Santa Ynez River, the largest of these, had a run size estimated at about 10,000 to 20,000 adults during extreme wet cycles. The smallest, Malibu Creek, the present-day southern limit of steelhead, historically had about 1,000 adults. All of these stocks are threatened by loss of habitat due to dams and habitat damage. Five central California populations (originating in the Little Sur, Big Sur, Carmel, Salinas, and Sacramento rivers) are affected primarily by water withdrawals, while stocks in Pajaro and Napa rivers and tributaries of south San Francisco Bay have been depleted primarily by habitat damage.

On the Oregon coast, winter steelhead stocks from Siuslaw River north to Tillamook Bay appear to be declining. The cause of the apparent decline is unknown but has been attributed to ocean feeding conditions, widespread use of hatchery stock, predation by marine mammals, and ocean drift-net fishing. In the Illinois River (tributary to the Rogue River), winter steelhead catches have declined since the mid-1970s; the decline is attributed to water withdrawals for irrigation.

In the Columbia River basin, all winter steelhead stocks appear on our list. Columbia River basin winter steelhead stocks above Bonneville Dam, in Wind, Hood, White Salmon, and Klickitat rivers, 15-Mile Creek, and small Columbia River tributaries, are all at very low levels, primarily as a result of mainstem dam passage and habitat damage (CBFWA 1990a, b). Below Bonneville Dam, hatchery production of winter steelhead is extensive, and small native populations are supplemented with, coexist with, or are subsumed by hatchery stocks in Grays, Washougal, Lewis, Elochoman, Kalama and Cowlitz rivers (Washington), Clackamas River (Oregon), and small Columbia River tributaries in Oregon and Washington (in Oregon they may be extinct) (CBFWA 1990a, b). These stocks are threatened primarily by habitat damage and by interactions with hatchery fish. Only the Toutle River is managed for natural production of winter steelhead. This population was devastated by the eruption of Mount St. Helens in 1980. Although much of the Toutle River is recovering, recovery of the North Fork is impeded by a sediment control structure that is flooding habitat and impeding passage of fish.

Several winter steelhead populations in the Puget Sound area of Washington have declined primarily as a result of habitat damage, such as water quality problems, siltation, and sedimentation. Depleted populations occur in the Nooksack, Samish, Tahuya, Dewatto, and Skokomish rivers. The winter steelhead stock in Lake Washington has decreased from an escapement of about 2,000 prior to 1983 to about 700 in 1988 -89, reportedly as a result of sea lion predation.

#### *Summer Race*

In California, summer steelhead have declined in most river systems; most California stocks are represented by fewer than 100 spawners each. Only the Middle Fork Eel (600-1,700 spawners annually) and Klamath River tributaries, such as North Fork Trinity, Clear Creek, Dillon Creek, New River, and Salmon River (300-500 spawners annually each) retain substantial populations (Eric Gerstung, California Department of Fish and Game, personal communication; Moyle et al. 1989). California summer steelhead were severely affected by floods in 1964 that caused extensive erosion and habitat damage in watersheds stressed by poor land management. The habitat is gradually recovering but populations have not increased substantially because of poaching and habitat damage (Moyle et al. 1989).

On the Oregon coast, Rogue and Siletz river summer steelhead populations have declined, reportedly owing to adverse ocean feeding conditions and marine mammal predation on both stocks; additional threats are posed by habitat damage and water withdrawals in Rogue River and possibly by hatchery fish interactions in the Siletz River.

In the Columbia River basin, nearly all upriver and many lower river summer steelhead stocks appear on our list (CBFWA 1990a, b). Stocks in the Kalama, Yakima, Grande Ronde, John Day, and Deschutes rivers did not qualify. Most

Snake River native stocks (Tucannon, Clearwater, Salmon, and Imnaha rivers) are considered of special concern because they appear to be improving after having declined. These Snake River steelhead populations are primarily affected by mainstem passage problems, inadequate water flows, and habitat degradation.

Hatchery programs exist in all mid-Columbia summer steelhead-producing areas, with the result that naturally-spawning fish may be of hatchery, native, or mixed origin. In the Wenatchee River, the naturally-spawning component is estimated at about 7%, with an escapement of about 1,000 (CBFWA 1990a, b). Natural escapement to the Entiat River is unknown but believed to be well below historical levels (CBFWA 1990 a, b). The naturally-spawning component in Methow River is estimated at about 5%, with escapement estimates ranging from a few to 400 (CBFWA 1990a, b). In the Okanogan River, few if any native fish remain (CBFWA 1990a, b). All of these populations are threatened by mainstem passage, habitat damage, and interactions with hatchery fish.

Hatchery programs dominate the lower Columbia River. Few if any native fish remain in the Washougal, North Fork Lewis, Cowlitz, and White Salmon rivers (Washington). In the lower Columbia River area, the major threats to native summer steelhead stocks are habitat damage and loss and interactions with hatchery fish. Above Bonneville Dam, the Wind and Klickitat rivers (Washington), Hood River (Oregon), and Walla Walla River (Oregon-Washington) are supplemented with nonnative hatchery stocks; populations are also affected by Bonneville Dam passage. Small Columbia River tributaries above Bonneville Dam do not receive hatchery releases. Populations in these tributaries are believed to be very low.

Summer steelhead populations in three northern Puget Sound (Washington) streams appear to be declining. A native run in Deer Creek, in the otherwise hatchery-dominated North Fork Stillaguamish River, has declined to about 100 fish because of habitat damage and siltation from logging. This run was historically the largest summer steelhead run in Puget Sound. Escapement of a hatchery-augmented population in Tolt River, tributary to the Snoqualmie River, has declined to about 20 adults; the wild:hatchery ratio decreased from 8.3:l in 1981 to 1:2 1989. This stock is threatened most by overfishing, poaching, habitat damage, and interactions with the hatchery fish (Pfeifer 1990). The summer steelhead population in Nooksack River has declined as a result of habitat damage from logging and poaching.

### *Sea-run Cutthroat*

This historically abundant and widespread species has undergone a major decline in the past 15 – 20 years (Gerstung 1981; Trotter 1989). The decline appears to be widespread throughout the survey area and may represent the most precarious situation. Few data are available, but what data there are indicate that a major decline is occurring, owing principally to habitat damage and overfishing. For populations above Bonneville Dam, dam passage takes a toll as well. Many areas are augmented by hatchery production, which may further erode native stocks. The state of Oregon has added sea-run cutthroat populations to its Sensitive Fish Species list (ODFW 1990).

## *Extinct Populations*

Records of extinct salmon and steelhead populations along the West Coast are sketchy. The earliest documented stock extinction called to our attention occurred in 1852.

> There were some sockeye in Mason Lake, south of Hood Canal (Puget Sound area). These ran up Sherwood Creek from Allyn on Case Inlet. They'd hang around the lake till ripe, then run up the creeks from there. The Squaxon got them with a weir in Sherwood Creek. Finally a pioneer named Sherwood built a little dam in the creek and stopped the fish, and they named the creek after him.
>
> -Henry Allen, a Twana Indian born about 1865. (Elmendorf 1960, p. 62, cited by Lane 1972, p. 2).

As early as 1880, Stone (1883) was convinced that all salmon populations in the Feather, Yuba, and American rivers, and all major tributaries of the Sacramento River had been lost because of the effects of extensive hydraulic mining. Although salmon populations have been reestablished on these rivers, the original genetic material comprising an unknown number of runs has been lost. In addition to a lack of historical data, estimation of stock losses also can be obscured if strays from adjacent drainages are present. It may be difficult to distinguish the last individuals of one population from strays of another without adequate life history and genetic data. The 18 stocks we list for which data are insufficient to determine whether they are extinct illustrate this problem.

The loss of other runs has been well documented. Dams and logging on Washington's Elwha River sharply reduced salmon populations, leading to the loss of spring chinook and sockeye populations (Brown 1982). Elwha River spring chinook apparently lived 10 or 12 years and commonly reached 100 pounds, the size needed to ascend numerous steep canyons and rapids (Brown 1982).

At least 106 major populations of salmon and steelhead on the West Coast have been extirpated (Table 2). Including smaller tributaries, Oregon Trout listed over 200 stock extinctions in the Columbia River basin. Oregon Trout identified 95 streams where chinook have disappeared, 83 streams where steelhead have been lost, 17 streams where coho are gone, and 12 Columbia River basin tributaries where sockeye salmon have been extirpated (Paul Felstiner, Oregon Trout, personal communication).

Stocks have been extirpated as a result of many factors. Many dams lacked fish passage facilities, causing failure of upstream salmon populations. Construction in 1916 of Iron Gate Dam on the Klamath River in northern California blocked access to chinook salmon into the Klamath, Sprague, Williamson, and Wood rivers in Oregon, resulting in loss of these populations. Completion of Dworshak Dam in 1974 on the Clearwater River (Idaho) established a total block to steelhead and chinook salmon entering this tributary of the Snake River.

Many other dams in the Columbia River basin were also constructed without fish passage facilities, resulting in widespread population losses. It has been estimated that one-third of salmon and steelhead habitat in the Columbia River basin has been lost as a result of impassable dams (Northwest Power Planning Council 1986). Because of major declines in salmon and steelhead runs due to dams and other factors and increased reliance on hatchery fish (Columbia River fish runs average about 75% hatchery-produced fish),

**Table 2. Partial list of extinct native stocks of salmon and steelhead from California, Oregon, Idaho, Washington, and Nevada.**

## Chinook salmon — *Oncorhynchus tshawytscha*

**Winter race**

Calaveras River (CA)

**Spring/summer races**

Sprague River (OR)
Williamson River (OR)
Wood River (OR)
Klamath River (OR)
San Joaquin River (including all tributaries) (CA)
American River (CA)
McCloud River (CA)
Pit River (CA)
Weiser River (spring) (ID)
Powder River (spring) (ID)
White Salmon River (spring) (WA)
Umatilla River (spring) (OR)
Metolius River (spring) (OR)
Clearwater River (spring and summer) (ID)
Columbia River small tributaries from Bonneville to Priest Rapids dams (spring) (OR-WA)
Walla Walla River (spring) (OR-WA)
Yakima River (summer) (WA)
Entiat River (summer) (WA)
Okanogan River (spring) (WA)
Lewis River (spring) (WA)
Payette River (ID)
Malheur River (OR)
Boise River (ID)
Owyhee River (OR)
Bruneau River (ID)
Spokane River (WA)
Colville River (WA)
Kettle River (WA)
San Poil River (WA)
Pend Oreille River (WA)
Snohomish River (spring) (WA)
Duwamish-Green River (spring) (WA)
Puyallup River (spring) (WA)
Nisqually River (WA)

**Fall race**

Sprague River (OR)
Williamson River (OR)
Wood River (OR)
Klamath River (OR)
Pysht River (WA)
Wind River (WA)
Clearwater River (ID)
Umatilla River (OR)
Willamette River (OR)
Snake River and tributaries above Hells Canyon Dam (OR-ID-NV)
Walla Walla River (OR-WA)
San Poil River (WA)
Spokane River (WA)
Pend Oreille River (WA)
Kootenay River (BC)

## Coho salmon — *Oncorhynchus kisutch*

Malibu Creek (CA)
Euchre Creek (OR)
Grande Ronde River (OR)
Wallowa River (OR)
Tucannon River (WA)
Clearwater River (ID)
Walla Walla River (OR-WA)
Spokane River (WA)
Snake River (OR-WA-ID)
Methow River (WA)
Columbia River small tributaries from Bonneville Dam to Priest Rapids Dam (OR-WA)
Yakima River (WA)
Umatilla River (OR)
Wenatchee River (WA)
Entiat River (WA)

## Sockeye salmon *Oncorhynchus nerka*

Payette River (ID)
Metolius River (OR)
Wallowa River (OR)
Yakima River (WA)
Skaha, Okanogan (Okanogan Basin, WA)
Alturas, Petit, Stanley, Yellowbelly (Salmon Basin, ID)
Columbia River tributaries above Grand Coulee Dam (Upper Arrow, Lower Arrow, Whatshan, Slocan lakes; WA and Canada)
Elwha River (WA)
Mason Lake (WA)

## Chum salmon — *Oncorhynchus keta*

Umatilla River (OR)
Walla Walla River (OR-WA)
Klamath River (CA)
Sacramento River (CA)
Nisqually River, normal timed (WA)

## Pink salmon — *Oncorhynchus gorbuscha*

Klamath River (CA)
Sacramento River (CA)

## Steelhead trout — *Oncorhynchus mykiss*

San Luis Rey River (CA}
San Mateo Creek (CA)
Santa Margarita River (CA)
Rincon Creek (CA)
Gaviota Creek (CA)
Maria Ygnacio River (CA)
Los Angeles River (CA)
San Gabriel River (CA)
Santa Ana River (CA)
San Diego River (CA)
Sweetwater River (CA)
Spokane River (WA)
Owyhee River (OR)
Malheur River (OR)
Bruneau River (ID)
Weiser River (ID)
Boise River (ID)
Sandy River (OR) (summer steelhead)
Powder River (OR)
Burnt River (OR)
Payette River (ID)
Pend Oreille River (WA)
South Umpqua River (OR) (summer steelhead)

## Sea-run cutthroat trout- *Oncorhynchus clarki*

Wind River (WA)
Klickitat River (WA)

natural production in the Columbia River basin now is about 4-7% of pre-development levels. This likely represents a significant loss of genetic diversity.

In California, dams, water diversions, and pollution have caused the loss of most salmon and steelhead populations south of Point Conception. One exception is the southernmost extant run of steelhead, a remnant population in Malibu Creek, Los Angeles County. Other Los Angeles County steelhead populations and those of San Diego County are extinct. Historically, most larger southern California streams supported annual steelhead runs of 5,000 to 20,000 adults (Shapovalov 1944; Moore 1980).

With the loss of so many populations prior to our knowledge of stock structure, the historic richness of the salmon and steelhead resource of the West Coast will never be known. However, it is clear that what has survived is a small proportion of what once existed, and what remains is substantially at risk.

## Recommendations

Successful management of anadromous salmonid populations requires an integration of short-term strategies aimed at preventing further erosion of genetic resources with longer-term strategies of conservation, protection, and monitoring. We begin with the short-term strategies, to protect, as Aldo Leopold calls them, "every cog and wheel."

> The last word in ignorance is the man who says of an animal or plant: "What good is it?" If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.
>
> Aldo Leopold (1953). Round *River*.

### *Short-Term Management of Stocks Threatened with Extinction*

- Develop and implement interim recovery programs for those populations at greatest risk of loss. Interim recovery actions may include increases in flows and changes in flow timing to facilitate fish passage, protection and restoration of habitat, special fishing regulations, or temporary hatchery programs (but see discussions in Goodman 1990; Waples and Teel 1990).
- List populations pursuant to the Endangered Species Act of 1973 in cases where other strategies are insufficient to prevent extinction. Populations may be listed by emergency rule, if necessary, which provides immediate but temporary protection (for 240 days) under the Endangered Species Act.

### *Long-Term Management of Declining Stocks*

- Management efforts should focus on conservation of ecosystems through perpetuation of natural reproduction of wild stocks. Flows will need to be reallocated to increase natural spawning and fish passage. Basic habitat integrity and ecosystem processes need to be stressed in management plans. The needs of other native aquatic species must also be incorporated into management schemes.
- Existing programs of interbasin transfers of stocks and artificial propagation in hatcheries should be greatly curtailed and reorganized. Hatcheries, which can be a successful management tool, often have posed threats to integrity of wild populations (Reisenbichler and McIntyre 1977; Chilcote et al. 1986; Nickelson et al. 1986). Problems of stock conservation have led to a succession of guidelines for genetic conservation (Lannan and Kapuscinski 1984; Riggs 1986, 1990), but these measures need to be fully implemented. Federal regulation of hatchery programs is needed to direct propagation facilities to preserve existing genetic diversity of wild stocks. As Goodman (1990) pointed out, federal regulation of hatcheries producing salmon and steelhead could prevent the future need to list certain stocks pursuant to the Endangered Species Act.
- NMFS and Fish and Wildlife Service (FWS) should renegotiate their respective roles for protection of anadromous species pursuant to the Endangered Species Act. Both agencies should consider a shared responsibility where NMFS maintains responsibility for implementation of the Act while the populations are in marine habitats, but FWS maintains responsibility for populations in freshwater habitats. A similar shared responsibility is in place for endangered and threatened sea turtles, where NMFS manages the species in the oceans and FWS manages the species on beaches.
- NMFS and FWS should develop a comprehensive list of category 1, 2, and 3 candidate species to be considered for protection pursuant to the Endangered Species Act. The list of declining populations presented here is not complete, but might serve as a starting point for development of a candidate species list. The candidate species list should be revised frequently to incorporate results of monitoring programs, plus the inclusion of other populations as more information becomes available.
- Develop a long-term monitoring program that tracks the status of *all* anadromous fish populations on the Pacific Coast. The number of populations considered herein may be an appropriate starting point, but coverage should be expanded to include stocks with unknown, stable, or increasing populations, plus those in British Columbia and Alaska. Also, our list undoubtedly is incomplete for the states of Washington, Oregon, Idaho, and California. This monitoring program should be organized by NMFS and FWS with the cooperation of state fish and wildlife agencies, appropriate Indian tribes, the Northwest Power Planning Council, and other appropriate regional planning entities. All category 1 and 2 candidate populations should be included in the monitoring program.
- Continue studies designed to identify stocks of Pacific salmon. Evidence presented by Ricker (1972), Howell et al. (1985), and Nicholas and Hankin (1988) suggested that where observations have been made differences in stocks have been found. Many of our existing stock identification studies have been guided by contemporary needs. For example, differences have been found in disease resistance in stocks of salmon and steelhead (Buchanan et al. 1982; Hemmingsen et al. 1986; Wade 1986) because that information was important to the success of hatchery outplanting programs. Ocean distribution patterns of stocks have been identified to aid in allocating catch among political harvesting units. Timing of migration has been determined to help operate hydropower facilities. Juvenile life histories are determined to devise better ways of protecting habitat from logging, agriculture, and other developments. But who can determine what environmental and political conditions will

exist in the future, what stock traits future biologists will be looking for, (and more importantly, what traits the stocks will need) to cope with future conditions? Our knowledge of the uniqueness of stocks, because it has been so strongly shaped by contemporary needs and problems, should not be viewed as a complete determination of the value of stocks, especially the value of existing stocks, in resolving future management problems. For example, in future environments, resistance to acidic water or warmer temperatures may be extremely important stock attributes. To date, stocks have not been examined for these and a myriad of other potentially valuable traits.

Finally, in spite of data limitations and inadequate development of some fundamental concepts, we believe that this report is a necessary first step in addressing the deteriorating status of native anadromous fish stocks. Broad concern for the anadromous fish resource must now be translated into on-the-ground actions. Other opportunities to save fisheries have been squandered because of concerns for adequate data. This lesson was clearly noted for another Pacific fishery.

> The California sardine fishery is a monument to the failure to act in time, and to the insistence of having conclusive scientific evidence before acting.
>
> -J. A. Gulland (1974, p. 8). The *Management of Marine Fisheries*

## Acknowledgments

Many agencies and individuals generously provided status information on declining anadromous fish runs and thoughtful reviews of the manuscript. In particular, the Committee thanks Pat Bigelow, Fish and Wildlife Service, Olympia, WA, for her significant contribution. Others whose help was instrumental include California Department of Fish and Game, especially Eric R. Gerstung, Shoken Sasaki, and A. E. Naylor; Mark H. Capelli, California Coastal Commission; Doug Cramer, Portland General Electric; James Edmondson, California Trout; David W. Hamilton, Grays Harbor Fisheries Enhancement Task Force; Pat Higgins, Arcata, CA; Idaho Chapter American Fisheries Society, especially David Burns and Cleve Steward; Idaho Department of Fish and Game, especially Bruce Rieman; Mark LaRiviere, Makah Tribe; Bill McMillan, Clark-Skamania Flyfishers; National Park Service, especially John Aho and John Meyer; Nisqually Indian Tribe; Northwest Indian Fisheries Commission; Northwest Power Planning Council, especially Rick Applegate, Chip McConnaha, and Duane Anderson; Oregon Department of Fish and Wildlife, especially Jay Nicholas, Al McGie, Steve Jacobs, Dave Buchanan, Phil Howell, Mark Chilcote, Steve King, Steve Mamoyac, Gene Stewart, Rick Klumph, and Jerry McCleod; Oregon State University, especially Rich Nawa, Chris Frissell, and Jim Lannan; Oregon Trout, especially Paul Felstiner and Bill Bakke; Quinalt Indian Nation, especially Jim Harp, Larry Lestelle, and Gary Morishima; William Royce, Seattle, WA; David Schuett-Hames, Squaxin Island Tribe; Tom Taylor, California Department of Parks and Recreation; Patrick Trotter, Seattle, WA; Tulalip Tribes; USDA, Forest Service, especially Maeton Freel, John West, and Jeffrey Dose; USDI, Fish and Wildlife Service, especially Ralph Boomer, Ron Iverson, Monty Knudsen, and Tom Richardson; William A. Warren, Puyallup Tribe; Washington Department of Fisheries, especially Kahler Martinson, Sam Wright, and Craig Busack; Washington Department of Wildlife, especially Bob Gibbons, Thorn Johnson, John Loch, Bob Pfeiffer, Jim Johnston, and Steve Foley.

The authors very much appreciate financial assistance provided by the AFS Oregon Chapter, for printing.



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