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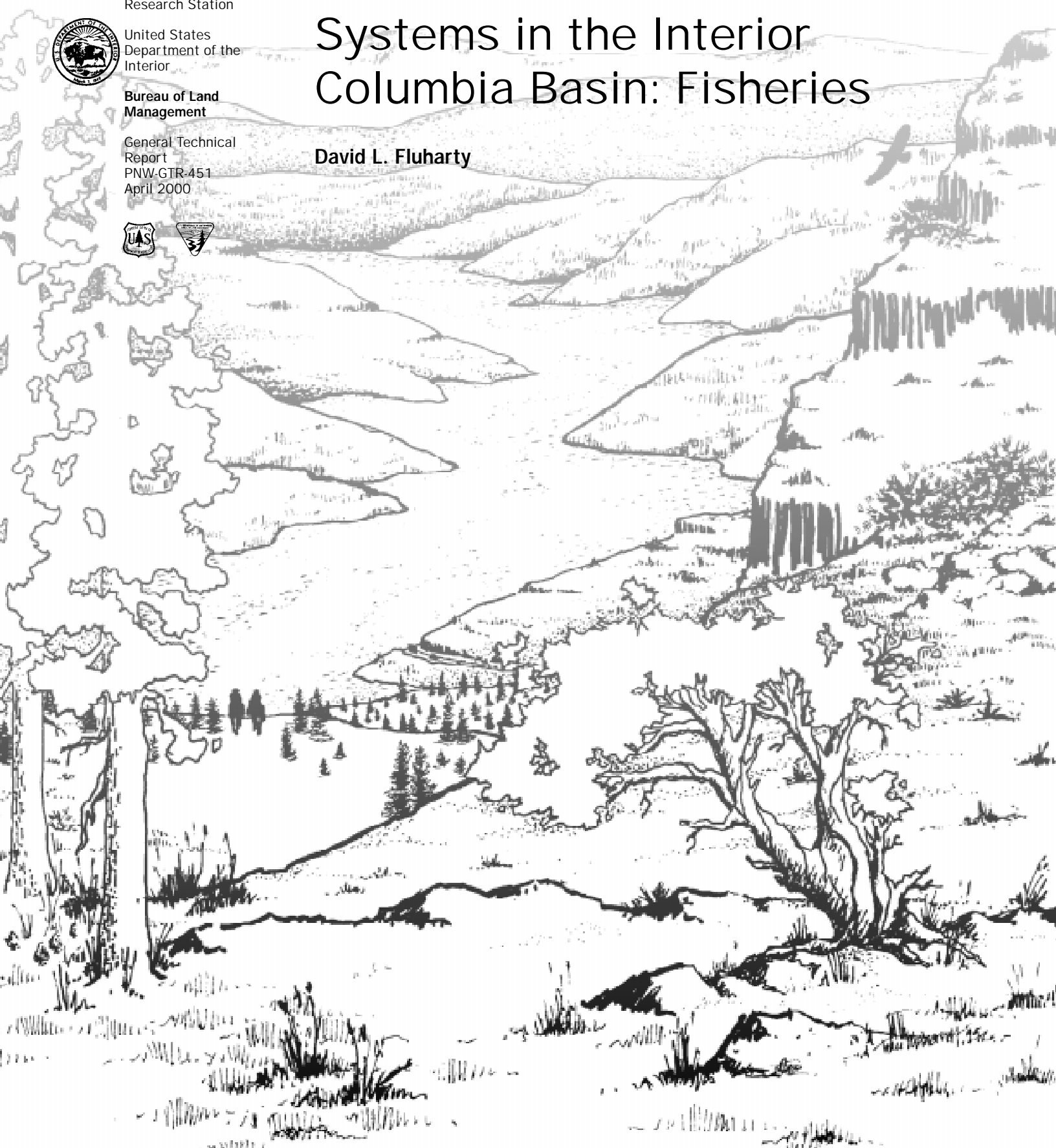
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Characterization and Assessment of Economic Systems in the Interior Columbia Basin: Fisheries

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Characterization and Assessment of Economic Systems in the Interior Columbia Basin: Fisheries

David L. Fluharty

**Interior Columbia Basin Ecosystem Management
Project: Scientific Assessment**

Thomas M. Quigley, Editor

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Abstract

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Economic value of commercial, recreational, and tribal fishing is one measure of the importance of fisheries in the interior Columbia River basin (the basin) but only part of the values associated with fish of that region. The basin historically has provided substantial intraregional anadromous stock fisheries and contributes to interregional fisheries along the entire west coast of the United States and Canada. Harvest management, construction of dams and irrigation facilities, changes in habitat, and other factors have led to significant declines in some stocks of fish, thereby diminishing their economic importance to the region. Resident fish like trout, sturgeon, sucker, lamprey, whitefish, and other species are harvested in tribal and recreational fisheries. With the exception of sturgeon, these species do not support significant commercial fisheries. Introduced species of many warm water recreational fish, like the walleye, have brought additional changes to the ecosystem of the basin and affect economic values of fishing.

Future economic and societal values of fisheries can be expected to increase because of major ongoing efforts to recover stocks of anadromous salmon; however, the magnitude and timing of recovery are uncertain. Increasing human populations in the basin along with steady or increased demand for recreational fishing will continue to raise the value of both native and introduced species. This will make food and recreational fisheries enhancement through artificial propagation more likely, but at the same time, raise the demand for protection of wild stocks and conservation-oriented management to produce low environmental impact and high-quality fisheries. Shifts in social preferences may bring demands for commercial and recreational allocation adjustments, which can greatly impact economic valuation of fisheries. Global climate change, intermittent drought, and interdecadal shifts in ocean conditions provide additional complexity and uncertainty that affect fish values.

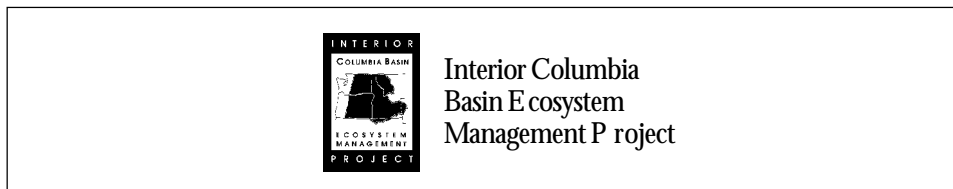
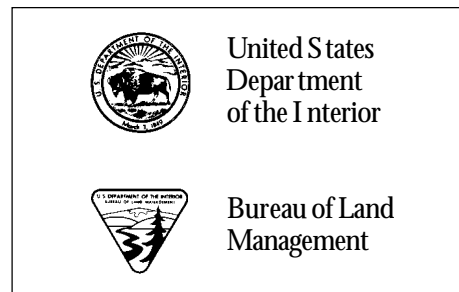
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Preface

The Interior Columbia Basin Ecosystem Management Project was initiated by the Forest Service and the Bureau of Land Management to respond to several critical issues including, but not limited to, forest and rangeland health, anadromous fish concerns, terrestrial species viability concerns, and the recent decline in traditional commodity flows. The charter given to the project was to develop a scientifically sound, ecosystem-based strategy for managing the lands of the interior Columbia River basin administered by the Forest Service and the Bureau of Land Management. The Science Integration Team was organized to develop a framework for ecosystem management, an assessment of the socioeconomic and biophysical systems in the basin, and an evaluation of alternative management strategies. This paper is one in a series of papers developed as background material for the framework, assessment, or evaluation of alternatives. It provides more detail than was possible to disclose directly in the primary documents.

The Science Integration Team, although organized functionally, worked hard at integrating the approaches, analyses, and conclusions. It is the collective effort of team members that provides depth and understanding to the work of the project. The Science Integration Team leadership included deputy team leaders Russell Graham and Sylvia Arbelbide; landscape ecology—Wendel Hann, Paul Hessburg, and Mark Jensen; aquatic—Jim Sedell, Kris Lee, Danny Lee, Jack Williams, and Lynn Decker; economic—Richard Haynes, Amy Horne, and Nick Reyna; social science—Jim Burchfield, Steve McCool, and Jon Bumstead; terrestrial—Bruce Marcot, Kurt Nelson, John Lehmkuhl, Richard Holthausen, and Randy Hickenbottom; spatial analysis—Becky Gravenmier, John Steffenson, and Andy Wilson.

Thomas M. Quigley
Editor



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Introduction

Despite the many problems presented to users and managers by declines, extinctions, and introductions of new species, fish have been supporting and continue to support commercial, recreational, and tribal fisheries throughout the interior Columbia River basin (the basin).¹ Enormous shifts have occurred in the region in terms of the location of fisheries and in their allocation through time as well as the conditions under which they are pursued.

Terms of Reference

The Eastside Ecosystem Management Strategy project is chartered by the Chief of the U.S. Department of Agriculture, Forest Service, and the Director of the U.S. Department of the Interior, Bureau of Land Management (BLM), to develop a scientifically sound, ecosystem-based strategy for the basin in conjunction with other Federal, state, and tribal entities (USDA and USDI 1994a).

This study was contracted to examine economic values of fisheries in the basin (and south-central Oregon) with a focus on tribal, commercial, and recreational fisheries for anadromous, cold water, and warm water species. It is part of a series of economic studies covering major economic activities in the region including grazing, mining, timber, and recreation for the period 1800 to the present. To the extent feasible, factors influencing the future of fisheries are identified and projections made. The study summarizes existing information only; no original survey research is undertaken.

This study fills a major gap in fisheries literature by synthesizing historical and current data from various sources for the basin. In the literature, most research has focused on native salmon and trout species, with limited focus on reservoir fisheries, and the least focus on warm water

¹The area covered by this study includes Oregon and Washington east of the Cascade crest, Idaho, and parts of Montana, Wyoming, Nevada, and Utah consistent with the definition in the U.S. Department of Agriculture, Eastside Ecosystem Assessment Strategy project.

species.² This bias is largely based on preferences of users and managers. This study is viewed as a first stage in the examination of the economics of fisheries in the basin from an ecosystem perspective. Sufficient information has been obtained to assist in the development of an ecosystem-based strategy for the basin.

Organization of the Study

This assessment of the economic significance of fish in the basin focuses on three periods. The first begins in about 1800—before extensive contact between Native Americans and the predominately European explorers, fur traders, and settlers. The second period begins when settlers began large-scale fishing and commercial canning of salmon in the 1860s and ends about 1980 with anadromous species in severe decline. The third period, and chief focus for analysis, begins in the early 1980s when serious concerns about the status of salmon stocks and other wildlife received increased priority, and basin-scale plans were developed to improve the situation. Throughout each period, many species of fish (besides anadromous species) in the basin lakes, streams, and rivers provided commercial sustenance and sport for a burgeoning regional population and provided part of the attraction and enjoyment for visitors. Other fisheries valuation issues are discussed, such as cost of illegal fishing, compensation to Native Americans for loss of access to fishing, and other factors. The study concludes with economic reasoning about fisheries in the basin over the foreseeable future.

² Native species are those indigenous to the basin. They are considered resident if their entire life cycles occur within the basin. Anadromous species, like salmon, spawn and rear in the basin but spend most of their lives at sea before returning to spawn. Over time, a number of nonnative species have been introduced to the area and make up a significant portion of the fish species in the basin. Many of these warm water species such as pumpkinheads (or other common species) occupy the relatively new aquatic ecosystems developed by reservoirs and irrigation; however, some such as brown trout, thrive in cool waters and compete with native species. Hatchery reared fish are another category of species that may be genetically native but differ in terms of their interactions in the ecosystem.

In the precontact and early contact period between Native Americans and Europeans, fish was a major source of protein and calories for Native Americans and also was revered in their cultures. Native Americans existed for thousands of years in a respectful dependence on fisheries of the basin (Hunn 1990). Fish products, particularly salmon, were traded among tribes and served as barter in exchanges with tribes outside the basin in years of surplus. Trade in fish was established at an early date between the tribes and the new settlers. Small-scale subsistence fish catching by settlers also occurred.

During commercialization and expansion of the fisheries, the early settlers rapidly built their fisheries to the point that as early as 1884, concerns were being expressed about exploitation of the previously abundant runs (Smith 1979). Severe declines in Native American populations and their placement on reservations drastically decreased their participation in fisheries despite continued subsistence and traditional fishing and some harvesting for commercial sale. State and Federal Governments attempted to control fishing and to enhance stocks of fish through hatchery production and introduction of new species. World War I and intervening economic conditions put additional pressures on the stocks into the 1930s. Depression recovery measures and later World War II transformation efforts brought massive national public works programs to build dams for generation of electricity, irrigation, flood control, and navigation in the basin. The post-World War II booming economy fueled continued dam construction. It also brought the development of measures to compensate for the declines in fish runs—mainly in the form of fish bypass facilities and hatchery programs (see Barker 1994, Cone 1995, Netboy 1980, Palmer 1991). Outdoor recreation expanded because of the burgeoning economy as well as the availability of cheap transportation and increased leisure time. Abundant cold water and marine fisheries dominated the recreational fisheries.

With establishment of the Northwest Power Planning Act and the Northwest Power Planning Council (NPPC) in the early 1980s, management of the major anadromous fisheries shifted toward making fish a higher priority in decisions relating to operation of hydroelectric facilities and irrigation systems and in activities affecting fish habitat. A series of court decisions, culminating in the 1979 Supreme Court Decision (*United States v. Oregon*), settled long-standing disputes about treaty fishing rights and provided the basis for comanagement of mid-Columbia River fisheries.³ Despite the increased attention and improved environment for management, salmon stocks in the Columbia River generally have continued to decline. Along with this decline, demographic changes in the basin have resulted in increased demand for recreational fisheries for salmon, steelhead, and alternative recreational fisheries. Warm water recreational fisheries, based almost exclusively on introduced species, are attracting considerable attention. Participation in recreational fisheries tended to increase along with population growth and leisure until recently. Absolute decline in fishing license sales has occurred in some states, and fishing as a percentage of recreational activity also may have declined.

Context of the Study

Recent listing of spring-summer and fall chinook⁴ and sockeye salmon⁵ in the Snake River under the Endangered Species Act (ESA) is the focus of much present-day freshwater fisheries concern. It illustrates the status of all salmonids in the basin.

³The Shoshoni-Bannock Tribes were not part of this settlement, and similar issues are still outstanding with respect to tribal fisheries in the Snake River (see Barker 1993).

⁴Scientific names of freshwater fish species are given in table 1, native fish species in appendix A, and introduced species in appendix B, table 17.

⁵On November 20, 1991, the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service listed the sockeye as endangered, and on April 22, 1992, it listed the chinook as threatened (U.S. Department of Commerce 1991, 1992).

An unknown number of native anadromous stocks are extinct already. Nehlsen and others (1991) report that 76 anadromous salmon stocks in the basin are of special concern, with 26 species at high risk, 36 at moderate risk, and 14 at low risk of extinction. More recently, Williams and others (1992) assess that of 192 anadromous stocks identified in the basin, 35 percent are extinct, 19 percent are at high risk of extinction, 7 percent are at moderate risk of extinction, 13 percent are of special concern, and 26 percent are considered secure.

Populations of resident fish that contribute to recreational fisheries as well as to ecosystem health also are in serious decline. The bull trout (Hass and McPhail 1991, Washington Department of Wildlife [WDF] 1993) and the white sturgeon in the Kootenai River (USDE 1994b) are but a few prominent examples. Williams and others (1989) report at least 29 fish species in Oregon, Washington, Idaho, and the basin areas of Wyoming, Montana, Nevada, and Utah to be of special concern, threatened, or endangered according to American Fisheries Society criteria. Most of these species are chubs, trouts, and sculpins with relatively limited ranges. Hybridization with introduced species is the main concern for species like native trouts (Bisson and others 1992).

In addition, introduced species like the walleye now constitute commercial fisheries as well as new predators in the basin ecosystem. Introduced warm water species, in particular, have considerably altered the species composition and ecosystem relations in aquatic environments (Li and others 1987). Massive changes in fish habitats, especially the creation of extensive reservoirs and irrigation facilities, have favored the spread of introduced species and tended to cause conditions for native species to deteriorate (Bisson and others 1992). Preliminary assessments of habitat changes potentially affecting fish are being done (for example, McIntosh and others 1994), but synoptic and comprehensive analyses currently are not available.

Geographic Scope

Interior Columbia River basin—In this report, the area defined as the interior Columbia River basin by the Eastside Ecosystem Assessment Strategy project includes nearly all of Oregon and Washington east of the crest of the Cascade Range and parts of Montana, Wyoming, Utah, and Nevada within the Snake River basin. A portion of the Great Basin located in south-central Oregon is not in the basin but lies east of the Cascade crest and is included in this study; that is, the Northwest Lakes (Houghton 1994). The Upper Klamath River basin also is included in this report though not part of the basin. Given the limited water sources of Nevada (headwaters of the East and South Forks of the Owyhee River and the Salmon Falls River) and Utah (no major water bodies) that drain into the basin, only a brief description of these areas is provided in this paper. Similar treatment is accorded the upper Snake River basin (Gros Ventre, Rocky Fork, Greys River, and Salt River) located in Wyoming. These areas do not correspond to state statistical areas for fisheries in a way that allows convenient access for this study; however, some studies provide a basis for description of fish values.

Lower Columbia River—The lower Columbia River basin refers to the river and its tributaries downstream of Bonneville Dam. This area is not part of the east-side assessment area, but it is a key harvest area for nontreaty and sport harvests (Fishery Management zones 1-5 in appendix I, table 32) with respect to anadromous fisheries that spawn and rear in the basin.

Mid-Columbia River—Mid-Columbia River designates the main stem of the Columbia between Bonneville Dam and Chief Joseph Dam—the modern limit of anadromy in the Columbia River. The three reservoirs of the mid-Columbia (Bonneville, John Day, and The Dalles Dams) below McNary Dam constitute zone 6 (see appendix I, table 32), which is the principal treaty fishing zone.

The upper Columbia River—This area extends farther eastward and northward from Chief Joseph Dam entering Canada with tributaries returning to northern Idaho and western Montana.

The Columbia River system— The Columbia River system refers to the entire Columbia River basin area including the area that extends into Canada.

Fish Fauna of the Basin

Fish fauna in the basin is diverse, consisting of about 90 native species (see appendix A) and about 30 established (that is, reproducing) introduced species (see appendix B). Exclusive of the anadromous stocks mentioned above, at least 3 native species are known to be extinct (Miller Lake lamprey, Snake River sucker, and Alvord cutthroat trout), and 29 other native species are considered by the American Fisheries Society to be of special concern, threatened, or endangered (Williams and others 1989). Only a few of either the native or introduced species have commercial significance in the basin, and most commercial species are salmonids. About 20 percent of the native and 65 percent of the introduced species have significant value as sport fisheries. This is due not only to size and other characteristics desired in targeted recreational fish species, but also to the extremely restricted distribution of some species and their low abundance. A third of the native species are known to have subsistence, religious or spiritual, or trade values for Native Americans in the basin (see below).

Bisson and others (1992) observe that most fisheries science in the basin is oriented to salmon and trout, given their importance in the region. There seem to be no basinwide assessments of the abundance of nonsalmonid native or introduced species. An interagency specialist team has recently been formed under the title "Inland Native Fish Strategy" as part of an effort to develop long-term management of habitat for the basin's native fish species. Still, it is apparent from a biological or ecosystem perspective that the native fish assemblages are severely compromised by introduced species as competition and predation occurs between native and introduced species.

Economically, these introduced species add to the diversity of recreational opportunities available but frequently do so at the cost of values associated with native species. For various reasons, few long-term records exist of nonsalmonids—especially those that lack commercial or recreational significance. This lack of information about such species makes assessing the economic value of fish in the basin difficult. Thus, this report focuses on aggregate levels of participation in fishing as an economic activity and not on more sophisticated factors such as species, size, type of fishing, and harvest success rates.

Approach to Economic Assessment

The purpose for economic valuation of environment-resource systems is to assist in making informed tradeoffs among various management options. This study attempts to identify the economic values associated with fisheries in eastern Oregon and Washington. Neither the benefits and costs nor the economic impacts of any specified action are analyzed. This study provides an understanding of fisheries values as a component of the larger environment-resource assessment under the east-side assessment aegis (see footnote 1) and requires examination of past, present, and future fish values. As the assessment proceeds, further economic analysis will be required relative to impacts or effects of specific measures. This study helps to provide a baseline.

One of the most difficult economic questions is how to accurately portray the value of an asset, like the salmon fishery, that has depreciated greatly over time. Is its value properly represented by current levels of harvest? Or, is it more appropriate to assume that it can recover in abundance to some level approaching its former high abundance and assign a value based on its potential? This debate cannot be resolved in the context of this study. The approach to valuation taken, however, tends to focus on commercial and recreational fishing values associated with current outputs with the caveat that these values are only for certain times. Various considerations influence how values are assigned.

Theoretical Considerations

Economic valuation in the context of ecosystem assessment is theoretically complex and empirically difficult (Costanza and others 1993, Norton 1991). The requirement of developing an understanding of ecosystems forces economists to view natural and environmental resources as systems with multiple outputs and joint products. This environmental and economic system can be seen as generating four kinds of "service" flows to the economy (Freeman 1993):

First, as in the conventional view of resource economics, the resource-environment system serves as a source of material inputs to the economy such as fossil fuels, wood products, minerals, water, and fish. Second, some components of the resource-environment system provide life support services in the form of a breathable atmosphere and a livable climatic regime. Third, the resource-environment system provides various amenities, including recreation, wildlife observation, scenic views, and perhaps services that are not related to any direct use of the environment (sometimes called nonuse or existence values). Finally, this system disperses, transforms, and stores the residuals that are generated as by-products of economic activity.

Economic valuation of the fishery component of the basin resource-environment system focuses on the conventional resource economics and the provision of amenities in the form of recreation and not on more global issues. Analysis of the resource-environment "life support" derived from the environment-resource system in question goes beyond the present task. Because of the strong association of abundant stocks of anadromous fish and recreational fishing with quality of life in the Pacific Northwest, the nonuse and existence values of fish in the basin take on considerable importance. The presence of many species of fish not used by commercial and recreational fishers has ecological significance. Furthermore, some of

these species have significant nonmarket values for Native Americans in the basin. Even species normally considered by anadromous aficionados as introduced "trash fish" are gaining in popularity in the recreation sector, and some produce commercial value. Finally, no attempt is made in this report to evaluate the residuals-management aspect for basin fisheries despite its potential significance. It is beyond the scope of this study.

Net economic value or total economic value (Pearce 1993) is composed of user values (market values with user costs subtracted and consumer and producer surplus identified), option values, and existence values. Huppert and Fight (1991) review the conceptual basis for and measurement of economic value relative to salmonid fisheries and recreational fisheries for cold water species. The basic concepts and measurement issues relate equally well to recreational fisheries for warm water species.

Empirical Considerations

Market value of commercially caught species of fish can be obtained from harvest data and prices. The more difficult problem comes with obtaining reliable estimates of the fixed, variable, and opportunity costs of operating a fishing enterprise. Because of the proprietary nature of these production data, they seldom are available for research purposes in the United States. Rettig and McCarl (1984) suggest using surrogate values of 50 or 90 percent of gross revenues to represent these costs for fishing and processing. This assumes that those fishing are acting rationally; that is, that they do generate a producer surplus in the fishery over a reasonable period, if not each year.⁶

⁶Smith (1979) shows one example of a negative return on investment. His discussion of Columbia River commercial fishing entities as professional, part-time, and sport-commercial strongly suggests that economic values are not the sole motivation for those fishing. Further, it seems that for the Columbia River gillnet fishery, distribution of income is not normal—it is highly distorted toward the low-income range. It is probable this skewed distribution is characteristic of other gears as well.

This assumption, however, is increasingly difficult to maintain for fisheries dependent on basin anadromous stocks. This is because sunken costs, low market value for factors of production, fisher optimism, anticipation of buyouts, and other factors may distort the influence of market forces on the choice to continue fishing. Under these conditions, the appropriate value to use from Rettig and McCarl is the higher one. With an expanding fishery or rapidly increasing prices (even temporarily), the lower figure may be more appropriate. The current (1994) ban imposed on most commercial salmon fishing in Oregon and Washington obviates this discussion entirely except for British Columbia and Alaska fisheries. Detailed discussion of commercial salmon values is included below.

Native Americans in the basin maintain ceremonial, religious, and subsistence-oriented fisheries. Economists seldom attempt to place a monetary value on fishing done for ceremonial and religious purposes by Native Americans, but some do make an effort, inappropriately, however, to account for subsistence values. The value accorded Native American subsistence fisheries in previous economic studies tends to be the retail price of the equivalent amount of fish (Tripp and Rockland 1990). In the present study, the subsistence harvests are reported where known. No attempt is made to place an economic value on them except where they are inextricably mixed with commercial reporting.

Recreational fishing in the Pacific Northwest is done primarily on public lands and waters. There is a limited market for access to fishing. Thus, resource economists have developed ways to estimate the preferences of consumers for sport fishing to compensate for the lack of a market. Travel cost models (TCMs) were first developed to provide a surrogate price for recreation activities for which there was no market. The TCM estimates are based on the observed behavior of recreational users in direct response to travel costs and travel time. There are various methods of estimating travel costs, the details of which are not addressed

in this study.⁷ The TCM surveys have given way to the prevailing contingent valuation methods (CVM) that survey the consumer's willingness to pay to participate in a particular recreation activity contingent on change in the availability of fishing opportunity or willingness to accept payment to forego participation in a recreational activity (Pearce 1993, Walsh and others 1988). Further discussion of recreational fishing values for the basin is provided below under the topic of recreational fishing for anadromous, cold-water, and warm-water species.

Not all values of fish are captured by commercial and recreational fisheries. Option values and existence values are mentioned above but are not assessed in this study. Other nonconsumptive values of fish in the basin are found in the popular fish-viewing sites at dams, hatcheries, and natural spawning and rearing areas. People enjoy watching fish as part of their recreational experiences, and some even like watching others fish. Fishing festivals sponsored by towns and organizations in the basin represent further fish-oriented values to society that do not necessarily involve harvest.

Reliable studies of net economic value of fisheries usually are difficult to obtain owing to (1) lack of data, (2) the need to make assumptions to make up for data, (3) errors associated with reporting, and (4) comparability and transferability of data. The present study faces an even more daunting prospect: the enormous task of examining commercial, sport, and tribal fisheries in a context relevant to understanding ecosystem management in the basin. The large temporal and spatial scope for this assessment places considerable constraints on the analysis that can be performed.

Constraints include:

- Lack of data from early historical periods. This discussion relies on accounts of travelers and on estimates made by anthropologists (Schalk 1986).

⁷See Walsh and others (1988) for a review of methods and their applications.

- Spotty coverage of later periods with respect to harvest data and the relation to overall production. Run sizes were not calculated until 1938, although some efforts have been made to extrapolate run sizes from harvest and packing data (Smith 1979).
- Nature of fisheries and the difficulty of intertemporal comparisons of economic production data because of factors including natural variability of fish stocks, impacts of fish harvesting, impacts of fish management, changes in technologies, changes in product type, and "exogenous" changes in market prices (Hanna 1983).
- Lack of systematic collection of data relevant to performance of economic analysis, especially on capital and operating costs of commercial fishing and processing. Some time series of data on harvests and prices exist, however, from as early as 1866 (Netboy 1980, Smith 1979).
- Sport fishing data are also scant and cover either narrowly constrained species and areas (so their transferability is limited) or broad species and areas (so their utility is limited relative to a species and area).
- Considerable debate is now underway in the professional economic community about fundamental technical issues of measurement of contingent valuation (Adamowicz and others 1994, Morely 1994) and over benefit transfers (Brookshire and Neill 1992, Loomis 1992, McConnell 1994, Vatn and Bromley 1994).

Limits of time and resources that could be devoted to this study further constrain the product. No original survey research is performed to determine economic value of commercial, sport, and tribal fisheries. Instead, existing studies are examined for relevant data and analysis for the areas and time periods under consideration. Effort is made to use the most recent reliable information and to adjust to current conditions. For these fisheries, the data are indicative and not definitive.

Native Americans believe that the effort to assign monetary values to salmon is misplaced. This contrasts with the perspective of economists who believe that monetary values are a shorthand way of reflecting the relative value to consumers. For Native Americans, salmon and other species of fish are components of a traditional diet and may hold sacred positions in traditional cultures of the basin that cannot be represented in monetary terms. This does not imply that trade and barter for salmon are not significant. It also does not preclude Native Americans from harvesting fish for sale.

An increasing number of non-Native Americans concerned about fisheries agree with the assessment that commercial value does not represent the true value of salmon or other species. Salmon are symbolic of quality of life (Oregon State University 1978, SOS 1995) and health of the environment (Karr 1993) in the Pacific Northwest. Economists acknowledge these concerns but argue that assessment of the economic value of salmon and economic impacts of changes in salmon management conditions also can be helpful. Still others argue that what economists measure as value may not be relevant to the critical decisions society must make about things like recovery of salmon in the basin (Vatn and Bromley 1994).

Precommercial Fisheries to 1860

The economic value of fisheries to Native Americans of the interior Pacific Northwest nearly 200 years ago cannot be calculated in conventional economic terms. This section establishes a baseline of usage of the fish resources and their significance for Native Americans living in the basin in the early and mid 1800s. The anthropological record and reports of early travelers reveal that salmon was a keystone of year-round diet for many Native Americans and that other fish species provided variation and complemented salmon as part of the diet. Within the basin, salmon may have provided between 30 and 40 percent of dietary needs (Hunn 1990). Significant amounts

of processed salmon constituted a chief trade item among Native Americans and, later, were important in barter with fur traders and settlers. One expression of the transcendent value of salmon to Native Americans in the basin is that of Matilda Mitchell (translated by Delbert Frank, Sr.) at Warm Springs (Meyer Resources, Inc. 1983):

We were talking about the essence of the teaching as our Creator handed down to our people, which has been handed down through centuries or through generations The first food is salmon to us; that is our first food. And we recognize that, as such, without it our life would not have its full potential as far as our existence is concerned

A statement on the broader economic significance of salmon to Native Americans of the basin is found in Rostlund (1952):

The annual coming of the salmon was an event of great economic importance; there was nothing comparable to it in other parts of the continent. In no other waters of North America during aboriginal time was the seasonal range from abundance to scarcity of fish so great as in the western salmon rivers. Even to the salt-water tribes, who could fish in the sea at any time, the coming of the salmon was a great annual event. It can be said without exaggeration that no aspect of nature in North America was so critically important in the economic life of a fishing folk as was the salmon run in the West.

Native Americans were major users of anadromous and other fish species in the basin where spawning habitat was accessible. The Pacific Northwest fishing societies had relatively "high population densities, complex social organization, large villages, and other features ordinarily found only among agricultural people" (Schalk 1986). Even among the basin fishing societies, as much as a tenfold difference existed in the population densities among tribes—midriver tribes being more densely spaced than interior tribes (Hunn 1990). Four culturally distinct groups are recognized among tribes in the basin:

1. The Northwest coastal group (mid-Columbia being the eastern extension).
2. The upper Columbia (Plateau) group.
3. The south-central Oregon and northwestern Great Basin group.⁸
4. The upper basin group (which belongs to Great Plains tribes).

For the main Columbia-Snake River groupings, each is made up of bands or tribes that share a village or camp during the course of an annual economic cycle and who share a common language. Usually, the common habitation occurred during the major salmon fishery. Within each of these tribal groups, there is considerable diversity in patterns of food resource use, with mid-Columbia and Plateau groups focused on riverine resources, roots, and large game and the southern groups dependent on salmon and other fish, seeds, and small game. The Great Plains tribes were less dependent on fish and more dependent on hunting of buffalo and other game. They traded dried meat, horses, and skins as well as obsidian and other resources where they had a comparative advantage for dried salmon and pemmican (a mixture of dried meat, fat, and berries pressed into small cakes). They came long distances to participate in salmon fishing and to trade.

At the beginning of the 19th century, significant changes were underway affecting tribal societies and their relation to fish resources. Contact with ocean explorers and their goods came indirectly through trade with coastal tribes; however, at this time, these external impacts were minor. The introduction of horses to the Columbia Plateau area in the 1700s allowed travel for hunting and gathering and transport of trade goods, including salmon. By the late 1700s, eastern Columbia

⁸Tribal names and organizations of 1800 do not necessarily correspond to current designations. The three main language families represented in eastern Oregon and Washington are the Shahaptian, Salishan, and Shoshonean (Ruby and Brown 1981).

Plateau tribes were hunting for buffalo in present-day Montana. The horse also allowed tribes to travel to places where salmon fishing was better and fish were in better condition.

Spread of disease had a profound impact on Native Americans living in the basin. The Native American population before contact with Europeans may have been as high as 100,000 people (Boyd 1985). The spread of smallpox around 1775 and another epidemic (malaria according to Cone 1995) in 1801, however, caused many deaths, resulting in an estimated combined mortality of 45 percent (Schalk 1986). By mid-19th century, the basin population had dwindled considerably, such that early settlers met with a vastly depauperate human environment compared to that observed by Lewis and Clark.

The most commonly cited estimate of early use of salmon by Native Americans in the basin is that of Craig and Hacker (1940).⁹ Craig and Hacker's estimate is based on a population of about 50,000 Native Americans occupying the basin in the early 19th century, each of whom is thought to have consumed an average of 1 pound of salmon per day.¹⁰ This results in an estimated annual consumption of over 18 million pounds of salmon. Sharp decimation in the populations of Native Americans in the basin occurred in the first half of the 1800s. By mid-century, the estimated population stood at about one-sixth (8,280) that of the previous population levels. The tribal population

⁹All estimates are for the entire Columbia River basin. This includes the Columbia River reaches in Canada, Idaho, and below the current Bonneville Dam (that is, Willamette River, Chehalis River). These areas are not in the east-side assessment area, and so the quantities are overstated. Based on discussions and tables in Hewes (1947) and Schalk (1986), a reasonable partitioning of the production to just the east-side assessment area might be 40 to 50 percent.

¹⁰The reliability of estimates is highly susceptible to the assumptions about population size and the nutritional value and availability of the fish in various parts of the river basin. See Hunn's (1990) review and discussion of population estimates and Schalk's (1986) review and discussion of nutritional values. These estimates are adopted for purposes of this study.

was below the combined population of settlers in Oregon and Washington by 1860. Western Montana and Idaho had relatively few settlers at that time. This precipitous drop in population must have been reflected in the consumption of fish resources.

Hewes (1947) uses additional ethnographic data and revised population estimates to arrive at an annual consumption of salmon by basin tribes of about 22.3 million pounds. Schalk (1986) considers that both prior estimates could understate the usage because they do not take into account the loss of caloric content by migrating salmon, fail to adjust the weight for inedible portions like the head and bones, and do not include all uses of salmon by Native Americans, that is, dog food, fuel, as well as internal and external basin trade. Schalk's estimate is nearly 41.8 million pounds consumed annually, which still excludes possible use as dog food and fuel (see appendix C).

The Northwest Power Planning Council (NPPC 1986) examined historical data to determine original run sizes for Columbia River salmon and steelhead. It estimated that between 11 and 16 million salmon and steelhead was the long-term average "natural" production.¹¹ Schalk regards this run size as consistent with his own estimate, if the NPPC conversions of his estimates of consumption to numbers of fish (4.5 to 6.3 million fish using lower Columbia River commercial catch data 1880-1920) are accurate and if one assumes a 50-percent catch-efficiency quotient. This would translate into a run size of 9 to 12.6 million fish—the low end of the NPPC estimate.

¹¹The NPPC 1986 estimate is criticized by some for taking the peak catches of all runs and then assuming a 50-percent harvest rate. A more restrictive total run based on average run sizes might be on the order of 7 to 9 million salmon (Turner 1994).

Analysis of economic value of the fisheries normally would require adjustment of the value of the harvest by the costs incurred in obtaining and processing the fish. No studies of the capital costs of gear and facilities used in Native American harvests have been located; such costs probably would seem minimal by modern standards. Native Americans relied on locally available materials. The only major costs were the opportunity costs of labor in gathering the materials and crafting them into serviceable nets, canoes, weirs, etc., and using them to harvest fish and then process, transport, and store the fish. Labor costs can be considerable, but when compared to the effort required to obtain a comparable amount of high-quality food from other sources, the investment must be seen as highly favorable. This conclusion is supported by the pre-European contact high-population densities among the tribes.

Considerable agreement exists among anthropologists and early historians over the role salmon played in the diets of Native Americans in the basin, and these observations are confirmed by the oral histories of Native Americans. Salmon were available in massive quantity in relatively few areas but were locally abundant (and catchable) throughout the basin. Kettle Falls and The Dalles (Celilo Falls) were the major sites for harvest and processing for storage and trade. At such sites, many Native Americans congregated to fish, gamble, race horses, and maintain social interaction. At places such as Celilo Falls, some families were accorded a traditional use-right for a particular fishing spot. These seem to have been freely shared with relatives, friends, and even strangers.

Although the major sites are best known, harvest activities occurred on a smaller scale throughout the portions of the ecosystem occupied by salmon. Usage in the Wenatchee, Entiat, and Methow and upper Columbia River basins is reviewed by Mullan and Williams (1993). Small fishing camps throughout the basin are known from tribal accounts, travelers' reports, and archeological research.

The sharing of resources and fishing sites under the direction of salmon chiefs is a remarkable institutional adaptation to the mixed groupings of peoples who depended on these sites (see Chance 1973). There was an adequate to abundant supply of food for the tribes throughout most of the basin. The main exceptions were tribes in the extreme northeast and southern part of the area who frequently suffered hunger in low salmon years (Hewes 1947). For the mid-Columbia tribes, fish were available in large quantities for about 6 months of the year, and dried and smoked salmon were a major source of nourishment the rest of the year.

Compared to Native American cultures elsewhere, the "salmon people" density in the basin was much higher than could be sustained by mere hunting and gathering (Schalk 1986). Others agree with the importance of salmon and other fish in the diets but point to strong evidence that seasonally and in years of low abundance, starvation occurred among many tribes. Obviously, main-stem Columbia River tribes would be in a better position to harvest fish from multiple runs, and there would be less fluctuation in their catches. Upriver tribes and those on single tributaries would be much more vulnerable to fluctuations.

It is important to consider the influence of trade on Native Americans and their environment in the first half of the 1800s. By 1810, the fur trade (beavers, marten, and muskrats, etc.) had started at places like Fort Colville, Fort Spokane, and Fort Vancouver. According to Hudson's Bay Company records, formal trade in salmon and salmon products at Fort Colville was a minor activity although a critical one for survival of the fur traders (Chance 1973). Schalk (1986) reports, however, that the Lewis and Clark Expedition observed "stacks" of baskets of processed salmon (pemmican) containing an estimated 115,000 to 128,000 pounds of fish. The implication is that these baskets were suitable for horse transport and would be used in trade with Columbia Plateau tribes and with south-central Oregon tribes that

lacked access to rivers with salmon. The ability to dry and process salmon into pemmican gave basin peoples an item for trade with coastal Native Americans who were not able to preserve salmon in this way because of the more humid climate (Spranger and Anderson, n.d.).

Manufactured goods like guns and ammunition, horse riding gear, and tobacco were available through fur trading, and probably fish trading as well, and these continued to alter cultural and environmental relations in the early and mid 1800s (Chance 1973). Fish trade by Native Americans is believed to have been largely internal to the basin. External trade is thought to have been greater in years of high abundance and mostly among tribes existing in the eastern portion of the basin (NPPC 1986). Trade with tribes of western Montana and Idaho brought dried buffalo, animal skins, and other items of comparative advantage in exchange for dried fish and roots. There seem to be no systematic studies to quantify trade relations existing among tribes in the basin in pre-European contact times—what is known (and knowable) is largely anecdotal.

Salmon were the dominant species of fish used by Native Americans; however, whitefish (various species), squawfish, chubs, lamprey, sturgeon, trout, etc., were important also, not only for subsistence but also for ceremonial and religious purposes (table 1). Compared with salmon, the remainder of the native western freshwater fish fauna was relatively poor with the possible local exception of trout (Rostlund 1952). Tribes with less access to salmon resources, like the Upper Klamath, made greater use of species like chubs and suckers (Hewes 1947).

Estimates of annual harvests are lacking for freshwater species. Rostlund (1952) estimates that the tribes located near salmon consumed an average of 800 to 1,000 pounds of fish per square mile of territory, whereas the tribes in south-central Oregon may have used 50 or less pounds of fish per square mile of territory. Some of this probably came through trade. Usage among tribes probably differed according to taste preferences as well as

with availability of alternative sources of food. Hunn (1990) confirms that for mid-Columbia peoples, suckers (note the difference in terminology from table 1; large-scale sucker and bridgelip sucker) were valued on par with salmon, at least seasonally, despite being far less abundant. They served as a late winter and early spring source of food to break the monotony of dried fish and root rations and may have staved off famine in low-food years. Mountain whitefish were known to be fished through river ice when food reserves were low. Pacific eels were and continue to be considered a delicacy. The small redshiners also were used for food. Freshwater mussels were eaten in great quantities according to archaeologists studying shell middens in the mid-Columbia.

Mid-Columbia tribes did not make use of the white sturgeon, but lower Columbia tribes did. Myths of mid-Columbia tribes about the sturgeon being capable of swallowing a human and thereby being cannibalistic, and therefore taboo, may have contributed to this difference. The Dolly Varden char, which eats mice and frogs, was similarly shunned by some tribes. Sculpins (at least eight *Cottus* species exist in the river) and crayfish are not used because of their perceived spiritual powers, such as the Indian doctor fish. That many other fish exist in the basin but do not seem to be formally addressed in the tribal language, indicates that they were probably not heavily used by the mid-Columbia tribes (Hunn 1980). Hunn notes, however, that it is possible whitefish constitute a category of fish and not just a single species in tribal nomenclature.

The ability of Native Americans to manage fisheries for purposes of conservation is difficult to assess. The mere existence of large numbers of salmon and Native Americans over a considerable length of time (5,000 to 10,000 years) could be cited as evidence of sustainable management. Native Americans knew salmon behavior intimately and understood the need for salmon to migrate to spawn. Many of the cultural practices

Table 1—Principal freshwater fish used by Native Americans, interior Columbia basin

Common name	Scientific name	Distribution of use
Western sea lamprey	<i>Entosphenus tridentatus</i> (<i>gairdnerii</i>)	Columbia-Snake River basin and tributaries
White sturgeon	<i>Acipenser transmontanus</i>	Main-stem Columbia-Snake Rivers
Salmon, steelhead, kokanee	<i>Oncorhynchus</i> spp.	Basin where accessible—chief exception in south-central Oregon
Montana grayling	<i>Thymallus arcticus</i> <i>montanus</i>	SW Montana
Cutthroat trout, rainbow trout	<i>Salmo clarkii</i> , <i>S. gairdnerii</i>	Same as above—limited distribution in south-central Oregon
Dolly Varden ^a	<i>Salmo malma</i>	Same as salmon
Rocky Mountain whitefish	<i>Coregonus</i> spp.	Basin
Columbia sucker	<i>Catostomus machrocheilus</i>	Basin
Klamath sucker	<i>Chasmistes</i> spp. <i>Deltisties</i> spp.	Klamath River-Klamath Lake
Mountain sucker	<i>Pantosteus</i> spp.	SE Washington-Snake River
Columbia River squawfish	<i>Ptychocheilus oregonis</i>	Basin
Columbia River chub (peamouth)	<i>Mylocheilus caurinus</i>	Basin
Chiselmouth (chub)	<i>Acrocheilus alutaceus</i>	Lower Columbia-Snake River
Lake chub	<i>Siphateles</i> spp.	Moses Lake and Crab Creek southern Oregon
Freshwater cod (burbot, ling)	<i>Lota leptura</i>	Lake Chelan-N. Idaho-western Montana
Trout perch (sandroller)	<i>Columbia transmontana</i>	Lower to mid-Columbia
Smelt, eulachon, candlefish	<i>Thaleichthys pacificus</i>	Lower Columbia

^a Currently Dolly Varden and bull trout (*S. confluentus*) are considered separate species. Bull trout is more common in the basin, and fish that had previously been identified as Dolly Varden may actually have been bull trout.

Source: Prepared from distribution maps and text in Rostlund (1952). Fish nomenclature same as source.

(that is, first salmon ceremony and no night fishing) allowed fish to reach the spawning grounds. Certainly, the reverence Native Americans accorded the salmon is an indication that they would practice measures to protect salmon survival. Still, the great abundance of salmon and the limited ability to harvest all of them by using dipnets and other gear may have made this question moot given the population levels and distribution.

Relatively little is known about what might be termed recreational or incipient commercial fisheries of the period. There is little evidence that Native Americans viewed fishing as anything other than a food-gathering activity. Fishing by Native Americans does not seem to be a sport in the context of what is now thought of as recreational activity. This is not to say that no pleasure or satisfaction was derived from the activity or that there was not competition among individuals to see who could be most skillful or fortunate.

Early settlers used salmon to augment their diets of game and agricultural products (Craig and Hacker 1940). In most cases, individuals probably harvested their own subsistence fish, but some evidence suggests that settlers were dependent on Native Americans to supply their fish (Cohen 1986). Native Americans supplied trading posts with fish, presumably in barter arrangements, and it is likely that such exchange extended to other settlers, although there were few settlers in the basin at this time. Traders, explorers, miners, and settlers probably enjoyed fishing as recreation, but there is little documentation of such activity. Commercial salting for export is known from the lower Columbia River area in the 1830s (Cone 1995), but commercial harvest did not occur in the mid and upper Columbia river area. Vessels visiting the Columbia River often took away a part of a cargo of barrels (ca.140 pounds) of salted salmon and sold it for \$12 to \$14 per barrel (Craig and

Hacker 1940). One of the chief constraints on transport of salmon was the need to transit tropical regions before reaching destinations of sale as far away as Hawaii and the east coast of the United States. By the 1860s, lower Columbia salteries were producing 1 to 2,000 barrels of salmon per year. Native Americans caught most of this fish and were paid \$40 per month.

The last decade of the precommercial period in the basin is characterized by conflict between Native Americans and settlers. Encroachment on the basin lands by settlers had begun in earnest, and unfortunate incidents occurred to sour what had been generally amicable relations. Territorial Governors like Isaac Stevens in Washington were under pressure from the Federal Government to use treaties to acquire title to the tribal land (Hunn 1990). Native Americans were understandably alarmed about losing lands and resources they had always known and used, and their concepts of property probably were not understood by settlers (Cohen 1986). Nevertheless, treaties were signed with many of the tribes in the basin by the middle of the 1850s. In economic terms, these treaties represent an incalculable allocation of land and resources away from Native Americans and towards settlers. One estimate is that tribes gave up use of 64 million acres in these treaties in exchange for reservations but mostly for the right to fish in usual and accustomed places (Barker 1993). The treaties set a pattern of interaction between tribes and resource managers that affected and continues to affect the management and allocation of fish.

Commercial and Recreational Fisheries, 1860 to 1980

The era of commercial fisheries in the basin was heralded by a turbulent decade in the 1850s with so-called "Indian wars" that in some cases pitted tribes against each other and against the U.S. Army and territorial and state militias. Joint occupation of Oregon territory by the British and the United States in 1818 had resolved in the United States becoming sole authority as a result of the Treaty of 1842, with movement toward statehood for Oregon (1859) well underway. Territorial governors began to exert pressure to open up land for immigrants. Settlement negotiations resulted in treaties, like the Yakima Treaty, June 1855, that ceded Native American lands to the U.S. Government while guaranteeing exclusive use of areas to be known as reservations and retaining tribal rights to fish in usual and accustomed places (Freeman and Martin 1954, Hunn 1990, Johansen and Gates 1957). The treaties set the stage for a wave of settlements by non-Native Americans in the lower Columbia River area as well as in the basin.

This section examines the qualitative economic impacts of commercial fisheries development, focusing first on the tribal fisheries, then commercial fisheries, and finally on recreational fisheries. A qualitative approach is adopted for this section because the trends in numbers of fish and participation in fisheries tend to track the same trends in value of fish. Significant changes occurred in the habitat and institutional arrangements for the commercial and other fisheries over the course of this period that influenced their allocation and value.

Native American Fisheries

The preponderance of the commercial fishery in the late 1800s took place in the lower Columbia River basin with trap nets, purse seines, and drift gillnets. Native Americans in this area were some of the best suppliers of fish to canneries in their early days; however, they increasingly were sup-

planted by non-Native Americans. In the basin, Native Americans participated in the burgeoning commercial fisheries to a relatively modest degree. Tribal fisheries occurred in the mid-Columbia reaches of the basin and used predominantly dipnets with spears, nets, and baskets in some cases. The main effort was concentrated at traditional fishing sites for subsistence and other cultural and religious uses rather than for commercial use. Total quantities taken by Native Americans in commercial fisheries are not separately reported during this period. The quantity taken for traditional uses can be estimated to be considerably less than in earlier times because the Native American population was much lower and because the adoption of agriculture, ranching, and other employment made them less dependent on salmon for sustenance than they were as hunter-gatherers. Even if the quantities of fish taken were lower, the subsistence value and other values to tribal people remained high.

In the mid-Columbia River basin, many conflicts occurred between Native Americans dipnetting salmon and non-Native American fishing. Fishwheel operators were in direct competition over the best sites for harvesting salmon and competed indirectly by harvesting fish before Native Americans could harvest them. When fishwheels were banned from the Columbia in 1935 (see below), the Native American share of total catches more than tripled—from 2.7 percent in 1930-34 to 9.1 percent in 1936-39 (Smith 1979). Competition with dams and other habitat loss made inroads into the tribal dipnet fisheries. The main dipnet fishery at Celilo Falls continued until 1957, when it was flooded by the water behind The Dalles Dam (see appendix D). For 1938-57, salmon and steelhead catches at Celilo Falls by Native Americans ranged from 800,000 to 3.5 million fish and averaged about 1.7 million fish—mostly chinook and steelhead with some sockeye (WDFW and ODFW 1994). When Celilo Falls was inundated by construction of The Dalles Dam, a lump sum payment of \$23 million was made for a "flowage easement" over the lost fishing site. The tribes were adamant, and courts upheld their view that rights to fish were retained

(Wilkinson 1992). Catches dropped in 1958 to only a few thousand fish as tribal fishing was forced to convert to set nets fished in the reservoirs. By using set nets, catches averaged about 1.3 million pounds (93,000 fish) per year through the mid 1960s and 1970s (Smith 1979).

The most important issue facing the claims of Native Americans to fish resources in the basin was litigated in the 1970s. With the treaty fishing zone being located upstream (zone 6) and most of the fishery occurring downstream or in the ocean, questions about the meanings of the treaty language and particularly the share of the harvest accruing to Native Americans were raised. In landmark decisions by Judge Belloni in *United States v. Oregon* 1969 and Judge Boldt in *United States v. Washington* 1974, it was determined that fishing "in common" meant that fisheries management should ensure that the harvests were split 50-50 between treaty and nontreaty fishing entities (see Cohen 1986; Smith 1979; Spranger and Anderson, n.d.). These decisions helped set the stage for a new era of fisheries management with vastly different allocation parameters and with tribes at the negotiating table with respect to management. In 1977, four major Columbia River fishing tribes established the Columbia River Inter-Tribal Fish Commission (CRIFC). These legal affirmations of tribal fishing rights set the stage for shifts in the share of catch between treaty and nontreaty fishing (see below).

Although most of the attention by tribes is accorded salmonids, Native Americans continued traditional fisheries for other species in the basin, including Pacific lamprey, sturgeon, squawfish, whitefish, trouts, suckers, and chubs. For tribes with reservations distant from fishing sites, these other species where locally abundant had greater significance. Relatively little documentation of these fisheries is in the literature for most of this period. Hunn (1990) describes some aspects of the usage of nonsalmonid resources by one family. (Unfortunately it was beyond the scope of this inquiry to obtain broader oral histories concerning fishing practices for these species, as this could be critical information for the tribes and for land and resource managers in the future.)

Commercial Fisheries

Commercial fisheries in the basin evolved rapidly to reach and exceed the levels of salmon harvest seen in the precommercial era (appendix D). Commercial fishing started in the early 1860s on the the lower reaches of the river for salmon, sturgeon, and the introduced shad and gradually expanded toward the ocean and upstream as competition for fish increased. Agricultural and forest practices were of such relatively limited extent that they did not have an appreciable impact on fish habitat until the 1960s and 1970s when irrigated agriculture developed as part of massive dam construction. Construction of dams for production of hydroelectricity, flood control, irrigation, and other purposes started early on the tributary rivers of the basin, but main-stem dams with high potential to affect migratory fisheries did not develop until the 1930s and 1940s. Almost as soon as commercial fisheries began, overharvesting was a concern. Early efforts were made to regulate the fisheries and to augment natural production of salmon by using fish hatcheries. Spread of trout-culturing techniques led to the establishment as early as 1910 of commercial rainbow trout-raising activity along the Snake River in southern Idaho and to a more limited extent elsewhere as well.

Salmon—By 1866, advanced canning technology made it feasible to process the otherwise perishable salmon for distant markets. In that year, the first cannery was established in Astoria, Oregon, with production commencing in the following year. Early fishing with drift gillnets, purse seines, trap nets, beach seines, and fishwheels rapidly expanded the harvests and dominated the production from the lower Columbia River. Commercial fishing with fishwheels, first tried in 1879, was especially suited for the Columbia Gorge and Cascade Range areas of the Columbia River upstream from the current Bonneville Dam. Fishwheels took advantage of the power of the swiftly flowing river to turn the wheel in places where the migratory behavior of salmon caused them to congregate

(Spranger and Anderson, n.d.). It also allowed operators to avoid competition with the established operations downstream.

Fishwheels in their heyday (1899) numbered 76 and caught about 5 percent of the total salmon harvested in the river (Donaldson and Cramer 1971), but they caught virtually all the commercial salmon in the basin. An indication of the split in relative level of effort is seen by most of the salmon being caught by the 2,500 to 3,000 fishing boats and many traps in the lower Columbia River. The fishwheel properly situated and operating was an extraordinarily effective method of harvesting fish. Its operation could be closely coupled with that of the processing plant. As conflicts between gear types escalated in tandem with declining fish runs, the company-owned fishwheels garnered less sympathy than gillnetters and sports fishing interests with voters. Fishwheels were outlawed by Oregon in 1926 and in Washington in 1934. With them went the chief component of the basin commercial fishery. Other gear types caught relatively modest amounts of fish above Bonneville Dam. In the 1930s, the income generated by salmon harvests from the full Columbia River system was estimated at about \$10 million annually (Craig and Hacker 1940).

Gear conflicts continued to be a highly politicized issue on the Columbia River. By 1950, the only non-Treaty commercial fishing gear allowed was the drift gillnet. Sport fishing with hook and line and treaty fisheries using dipnets are the only other fishing methods allowed (a detailed history of these conflicts about gear is documented in Smith [1974]).

The Columbia River chinook salmon was the almost exclusively targeted species in the early fisheries because of its abundance and value (see appendix D, tables 20-24). This heavy selective fishing pressure resulted in a decline in chinook stocks so that by 1884, some were prompted to argue for state regulations to limit the amount of catch (Seasons and other regulations were established in 1871). This measure was largely ineffectual in conserving salmon because of the

availability of abundant coho, chum, sockeye, and steelhead salmon. With decline in the chinook numbers, the fishery simply began to focus on other species. Total harvest of all species fluctuated between 24 and 49 million pounds annually from 1880 to 1930, averaging 33.9 million pounds (Smith 1979); also 1.3 million to 3.6 million fish and averaging 2.3 million fish per year [NPPC 1986]. After this time, harvests gradually fell to lows of 10.9 million pounds annually by the 1950s and 1960s (an average of about 630,000 fish annually). Changes in size of fish harvests were somewhat offset by efforts of processors to stabilize the price of salmon on the market to maintain market position (Smith 1979).

Harvests in the lower Columbia were based largely on fish that spawn and rear in the basin portions of the watershed; therefore, not only did commercial fishing in the basin affect stocks, but the bulk of the harvests of basin-origin fish occurred downstream. This situation continued to worsen from the standpoint of management for conservation of stocks, as new types of gear played leapfrog with the other types in getting first opportunity to catch the fish. Harvests at sea in the troll fleets off the coasts of California, Oregon, and Washington began in the late 1910s and early 1920s to intercept fish in the basin. In addition, harvesting along Canada's west coast and Alaska included basin salmon as did harvests in the north Pacific by foreign fleets. The level of interceptions is difficult to document over time. One estimate for the period 1969-73 based on tag returns for chinook salmon shows troll harvests in southeastern Alaska to have an interception rate of 45 percent; British Columbia, Queen Charlotte Island—25 percent; British Columbia, west coast of Vancouver Island—45 percent; Washington, Puget Sound—50 percent; Washington, coastal—65 percent; and Oregon, coastal—47 percent based on the ratio of fish caught in the Columbia River to fish caught elsewhere (Smith 1979 citing Hatley 1976). Thus, the basin contributed significantly to commercial fisheries outside its boundaries.

Through the Great Depression, salmon was seen as a staple food at a lower price than most cuts of meat in domestic and foreign markets. Its high protein content made it an extremely good value nutritionally. The Depression years resulted in declines in the amount of fish canned, which coincided with continued declines in the abundance of salmon in the Columbia River as well as lower prices for fish. World War II buoyed the price of salmon, and in the post-War era, canned salmon shifted its status from a staple food item to a luxury food. Of course, the price of salmon was not determined totally by Columbia River stocks. Alaska's and Japan's canned salmon figured heavily into the international market price. Besides these price effects, canned salmon lost considerable market share as incomes and taste preferences changed to favor fresh and frozen salmon. Consequently, almost all salmon canneries on the Columbia River had closed by 1975 (Smith 1979).

White sturgeon—White sturgeon is a native anadromous fish in the Columbia River system. Its highest abundance and harvest is in the slow-moving waters of the main-stem river (Pacific States Marine Fisheries Commission [PSMFC] 1992), but it is found throughout the Columbia River system as far upstream as the Kootenai River in Montana and in the upper Snake River in Idaho. Columbia River harvest began fairly early on a small scale (see appendix E). Starting in 1884, commercial catches rose rapidly to 5.5 million pounds in the 1890s and then dropped precipitously as the stock was overexploited. Sturgeon caviar and smoked or canned flesh were popular and found an export market because they could be preserved. The combination of high demand and value balanced against the slow growth rate of sturgeon required careful management, which the sturgeon did not receive. In about a decade, sturgeon was eliminated as a significant commercial species (Craig and Hacker 1940). Catches remained low from the early 1900s to the 1960s (PSMFC 1992). They ranged between 54,000 and 388,000 pounds until in the 1970s, when their numbers began to rise again.

The fishery above Bonneville Dam (zone 6) is a consistent but modest part of the total harvest in the river. Extremely small and closely regulated commercial fisheries exist in some parts of the river system, but sturgeon is scarcely considered a significant source of income except on a local basis.

Construction of dams on the Columbia River severely restricted the movements of large, old, slow-growing fish that represent the spawning population. It is thought that juvenile and small sturgeon may be carried downstream past dams in the basin and in that manner be recruited into the lower river fishery. Upstream fish ladders and bypass facilities are not considered to be designed to facilitate upstream migration. Some efforts have been made to explore hatchery production for supplementation and for commercial culture in Idaho (PSMFC 1992). In summary, the basin contains a small commercial harvest of sturgeon and may contribute to the lower river fishery.

Shad—Shad were introduced into California rivers from New England in 1871 and spread along the coast as far north as Alaska. By 1876-77, shad were known in the Columbia River system (Wydoski and Whitney 1979). A commercial fishery started in the late 1800s for shad and continued sporadically in the lower Columbia depending on the price, especially for shad roe (Craig and Hacker 1940). Main-stem dam construction starting in the 1930s seems to have been beneficial for shad populations. They have increased considerably in the slower waters of the reservoirs to where they support a fishery that since 1938 has ranged from 150,000 pounds to 1.5 million pounds (see appendix E). Before the damming of the Columbia River, Celilo Falls was a natural barrier to shad. Now shad have extended their range to the Priest Rapids Dam on the mid-Columbia and into Idaho on the Snake River.

The value of shad actually decreased relative to other seafood over time because of a lack of demand and high abundance. Harvest management of shad is difficult because it spawns at about the same time as higher value summer chinook salmon

species that are protected when the fishery occurs, therefore the higher valued salmon is more profitable than the shad. Thus, full usage of shad is subjugated to other management objectives. Most of the shad fishery takes place in the lower Columbia River, and yet much of the spawning and rearing habitat is in the basin. Shad harvest by tribes in zone 6 is a relatively small part (usually less than 10 percent) of the total river catch. Thus, the chief economic contribution to this fishery from the basin is in the form of habitat for spawning and rearing.

Trout culture—Trout culture is over 100 years old in the basin (Glude 1989). It was an easy step from private and public trout hatcheries for recreation to trout farms for commerce. Starting in the late 1920s, commercial production of rainbow trout stayed low until the late 1950s when production began to increase rapidly. By the end of the 1970s, about 30 million pounds of rainbow trout were produced annually (Brannon and Klontz 1989). The Thousand Springs area of Hagerman Valley in Idaho dominates the U.S. production of commercial rainbow trout with some 14 companies, 30 farms, and 16 fee-fishing pond operations for sport fishing. Other trout fish farms and aquaculture facilities growing catfish and tilapia exist in Idaho as well as eastern Oregon and Washington that add to the commercial and recreational (trout) values from fish culture. The products of these aquaculture efforts serve markets throughout the United States and Canada.

Recreational Fisheries

Nontribal subsistence fisheries for salmon and trout began with exploration and mineral prospecting and continued with settlement. It was not long, however, before the first urban dwellers and travelers sought recreational fishing opportunities—especially with the advent of transcontinental railroad transportation (Craig and Hacker 1940). Early travel accounts abound with descriptions of the remarkable fishing opportunities that existed in streams and lakes in the basin (see examples in Byrd 1992, Stone 1983). Hook and line fishing

for salmon seems to have been little known or practiced in the Pacific Northwest as a recreational fishery until the 20th century (Smith 1979). No systematic source of information on early sport fisheries has been located in the course of this study. It is impossible, therefore, to provide other than anecdotal information on the development and economic significance of sport fishing in the basin.

Recreational salmon and trout fishing in the Columbia River system began in the early part of the period and has steadily grown along with population, leisure, and income. Demand for improved sport fishing conditions has been one of the main drivers of commercial gear and quota restrictions on the Columbia River, particularly after World War II (Smith 1974). Catch from recreational fisheries grew from an insignificant amount at start of the 20th century to a major component of the river fishery. Recreational fishing occurred throughout the range of salmonids in the Columbia River basin, but the greatest part is found in the lower river where fish quality is highest. Chief targets for recreational fisheries have been chinook, coho, and steelhead salmon. Rainbow, bull (and Dolly Varden), and cutthroat trout have been the main native species taken, but the introduced brown trout has provided a significant fishery as well (Ames 1966).

Demand for recreational fishery for trout in streams, rivers, and lakes has continued to increase. To accommodate the demand, state and Federal fisheries officials have instituted trout hatcheries to augment natural production in many lakes and streams. In most Northwest states, trout hatcheries were developed in the 1880s to fill the demand for recreational trout fishing (Wiley 1994). States and the Federal Government did research, regulated fisheries, enforced regulations, protected habitat, and even purchased habitat. Costs of these measures have been borne by general tax revenue, license fees, excise tax on purchase of fishing gear (under the Dingell-Johnson Act 1950), and on arms and ammunition (under the Pittman Robertson Act 1937) (see Cubbage

and others 1993). All this has served to increase fishing opportunity and encourage fishing at higher levels than could be supported by naturally occurring stocks and without management intervention. Such measures provide economic spinoffs to resort operators and tourist industry services near fishing lakes and streams. Time series data on the contributions of recreational fisheries to local, largely rural economies are not available for the basin.

In the arid central basin portions of Oregon, relict populations of many native stocks exist. Recreational fisheries in these areas have long required special management by the Oregon Department of Fish and Wildlife (ODFW) and special measures to manage habitat by Federal, state, and private land managers (ODFW 1994, USDI BLM 1991). The areas supply recreational fishing but with gear, area, and season restrictions that are particular to the area. To some extent, the presence of rare and endangered species has resulted in restrictions on supplementation programs as well.

Sturgeon sport fisheries have been a component of the recreational fisheries throughout the Columbia River system. Catch rates, gears, fish size, and areas have been subjects of regulations to control harvests of these slow-growing, long-lived fish (PSMFC 1992). Most of the sport fishing occurs in the lower Columbia River, and sturgeon fishermen tend to be from the local area. The sport fishery on the main-stem Columbia River has been consistently small scale. Sturgeon recreational fisheries in other parts of the basin in Idaho and Montana have been heavily restricted and subject to many closed periods. Efforts have been made to experiment with sturgeon propagation for recreational fisheries supplementation.

One of the major changes in the basin aquatic ecosystems is the introduction of nonnative species. State agencies and private individuals have intentionally and unintentionally brought new species into the basin. Some of these have

recognized recreational fishing value, like largemouth and smallmouth bass, crappies, sunfish, catfish, and perch in the warm water category and the brown and lake trouts in the cold water category. In the generally dry intermontane basin, the increase in aquatic environments because of filling of reservoirs and irrigation facilities has expanded the availability of habitat for various native and nonnative species (Bennett and others 1991). Fishing for these warm water species began in the early 1900s throughout most of the region, but they were not heavily targeted by recreational fishing until after World War II. These species were subject to liberal regulations until demand increased dramatically and fishing pressure was greater than that sustainable by the resource (Van Vooren 1991). In ecosystem terms, some of these introduced species prey on the native species of trout and salmon. These native species have been preferred by traditional basin recreational fishing enthusiasts. As recreational fishing opportunities for the traditional sport species declined, however, there was little hesitancy in shifting to fishing for introduced species.

Warm water fish species increased the opportunity for recreational fishing in the basin, which translates into purchases of gear and services in areas that previously had no or only modest fishing attraction. Examples from the basin include sport fishing—the introduced shad began to develop at the end of the 1970s (Wydoski and Whitney 1979). Walleye that were introduced into the basin in the 1940s reached sufficient abundance and size to begin to attract sport fishing interest at the end of the 1970s (Smith 1991).

Change in Conditions for Fishing

Major changes occurred in the development of the fisheries. Overfishing was one component that led to a decline in fish production in the latter part of the period but also implicated were changes affecting the whole river system and its ability to produce wild fish in natural habitats.

Habitat change—Besides the habitat changes due to dam construction mentioned previously, land use practices also changed. During the early commercial period, mining, grazing, logging, agriculture, and water diversion activities also began in the Columbia River watershed. In some cases, the exploitative activities had localized, devastating consequences for fish in rivers. Changes in habitat due to extractive activities are not well documented relative to impacts on fish harvests or habitats as little monitoring on a watershed basis existed. Literature on significant recent efforts to reconstruct the ecological health of selected basin watersheds have been published by Inland Empire Public Lands Council (1993) Wissmar and others (1994). The kinds of impacts identified for these representative watersheds occurred over time throughout the basin and resulted in long-term changes in the suitability of salmon spawning and rearing habitats. Catastrophic natural events like landslides and eruptions as well as natural processes of change in ecosystems (Harvey and others 1994, Lehmkuhl and others 1994) including fire (Agee 1993) and extreme weather conditions (Agee 1994) also play a role in influencing salmon habitat. But the overwhelming forces changing the landscape have been human caused, and the impacts on salmonids and resident fish have been largely negative.

Some of the human impacts have been severe but short term. Natural processes have restored the fish habitat to near pristine conditions. Other impacts, like water withdrawal are continuous and increasing and play a greater role on salmon survival during dry years than in wet ones. Other impacts, like pollution from toxic mining waste and sedimentation can be chronic and continue to influence the quality of habitat for fish.

Dams—By the late 1970s, the Columbia River and its tributaries were blocked by more than 190 dams or impoundments—about 140 of which are within the basin (see appendix F). Vast portions of the prime habitats for salmon spawning and rearing in the Columbia River either were placed out of reach to spawners or were heavily altered by

inundation or by changes in the flow regime. In almost all cases, this results in negative impacts on salmonid survival.

The relative contribution of dams to salmon losses is a major point of contention, given that harvest management, and habitat-altering activities in agriculture, range, and forest management, also are implicated. The biggest direct and indirect impacts on salmonid habitat in the Columbia River system likely are due to dam construction and operation. At least one estimate places the contribution of power system to the loss of fish runs at 80 percent in the basin (Lee 1993). Although it was well known that salmon spawned in the rivers, no conclusive evidence existed to support the theory that salmon returned to their home stream to spawn until the early to mid 1950s (Stickney 1994 citing Hasler 1954). How such knowledge would have affected the decisions about dam construction, provision of fish bypass facilities, and other mitigation made earlier is unknown. It can be argued that in the traditional knowledge of Native Americans, homestream spawning was known, but such information was discounted or ignored by scientists and planners.

Main-stem dams on the Columbia River at Rocky Reach (1933) and Bonneville Dam (1938) marked a new era in hydropower development in the Pacific Northwest. Smaller dams existed on tributaries to the Columbia River, like the Swan Falls and Lower Salmon Falls Dams completed in 1910 on the Snake River (Stickney 1994), but main-stem dams forced significant changes in the migratory pathways of salmonids. Direct losses of fish habitat occurred when the combination of Chief Joseph and Grand Coulee (1941) dams were constructed and further when the Hells Canyon Dam was completed in 1967. These dams block access to about one-third of the basin—90,000 square miles lost out of a total of 260,000 square miles in the Columbia River watershed. The impact is more appropriately stated in terms of the

163,000-square-mile area of the basin historically accessible to salmon. The direct loss of spawning and rearing habitat rises to 55 percent of the area previously used by anadromous salmon (NPPC 1986).

The total length of main-stem and tributary rivers supporting salmon habitat is about 11,800 miles, of which 7,400 miles (64 percent) remains accessible and 4,200 miles (36 percent) is no longer accessible. Much of this loss occurred above Bonneville Dam. Over 500 miles of the main-stem upper Columbia River were lost when Grand Coulee Dam was completed and 50 more were lost with Chief Joseph coming on line. In the Snake River basin, 50 percent of the main-stem river used by anadromous fish was lost as a result of Hells Canyon Dam (WDFW and ODFW 1994). Sockeye salmon are perhaps the species most affected by loss of habitat (table 2).

Accessibility to spawning grounds is only part of the habitat suitability equation. Habitat quality also is important. On the main stem of the Columbia River above Bonneville Dam, only the 50-mile-long Hanford Reach is still riverine in character and capable of supporting significant spawning grounds. Columbia River production salmon is affected by the highly regimented flow due to operations of the Columbia River hydroelectric complex (USDI NPS 1994). This means that much of the Columbia and Snake River main-stem habitat is under the surface of reservoirs, which increases the effective area lost even more. In the Snake River tributaries, once major habitats for chinook and coho, some 3,560 linear miles of habitat (45 percent) have been lost out of a total of 7,740 miles (NPPC 1986).

Predevelopment distribution of inriver production of all species of salmon is estimated to have been split 23 percent below and 77 percent above Bonneville Dam (Lee 1993). By the late 1970s, the upstream Bonneville Dam production (including hatchery production) had dropped to 42

percent with the lower river contributing 58 percent. Thus, not only did the absolute amount of production plummet above Bonneville Dam, but the relative amount of production supplied by upriver habitat also dropped enormously. Much of the lower Columbia River production is a result of early decisions to place hatchery production west of the Cascade Range, a policy decision that responded well to nontreaty commercial and recreational fishing demands but not to basin treaty fisheries.

The species composition of total harvest for the precommercial versus late-1970s fish populations remained about the same for chinook (60 percent) and steelhead (8 percent), although a large share of each comes from hatchery production. Sockeye dropped in abundance over the same period from about 16 percent to only 2 percent. There is negligible hatchery production of sockeye salmon. Coho stocks, augmented by hatchery production increased their share of the population from 11 to 28 percent. Chum salmon declined from 8 to about 1 percent over the same period.

Other direct and indirect losses of salmon associated with dam construction and operation come from juvenile fish mortality passing through or around dams and reservoirs and adult mortality in fish bypass facilities and reservoirs. Delays in fish migration downstream and upstream are increasingly seen as problems affecting salmonid survival. Lack of screened water diversions and changes in the flow quality and quantity associated with reservoir-assisted irrigation projects all contribute to the cumulative mortality affecting salmon. High harvest rates of hatchery salmon stocks in the ocean and river also have exacerbated the problem of survival of wild stocks.

Catch history of salmon species from the Columbia River is provided in appendix D. During the 1940s, salmon production from the Columbia River system dropped to about 23.8 million pounds annually (Smith 1979) average 1.4 million fish. In the 1950s, harvests declined further to about 10.9 million pounds (average 650,000 fish).

Table 2—Sockeye habitat change in the basin

River	Lake	Area	Year access blocked	Remaining habitat ca. 1970
		<i>Acres</i>		
Upper Columbia		110,150	--	0
	Upper Arrow	51,904	1939	0
	Lower Arrow	37,504	1939	0
	Whatshan	4,004	1939	0
	Slocan	16,738	1939	0
Middle Columbia:		97,554	--	8,174
Okanogan	Osoyoos	--	--	5,729
	Skaha	4,967	1921	0
	Okanogan	85,990	1915	0
Yakima	Bumping	631	1910	0
	Cle Elum	1,982	1909-10	0
	Kachess	2,744	1904	0
	Keechelus	1,240	1904	0
Wenatchee	Wenatchee	2,445	--	2,445
Snake		6,722	--	1,500
Payette	Payette Lakes ^a	1,500	1914	0
Wallowa	Wallowa	1,777	1929	0
Salmon	Stanley Lakes ^b	3,445	Blocked 1913-34 (Redfish Lake only with sockeye now)	1,500
Lower Columbia:		250	--	0
Metolius	Suttle	250	1930	0
Total		214,658		9,674

-- = Not available.

^a Little Payette Lake, Payette Lake, and Upper Payette Lake.

^b Redfish Lake, Yellowbelly Lake, Pettit Lake, Stanley Lake, and Alturas Lake.

Source: NPPC 1986a.

Decline in yields slowed during the 1960s, and average catch increased slightly in the 1970s, but by the early 1980s, harvest declined to only 1.2 million pounds (average 230,000 fish). In this discussion, harvest history is used as a surrogate for run size under the tenuous assumption that a strong relation exists. Many factors influence both harvest and run size. It is, therefore, unlikely that they co-vary. Still, use of decadal averages provides a cross section of the data that reliably indicate the trend in both harvests and run size. If the estimate of an original run size of 10 to 16 million fish and harvests of 5 to 6 million fish per year is accepted for the unaltered Columbia River system, then the direct loss of 50 to 60 percent of the habitat would translate into a run size of 5 to 9.6 million fish as the maximum expected under current conditions. If indirect mortality associated with habitat loss and hydrosystem operations are added, it is understandable how salmon harvests can be reduced to their current low numbers. Finally, the low stocks are subject to other negative influences occurring concurrently; that is, persistent droughts that affect runoff and river conditions and El Niño affecting ocean production (Beamish 1995, Miller and Fluharty 1991, Schoener and Fluharty 1985).

The use of aggregate harvests masks the differential declines and increases in catch (and assumed abundance) among the main species of salmon in the basin. Between 1860 and 1980, many species of salmon became extinct in the basin, and others declined to the point of either being listed or being candidates for listing as threatened or endangered (Williams and others 1992).

Hatcheries—Even before the late 1930s, the perceived and real declines in fish stocks had sparked interest and investment in fish hatcheries to artificially augment production. As early as the 1870s, fish processors had begun to experiment with hatchery operation to supplement fish stocks in the lower Columbia River tributaries. In the 1890s, Oregon and Washington as well as the Federal Government were engaged in hatchery operations, which were producing 62 million eggs and fry by

1905 (Smith 1979). Hatchery men formed an association in 1910 to promote hatchery activities. Strong claims to the success of hatchery operations were made, but their contribution could not be separated from wild stocks. As stocks of hatchery-raised species were perceived to have declined (post-1890) relative to peak levels of abundance (1880s), fish hatcheries came to be seen less as a panacea and more as an unrealized hope. In reality, stock fluctuations were probably not attributable to any single factor. When studies were commissioned in the early to mid 1930s to evaluate what should be done to offset the habitat losses from proposed dam construction, hatcheries again attained prominence (Rich 1942).

Relatively few new hatcheries were constructed under these uncertain conditions (1910-40) until costs of hatchery construction and operation began to be paid from compensation funds for dam losses under fish and wildlife laws (Netboy 1980) (see appendix G). Capital costs for fish passage facilities, research, and monitoring were a significant part of each dam design and construction project as well, averaging perhaps as much as 6.5 percent (Smith 1979). Although hatchery production has not lived up to expectations, hatchery production supplies considerable quantities of the catch inriver and in the ocean. This has allowed fisheries to continue when they might otherwise be shut down were they based solely on wild stocks. Hatcheries also allow a higher exploitation rate to be applied in a fishery than if only wild stocks are targeted (Stickney 1994).

The scale and cost of the hatchery operations by tribes, states, power companies, and Federal agencies were large. Between 1938 and 1975, about \$400 million dollars was spent on mitigation in the form of fish passage facilities at dams, and a small amount was spent for hatcheries and spawning channels. Monitoring of the impacts of Bonneville Dam on salmon fisheries showed declining runs. Therefore, a series of 21 hatcheries, 86 fish ladders, and spawning habitat restoration

projects was initiated in 1949 at a cost of an additional \$84 million by 1975 (Smith 1979). Mitchell Act mitigation was designed to produce fish in the lower Columbia River area, which meant that tribal fisheries taking place above Bonneville Dam (zone 6) received little benefit (Berg 1993). Despite the checkered experience of using hatcheries as mitigation of habitat loss on the Columbia River, the same method was selected to offset the losses of the lower Snake River project. The last of the four lower Snake River project dams was completed in 1975; however, the first appropriation for mitigation facilities came in 1976, and the first fish were produced by the McCall Hatchery in 1981 (Lothrop 1986).

Modification of dam structures and operations to provide better conditions for fish survival can result in major capital costs. Changes in their use of the flow regime to produce power may reduce output and result in power revenues foregone and increases in the cost to purchase power from other sources (Huppert and Fluharty 1995).

Fishery regulation—Fishery regulation, mainly directed at salmon, has had important conservation and allocative consequences in the basin (see appendix H). Throughout the early part of this period, state management by Oregon and Washington tended to be competitive rather than cooperative. More stringent measures implemented on one side of the Columbia River allowed fishermen to avoid enforcement by shifting landings to the other side. In 1918, Oregon and Washington signed the Columbia River Compact with the intent to harmonize and make more effective salmon management for domestic salmon fishing inshore (Smith 1979). Although not entirely successful in its early years, the compact has provided a forum for exchange of management perspectives and has resulted in better coordination (see appendix I). In 1968, a Columbia River Fisheries Advisory Council was established by the governors of Idaho, Oregon, and Washington to allow fisheries directors from each state to better coordinate management.

For managing their fisheries, Oregon and Washington established a geographic fishing area system with six fishing zones for the Columbia River. Five zones occupy the 140-mile-long section of river downstream of Bonneville Dam where nontreaty fishing occurs (appendix H). Zone 6 is the 130-mile stretch of river between the Bonneville and the McNary Dam where an exclusive treaty commercial salmon setnet fishery takes place (Madson and Koss 1988); tribes reserve the position that they may fish in the downstream zones but have seldom forced that position in fisheries or in the courts. The states, through the compact, and tribes, through the CRITFC, established in 1977, coordinate the management of fisheries in the Columbia River under their various authorities through the Columbia River Fish Management Plan. The plan is a result of court decisions clarifying fisheries management with respect to the treaties with the tribes. Each state regulates recreational fisheries and resident fisheries within its respective jurisdictions, and tribes, through CRITFC, manage their own fisheries. The plan governs fisheries for chinook, sockeye, and coho salmon, steelhead, white and green sturgeon, and shad.

The PSMFC is a regional group established by Congress in 1948 to coordinate state marine fisheries policies coastwide (PSMFC 1994). In 1976, Congress passed the Magnuson Fishery Conservation and Management Act, which established a regional fishery management body, the Pacific Fisheries Management Council (PFMC), for fishery conservation in the 200 nautical-mile zone off the west coast. The PFMC coordinates on some aspects of fishery management with the North Pacific Fisheries Management Council—especially with respect to Columbia River salmon migrating through waters off Alaska (PFMC 1991).

International management of salmon stocks from the Columbia River occurred under the International Convention for the High Seas Fisheries of the North Pacific Ocean signed originally in 1956. It was amended in 1978 when the U.S. and Canadian 200-mile fishing zones were declared and again in 1986. Management of interceptions of Columbia River fish between Canada and the United States occurred under the International Pacific Salmon Fishery Convention (Fraser River Convention) signed in 1930 and was revised in 1956 and replaced by the Treaty Concerning Pacific Salmon in 1986 (see Burke 1994, Jensen 1986, Miles and others 1982).

Valuation of Contemporary Fisheries, 1980 to Present

Previous sections have provided background on precommercial use of fish in the basin and the development of tribal and commercial and recreational fisheries. This section details the current economic value of fisheries in the area subject to the theoretical and empirical constraints mentioned above. This section provides an overview of economic aspects of contemporary fisheries as background for assessing integrated land and resource management needs and options. We first examine treaty fishing rights of Native Americans and then review the nontreaty commercial fisheries. We next investigate recreational fishing values and briefly review other related fish valuation issues. Salmonids continue to dominate the commercial and, to a certain extent, recreational fisheries, but other cold and warm water resident fish have considerable significance as well.

Passage of the Northwest Electric Power Planning and Conservation Act (Northwest Power Act 1980) by Congress set the stage for added regional efforts to restore fish and wildlife in the basin (Hildreth and Thompson 1994). Besides a genuine interest in balancing fish and wildlife protection with hydrosystem operations, the proposals in

the 1970s to list some Columbia River salmon species under the ESA were some of the threats legislators sought to avoid through passage of the Northwest Power Act. The Northwest Power Act staved off the more restrictive actions with its promise of a coequal partnership between fish and wildlife and hydroelectric generation to be administered by a regional body of the NPPC (Carlough 1992, Natural Resources Law Institute 1990). Despite the stated desire to prevent ESA listing by improving fish runs and significant efforts and expense to accomplish this in its first decade, NPPC did not succeed in achieving all its objectives. Current levels of abundance for many salmonid species in the basin are at an all-time low even with extensive hatchery supplementation.

The current status of most Columbia River salmon stocks is precarious. Snake River summer and fall chinook and sockeye salmon are listed as endangered under the ESA. Snake River coho have not been observed since 1985 and are presumed extinct. These listed species and other weak stocks are driving fishery management decisions to be increasingly restrictive of other stocks to protect them. Yet more stocks are proposed for listing as threatened or endangered, and decisions in this regard are expected over the next several years.

Along with salmon, many other species of resident native and nonnative fish contribute to fish values in the area. Relict stocks of rare species exist in limited ranges in eastern Oregon. Bull trout, white sturgeon, and other widespread species face loss of habitat and other threats to their continued existence. Some introduced species are thriving to the extent that they provide a large amount of popular recreational activity and at the same time compete for habitat or directly prey on native resident species.

Under these circumstances, the value of commercial fisheries in the basin is difficult to calculate. The basin commercial fisheries are almost exclusively limited to zone 6 and yet fish spawned,

reared, and cultured in the basin contribute to fisheries in the lower Columbia River (zones 1-5) and to ocean and coastal fisheries from California to Alaska. Estimates of the contribution to these fisheries and their values change through time with abundance, ocean conditions, and other little-understood factors. In addition, many of the major fisheries for salmon from the basin are at historical lows or are fished at low levels to protect other stocks. Thus, today's commercial fishing values based on restricted catches tend to be less than the value of a fishery managed for strong stocks and hatchery stocks. Finally, if production of wild stocks of salmon and other native species is considered the only appropriate fishery value to apply in an ecosystem-oriented valuation approach, the production from hatcheries (70 to 80 percent) would receive low or no value. Perhaps, hatchery fish may even impose an ecosystem or genetic cost beyond the capital and operational costs to keep producing them. All these factors tend to undervalue current salmon stocks relative to even the recent past. In 1994, commercial fishing of salmon stocks in the basin was almost completely curtailed, and 1995 seems to be little different.

In this analysis, a 13-year period between 1981 and 1993 is averaged to obtain a baseline value for the recent past and adjusted to 1993 dollars. Data presented show the trends and range of values surrounding these averages. Most of the discussion is of aggregate harvests of fish despite the fact that the fishery is predicated on a geographically and temporally diverse set of stocks. For more detailed examination of just the major stocks, see WDFW and ODFW (1994—commercial fisheries in the Columbia); Palmisano and others (1993—Washington); Kaczynski and others (1992—Oregon).

Treaty Fisheries—Commercial

Columbia River treaty fisheries occur almost exclusively upstream of Bonneville Dam (in zone 6) under management of the CRITFC in concert with state, regional and Federal entities. As a result of the treaties negotiated in 1855 and subsequent judicial interpretation, the 1980s witnessed a major reallocation of commercial fisheries in the Columbia River basin toward treaty fisheries and from lower River fisheries to zone 6 fisheries. At the same time, the declines in the stocks severely limited the commercial harvests available to treaty fishing. The fishery uses set (gill) nets to capture coho and chinook salmon and steelhead (pink and chum salmon are no longer present in commercial quantities above Bonneville Dam). No commercial sockeye salmon fishery has been in the Columbia River since 1988, and chinook and coho fisheries are greatly restricted. Subsistence and ceremonial harvest of salmon also occurs in the zone 6 area as well as at traditional sites throughout the basin.

As can be seen in table 3, total treaty harvest of all commercially harvested species averaged about \$3.0 million (in 1993 dollars) over the 1980s and early 1990s. The lowest total value of catch in zone 6 was about \$530,000 in 1983 (\$757,000 in 1993 dollars) and the high-value catch was \$8.2 million in 1988 (\$9.8 million in 1993 dollars). At the high point, chinook and steelhead catches were considerably greater than in other recent years, and sockeye salmon from the upper Columbia River in Washington also were abundant. Besides the salmonids, white sturgeon is the most valuable treaty commercial fishery with shad and the relatively new commercial fisheries for the introduced walleye running distant second and third. Legal commercial sale of steelhead can take place only under treaty fisheries.

Net economic values for treaty salmon fishing are assumed to be similar to those of fisheries in the lower Columbia River and along the coast. No

Table 3—Treaty commercial fishery in the basin (zone 6), 1980 to present^a

Year	Chinook	Coho	Sockeye	Steelhead	White sturgeon	Shad	Walleye	Total, all species
1981	974.9	12.2	0	119.6	69.0	0		1175.7
1982	704.5	23.2	.7	107.1	45.2	.9		881.7
1983	356.3	.7	4.4	120.7	48.7	.2		531
1984	1,028.5	8.4	85.0	953.8	120.1	.7		2196.5
1985	1,213.5	28.8	170.5	360.1	235.9	.0		2008.8
1986	1,607.7	72.1	19.7	382.9	521.8	.3		2604.5
1987	4,504.5	16.6	219.0	829.2	672.2	1.5		6243
1988	6,483.1	69.2	246.4	1,093.7	266.4	5.9		8164.7
1989	1,831.9	8.9	.1	319.1	269.9	.1	6.1	2436.1
1990	2,082.3	5.6	.0	268.1	242.6	.1	2.2	2600.9
1991	569.9	29.5	.0	187.5	110.7	.0	3.2	900.8
1992	467.9	3.2	.0	307.0	121.2	.1	5.2	904.6
1993	362.3	7.4	.0	134.1	108.4	.4	4.2	616.8
Average	1,707	22	57	399	218	.8	4	2,408
Average ^b	2,119	27	71	495	270	1	5	2,988

^a Ex-vessel value \$1,000—nominal dollars unless elsewhere indicated.

^b 1993 dollars, 5-year average.

Source: WDFW and ODFW 1994 (rounding may affect some totals).

estimates of net economic values for other commercial species seem to be available. Rettig and McCarl (1984) suggest using a surrogate net economic value of 10 percent of gross revenues (that is, costs set equal to 90 percent of gross revenue) for fisheries under depressed and declining conditions as exist in these fisheries and 50 percent for fisheries that are expanding. The Columbia River system operation review (SOR) adopts the 50-percent recommendation and applies it in its analyses (USDE and others 1994d). This translates into an average annual net economic value for tribal basin commercial salmon of about \$220,000 to \$1.1 million (\$273,000 to \$1.4 million in 1993 dollars).

Tribal commercial fishing in the basin has come much closer to parity with nontreaty fishing during the present period (see appendix J). In the 1970s, treaty fisheries averaged about 25 percent of the Columbia River landings. By 1990, the average was closer to the 50-50 split mandated in court decisions. With respect solely to the ecology of salmon stocks in the basin, the allocation element is inconsequential as long as total escapement is controlled. For user groups, however, the change in allocation had the effect of shifting the harvest into the basin and toward the tribal component. This is seen by some as an advantage for tribal interests and as a disadvantage for nontribal fishing interests. A larger proportion of fishing occurring

in the basin by tribes may result in a diminution of the commercial value of salmon caught because the salmon are captured farther from the sea. The salmon may be lower in quality and command a lower price. In addition, there may be greater transportation costs from the fishing area to the processor or consumer market because of how river fisheries are pursued. Counterbalancing these factors is the ability of tribal fisheries to supply fresh fish at times when other fisheries are closed and, thus, may command a higher price. Similarly, commercial sales of steelhead are solely available from treaty fisheries. Accordingly, the price situation is mixed.

Tribal fisheries for noncommercial species in the basin are not separately reported. For the most part, these fisheries are subsistence and ceremonial fisheries including those for salmon. Even these fisheries are much circumscribed by conservation efforts by tribes themselves and because of the low abundance of salmon. In 1992, for example, tribal subsistence harvests in zone 6 of the basin were estimated at 5,700 spring chinook, 60 summer chinook, and 2,250 sockeye (CRITFC 1992b). Other subsistence and ceremonial salmon fisheries occur throughout the basin salmon habitat but are not systematically reported. Native Americans still fish for and use other species, such as Pacific lamprey, trout, and squawfish, but this does not seem to constitute a major tribal fishing activity in the basin relative to the commercial fisheries.

Commercial Fisheries

Inriver—Chinook, coho, and sockeye salmon from the basin contribute to the fisheries in the lower Columbia River and to ocean fisheries. (Other salmonid and nonsalmonid fisheries exist in the lower Columbia River and its tributaries. This treatment focuses on the subset of stocks that includes basin stocks). Shad and, to a more limited extent, white sturgeon also have spawning and rearing grounds in the basin but may be caught outside the region. As seen in table 4, the total average annual landed value for commercial

fisheries for basin-related fisheries amounts to about \$5.5 million (\$6.8 million in 1993 dollars). Chinook and coho landings dominate the commercial value, but white sturgeon make a major contribution. Sockeye salmon contribute sporadically to the value. Shad is a relatively consistent fishery and highly dependent on the prevailing price.

Calculating the contribution from the basin to total salmon production and harvest is problematic. The approach used here is to apply recent average harvest from the basin by species to the values for total landings in the lower Columbia River fisheries. Note that year-to-year differences exists in the relative rates of the interceptions that are not accounted for in this study. Based on this approach, the basin contribution to the total value of lower Columbia River fisheries can be estimated at about \$3.2 million (\$4.0 million in 1993 dollars) or about 56 percent of the value. Net economic value for salmon is pegged at a bit less than \$320,000 to about \$1.6 million (\$400,000 to \$1.9 million in 1993 dollars) by using the method to estimate fishing costs as a proportion of gross revenues suggested by Rettig and McCarl (1984) and the Columbia River SOR (USDE and others 1994d). Even this estimate of net economic value may be high given the extremely low levels of harvest and the number of fishing units.

If one were interested in the number of full-time jobs associated directly with these fisheries, annual income divided into the gross revenue might provide a reasonable approximation. According to one recent source, 80 percent of the number of vessels gross less than \$10,000, and 89 percent gross less than \$20,000 (Washington Department of Community Development 1988). Assuming an annual income of \$10,000 or \$20,000, the related jobs would be \$4.0 million divided by the annual salary resulting in a range of from 200 to 400 jobs. Obviously, the number of full-time job equivalents is highly sensitive to the income level assumed. Further, the number of participants in the com-

Table 4—Nontreaty Columbia River commercial landings, 1980 to present^a

Year	Chinook	Coho	Sockeye	White sturgeon	Shad	Total, all species
1981	1,307.3	512.7	0	449.3	16.7	2,286.0
1982	1,935.1	1,353.9	0	381.2	64.1	3,734.3
1983	843.2	47.1	0	462.4	45.9	1,398.6
1984	1,745.1	1,854.4	37.0	723.7	12.6	4,372.8
1985	1,687.9	1,371.2	128.5	416.4	21.1	3,625.1
1986	2,524.7	6,724.0	7.6	590.8	64.8	9,911.9
1987	8,644.4	2,443.4	164.5	491.2	62.7	11,806.2
1988	13,771.6	5,820.1	111.7	388.6	52.2	20,144.2
1989	2,899.5	2,294.7	0	290.0	28.8	5,513.0
1990	2,197.3	578.3	0	354.2	72.0	3,201.8
1991	1,502.0	2,121.5	0	223.1	27.8	3,874.4
1992	618.6	269.1	0	274.1	71.1	1,232.9
1993	347.1	214.9	0	260.5	64.8	887.3
Average	3,078.7	1,969.6	34.6	408.1	46.5	5,537.6
Basin (%)	95 ^b	<10 ^c	100 ^d	<5 ^e	70 ^f	NA
	----- <i>Value</i> -----					
Basin average	2,925	197	35	20	33	3,210
Basin average in 1993 dollars	3,632	244	42	24	40	3,985

NA = not available.

^a Ex-vessel value \$1,000—nominal dollars unless elsewhere indicated.

^b Based on USDE and others (1994d, appendix 0).

^c Author's estimate based on USDE and others (1994b; see appendix C-1 table 19).

^d All sockeye in lower basin are from above Bonneville Dam.

^e Author estimate based on PSMFC 1992.

^f Author estimate based on WDFW and ODFW 1994.

Source: Derived from WDFW and ODFW 1994.

Table 5—Estimated annual average value of basin salmon caught in commercial ocean fisheries, 1987-91^a

Fishery and area	Fall chinook	Spring and summer chinook	Steelhead	Sockeye	Total basin	Total basin
	----- Thousand dollars -----					1993 dollars
Alaska low	602	0	0	0	602	635
Alaska high	1,203	0	0	0	1,203	1,269
Canada low	1,969	38	0	0	2,007	2,117
Canada high	3,938	78	0	0	4,016	4,236
CA-OR-WA low	433	0	0	0	433	456
CA-OR-WA high	875	1	0	0	875	923
Total basin low	3,004	38	0	0	3,042	3,209
Total basin high	6,016	79	0	0	6,095	6,430
Average basin	4,510	59	--	--	4,569	4,820

^a Value \$1,000—nominal dollars unless elsewhere indicated.

Source: USDE and others (1994d; tables 3-2, 3-5, 3-6).

mercial fisheries is much higher, but the time involved and the income generated are generally small under current catch levels. A more precise estimate of employment generated would require significant investment of resources and lies beyond the scope of this study.

Ocean—Basin salmon are caught in mixed-stock fisheries off Alaska, British Columbia, California, Oregon, and Washington. As shown in table 5, fall chinook from the basin contribute the greatest amount of salmon from Columbia basin stocks to west coast ocean fisheries in Alaska, Canada, and the United States. The gross revenue data (high estimate) correspond to the inriver values in table 4, although the time period differs from which the annual average is calculated. From comparison with table 4, ocean harvest values of fall chinook are considerably greater than the total value of the inriver harvests.

In table 5, low values represent an estimate of net economic value based on a net-to-gross ratio of 50 percent for commercial fishing. High values represent gross revenues in commercial fishing. The basin proportion of total Columbia River value is calculated from the ratio of the number of basin fish caught in each area to total Columbia River production caught in that area.

Direct economic comparisons do not equate to numbers of fish because the ocean-caught fish tend to command a higher price for quality, whereas inriver harvests represent higher weight per fish. Still, the basin contributes significantly to the ocean harvest of fall chinook. Employment-related impacts can be expected to be slightly higher than inriver fisheries owing to the greater amount of catch taken there.

The ocean-catch estimates for 1987-91 illustrate the importance of negotiations under the Pacific Salmon Treaty to reduce or eliminate interceptions of fall chinook salmon off Alaska and Canada to rebuild basin runs. United States west coast interceptions of the fall chinook are relatively smaller than in other areas in Canada and off Alaska, largely because of management measures under the Pacific Marine Fisheries Council. Spring and summer chinook stocks seem to escape interception in the northern fisheries as do steelhead and sockeye. While these reference data were being collected, considerable controversy was raging about interceptions of U.S. salmon in high seas drift net fisheries in the North Pacific. Reports from official observers monitoring these high seas fleets under bilateral agreements with the United States seem to indicate that during the period of observation, salmon interception rates were lower than most perceived them to be. High seas driftnet fishing was banned in 1992 (Burke 1994).

Looking more broadly at the net economic values in the commercial salmon fisheries, the cost factors relevant to understanding the net economic benefit to the Nation would include costs of hatchery construction and operation as well as other management and mitigation activities (Huppert and Fluharty 1995). Presently, these costs relative to the commercial value of salmon seem large. Obviously, increased abundance of salmon from recovered populations and more successful fish hatchery programs would tend to balance this ratio better than is now the case. In addition, consideration of other types of value associated with commercial salmon runs and the benefits from maintaining suitable habitat also would tend to balance the ratio (Alkire 1993). It is critical to know that commercial fishing values are not the only relevant statement of values for fish in the basin. Also, direct employment in fish harvesting and processing is not the only measure of employment. Many biologists, hatchery managers, enforcement agents,

and fishery managers also are employed in the fishery. It is ironic that employment in indirect aspects of the fishery may be increasing as jobs directly related to fishing are declining.

Translating these commercial values for salmon and other fish into employment and income generation for basin communities in a systematic fashion goes beyond the scope of this study. Separate analysis of treaty fisheries as well as nontreaty fishing would have to be performed to obtain suitable data. For the basin, there is no source of separate commercial fisheries employment (harvesting, processing, and marketing), but currently, it is reasonable to assert that it is a small component of total employment in the region, although locally significant. Little commercial fishing is allowed or possible on the small stocks sizes as seen in table 3. Employment in fisheries is small (table 4), and in 1995, the salmon component was nearly zero because of low stock abundance. Other species are only marginally produced in the basin. The gross income produced from basin fisheries in recent times averages (tables 3, 4, and 5) about \$12 million annually but is much below that in 1995. Calculation of indirect effects is complicated by the need to use different coefficients for different species, gear types, and harvest locations as illustrated in a recent study of the ocean fisheries of Oregon (Radtke and Davis 1994).

Recreational Fisheries

Recreational fisheries in the basin are less well documented than are commercial fisheries. This is, in part, a function of their complexity and the difficulty in monitoring the activity levels, and also a function of a perceived low value, in general, of acquiring this information. In the basin, much of the recreational activity occurs on public lands and waters. Free access for fishing tends to equate to low value to users and land managers alike; access, however, is only one part of the equation. Purchases of food, equipment, lodging, transportation, licenses, and other accouterments of recreational fishing add up to a significant expenditure.

In some areas, whole towns, resorts, businesses, and individuals are highly dependent on sale of services to people who participate in recreational fishing. Change in consumer preferences, catch rates, and regulations all may affect the survival and success of businesses that are only indirectly associated with fishing (Radtke and Davis 1994). The focus for this analysis is on the primary economic impacts associated with recreational fishing.

In this section, various components of recreational fishing values are assessed. The key economic valuation issue is linking estimates of use of recreational fishing with estimates of consumer surplus across a large geographic area with diverse types of fishing opportunities. This section starts with review of existing studies of consumer surplus and then seeks to apply selected ones as appropriate. The only synoptic approach to fishing participation rates and expenditures, as opposed to economic values, for all areas and fisheries of the basin is found in the U.S. Fish and Wildlife Service (USDI FWS 1985, 1993). The Columbia River SOR is another source of information on recreational fisheries associated mostly with Federal water resource projects in the basin (USDE and others 1994d). Preliminary analyses of use and value are available in the SOR draft environmental impact statement. Results of a formal new recreation value survey and analysis undertaken as part of the SOR work were not available at the time of this writing. On completion, that study is likely to represent the most authoritative and timely basis for net economic value of many types of recreational fisheries in the basin. The states of Idaho, Montana, Oregon, and Washington also have sought to assess the value of recreational fisheries as well as to obtain information for specific management issues in recent years.

Several caveats may be in order at the beginning of the examination of recreational fishing:

First, there is no explicit discussion of tribal recreational fisheries. Traditional fishing and subsistence food gathering activities by Native Americans may be carried out by using equipment and practices

that seem comparable to recreational fishing taking place at the same time and place by non-Indians. This is not to say that Native Americans do not participate in recreational fishing, but it does not make the traditional fishing a recreational activity; that is, fishing occupies a different place in the culture of Native Americans than it does in that of non-Indians. Because relatively little study has been accorded noncommercial fishing by tribes in the basin today, however, there is little basis for reporting on that activity in this study.

Second, the diversity of recreational fishing activities (anadromous, resident, warm water, cold water, ice fishing, and specialized gear fisheries—flies, plugs, etc.) and the vast geographic scale of the basin make it difficult to provide detailed treatment of each. Also, the lack of comprehensive surveys is limiting. The economic values of recreational fishing are significant, diverse, and pervasive in the basin.

Economic evaluation—Economic evaluation for recreational fishing depends on clear specification of measures of use reflected in estimates of consumer surplus and recreational expenditure patterns. Ideally, monitoring of use and survey of economic parameters occurs simultaneously. In practice, the expense and logistics of performing such studies on the time and space scales necessary for management make it unusual for the ideal approach to be used. Instead, it is common to seek the most comparable analysis of consumer surplus for the geographic area and activity and apply it to the question under examination. In a descriptive analysis of a large region with diverse fisheries, such as the present study, it is useful to compare existing studies of net economic values for fishing. Walsh and others (1988) present a comprehensive analysis of 88 TCM or CVM studies (table 6). These values cover various surveyed locations and fisheries. Each study has been screened for adherence to fundamental economic tenets. Thus, any major deviation from the range reported should be explained by special circumstances, such as regional differences, high-quality fisheries, etc.

Table 6—Estimates of fishing net economic values by travel cost model and contingent valuation method demand studies

Type of fishing	Number of estimates	Mean	Median	Standard error of mean	95-percent confidence interval	Range	Mean 1993 dollars ^a
Cold water	39	30.62	28.49	3.24	24.27-36.97	10.07-118.12	38.03
Warm water	23	23.55	22.5	2.46	18.73-28.37	8.13-59.42	29.25
Anadromous	9	54.01	46.24	11.01	32.43-75.59	16.85-127.26	67.08
Salt water	17	72.49	53.35	14.05	44.95-100.03	18.69-219.65	90.03
All fishing	88	39.25	29.59	3.80	31.80-46.70	8.13-219.65	48.75

^a 1987 dollars converted to 1993 dollars by using GNP price deflator.

Source: Walsh and others 1988.

Most of the studies in Walsh and others (1988) are somewhat dated. It may be bordering on inappropriate to update them by using the GNP price deflator without further examination. Recent derived and empirical studies from the Pacific Northwest therefore are reviewed in table 7, and their results can be compared with those of Walsh and others (1988). Most studies are built from prior studies and simply produced by using some price deflator. Thus, until the SOR work is completed, there is no more definitive study available.

Fish and Wildlife Service survey—Estimates of the number of persons participating in recreational fisheries nationally are made by the U.S. Fish and Wildlife Service. The "National Survey of Fishing, Hunting and Wildlife-Associated Recreation" is performed at about 5-year intervals (see appendix L). The latest available survey is for 1991 (USDI FWS 1993). State data were available for this analysis, but a breakdown by wildlife management regions was not available. The wildlife management regions from the 1985 survey by state (USDI FWS 1989a, 1989b, 1989c, 1989d) therefore were used to obtain an approximation of recreational fishing participation in the basin.

It was assumed that the relative proportions of fishing activity remain the same by state and wildlife management area. This assumption is

reasonable in light of the alternatives; the mid-1980s, however, show a strong increase in several salmon populations in the basin, which may have skewed participation rates upward when compared to the sharp declines in salmon abundance in 1990. Another confounding factor could be the increased popularity of walleye sports fishing in the Columbia River in Washington. In addition, displacement of effort formerly in saltwater and freshwater salmon fishing into warm water fisheries may have occurred in Oregon and Washington. Data confirming these considerations are mostly anecdotal although initiatives in Washington to obtain better funding for staff and research make a compelling argument for greater recognition of the warm water fisheries in the basin.¹² The final issue is that improvements in the technical aspects of methods used in the 1991 survey differ somewhat from those used in the 1985 survey but not in ways that affect the utility of the assumption made.

¹² Central Washington Fish Advisory Committee. [n.d.]. Lets [sic] stop these tax dollars . . . from getting away. Moses Lake, WA. 16 p. Draft on file with author.

Table 7—Estimates of fishing net economic values in the Pacific Northwest^a

Source or location	Year	Fishery	Method	Estimate	
				Nominal dollars	1993 dollars
USDE and others 1994b	1994	A	Modification of Walsh and others 1988 [AD]	50.50 low 63.50 high	50.50 low 63.50 high
USDE and others 1994c	1993	R	Modification of other studies; new analysis pending	24.90 low 44.00 high	24.90 low 44.00 high
USDA FS 1990	1989	CW+A WW	Empirical studies and review of literature [AD] [WFUD]	Reg. 6 [AD] 22.47 AF 23.00 CW 12.00 WW Reg. 1 [AD] Reg. 4 [AD] 15.59 AF 16.00 CW 12.00 WW	25.73 26.33 13.74 17.85 18.32 13.74
Montana:					
Duffield and others 1987	1985	Lake Stream CW	TCM	89.00 L [T] 70.00 L [D] 113.00 S [T] 102.00 S [D]	117.12 92.12 148.71 134.23
Duffield and Allen 1988	1986	CW River Trout	CVM survey	117.00	150
Oregon:					
Davis and Radke 1991	1988, 1989	AF	Expenditure	42.15 [D]	
Washington:					
Southwick Associates 1992	1991	AF	Expenditure	Aggregate expenditure	
Olson and others 1991	1989	A, St	CVM sport and existence Columbia basin	90.08 A 46.36 St	103.14 53.08
Department of Community Development 1988	1988	A, Stur.	NEV Columbia basin (and other regions)	30.75 A (avg.)	36.90
Mongillo and Hahn 1988	1987	RGF	Angler survey (not econ.)		

^a A = Anadromous; CW = cold water; WW = warm water; SW = saltwater; AF = all fishing; R = reservoir; L = lake; S = stream; St = steelhead; Stur. = sturgeon; RGF = resident game fish. NEV = net economic value ; [AD] = activity day; [WFUD] = wildlife and fish user day; [D] = any part of a day; [T] = trip; TCM = travel cost model; CVM = contingent valuation method.

A summary of survey results relative to freshwater recreation in the basin is presented in table 8. In the four-state region, there are about 2 million anglers over the age of 16, of which about 75 percent are residents of the states and 25 percent are nonresidents. Participation seems relatively proportional to total state population, except nonresidents boost Idaho and Montana totals considerably. Washington has the lowest proportion of nonresident participation (8 percent), whereas Montana's nonresident fishing anglers (52 percent) exceed resident participation. More than one-third of anglers in Idaho are nonresident, and in Oregon about one-quarter are nonresident. In the basin, the number of anglers in the wildlife management regions is about 1.1 million, about 70 to 30 percent residents and nonresidents, respectively. The statewide distribution of resident versus nonresident participation remains close (within a few percentage points) to the general participation rates by states except for Washington where the nonresident angler days is double the proportion of nonresident anglers in the basin.

Total days fishing (any part of a day spent fishing) in the four-state region amount to 21.4 million days. Of the total days fishing, residents fished on more days than did nonresident anglers. This result is consistent with the nonresident fishing being associated with travel. About half of the fishing days in the four-state region are spent in the basin. The even geographic split between days fishing in eastern and western Oregon and Washington is somewhat surprising given the larger population distributed in the western portions of these states. This observation probably reflects the popularity of fishing trips and vacations to the warmer, drier, and more diverse fishing opportunities in the eastern parts of the states. The relatively high number of Montana resident fishing days in the basin also may reflect a preference to travel to the high-quality fishing country in western Montana.

Expenditures for fishing include money spent on fishing trips and recreational equipment and take into account expenditures by the individuals themselves and the value of gifts they received. Total fishing-related expenditures amounted to \$1.7 billion in the four-state region. Calculation of the amount of those expenditures occurring in the basin was done by allocating the expenditures in proportion to the number of anglers participating in fishing in the wildlife management regions. The result is that about \$725 million was spent on fishing in the basin in 1991 (\$764 million in 1993 dollars). It may be that this tends to underrepresent expenditures in the basin based on freshwater angling taken by itself. This approach was necessary because only statewide fishing expenditures were available. For Oregon and Washington, statewide fishing expenditures included expenditures for saltwater and freshwater fishing. Thus, the number of anglers from those states and nonresidents increased along with the number of fishing days. Without further information, it is not possible to arrive at a more precise estimate of basin expenditure.

Recreational fishing—salmon—The U.S. Fish and Wildlife Service survey does not adequately distinguish recreational fisheries for salmon and steelhead from other saltwater and freshwater fishing. Recreation data for the basin are shown in table 9. The inriver recreational fishery in the basin is largely made up of fall chinook and steelhead with a few spring and summer chinook as well. The total value (in 1993 dollars) of the inriver recreational salmonid fishery is estimated to be between \$7.4 and \$9.2 million dollars based on the catch years 1987-91. Since that time, harvests have declined so that the current value is considerably less than that of the early 1990s assuming no change in consumer surplus measured as willingness-to-pay or TCMs.

Table 8—Freshwater fisheries-associated recreation in the basin,1991

Parameter	Idaho	Montana	Oregon	Washington	Total no.
Total anglers:	365,000	342,000	605,000	681,000	1,993,000
Resident no.	232,000	164,000	457,000	626,000	1,479,000
Resident (%)	64	48	76	92	74
Nonresident no.	133,000	178,000	147,000	56,000	514,000
Nonresident (%)	36	52	24	8	26
Basin anglers: ^a	365,000	135,774	225,060	397,023	1,122,857
Resident no.	232,000	68,430	178,022	329,926	808,378
Resident (%)	64.0	50.7	79.1	83.1	72.0
Nonresident no.	133,000	67,344	47,037	67,097	314,478
Nonresident (%)	36	50	20	17	28
Total days fishing:	3,157,000	3,156,000	6,490,000	8,583,000	21,386,000
Resident no.	2,495,000	1,872,000	5,817,000	8,285,000	18,469,000
Resident (%)	79	59	90	97	86
Nonresident no.	662,000	1,284,000	674,000	298,000	2,918,000
Nonresident (%)	21	41	10	3	14
Basin days fishing:	3,157,000	959,424	1,518,660	4,617,654	10,252,738
Resident no.	2,495,000	767,539	1,131,401	4,128,182	8,522,122
Resident (%)	79	80	74	89	83
Nonresident no.	662,000	191,885	387,259	489,471	1,730,615
Nonresident (%)	21	20	25	11	17
Total fishing expenditures: \$1,000 ^b	145,456	71,200	461,297	1,009,309	1,687,262
Total anglers	365,000	342,000	717,000 ^c	995,000 ^c	2,419,000
Basin anglers	365,000	135,774	225,060	397,023	1,122,857
Basin R/NR	100	40	31	40	46
Basin fishing expenditures \$1,000	145,456	28,266	144,847	404,714	723,283 ^d
Basin fishing expenditures in 1993 dollars	153,456	29,820	152,813	426,973	763,063 ^d

^a Basin values assume the pattern and distribution of activities remains proportional to 1985 data (USD I FWS 1989a, 1989b, 1989c, 1989d, table 23; USD I FWS 1993, table 65).

^b Assigns same value to all types of fishing. Basin values for salmon, freshwater (cold and warm water) and resident and nonresident not distinguished in original source (USD I FWS 1993, table 68).

^c Total fresh water and saltwater anglers for Oregon and Washington (USD I FWS 1993 table 60).

^d Sum of total weightings.

Table 9—Estimated annual average value of basin salmon caught in recreational fisheries, 1987-91 (dollars × 1,000 – nominal dollars)^a

Fishery and area	Fall chinook	Spring and summer chinook	Steelhead	Sockeye	Total basin	Total basin 1993 dollars
Alaska low	102	0	0	0	102	108
Alaska high	130	0	0	0	130	137
Canada low	461	0	0	0	461	486
Canada high	586	0	0	0	586	618
CA-OR-WA low	1,044	0	0	0	1,044	1,101
CA-OR-WA high	1,314	0	0	0	1,314	1,386
Inriver low	615	10	6,430	0	7,055	7,443
Inriver high	620	10	8,080	0	8,710	9,189
Total basin low	2,222	10	6,430	0	8,662	9,138
Total basin high	2,650	10	8,080	0	10,740	11,331

^a Low values represent a recreation day value of \$50.50, and high values represent a recreation day value of \$63.50. These values are consumer surplus values based on other studies described in the source. Basin proportion of total Columbia River value calculated from ratio of numbers of basin origin fish caught in each area to total Columbia River production caught in that area.

Source: USDE and others 1994d (tables 3-3, 3-5, 3-6).

This assumption may be open to challenge as the basin salmon resource becomes more scarce. A new household survey of fish values in the basin is underway as part of the Columbia River SOR (USDE and others 1994b).

Fall chinook salmon in the basin contribute substantially to recreational fisheries in the lower Columbia River, U.S. west coast, British Columbia, and Alaska (table 9). The lower Columbia River harvests of basin fall chinook (not shown) are about equal in value to those harvested above Bonneville Dam. The U.S. coast harvests of fall chinook come to a large extent (ca. 90 percent) from the basin. The value of interceptions by Canada of fall chinook from Columbia River stocks is almost exclusively (96 percent) from

basin stocks. Interceptions by Alaska of Columbia River stocks also have a high percentage (90 percent) from the basin. The total contribution of basin stocks to recreational fish values (in 1993 dollars) in the Pacific Ocean is estimated to be between \$9.1 and \$11.3 million based on the catch years 1987-91. Since that time, harvests have declined to a point that the current value is considerably less than that of the early 1990s as noted above.

Most of the recreational harvests of basin salmonids occur outside the area. For upriver fishing interests, especially in Idaho, the harvest of steelhead has been particularly valuable as seen in table 10. Although the present level of abundance of summer steelhead is low in comparison with earlier times, the numbers have increased over the last 15 years.

Table 10—Recreational catch of upriver summer steelhead in main-stem Columbia and tributaries, 1979-93

Run year	Idaho	Oregon	Washington	Total
	<i>In thousands</i>			
1979-80	2.8	7.0	11.9	21.7
1980-81	12.1	11.5	13.4	37.0
1981-82	10.9	11.2	21.9	44.0
1982-83	27.9	9.9	16.3	54.1
1983-84	28.1	14.0	23.3	65.4
1984-85	32.0	16.1	35.1	83.5
1985-86	32.6	18.5	36.8	87.9
1986-87	47.9	25.4	40.6	113.9
1987-88	18.0	26.3	25.2	69.5
1988-89	23.5	26.5	30.2	80.2
1989-90	48.9	27.4	32.8	109.1
1990-91	19.0	18.5	23.8	61.3
1991-92	28.6	36.2	36.6	101.4
1992-93	44.7	(35.0) ^a	52.2	(131.9) ^a

^a Figures in parentheses are preliminary. Please note that Nota benna includes main-stem harvests of lower river steelhead producing tributaries.

Sources: WDFW and ODFW 1994.

Recreational fishing—other species—Recreational fisheries for white sturgeon, walleye, and shad exist in the basin and the lower Columbia River. Data on harvests but not levels of participation and value of recreational fisheries are available. As shown in table 11, data are scant but indicative of increasing levels of effort targeting species other than salmonids. White sturgeon have at times become the prime recreational fishery target in the lower Columbia River (Department of Community Development 1988). Most of the sport fishery takes place below Bonneville Dam. Above Bonneville Dam, the data are spotty but show small harvests by sports fishing in the

reservoirs of the upper Columbia and lower Snake Rivers. Sturgeon angling in the Idaho portion of the Snake River has been under catch-and-release management since 1970 and has been classified by Idaho as a species of special concern. The Bureau of Land Management and the U.S. Fish and Wildlife Service give special management status to white sturgeon (PSMFC 1992). The white sturgeon population in the Kootenai River has recently been listed as endangered under the ESA.

Walleye and shad are not native to the basin; both, however, are well established and support recreational fisheries. Shad in the lower Columbia River are quite popular as a sport fishing target.

Table 11—Recreational harvest of nonsalmonid species in the basin

Year	White sturgeon	Walleye harvest (survey) Bonneville Dam	Walleye harvest The Dalles pool	Walleye harvest John Day pool	Walleye survey total
1980	5.0				
1981	5.0	0	2,062	164	2,226
1982	5.0	NS	NS	NS	NS
1983	5.0	NS	NS	463	(463) ^a
1984	5.0	NS	NS	349	(349)
1985	5.0	NS	NS	186	(186)
1986	5.0	NS	NS	291	(291)
1987	6.7	NS	1,660	NS	(1,660)
1988	3.3	394	3,480	NS	(3,874)
1989	4.0	1,066	7,556	1,718	10,340
1990	3.1	1,351	NS	3,088	(4,439)
1991	2.6	NS	NS	2,207	(2,207)
1992	2.0	100	1,000	1,780	2,880
1993	2.6	82	2,200	2,747	5,028

^a Parentheses indicate incomplete data.

NS = no survey.

Source: WDFW and ODFW 1994.

The extent to which sport shad fisheries will develop in the basin remains to be seen (Hislop 1994). The time adult shad spend in the river severely limits the sport fishery. Walleye, introduced in the upper Columbia River in the 1940s are spreading downstream and are attracting considerable recreational fishing interest (Beath 1991; Bisbee 1981; Hartzell 1991; Sullivan 1990, 1993). The Columbia River and lakes in the basin seem to provide ideal habitat for walleye, and catches close to the world record have been made.

Reservoir recreational fisheries—The transformation of a major part of the basin main-stem river habitat to reservoirs has altered the type of

recreation available to sport fishing. Reservoir fishing is a significant component of the recreational fishing spectrum as shown in table 12. Data on visitation are not maintained for all reservoirs, but where counts are made, reservoir fishing days constitute a major recreational activity. The Hanford Reach of the Columbia River is a 55-mile-long stretch of undammed river, although its hydrology is much altered by releases from dams upstream. It offers the closest recreational fishing experience to that before the dams. As seen in table 12, it provides a small but unique portion of the Columbia River recreation.

Table 12—Fishing activity and value at main-stem Columbia River basin dams in the basin

Dams	Year built	Reservoir length	Visitor days 5-yr avg.	Fishing days	Fishing value, low	Fishing value, high
		<i>Miles</i>	<i>--- Thousand days ---</i>		<i>----- Thousand dollars -----</i>	
Federal:						
Bonneville-Lake Bonneville*	1938	45	3,354.1	1,166.2	29,038.4	51,312.8
Dalles-Lake Celilo*	1957	31	2,170.2	289.1	7,198.6	12,720.4
John Day-Lake Umatilla*	1968	76	2,300.0	507.0	12,624.3	22,308.0
McNary-Lake Wallula*	1953	61	2,971.2	379.4	9,447.1	16,693.6
Chief Joseph-Lake Rufus Woods	1955	51	356.6	79.0	1,967.1	3,476.0
Grand Coulee-Lake Roosevelt	1941	151	1,837.9	241.7	6,018.3	10,634.8
Ice Harbor-Lake Sacajawea*	1961	32	467.0	76.8	1,912.3	3,379.2
Lower Monumental-Lake West*	1969	29	141.4	30.9	769.4	1,359.6
Little Goose-Lake Bryan*	1970	37	238.5	26.0	647.4	1,144.0
Lower Granite-L. Granite Lake*	1975	39	1,437.1	155.4	3,869.5	6,837.6
Total			15,274.0	2,951.5	73,492.3	129,866.0
Non-Federal:						
Wells*	1967	30	NA			
Rocky Reach*	1961	42	621.8			
Rock Island*	1933	21	860.1			
Wanapum*	1964	38	NA			
Priest Rapids*	1959	18	NA			
Hells Canyon NRA	1967	22	43.5			
Oxbow	1961	12	NA			
Brownlee	1958	57	NA			
Other:						
Hanford Reach (controlled river reach)*		55	154.9	14.8	368.5	651.2

* = adult fish passage.

Source: Visitor days for recreation are from USDE and others 1994c. (Low consumer surplus recreation value is \$24.90, and high value is \$44.00 per activity day.) Fish passage status and reservoir length are from WDFW and ODFW 1992. Estimates of fishing days generated by Chuck Korson, SOR Recreation Working Group, June 1994, based on data from U.S. Army Corp of Engineers (USCOE), USDA FS, National Park Service, and Bureau of Reclamation, with USCOE load factors applied.

Table 13—Fish guide permits and revenues from public lands in the basin, 1994

Agency	Number of permits	Revenue (\$)
Bureau of Land Management	130	26,482 ^a
USDA Forest Service	23	11,026
National Park Service	2	200
U.S. Fish and Wildlife Service	13,050	0 ^b
Total	13,205	37,708

^a 1993.

^b Self-issue permit, self-guided and no fee charged.

Source: Personal communication, 1994. Amy Molitor, economist Walla Walla, WA 99362; preliminary data Eastside Forest Ecosystem Analysis Team 1995.

Other Fish Valuation Issues

To this point, tribal, sport, commercial, and recreational fisheries have been examined. These, however, do not fully capture the diverse fishery values associated with fish in the basin. In this section, examples of other fish valuation issues are presented, including revenues from fishing guide permits, the concept of value of genetic resources, problems of illegal fishing, the values associated with fish viewing, as well as fish festivals and competitions, compensation for lost fishing opportunities, and effects of introduced species. This is not an exhaustive examination of any of these topics, but it is intended to be indicative of the various fish values existing in the basin.

Fish guide permits—One measure of the value of fishing is the revenue derived from the licensing of fishing guides on public lands in the basin. Preliminary data¹³ indicate that the amount of such revenue is modest, and yet the number of permits belies a significant value associated with guided fishing on public lands (table 13). Much of this value is already reported in the freshwater fish valuation above; the revenue therefore should not be seen as additive to earlier numbers.

¹³Personal communication. 1994. Amy Molitor, economist, 545 Stone Creek Place, Walla Walla, WA 99362.

Genetic resources—Most economic valuation of genetic resources tends to focus on the potential value of pharmaceutical values or biotechnology values for commercial production from selected genes (Pearce 1993, Swanson and Barbier 1992). Seen more broadly, genetic resources are generally treated as public goods that provide benefits through use, such as commercial, recreational, tribal fisheries, and fish augmentation through hatchery production or transplantation of species. In other senses, genetic resources are public goods in that society allows free collection of gene materials for other purposes (study, experimentation, etc.) and for nonconsumptive use in the form of ecotourism (that is, fish viewing at passage facilities in situ). In assigning value to genetic resources, there is a problem of separating out the components of value associated with the genetic material itself from other ways of valuing the plants and animals in which it is incorporated (National Council on Gene Resources 1982).

Loss of genetic diversity in fish stocks in the basin can occur in native anadromous and resident fish as well as hatchery production and introduced species. Most attention has been given to the genetic values associated with endangered salmonids but, on one dimension, an irreversible loss of genetic diversity applies equally to all species. The main question for economic analysis is how to

value genetic diversity—for its intrinsic value or for its use value, or both. It is relatively simple to place use values on a fish species. Harvest value and even nonmarket values associated with its mere existence are within the range of economic methods. As commercial stocks decline, however, the use values decline also, especially for species such as salmon for which there are many other sources of supply. Should a noncommercial fish be treated as having zero value? What about its recreational value? Straight economic answers would tend to arrive at low values for scarce genetic stocks (from a use value perspective). Some involved in the debate over fish protection might argue, the scarcer the stock, the more likely the value borders on infinite. In their view, because it is impossible to replace the genetic material in fish that have evolved over eons and are represented in fish spawning in a single stream, the value must be large. Somewhat countering this point of view is the observation that many salmon species have become extinct in the last century in the basin, and yet most would regard the impact on society to be negligible (except in the abstract).

The incredible efforts the National Marine Fishery Service is making to maintain the genetic integrity of the Snake River sockeye salmon found only in Redfish Lake, Idaho, is an illustration of how costly it is to attempt to save a salmon species from extinction. The broodstock program alone is estimated to cost from \$3 to \$5 million per year over at least a 7-year period (Huppert and Fluharty 1995). From another perspective, the transfer of salmon from the Pacific Northwest to the Great Lakes in the Midwest resulted in establishment of a multimillion dollar recreational fishery. The adaptability of the transplanted salmon stocks, in this case, was remarkable. Many other transplants have not been so successful. Thus, the issue of valuation of genetic resources is only starting to gain attention and is far from being resolved.

Illegal fishing—Illegal fishing has posed problems in the basin. Salmon and sturgeon have been the main species poached. Despite a strong ethic of sporting behavior that prevails in the tribal, commercial, and recreational fishing communities, some fishers may occasionally ignore limits and seasons. Publicized planting of some lakes predictably leads to illegal sport fishing activity such as reported when nine anglers were caught with 140 German brown trout (Yuasa 1994). Sometimes, lack of knowledge of fishing regulations and inability to identify species of fish or to navigate may result in inadvertent illegal harvest of fish. High unemployment in rural communities may provide some incentive to fish illegally for subsistence. It can, however, be quite lucrative as two recreational fishers learned by selling \$20,000 of illegal salmon to restaurants. When apprehended and tried, one was sentenced to 30 days in jail, and the other paid a fine of \$1,000 and received a 1-year suspended sentence (Dietrich 1995). Still, recreational poaching does not seem to be a major fish conservation issue in the basin.

Commercial poaching can be significant and may be so severe that it impacts the success of management programs. Probably the most egregious case in recent years is the poaching of sturgeon in the mid-Columbia for sale of caviar. Catch of an estimated 350 large female sturgeon between 1985 and 1990 was estimated to have been required to procure the estimated 3,200 pounds of caviar worth \$240,000 that one poacher is thought to have accomplished. This amount dwarfs the annual legal harvest of sturgeon roe in Washington, which averages 650 pounds (Lewis 1993). It is not inconceivable that this level of activity has slowed recovery of mid-Columbia sturgeon stocks. With respect to salmon, the commercial operations tend to be composed of individuals catching and selling fish out of season. Typically, the sale is to a restaurant or retailer who may or may not know the origins of the fish. Sturgeon poaching is more limited than salmon in the number of individuals involved, but the quantities of caviar (sturgeon roe) have made for a lucrative trade.

No systematic estimates of poaching activities on salmon exists; an indication of the potential scale of activity, however, is shown by a poaching operation investigated several years ago where it was found that more than 50 tons of illegal Columbia River salmon were offered on the market.

Fisheries enforcement is carried out by state police, Federal agents, and CRITFC and tribal enforcement officers. A special antipoaching Columbia River Task Force has been formed among state and Federal agencies and the tribes with funding from a 3-year grant of \$10 million from Bonneville Power Administration (Norton 1992). Funding for the enforcement activities totals about \$3.5 million annually (Huppert and Fluharty 1995). In recent years, Columbia River fishery violations for which arrests resulted were about 1,750 cases with 97 percent involving fishing by non-Indians and only 3 percent being tribal fishing. In June 1994, a special-emphasis patrol in the basin (zone 6) found 17 non-Indians fishing out of compliance. These fisheries violations carry penalties as severe as \$2,500 in fines and a year in jail for serious cases (Craig 1994). Also, the level of expenditure contributes substantially to the employment of several enforcement personnel with attendant economic spinoff effects.

Nonconsumptive fisheries recreation—The saga of the salmon appeals to many who fish and even those who do not. Viewing salmon spawning in rivers and streams is popular but not nearly as well attended as viewing stations at dams and fish ladders. These facilities on major Columbia River dams account for millions of visits per year. This number is vastly more than the number of licenses issued for fishing. Valuation of these visits is methodologically difficult because they are frequently done as part of other tourist activities; some data, however, are available. Table 14 shows estimates for the amount of participation in nonconsumptive recreation related to fishing. This includes watching people fish, visiting hatcheries, and other activities associated with fish in addition to fish viewing at dams. There are some

interesting patterns to note. In the basin, there are about 210,000 visits related to fish with total spending of nearly \$80 million (in 1993 dollars) annually. In Montana, Idaho, and Oregon, non-residents make up a large portion of the nonconsumptive-fisheries oriented recreation in contrast to Washington where the residents outnumber the visitors in participation. Nonconsumptive fisheries recreation in the basin attracts a relatively small (8 to 14 percent) portion of all such recreation, and yet it can still represent a significant amount of economic activity.

Fish festivals and competitions—Fish festivals are currently celebrated throughout eastern Oregon and Washington. Leavenworth and Wenatchee, for example, sponsor salmon-day festivals as do other communities. No comprehensive listing of these festivals is available.

Compensation—As a result of treaty obligations, tribes are due compensation for "subordination" of fishing rights or loss of fishing access. This could be considered a partial measure of value of the fishery. It is key to point out that this is not compensation for the fishing right—that is unchanged. However, the right of access and fishing in a usual and accustomed place is lost. When most of the basin dams were constructed, compensation occurred only for property inundated by the dams. No systematic analysis of this issue is available.

When The Dalles Dam was built and flooded, the most important Native American fishing site in North America—Celilo Falls, a payment for "subordination" of usual and accustomed fishing sites to hydropower and other interests was negotiated with four mid-Columbia tribes (Yakama, Nez Perce, Umatilla, and Warm Springs). It amounted to the estimated "capitalization at 3 percent of the total value of the fish caught by the Indians in an average year and sold commercially or to tourists or used for subsistence"—a total of about \$26.9

Table 14—Primary nonconsumptive (NC) fisheries-oriented recreation in 1991 in the basin

Parameter	Idaho	Montana	Oregon	Washington	Total number
Total participants:	382,000	558,000	882,000	1,058,000	2,880,000
Residents	194,000	173,000	479,000	800,000	1,646,000
Residents (%)	51	31	54	76	57
Nonresidents	188,000	384,000	402,000	258,000	1,232,000
Nonresidents (%)	49	69	46	24	43
Basin participants:	382,000	221,526	328,104	569,204	1,500,834
Percentage of total	100	39.7	37.2	53.8	52.1
Fish related	49,660	28,798	26,248	102,457	207,163
Participation ^a percentage	13	13	8	18	14
Total expenditure (\$1,000):	68,017	102,205	362,111	511,218	1,043,551
Trip related	39,563	34,174	119,014	298,941	491,692
Equipment	25,171	63,986	227,909	178,044	495,110
Other	2,283	4,045	8,449	34,232	49,009
Basin (%)	100	39.7	37.2	53.8	49.7
Expenditure of basin NC ^b :					
Total (\$1,000)	68,017	40,575	134,705	275,035	518,332
Fish related (%)	13	13	8	18	14.4
Basin fish related NC ^b :					
Expenditures (\$1,000)	8,842	5,275	10,776	49,506	74,399
Percentage of fish related	12	7	14	67	100
1993 dollars	9,328	5,565	11,369	52,229	78,491

^a Fish related nonconsumptive recreation is calculated assuming the rate of primary residential (USDI FWS 1989a,1989b, 1989c,1989d, table 28) activities in 1985 for each state is representative of primary nonresidential activities. Total attributable to basin in state is assumed to be the same proportion as fisheries in the basin in the state.

^b Nonconsumptive expenditure data derived by applying fish related percentage of primary residential activity based on 1985 data (USDI FWS 1989a,1989b,1989c,1989d, table 28) to total expenditure data.

Source: USDI FWS 1993, tables 71 and 73.

million (Whitefoot v. United States, Oregon State University 1978). This did not compensate for the **right** to fish, and fishing by the mid-Columbia River tribes continues. It can be anticipated that when The Dalles Dam is relicensed, there will be an opportunity to obtain compensation for continuing impacts of the dams on fisheries where these cannot be mitigated.

The Colville Confederated Tribes, received \$60,000 for the inundation of several thousand acres of lands by construction and filling of Grand Coulee Dam in the late 1930s. In 1994, settlement of claims over loss of fishing access, riverbed, and free-flowing river was obtained. The Colville tribes received a lump sum payment of \$53 million and will continue to receive at least \$15.25 million per year in perpetuity. Tribal Chairman Eddie Palmanteer clearly states the tribal view with respect to compensation: "No amount of money can truly compensate the tribes and its members, especially our elders, for the way of life that Grand Coulee Dam took away, and to that extent the settlement is inadequate" (Seattle Times 1994).

A similar settlement was reached tentatively between the Spokane Indian Tribe and Washington Water Power in their long-standing dispute over the ownership of the bed and banks of the Spokane River 36-megawatt Little Falls hydroelectric project. It offers a one-time payment of \$3.2 million for fish and wildlife enhancement, an annual payment of \$375,000 (escalating according to a fixed formula), and \$1 million in exchange for an irrevocable license and easement (Puget Sound Business News 1994).

For basin tribes, the significance of salmon and steelhead as commercial resources transcends the economic valuation. Conventional cost accounting and discount rates simply do not represent the cultural and religious values tribes in the basin have for salmon. Even conventional economic analysis, however, shows the great dependence tribes have on salmon resources in the basin with respect to income and employment (Meyer Resources, Inc. 1983).

More than compensation is due tribes for loss of fish values. Dams licensed more than 50 years ago under the laws of the day are now due for relicensing under the aegis of the Federal Energy Regulatory Commission. The issuance of a new license entails a full environmental review under contemporary laws. Continuing impacts of the dams and their operations are required to receive mitigation. Many dams in the basin are scheduled for relicensing. This may result in changes in operations to protect fish and may mean improvements in recreational facilities and other amenities that increase visitation and thereby contribute to increased value of fish and wildlife resources associated with the projects (Federal Energy Regulatory Commission 1990, 1991).

Another interesting form of compensation, albeit not tied to treaty rights to fish, is harvest of northern squawfish. Studies link squawfish with a high predation rate on salmon smolts. The Bonneville Power Administration, therefore, has instituted the Squawfish Predation Control Program to reduce the abundance of this species. In 1991, CRITFC tribal crews of technicians were paid to fish for northern squawfish in the tailrace areas just below major dams as part of this program. This seasonal work is subcontracted to tribal members and produces about \$300,000 in income for the crews (Anon. 1991). The program pays a bounty for all squawfish caught. Recreational sport fishers also can receive a per-fish payment for northern squawfish.

Introduced species—The record of fish introductions in the basin is somewhat spotty as most such species arrived "informally" through the individual initiative of persons wanting to re-create fishing opportunities they knew in other areas. Most were intended to provide benefits from commercial or subsistence and recreational use, but many resulted in unintended consequences in the form of predation, competition, etc. The "pan" fish largely missing in Oregon and Washington were introduced by people missing that style of fishing from back home. The native species fitting in this

category comprise squawfish, bony chub, and sucker. German carp were possibly the earliest known species introduced via fish culture in 1880 to provide a popular European delicacy to Oregon markets. The Columbia River flooded the carp pond and released fingerlings throughout the river system. Shad were introduced to the basin in 1886.

Introduced species have had to fight for a place in the hearts of many Northwest anglers who are cold water devotees. Fishing can be a competitive sport, and many of the characteristics of warm water fish are conducive to fishing tournaments. Even when not part of a formal fishing contest, record-size fish and large lake and stream fish receive special notice in fishing magazines and newspapers and sometimes in regional media. Fishing derbies have become popular for warm water species at the same time derbies have been halted on anadromous fish (Bailey 1994). There has been slow and consistent growth in the fisheries of warm water species.

With declines in populations of anadromous stocks and limits on the production of resident native species, much interest has developed in fishing for warm water species, most of which are introduced to the basin. Despite the popularity of the warm water fishing opportunities, state and Federal management seem to give these fisheries relatively little management attention and resources. Advocates of more intensive development and management of warm water species are attempting to demonstrate how investments in warm water fisheries can yield large benefits for relatively low costs in comparison to the traditional cold water oriented investments (see footnote 12). With increased fishing pressure and insufficient management attention, declining fishing quality in some areas may indicate conservation problems relative to some stocks.

Future Fish Values in the Basin

Future fish values in the basin depend on demographic trends, social preferences, outcomes of various public policy debates, and biogeophysical events and trends. Generalizations are hazardous to make with respect to the future and especially so with respect to highly variable fisheries. In this section, positive and negative tendencies in fish habitat and its management can be outlined to provide "side boards" on future expectations about fish values.

Demographically, the eastern slope of the Cascade Range has served as the border to the so-called "Empty Quarter," the sparsely populated West (Rudzitis 1995). Populations in this area grew rapidly between 1890 and 1920 but then stabilized and, in some cases, declined because of agricultural rationalization and shift in opportunity (Robbins and Wolf 1994). Since the 1960s, the counties with high-amenity values as measured by adjacency to protected lands—usually Federal—grew rapidly in population. In the 1960s, the growth rate in these counties was three times that of other nonmetropolitan counties. In the 1970s, their growth rate was about twice that of other counties. "During the 1980s, their population increased 24 percent—six times faster than the national average of 4 percent . . ." (Rudzitis 1995). Counties without protected lands (and associated environmental amenities) had much lower population growth rates or declines in some cases. This is probably a reflection of the continuation of trends in agriculture toward larger farms and more mechanized as opposed to manual labor (Morrill and Downing 1986, Power 1995). Participation rates in fishing activity may fall as a percentage of the population, and yet the overall trend is toward steadily increasing use in an absolute sense (Wolf 1995).

These demographic trends seem slated to continue as electronic communication eases the demand to stay connected and yet be able to enjoy the benefits of rural life and the general coastward trends

in U.S. population. The Pacific Northwest region had a population of about 8 million people in 1980. By 1995 it reached nearly 10 million, and by 2015, it is estimated to exceed 12 million (USDE and others 1994b). This means new types of people with different lifestyles moving to rural communities and the economic base being transformed from a strictly extractive or agricultural economy to a more diverse set of footloose industries, service industries, and retirement communities (Power 1995). Such trends place more people in a residential position to participate in recreation activities like fishing in the basin.

There also may be a marginal impact on riparian areas as people build their residences close to the features that make living in amenity areas desirable. In Washington State alone, it is estimated that 30,000 acres of fish and wildlife habitat are lost each year (Turner 1995).

The trends in the various fish stocks (salmonids, cold water, warm water, and rare) and levels of fishing for them are hard to predict (Minkley 1991). In the near term, salmon fisheries in the basin are likely to be depressed and chaotic. Given present trends, the current low level of wild stocks and heavy reliance on hatchery stocks for production means that yields are likely to be at the low end of their range and possibly worsen in the near term. Virtually all commercial fishing for salmonids in the basin is halted or severely restricted relative to even the recent past. Recreational fisheries are similarly constrained, and serious questions are being raised by tribes about the commitment of fishery and hydrosystem managers to maintain the fisheries protected under treaties (Strong 1994). It is unlikely that this situation will change in the short run because relatively healthy wild or hatchery runs that could support a fishery are frequently mixed with runs listed as endangered. Unless some way can be discovered to control fishing pressure on the weak stocks, the "weak stock" management approach being used by state, Federal, and tribal managers will require continuation of the protection of basin stocks.

Despite the scenario for salmonids outlined above, there is a slate of possible habitat management actions for endangered salmon, probable listing of fish stocks under the ESA (1973), and proposed actions to cause recovery of endangered salmon stocks that seek to restore salmon to greater abundance (table 15).¹⁴ Even with the most optimistic conditions for fish survival, recovery of these stocks will be slow—four to five life cycles (12 to 20 years)—and recovery in ESA terms is not defined as recovery to levels of former abundance or to commercial abundance. Recovery is to "restore these distinct populations (and their genetic and demographic subunits) to viable, naturally reproducing self-sustaining numbers" (Snake River Recovery Team 1994). With recovery of the weakest stocks, it may be feasible to allow greater usage of stronger stocks, especially those from hatcheries.

Current costs (out of pocket expenses, loss of revenues of foregone production, and higher cost of offsetting energy purchases) for salmon restoration by Bonneville Power Administration amount to about \$350 million annually in 1994. This amount is more than double the expenditures for salmon restoration in 1991 and represents an increasing share of BPA's total revenues. Implementation of the National Marine Fisheries Service (NMFS) Recovery Plan has been variously estimated to cost \$160 million per year in addition to the existing BPA costs.

The program of restoring anadromous fish in the Columbia River system is the largest and most expensive known to be underway at this time. It exceeds, for example, the total annual budget of the NMFS, which manages all the U.S. marine fisheries and has responsibility for certain species like salmon under the ESA. Obviously, this scale of expenditure attracts attention. Some deem it

¹⁴This presentation is predicated on Federal law existing in May 1995. Efforts in Congress to exempt activities such as salvage logging from compliance with existing law may change this scenario in ways that cannot be anticipated. Similarly, efforts in Congress to revise or repeal existing Federal law may have comparable effect.

Table 15—Examples of existing or contemplated programs affecting fish values in the basin, 1995

Program	Lead agency and agencies	Reference
Salmon 2000	Washington Department of Fish and Wildlife	WDF 1992
Oregon Wild Fish Policy	Oregon Department of Fish and Game	State Legislature Passed Law 1991
Columbia River System Operation Review	Bonneville Power Administration, U.S. Army Corps of Engineers, Bureau of Reclamation	USDE and others 1994a
Forest Ecosystem Management Assessment Team (FEMAT)	Forest Service, National Marine Fisheries Service, Bureau of Land Management, Fish and Wildlife Service, National Park Service, Environmental Protection Agency	USDA and others 1993, USDA and USDI 1994b
Salmon Recovery Program for the Columbia River Basin	Columbia River Inter-Tribal Fish Commission	CRITFC 1992a
PACFISH	Forest Service, Bureau of Land Management	USDA and USDI 1994c
Eastside Ecosystem Management Strategy	Forest Service, Bureau of Land Management	USDA and USDI 1994a
Snake River Salmon Recovery Plan	National Marine Fisheries Service	Snake River Salmon Recovery Team 1994, NMFS 1995
Columbia River Basin Fish and Wildlife Program	Northwest Power Planning Council	NPPC 1993, 1994
Integrated System Plan: Columbia Basin System Planning Salmon and Steelhead	Columbia Basin Fish and Wildlife Authority	CBWFA 1991

too large, others as too little, and still others as misdirected. Economic analysts have sought to help frame the issues for anadromous fisheries and other fisheries in the basin in terms of value of increased fish abundance (Olson and others 1991), cost of proposed recovery measures for endangered species (Huppert and Fluharty 1995), cost-benefit analysis (Scott and others 1987), cost-effectiveness (Olson 1992), and natural capital (Alkire 1993). The SOR posits its economic analysis of the fish and wildlife program in terms of anadromous commercial and recreational fisher-

ies and its resident fish in terms of net economic development analysis, which might be termed the current best practice for cost-benefit analysis (USDE BPA and others 1994d).

Each approach offers insight in terms of economic analysis for policymaking processes. There is general theoretical agreement among economists on the elements of a proper approach to analysis of fisheries values; that is, it should be comprehensive geographically and across sectors of the economy, use common metrics, and use net economic benefits and costs to the Nation (or region) as its analytical perspective. Such a study is not available today,

although the SOR studies come closest. If such a study could be afforded and performed in a timely manner for decisionmaking, it is also apparent that the information such a study provides can be only one component of the myriad legal, social, biological, and political factors considered in setting policy. Until such determination is made, the future of restoration is unclear.

If measures to restore salmonid stocks are successful, it is not clear what remains as the carrying capacity of the basin for wild salmon stocks. Under current conditions, about 75 percent of the fish returning to spawn are from hatchery stocks and 25 percent are from wild stocks. There is no doubt that in some areas, high-quality habitat for wild stocks is not being used. In other areas, even full usage of remaining habitat may not be sufficient to develop large runs on which to base commercial, tribal, or recreational fisheries.

In March of 1995, the NMFS announced measures to cause recovery of Snake River endangered salmon and to protect salmon habitat. Still other efforts by Federal, state, and tribal land and resource managers under such programs as the Northwest Forest Plan are expected to have widespread beneficial effects on many salmon species in the river system. Efforts underway to improve habitat may assist, but the prognosis is that landscape-level changes will take place over the long term only if management and natural successional processes are in the right direction.

Considerable habitat is inaccessible to salmonids due to dam construction on the main-stem Columbia and Snake Rivers. Serious proposals have been made to restore salmon to the upper Snake River habitats (Armour 1990) but not for bypassing Grand Coulee Dam. Similar proposals have been made to remove the Condit Dam on the Big White Salmon River and the Enloe Dam on the Similkameen River (Heinith and Berg 1992). Relicensing of dams by the Federal Energy Regulatory Commission is another point where significant fish mitigation can be obtained. Projects built and operated to earlier standards must now comply with more recent environmental

regulations (Doppelt and others 1993, Echeverria and others 1989, Palmer 1986). The extent to which these efforts may affect fish values in the future is highly speculative. Still, the recreational value of additions to salmon stocks is large, and the significance for tribes now lacking access to former salmon abundance in the upper Snake River is inestimable.

Recreational salmon fisheries are a popular form of leisure in the Pacific Northwest and will remain so. Tight quotas for protecting Columbia River stocks place recreational, commercial, and tribal fisheries in increased conflict over a much diminished resource. The present division of catch among these parties is the result of difficult negotiations. Currently, demands are increasingly strong to eliminate or mostly curtail commercial fishing for salmon. Given the smaller number of fish, the question arises whether the fish are worth more in net benefit terms if taken in recreational fisheries than in commercial fisheries (Courtier 1995). In the basin, the remaining recreational fisheries argue strenuously for a larger share to be taken out of the lower river commercial fisheries.

Most attention given by Federal, state, and tribal fish management entities is devoted to salmonid species. To be sure, significant resources of these agencies are allocated to other rare or endangered species and to management of other cold water and warm water fisheries. If there are continuing losses of salmonids, the relative importance of other species is likely to increase; for example, bull trout. Recreational and commercial fishing patterns may shift to take advantage of remaining species of fish. Cold water fishing opportunities are notable in the basin, particularly in headwater streams supporting native trout but also in lakes and streams where native and introduced cold water species and hatchery stocks constitute the bulk of the fish. Warm water species are likely to play an increasing role in providing recreational opportunities. Comparatively little is known about the potential for warm water fisheries as management has allocated only limited resources

to monitoring and studying these fisheries. Management of the rare species of trouts and other native fish in south-central Oregon (and other areas where they are present) is likely to produce little in the way of increased fishing opportunity; yet it may ensure the survival of the species.

Restoration of habitats for fish in the basin is seldom a short-term uncomplicated, action with instant results. Recent studies have shown that landscape-level disturbance in the basin has occurred over more than a century (Lehmkuhl and others 1994, McIntosh and others 1994, Robbins and Wolf 1994, Wissmar and others 1994). Restoration of habitat by natural processes can be expected to require similar time and space scales. Hypothetical duration of impacts from disturbances range from less than a decade for the case of a drought to as much as 500 years in the case of a major debris flow although there can be considerable variability in resilience in stream systems (Bisson and others 1992). Human intervention in fish habitat restoration may accelerate certain changes; however, there is a lack of information on rates and effectiveness of possible measures. Besides the natural process of recovery of ecosystems, there is the derivative or interacting aspect of long-term change in use patterns and how they affect economic and cultural systems. Relatively little research is available on the relations between economic and ecosystem change, but indications are that societal systems can be slow to adapt to environmental change as well (Glantz 1988, Gunn 1993, Hughes 1994, Marsh 1974, Ponting 1991).

Probably the most important component of habitat is maintenance of an adequate quantity and quality of water. Most of the manipulation of the basin hydrology has hitherto come from impoundments and low-cost hydroelectric power generation. Although pumping of ground water has been a problem in some large areas, increasingly, pumping of ground water poses a threat to riparian ecosystems and their fish in places like the Snake River valley and other aquifers of Idaho used for irrigation. Ground-water pumping lowers the water table, which can affect stream flows

(Barker 1993, Palmer 1991, Stuebner 1995). In the water-parched basin, many rivers are oversubscribed for water withdrawals, leaving little for fish at the requisite times. Resolution of water rights issues on a state-by-state basis is on the agendas, and it remains to be seen if the allocations will be resolved in a way that benefits fish and wildlife. Without such consideration, fish are likely to have an increasingly difficult time, and commercial and recreational usage also will suffer; drought is a fact of life in the basin. When coupled with the increased demand for ground-water pumping to irrigate crops during droughts and the decreased supply of surface waters, the result is added pressure on fish (Broches and others 1984).

Changes in fish fauna of the region as a result of introduced fish species continues as seen in the surreptitious and illegal release of lake trout in Yellowstone Lake just outside the basin (Margolis 1994). If such introductions continue, there is no way to predict the fish species in the mix of the recreational or commercial targets. Such changes may make little difference in terms of aggregate recreational activity levels in terms of cold water versus warm water fishing; however, it may make a large difference in specialized fisheries such as exist in high-quality trout streams in Idaho and Montana. Another difficulty in predicting the nature of fisheries in the basin is seen in the ability of fish managers to choose alternative fishing objectives in response to fishing problems, pressures, and preferences. Already, trout hatcheries play a significant role in augmenting the supply of catchable fish in most aquatic environments in the basin--directly and indirectly. This serves to promote demand for such fisheries. Alternative management measures that reflect changing values of society or fish managers about the viability of continued stocking programs versus wild stock production or the mix of the two are possible but unpredictable.

Further complexity to the introduced species issues comes with the potential for introducing fish diseases like the myxosporean, *Myxosoma cerebralis* that causes whirling disease in salmonids.

This disease has caused the rapid decline in the rainbow trout in the Madison River just across the Continental Divide from the basin. According to the Montana Department of Fish, Wildlife and Parks, the most likely origin of the disease is illegal planting of infected trout from other waters. If infected fish were introduced into the river systems in the upper basin, there could be a massive drop in salmonid populations (Holt 1995). Loss of salmonids in the basin is already great cause for concern. High loss of salmonids and replacement by other species of native and nonnative trouts or other fish would be a major shift in recreational fishing, and the impacts would be long term. European experience indicates that once the whirling disease parasite is in the watershed, only sterilization removes it.

Loss of genetic stocks through attrition or extirpation as well as gain of genetic stocks through introductions or bioengineering are likely scenarios for future fisheries for commercial and recreational fisheries.

Impacts of global climate change on watershed management may be discerned over the next 50 years, but little research has been done in the basin to link postulated change to fish and fish habitat (Lawson 1993, Risser 1992). The long-term cumulative effects of present management are not well known, and they, perhaps more than climate change, are likely to be the dominant factor influencing the watershed. Similarly, choices about species conservation and management of watersheds for fish habitat also tend to dominate over potential global climate change influences. Global climate change may have subtle but pervasive influence over hydrology vegetation and habitats (Swanson and others 1992). Franklin and others (1992) conclude "that altered disturbance regimes will interact with global warming to produce major change in the forestscapes of the Pacific Northwest long before climate change alone would produce significant change in established forests Some probable overall effects of these changes include a net shift in area from forest to nonforest

vegetation, net loss of biotic diversity as some species fail to track suitable habitats, and minor additions to CO₂. . . ." Such changes in northern rivers like those of the basin can have impacts on the structure of the aquatic ecosystem and lead to profound changes in the abundance of salmon (Rubenstein 1992).

Simenstad and others (1992) suggest that, "Climatic variability may have had a larger effect on river temperature than the anthropogenic influences of impoundment, deforestation, irrigation (presumably raising river temperatures) and groundwater recharge (potentially decreasing river temperatures)." This observation could support the view that climate change may have similar effects on salmon in the river as experienced over the last 60 years with respect to temperature. It also could urge caution in efforts to predict the nature of changes in water temperature in the basin rivers because of the complex interplay among the components of river hydrology and temperature. Neitzel and others (1991) examine the slightly warmer, drier interval during the middle Holocene in the Pacific Northwest to assess possible impacts on salmonid populations in the basin. They conclude that the salmon and steelhead resource could both benefit from and be harmed by global climate change, depending on the characteristics and location within the basin. Impacts are variable in their estimation according to species and location. Thus, summer steelhead stocks may have no impact or a moderate improvement in the Snake River drainages, whereas upper Snake River sockeye would experience severe adverse impact (assuming, of course, the Redfish Lake stock survives the 50- to 100-year interval until such change may occur). Salmon from the basin also may benefit or be harmed by climate change impacts during the oceanic phase of their life cycles (Francis and Sibley 1991).

Conclusion

Systematic study of the fish values in the basin demonstrates that they are enormously complex and relatively unexplored. This effort to characterize fish values in the basin ecosystem and economy confirms that fish constitute an extremely valuable source of commercial and recreational benefits whether they are based on native stocks, hatchery populations of salmon and trout, or introduced species. For Native Americans of the basin, the present low level of abundance of salmonids has major economic and cultural impacts. The basin ecosystem can be seen as a supplier of ecological services to a large region that extends, in the case of salmonids, to the whole northeast Pacific fisheries. More broadly, salmon are rapidly becoming symbols of quality of life as well as part of the cultural heritage of the region (Smith 1994).

Fish values can be projected to increase over the middle to long term because:

1. Recovery measures will have a positive effect.
2. Human population in the region is growing rapidly in urban and rural areas, which will make whatever fish that exist more valuable.
3. Management will develop better tools to balance between supplementing fisheries in some parts of the ecosystem and developing quality wild stock fisheries in other areas.

Considerable uncertainty exists with respect to the future of fish values. Major issues like global climate change may have strong impacts over a fairly long period if there are not hidden surprises in the way fish stocks will respond to any change. On a shorter term basis, favorable (or unfavorable) estuarine and ocean conditions may occur, and it may be shown that they play a greater role than previously understood in survival of anadromous stocks. Finally, technological and operational innovation in the hydrosystem may solve some of the juvenile and adult mortality. Most likely, some combination of all these confounding variables may work in the end, in ways not understood, to restore a modicum of the former integrity to the once wilderness river now factory river (Fluharty and Lee 1988).

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Appendix A

Table 16—Native species of fish in the basin—status and use^a

Common name	Scientific name	Resident anadromous	Special status ^b	Location	Use
River lamprey	<i>Lampetra ayresi</i>	A			
Pit Klamath brook lamprey	<i>L. lethophaga</i>	R			
Western brook lamprey	<i>L. richardsoni</i>	R			T
Klamath lamprey	<i>L. similis</i>	R			
Miller Lake lamprey	<i>Lampetra minima</i>	R	Extinct	OR	
Pacific lamprey	<i>L. tridentata</i>	A	*	OR	T
Goose lake lamprey	<i>L. tridentata</i> ssp.	R	SC*	OR	
White sturgeon	<i>Acipenser transmontanus</i>	R	ESA (E)	MT	T, C, S
Pygmy whitefish	<i>Prosopium coulteri</i>	R			
Mountain whitefish	<i>P. williamsoni</i>	R			T, S
Lake whitefish	<i>Coregonus clupeaformis</i>	R			
Dolly Varden	<i>Salmo malma</i>	A			T, S
Chiselmouth	<i>Acrochelus alutaceus</i>	R			T
Lake chub	<i>Couesius plumbeus</i>	R			T
Alvord chub	<i>Gila alvordensis</i>	R	SC *	OR	
Utah chub	<i>G. atraria</i>	R			
Tui chub	<i>G. bicolor</i>	R			T
Sheldon tui chub	<i>G. bicolor eurysoma</i>	R	SC *	OR/NV	
Lahontan Creek tui chub	<i>G. bicolor obesa</i>	R	SC *	OR	
Oregon lakes tui chub	<i>G. bicolor oregonensis</i>	R	*	OR	
XL Spring tui chub	<i>G. bicolor oregonensis</i>	R	SC *	OR	
Goose Lake tui chub	<i>G. bicolor thalassina</i>	R	*	OR	
Catlow tui chub	<i>G. bicolor</i> ssp.	R	SC *	OR	
Summer basin tui chub	<i>G. bicolor</i> ssp.	R	E *	OR	
Warner basin tui chub	<i>G. bicolor</i> ssp.	R	*	OR	
Hutton tui chub	<i>G. bicolor</i> ssp.	R	ESA (T)	OR	
Borax Lake chub	<i>G. boraxobius</i>	R	ESA (E)	OR	
Blue chub	<i>G. coerulea</i>	R			
Leatherside chub	<i>G. copei</i>	R			

Table 16—Native species of fish in the basin—status and use^a (continued)

Common name	Scientific name	Resident anadromous	Special status ^b	Location	Use
California (pit) roach	<i>Hesperoleucus symmetricus mitrulus</i>	R	*	OR	
Oregon chub	<i>Oregonichthys crameri</i>	R	ESA (E)	OR	
Peamouth	<i>Mylocheilus caurinus</i>	R			T
Flathead minnow	<i>Pimephales promelas</i>	R			
Northern squawfish	<i>Ptychocheilus oregonensis</i>	R			T,S,C*
Longnose dace	<i>Rhinichthys cataractae</i>	R			
Nooky dace	<i>R. cataractae</i> ssp.	R	T	WA	
Leopard dace	<i>R. falcatus</i>	R			
Speckled dace	<i>R. osculus</i>	R			
Foskett speckled dace	<i>R. osculus</i> ssp.	R	ESA (T)	OR	
Redside shiner	<i>Richardsonius balteatus</i>	R			T
Lahontan redside shiner	<i>R. egregius</i>	R	*	OR	
Utah sucker	<i>Catostomus ardens</i>	R			
Longnose sucker	<i>C. catostomus</i>	R			
Bridgelip sucker	<i>C. columbianus</i>	R			T
Bluehead sucker	<i>C. discobolus</i>	R			
Largescale sucker	<i>C. macrocheilus</i>	R			T
Goose Lake sucker	<i>C. occidentalis lacusanerinus</i>	R	SC *	OR	
Mountain sucker	<i>C. platyrhynchus</i>	R			T
Klamath smallscale sucker	<i>C. rimiculus</i>	R			
Jenny Creek sucker	<i>C. rimiculus</i> ssp.	R	SC *	OR	
Tahoe sucker	<i>C. tahoensis</i>	R	*	OR	
Sacramento sucker	<i>C. occidentalis</i>	R			
Snake River sucker	<i>Chasmistes muriei</i>	R	Extinct	WY	
Warner sucker	<i>C. warnerensis</i>	R	ESA (T)	OR	
Klamath largescale sucker	<i>C. snyderi</i>	R			
Shortnose sucker	<i>Chasmistes brevirostris</i>	R	ESA (E)	OR	
Lost River sucker	<i>Deltistes luxatus</i>	R	ESA (E)	OR	T
Bull trout (char)	<i>Salvelinus confluentus</i>	R	ESA (P) *	Basin	T, S
Yellowstone cutthroat trout	<i>Oncorhynchus clarki bouvieri</i>	R			S

Table 16—Native species of fish in the basin—status and use^a (continued)

Common name	Scientific name	Resident anadromous	Special status ^b	Location	Use
Westslope cutthroat trout	<i>O. clarki lewisi</i>	R	*	OR	T, S
Lahontan cutthroat trout	<i>O. clarki henshawi</i>	R	ESA (T)	OR/NV	
Fine-spotted Snake River cutthroat trout	<i>O. clarki</i> ssp.	R			S
Whitehorse cutthroat trout	<i>O. clarki</i> ssp.	R	T	OR	
Bonneville cutthroat trout	<i>O. c. utah</i>	R	E	ID/UT/NV	
Alvord cutthroat trout	<i>O. clarki</i> ssp.	R	Extinct	OR/NV	S
Rainbow trout (steelhead)	<i>O. mykiss</i>	R/A			S, T, C*
Interior redband trout	<i>O. mykiss gibbsi</i>	R	SC *	OR/ID/NV	
Catlow Valley redband	<i>O. mykiss</i> ssp.	R	SC *	OR	
Goose Lake redband trout	<i>O. mykiss</i> ssp.	R	SC *	OR	
Warner Valley redband	<i>O. mykiss</i> ssp.	R	SC *	OR/NV	
Coho salmon	<i>O. kisutch</i>	A	ESA (P) *	OR/WA	T, C, S
“Redfish Lake” Sockeye salmon (kokanee)	<i>O. nerka</i>	A	ESA (E)	ID	T, C, S
Sockeye salmon (kokanee)	<i>O. nerka</i>	A		WA	T, C, S
Snake River Chinook	<i>O. tshawytscha</i>	A	ESA (E) *	OR/WA/ID	T, C, S
Chinook salmon	<i>O. tshawytscha</i>	A			
Montana arctic grayling	<i>Thymallus arcticus montanus</i>	R	SC	MT	
Sandroller	<i>Percopsis transmontanus</i>	R			T
Burbot	<i>Lota lota</i>	R			T, S
Threespine stickleback	<i>Gasterosteus aculeatus</i>	R			
Prickly sculpin	<i>Cottus asper</i>	R			T
Mottled sculpin	<i>C. bairdi</i>	R			T
Malheur (mottled) sculpin	<i>C. bairdi</i> ssp.	R	SC *	OR	T
Paiute sculpin	<i>C. beldingi</i>	R			
Slimy sculpin	<i>C. cognatus</i>	R			T
Shorthead sculpin	<i>C. confusus</i>	R			T
Shoshone sculpin	<i>C. greenei</i>	R			
Riffle sculpin	<i>C. gulosus</i>	R			T
Marbled sculpin	<i>C. klamathensis</i>	R			

Table 16—Native species of fish in the basin—status and use^a (continued)

Common name	Scientific name	Resident anadromous	Special status ^b	Location	Use
Wood River sculpin	<i>C. leiopomus</i>	R	SC	ID	
Margined sculpin	<i>C. marginatus</i>	R	*	OR	
Reticulate sculpin	<i>C. perplexus</i>	R			T
Pit sculpin	<i>C. pitensis</i>	R	*	OR	
Klamath Lake sculpin	<i>C. princeps</i>	R			
Torrent sculpin	<i>C. rhotheus</i>	R			T
Slender sculpin	<i>C. tenuis</i>	R	SC	OR	
Eulachon	<i>Thaleichthys pacificus</i>	A			T, S

^a Common and scientific names of fishes follow accepted nomenclature of the American Fisheries Society (Behnke 1992), Robins and others (1991), and Williams and others (1989).

^b Fish stock status classification: under the Federal Endangered Species Act: ESA(E) = endangered, ESA(P) = petitioned, and ESA(T) = threatened; under the American Fisheries Society: T = threatened, E = endangered, SC = special concern, and extinct; under the Oregon Department of Fish and Wildlife: * = Oregon's sensitive species list (includes critical, vulnerable, peripheral or naturally rare).

American Fisheries Society reports Oregon with 25 species in the T, E, or SC categories—all distributed in the east-side assessment area. One species, the Alvord cutthroat trout (listed as E in 1979), could be certified extinct by 1989. The status of two species, Oregon chub and Lost River sucker, declined from T to E between 1979 and 1989, and the status of shortnose sucker declined from SC to E in the same period. The Oregon chub was listed as endangered under the ESA in 1993, and the Lost river sucker and shortnose sucker were listed as endangered under the ESA in 1988. Some captive specimens may still exist of the Miller Lake lamprey. Some authorities consider Oregon lakes tui chub and XL Spring tui chub to be the same species. Similarly, some consider the Lahontan cutthroat trout and the Whitehorse cutthroat trout to be the same species. (Hal Weeks, ODFW, Fish Division, 2501 SW 1st Ave, P.O. Box 59, Portland, OR 97207 personal communication, 1994). Columbia River coho is considered extinct. The AFS reports Washington with four species in the T, E, or SC categories—two of which are distributed in the east-side assessment area.

Use classification: T = tribal usage can be commercial, subsistence or traditional/cultural;
 S = sport fishing is common;
 C = commercial fishing;
 C* = commercial steelhead harvest is carried out by tribes. Northern squawfish are harvested in a target bounty fishery and commercial usage is being investigated as a means to reduce predation on young salmon; and
 Blank = no information about usage.

Sources: Most species and scientific names are from list sent to author by Richard Everett and James Sedell, Eastside Ecosystem Management Strategy Project, 112 E. Poplar, Walla Walla, WA 99362 on June 10, 1994. Introduced species are deleted (see appendix B). Special status ratings and some additional species are based on Williams and others (1989) and Behnke (1992). Bull trout and Dolly Varden information from Washington Department of Wildlife. [n.d.] Federal listings and proposed listings from various sources: Oregon update and review supplied by Hal Weeks, ODFW, Fish Division, 2501 SW 1st Ave, P.O. Box 59, Portland, OR 97207 on April 3, 1994. Tribal usage ratings are based on Hunn (1980) and Rostlund (1952). Usage classification for sport and commercial are based on common knowledge and sources listed in text.

Appendix B

Table 17—List of introduced species in the basin^a

Common name	Scientific name	Year ^b	Usage ^c
Arctic grayling	<i>Thymallus arcticus</i>	1946	S
Atlantic salmon	<i>Salmo salar</i>	1950s OR 1973 WA	S
Brook trout	<i>Savelinus fontinalis</i>	ca. 1870-80s	S
German brown trout	<i>Salmo trutta</i>	1900	Culture, S
Mackinaw trout-Lake trout	<i>Salvelinus namaycush</i>	(?)	S
Golden trout	<i>Oncorhynchus aquabonita</i>	(?)	S
Lake whitefish	<i>Coregonus clupeaformis</i>	ca. 1900	S
Black bullhead	<i>Ameiurus melas</i>	(?) 1874 CA	S
Brown bullhead-horned pout	<i>Ameiurus nebulosus</i>	1882-83	S
Yellow bullhead	<i>Ameiurus natalis</i>	(?)	S
Channel catfish	<i>Ictalurus punctatus</i>	(?)	S
Tadpole madtom	<i>Noturus gyrinus</i>	1942	?
Flathead catfish	<i>Pylodictis olivaris</i>	(?)	S
White catfish	<i>Ameiurus catus</i>	(?)	S
Black crappie	<i>Pomoxis nigromaculatus</i>	1890-92	S
White crappie	<i>Pomoxis annularis</i>	1890-92	S
Flathead minnow	<i>Pimephales promelas</i> *	(?)	(?)
Bluegill sunfish-true sunfish	<i>Lepomis macrochirus</i>	1890	S
Green sunfish	<i>Lepomis cyanellus</i>	by 1970s	S
Pumpkinseed sunfish	<i>Lepomis gibbosus</i>	1893	S
Redear sunfish	<i>Lepomis microlophus</i> *	(?)	S
Golden shiner	<i>Notemigonus crysoleucas</i> *	(?)	(?)
Warmouth (rock) bass	<i>Lepomis gulosus</i>	(?) 1890 CA	S
Largemouth black bass	<i>Micropterus salmoides</i>	1890-95	S
Smallmouth bass	<i>Micropterus dolomieu</i>	1874 CA, 1925 WA	
Grass pickerel	<i>Exos americanus</i>	(?)	S
Goldfish	<i>Carassius auratus</i>	by 1942	?
Common (German) carp	<i>Cyprinus carpio</i>	1880	Culture
Western mosquitofish	<i>Gambusia affinis</i>	(?)	?

Table 17—List of introduced species in the basin (continued)^a

Common name	Scientific name	Year ^b	Usage ^c
Northern pike	<i>Esox lucius</i>	(?)	S
Sacramento perch	<i>Archoplites interruptus</i> *	(?)	S
Yellow perch	<i>Perca flavescens</i>	1890-92	S
American shad	<i>Alosa sapidissima</i>	1885-86	C, S
Walleye	<i>Stizostedion vitreum</i>	1940s	S, C
Tench	<i>Tinca tinca</i>	(?)	Culture

^a Common and scientific names of fishes follow accepted nomenclature of the American Fisheries Society (Behnke 1992), Robbins and others (1991) and Williams and others (1989).

^b Year introduced date CA = date introduced into California. Oregon and Washington introductions probably followed soon thereafter.

^c Usage: S = sport fishing, C = commercial, culture = commercial fish culture and, ? = usage unknown (introduction probably accidental)

Sources: List of species in the basin faxed to author by Richard Everett and James Sedell, Eastside Ecosystem Management Strategy Project, June 7, 1994. Information on introductions obtained from many sources by author. Primary sources for this listing are Ames (1966) and Wydoski and Whitney (1979).

Table 18—Native species introduced within the interior Columbia River basin

Common name	Scientific name	Year ^a	Usage ^b
Kokanee	<i>Oncorhynchus nerka</i>	various	S, C
Rainbow trout	<i>Oncorhynchus mykiss</i>	various	S, T
Salmon (all spp.)		various	S, T, C
Trout (all spp.)		various	S
White sturgeon	<i>Acipenser transmontanus</i>	various	S, C

^a Year introduced date CA = date introduced into California. Oregon and Washington introductions probably followed soon thereafter.

^b Usage: S = sport fishing, C = commercial, culture = commercial fish culture, and ? = usage unknown (introduction probably accidental).

Sources: Information on introductions obtained from many sources by author. Primary sources for this listing are Ames (1966) and Wydoski and Whitney (1979).

Appendix C

Table 19—Estimated tribal harvest of salmonids in the basin in the early 19th century

Tribe	Main fishing locations	Estimated per capita consumption Hewes and Schalk (pounds per year)	Population	Estimated	Estimated
				total annual consumption Hewes (pounds)	total annual consumption Schalk (pounds)
Chinook	Lower Columbia tributaries,	500-665	22,000	8,800,000	14,630,000
Tlatskanai	Willamette River	365-475	1,600	584,000	752,000
Kalapuha		100-255	3,000	300,000	765,000
Cowlitz and others		250-625	1,200	438,000	750,000
Subtotal lower Columbia			27,800	10,122,000	16,897,000
Wishram	Below The Dalles -	NA probably similar			
Wasco	Columbia Gorge	to Chinooks Tribe at 500-665			
Tenino:	Upstream of The Dalles	500-744	2,900	1,450,000	2,157,600
Tenino	E. of The Dalles				
Wayam	Celilo Falls				
John Day	Lower John Day and Col.				
Tygh	L. Deschutes				
Umatilla	E. Col. and Umatilla Rivers				
Walla Walla	L. Walla Walla R., Columbia and L. Snake Rivers				
Yakama	Yakima River and Kittitas Cr.	400-863	11,200	4,480,000	9,665,600
Kittitas	Lake Cle Elum				
Wailatpu (Cayuse)		365-564	500	182,500	282,000
Columbia	Columbia—no tributaries	Limited importance	Incl. in Yakama		
Wanapum	Columbia—no tributaries	Limited importance	Incl. in Yakama		
Wenatchi (Pisquows)	Wenatchee and Columbia Rivers	500-976	3,500	1,750,000	3,416,000

Table 19—Estimated tribal harvest of salmonids in the basin in the early 19th century (continued)

Tribe	Main fishing locations	Estimated per capita consumption Hewes and Schalk (pounds per year)	Population	Estimated total annual consumption Hewes (pounds)	Estimated total annual consumption Schalk (pounds)
Okanogan Lakes (mostly in Canada)	Okanogan River, Similkameen River, U. Methow River Kettle Falls	400-1,000	2,200	1,100,000	2,750,000
San Poil Nespelum	Columbia above Priest Rapids, Kettle Falls	500-976	Incl. in Wenatchi above		
Colville	Kettle Falls	500-976	Incl. in Wenatchi		
L. Kutenai (mostly in Canada)	Kootenai River, Columbia Lake	150-481	1,200	360,000	577,200
Spokan	Spokane River below falls to Columbia, Cow Creek	500-948	2,400	1,200,000	2,275,200
Coeur D'Alene Kalispel Flathead Pend D'Oreille	U. Spokane River, N. Fk. Clearwater	100-219	2,800	280,000	613,200
Nez Perce	Snake River by Tucannon River, Payette River, L. Salmon, Imnaha River, L. Grande Ronde, Celilo Falls	300-646	4,000	1,200,000	2,584,000
Shoshoni	So. Idaho, Snake below	50-179	3,000	150,000	537,000
Bannock	Shoshone Falls				
Northern Paiute	Great Basin, Malheur River Owyhee River	50-179	Incl. in Shoshoni above		
Total basin				12,152,500	24,857,800
Total Columbia			61,500	22,274,500	41,754,800

Sources: Modified from Hewes 1947, Shalk 1987, and NPPC 1986. Spelling follows original sources.

Appendix D

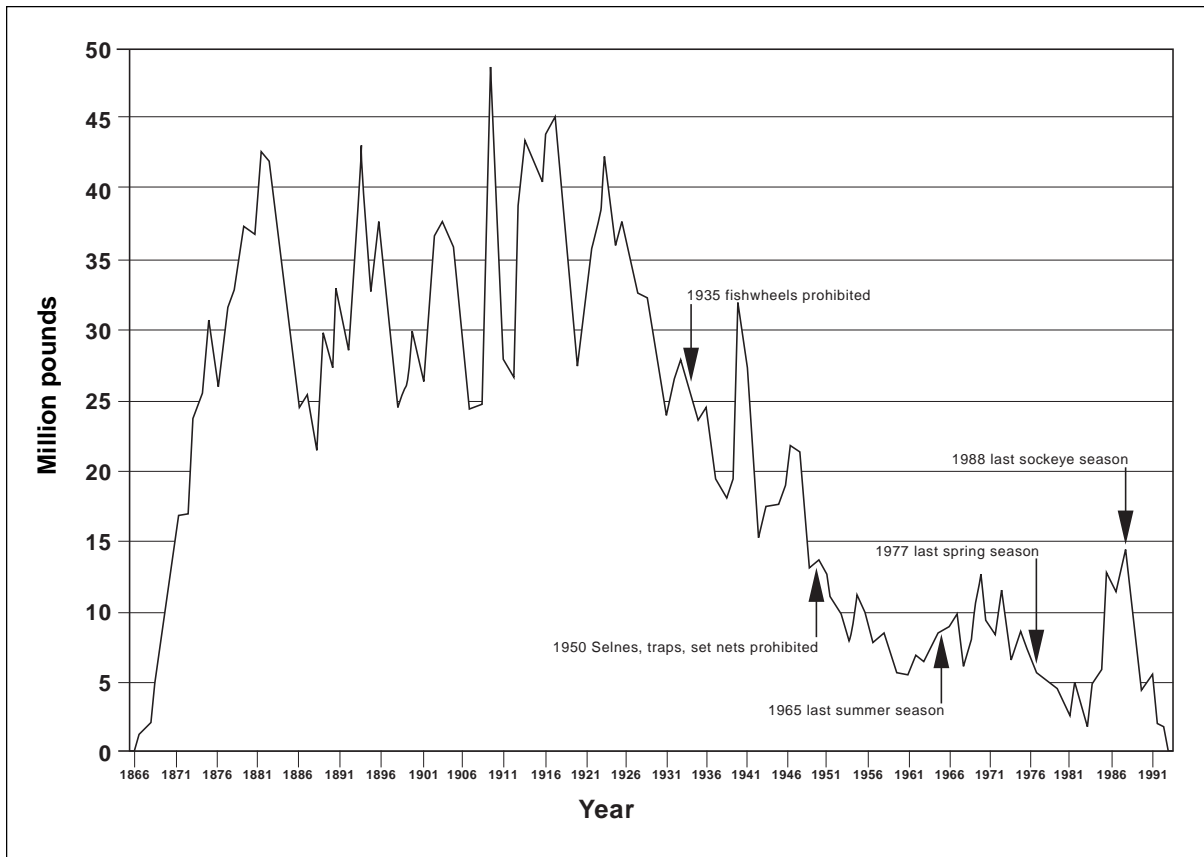


Figure 1—Commercial landings of salmon and steelhead from the Columbia River in pounds, 1866-1993.
Sources: WDFW 1994 and ODFW 1994.

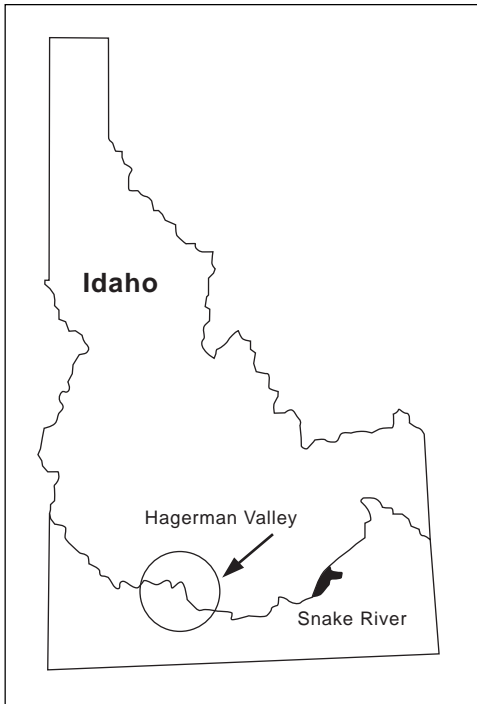


Figure 2—The Hagerman Valley on the Snake River Plain in Idaho. Source: Brannon and Klontz 1989.

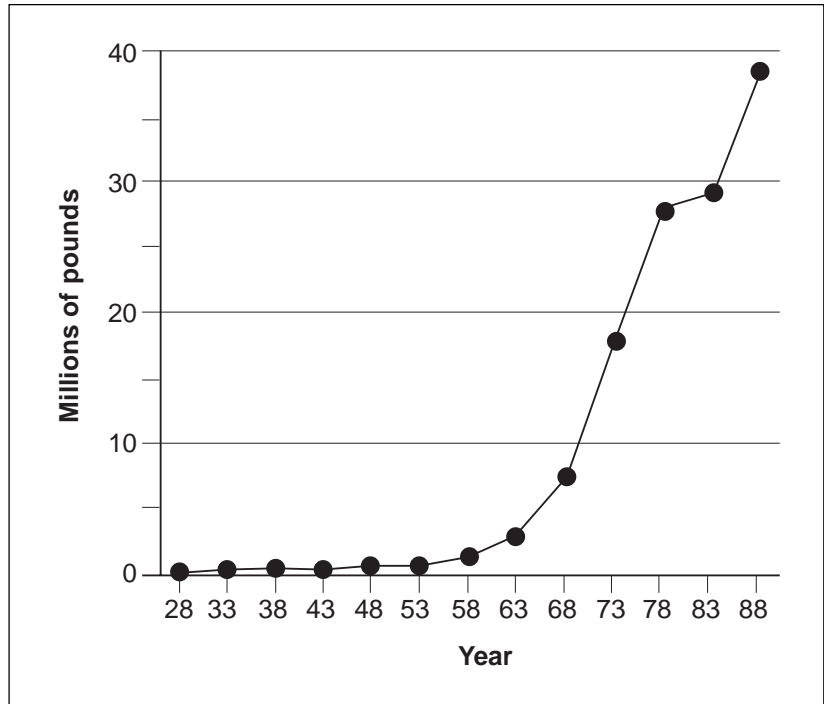


Figure 3—Growth of commercial rainbow trout production in Idaho from 1928 to 1988. Source: Brannon and Klontz 1989.

Table 20—Columbia River commercial landings of salmon and steelhead, 1866-1993

Year	Chinook	Coho	Sockeye	Chum	Steelhead	Total
<i>Thousands of pounds</i>						
1866	272.0	0	0	0	0	272.0
1867	1,224.0	0	0	0	0	1,224.0
1868	1,904.0	0	0	0	0	1,904.0
1869	6,800.0	0	0	0	0	6,800.0
1870	10,200.0	0	0	0	0	10,200.0
1871	13,600.0	0	0	0	0	13,600.0
1872	17,000.0	0	0	0	0	17,000.0
1873	17,000.0	0	0	0	0	17,000.0
1874	23,800.0	0	0	0	0	23,800.0
1875	25,500.0	0	0	0	0	25,500.0

Table 20—Columbia River commercial landings of salmon and steelhead, 1866-1993 (continued)

Year	Chinook	Coho	Sockeye	Chum	Steelhead	Total
<i>Thousands of pounds</i>						
1876	30,600.0	0	0	0	0	30,600.0
1877	25,840.0	0	0	0	0	25,840.0
1878	31,280.0	0	0	0	0	31,280.0
1879	32,640.0	0	0	0	0	32,640.0
1880	36,040.0	0	0	0	0	36,040.0
1881	37,400.0	0	0	0	0	37,400.0
1882	36,808.4	0	0	0	0	36,808.4
1883	42,799.2	0	0	0	0	42,799.2
1884	42,160.0	0	0	0	0	42,160.0
1885	37,658.4	0	0	0	0	37,658.4
1886	30,498.0	0	0	0	0	30,498.0
1887	24,208.0	0	0	0	0	24,208.0
1888	25,328.4	0	0	0	0	25,328.4
1889	18,135.4	0	1,210.2	0	1,726.6	21,072.2
1890	22,821.1	0	3,899.5	0	2,912.1	29,632.8
1891	24,065.7	0	1,052.8	0	2,010.4	27,128.8
1892	23,410.2	284.0	4,525.2	0	4,919.7	33,139.0
1893	19,636.6	1,979.3	2,071.2	157.1	4,435.4	28,279.6
1894	23,875.2	2,907.5	2,979.4	0	3,564.7	33,326.8
1895	30,253.8	6,772.9	1,225.0	1,529.5	3,378.1	43,159.3
1896	25,224.1	2,999.3	1,154.8	0	3,377.1	32,755.4
1897	29,867.2	4,137.8	882.1	0	3,137.9	38,025.0
1898	23,180.5	4,449.3	4,533.6	0	1,786.8	33,950.2
1899	18,771.0	2,013.3	1,629.9	773.8	815.6	24,003.6
1900	19,245.2	3,054.9	895.0	1,203.3	1,400.6	25,799.0
1901 ^a	—	—	—	—	—	29,832.4
1902	23,033.7	716.2	1,158.5	707.3	584.3	26,200.0
1903	27,917.3	828.3	570.0	680.0	493.1	30,488.7
1904	31,782.5	2,125.3	877.9	1,407.1	671.0	36,863.9
1905	33,028.7	1,824.2	528.2	1,751.1	667.9	37,800.1
1906	29,970.7	2,818.3	531.5	1,890.5	442.0	35,653.1

Table 20—Columbia River commercial landings of salmon and steelhead, 1866-1993 (continued)

Year	Chinook	Coho	Sockeye	Chum	Steelhead	Total
<i>Thousands of pounds</i>						
1907	24,250.4	2,159.5	374.3	1,533.8	402.6	28,720.6
1908	19,742.5	2,137.4	583.5	1,148.1	729.4	24,340.9
1909	17,118.9	2,868.1	1,704.2	1,668.9	1,175.2	24,535.3
1910	25,325.6	4,686.7	423.9	4,524.6	369.6	35,330.4
1911 ^b	36,602.1	5,400.3	407.2	3,636.0	584.4	49,480.0
1912	21,388.0	2,165.3	558.3	1,271.5	2,147.2	27,530.2
1913	19,384.5	2,785.9	758.3	904.6	2,167.9	26,556.2
1914	25,409.1	4,744.3	2,401.1	3,351.4	1,907.6	38,501.3
1915	32,126.8	2,266.8	371.2	5,884.0	2,690.2	43,838.7
1916	31,992.9	3,541.7	257.7	5,288.1	1,580.9	42,746.3
1917	29,521.9	4,372.3	541.8	3,648.8	2,233.1	40,448.0
1918	29,249.1	6,673.9	2,572.6	2,029.5	3,022.6	44,125.4
1919	30,325.3	6,169.5	494.2	5,133.5	1,899.9	44,934.5
1920	31,094.3	1,837.6	178.0	1,277.9	1,165.9	36,311.5
1921	21,551.7	2,337.9	411.1	327.8	1,021.11	26,712.5
1922	17,914.7	6,149.7	2,090.5	601.4	2,162.8	30,152.7
1923	21,578.3	6,965.1	2,605.0	1,734.5	2,684.3	35,667.3
1924	22,365.2	7,796.4	500.9	3,926.9	3,192.8	38,167.1
1925	26,660.0	7,936.6	384.2	3,795.2	2,907.2	42,333.4
1926	21,241.0	6,605.7	1,478.0	2,234.0	3,843.1	35,566.7
1927	24,010.7	5,209.5	408.3	4,654.5	3,147.3	37,688.4
1928	18,149.3	3,722.9	327.4	8,496.8	2,160.2	33,127.1
1929	18,151.1	6,701.1	684.9	3,714.1	2,870.1	32,321.3
1930	20,078.6	7,736.9	668.0	773.2	2,404.1	31,923.4
1931	21,378.4	2,714.2	280.5	239.2	2,126.0	27,031.8
1932	16,000.9	4,096.5	190.1	1,173.7	1,431.8	23,330.2
1933	19,528.4	2,701.6	470.6	1,659.1	1,958.3	26,846.8
1934	18,787.5	4,774.7	467.1	1,662.9	1,919.2	27,901.9
1935	15,266.4	7,108.3	88.5	1,053.7	1,472.2	25,756.0
1936	16,213.6	2,495.8	668.9	2,080.6	1,940.8	23,528.6

Table 20—Columbia River commercial landings of salmon and steelhead, 1866-1993 (continued)

Year	Chinook	Coho	Sockeye	Chum	Steelhead	Total
<i>Thousands of pounds</i>						
1937	18,653.6	1,841.6	335.1	1,909.8	1,933.4	24,673.5
1938 ^c	12,418.5	2,311.0	424.6	1,915.4	1,764.4	18,833.9
1939	13,498.8	1,529.7	269.8	1,174.4	1,438.5	17,911.2
1940	13,516.1	1,373.2	361.9	1,253.5	2,815.4	19,320.1
1941	23,238.5	1,045.0	505.7	4,149.8	2,663.7	31,602.7
1942	18,679.1	644.5	192.4	5,191.1	1,839.1	26,546.2
1943	11,426.5	706.3	146.1	959.9	1,514.5	14,753.3
1944	14,059.6	1,533.3	54.8	275.4	1,702.1	17,643.2
1945	12,972.1	1,835.5	8.7	588.8	1,963.5	17,368.6
1946	14,277.8	1,054.6	128.5	886.6	1,725.6	18,078.1
1947	17,302.7	1,498.1	718.3	496.2	1,648.7	21,664.0
1948	17,352.3	1,174.7	95.8	1,044.8	1,579.0	21,246.6
1949	10,768.5	899.2	24.0	545.0	814.0	13,050.7
1950	10,421.7	1,048.0	169.2	700.2	945.2	13,284.3
1951	10,036.3	968.0	169.4	532.3	1,207.2	12,913.2
1952	7,271.1	1,074.0	608.7	308.6	1,461.9	10,724.3
1953	6,966.6	457.5	146.2	249.2	1,898.3	9,717.8
1954	5,312.7	303.4	243.4	320.0	1,450.8	7,630.3
1955	8,581.9	598.8	200.4	125.6	1,320.0	10,826.7
1956	8,178.5	460.0	287.1	45.7	815.0	9,786.3
1957	5,918.9	390.7	240.2	32.1	741.0	7,322.9
1958	6,434.0	167.6	723.5	89.3	700.0	8,114.4
1959	4,594.3	119.7	635.8	42.9	628.5	6,021.2
1960	3,928.0	159.1	394.1	5.3	657.4	5,153.9
1961	4,160.2	382.6	158.0	17.3	612.3	5,330.4
1962	5,467.3	600.0	51.7	48.1	715.3	6,882.4
1963	4,346.1	501.1	48.8	15.3	972.9	5,884.2
1964	4,484.0	1,963.5	68.2	23.9	421.0	6,960.6
1965	6,142.9	1,901.8	22.9	6.1	510.1	8,583.8
1966	3,612.2	4,389.1	17.2	11.0	393.0	8,422.5

Table 20—Columbia River commercial landings of salmon and steelhead, 1866-1993 (continued)

Year	Chinook	Coho	Sockeye	Chum	Steelhead	Total
<i>Thousands of pounds</i>						
1967	4,974.1	3,817.9	195.1	9.7	445.6	9,442.4
1968	4,097.1	962.2	89.6	3.4	433.9	5,586.2
1969	5,775.9	1,663.3	104.5	4.0	495.0	8,042.7
1970	6,461.7	5,745.6	55.7	8.0	311.8	12,582.8
1971	5,967.2	2,277.9	285.6	5.9	467.5	9,004.1
1972	5,684.6	1,239.4	275.6	16.0	667.1	7,882.7
1973	8,552.4	1,904.8	15.9	18.0	634.1	11,125.2
1974	3,637.8	2,432.7	.2	10.7	185.2	6,266.6
1975	6,586.5	1,581.4	0	5.7	69.5	8,243.1
1976	5,586.7	1,328.6	.5	16.9	86.6	7,019.3
1977	4,688.4	316.6	.5	2.3	425.7	5,433.5
1978	3,674.4	1,096.9	.1	20.4	249.2	5,041.0
1979	3,226.3	1,096.8	<.1	1.6	68.6	4,393.3
1980	3,072.3	1,122.5	<.1	3.1	65.6	4,263.5
1981	1,739.4	473.2	<.1	18.5	98.0	2,329.1
1982	3,036.1	1,600.2	.5	22.3	96.5	4,755.6
1983	1,038.9	45.4	6.5	2.0	156.7	1,249.5
1984	2,069.0	1,621.3	110.5	22.1	908.4	4,731.3
1985	2,646.7	1,674.7	287.4	7.5	766.2	5,382.5
1986	4,729.0	6,820.1	23.8	20.2	683.8	12,276.9
1987	9,016.9	1,313.4	256.5	14.1	753.8	11,354.7
1988	10,539.1	2,683.5	181.1	30.2	764.8	14,198.7
1989	6,120.3	2,683.1	.1	17.3	591.0	9,411.8
1990	3,095.3	501.2	<.1	9.4	331.0	3,936.9
1991	1,994.5	2,730.3	<.1	4.2	307.4	5,036.4
1992	952.3	303.8	<.1	6.9	465.2	1,728.2
1993	877.8	271.4	<.1	.5	263.0	1,412.7

^a Landing by species unavailable.

^b From 1911 to 1936, totals include landings of unknown salmonid species.

^c Chinook totals for 1938-56 differ slightly from those calculated by summing individual landing tables from this report.

Sources: WDFW 1994 and ODFW 1994.

Table 21—Columbia River commercial landings of salmon and steelhead, 1938-93

Year	Chinook	Coho	Sockeye	Chum	Steelhead	Total
<i>Thousands of fish</i>						
1938	637.7	256.9	125.6	157.0	215.7	1,392.9
1939	690.8	170.0	81.0	96.3	175.8	1,213.9
1940	685.1	152.6	111.9	102.8	344.4	1,396.8
1941	1,180.0	116.8	150.0	340.1	325.6	2,112.5
1942	943.9	71.7	57.4	425.5	224.8	1,723.3
1943	583.7	78.5	42.9	78.7	185.1	968.9
1944	714.3	170.5	16.5	22.6	210.3	1,134.2
1945	657.0	204.0	2.7	48.3	240.0	1,152.0
1946	726.0	117.8	38.3	72.7	211.0	1,165.8
1947	877.7	168.9	211.4	40.7	201.6	1,498.3
1948	901.6	130.6	29.8	85.6	193.1	1,340.7
1949	558.7	99.9	7.7	44.7	99.8	810.8
1950	534.6	116.6	50.4	57.5	115.6	874.7
1951	475.0	107.6	46.3	43.6	150.2	822.7
1952	386.9	119.6	165.8	25.3	199.1	896.7
1953	345.1	51.6	41.0	20.4	233.7	691.8
1954	299.1	33.9	67.4	26.2	149.4	576.0
1955	505.7	68.9	59.7	10.3	166.3	810.9
1956	485.0	51.5	81.3	3.7	108.9	730.4
1957	339.1	46.3	65.1	2.7	96.8	550.0
1958	371.7	18.7	197.2	7.4	91.4	686.4
1959	267.8	15.2	185.0	3.5	103.5	575.0
1960	265.5	17.7	120.0	1.3	91.5	496.0
1961	253.6	37.7	40.7	1.4	99.9	433.3
1962	310.8	65.3	14.3	3.9	95.1	489.4
1963	251.1	65.2	14.0	1.2	114.4	445.9
1964	269.3	206.2	20.8	1.9	55.6	553.8
1965	335.5	234.7	5.9	.5	64.3	640.9
1966	201.0	423.8	4.4	.9	46.3	676.4
1967	262.6	382.4	55.7	.9	50.2	751.8

Table 21—Columbia River commercial landings of salmon and steelhead, 1938-93 (continued)

Year	Chinook	Coho	Sockeye	Chum	Steelhead	Total
<i>Thousands of fish</i>						
1968	220.0	132.7	25.3	.3	45.9	424.2
1969	317.9	197.9	27.5	.3	48.9	592.5
1970	356.5	536.3	17.1	.6	33.3	943.8
1971	331.5	277.4	76.2	.5	51.4	737.0
1972	318.7	140.0	77.9	1.3	62.1	600.0
1973	453.6	194.8	3.7	1.4	52.9	706.4
1974	190.9	267.8	<.3	.9	19.3	478.9
1975	323.0	162.3	0	.5	7.3	493.1
1976	288.4	172.4	.1	1.2	9.6	471.7
1977	255.6	40.0	.1	.2	35.2	331.1
1978	189.1	136.4	<.1	1.5	20.4	347.4
1979	171.0	131.5	<.1	.1	9.2	311.8
1980	150.3	150.4	<.1	.2	7.3	308.2
1981	95.1	61.6	<.1	1.4	10.0	168.1
1982	155.3	206.0	.1	1.8	9.4	372.6
1983	57.7	7.3	1.8	.2	18.5	85.5
1984	127.9	203.1	31.6	1.8	75.1	439.5
1985	151.4	195.2	81.3	.7	85.5	514.1
1986	283.1	997.8	6.1	1.8	72.0	1,360.8
1987	483.5	170.1	67.8	1.3	79.1	801.8
1989	489.0	368.2	48.5	2.5	78.5	986.7
1989	275.0	391.7	<.1	1.4	60.9	729.0
1990	148.0	76.2	<.1	.8	32.6	257.6
1991	106.9	416.0	<.1	.4	37.0	560.3
1992	53.2	58.8	<.1	.7	51.9	164.6
1993	50.8	37.0	<.1	<.1	27.7	115.5

Sources: WDFW 1994 and ODFW 1994.

**Table 22—Columbia River commercial landings of salmon and steelhead below Bonneville Dam, 1938-93
(in thousands)**

Year	Chinook		Coho		Sockeye		Chum		Total salmon		Steelhead	
	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.
1936	10,743.2	551.4	2,309.9	256.7	325.5	93.0	1,909.4	156.5	15,288.0	1,057.6	1,415.3	172.6
1939	12,004.8	611.4	1,528.3	169.8	180.0	51.4	1,154.2	94.6	14,867.3	927.2	1,204.8	146.9
1940	11,159.9	561.6	1,372.4	159.5	165.1	47.2	1,252.7	102.7	13,950.1	864.0	2,342.7	286.1
1941	18,891.2	949.8	1,022.4	113.6	377.7	107.9	4,149.8	340.1	24,441.1	1,511.4	2,177.3	265.5
1942	15,086.6	759.8	642.7	71.4	136.4	39.0	5,190.1	425.4	21,055.8	1,295.6	1,462.7	178.4
1943	9,376.3	478.6	705.6	78.4	117.7	33.6	959.9	78.7	11,159.5	669.3	1,231.2	150.1
1944	12,214.6	614.5	1,529.7	170.0	33.4	9.5	275.4	22.6	14,053.1	816.6	1,344.0	163.9
1945	11,593.4	585.6	1,834.3	203.8	4.8	1.4	588.8	48.3	14,021.3	839.1	1,616.0	197.1
1946	11,605.8	588.6	1,058.4	117.6	93.3	26.7	886.6	72.7	13,644.1	805.6	1,312.6	160.1
1947	13,888.7	702.2	1,484.8	165.0	574.7	164.2	496.2	40.7	16,444.4	1,072.1	1,299.0	158.4
1948	13,744.1	699.8	1,173.3	130.4	40.8	11.7	1,044.8	85.6	16,003.0	927.5	1,190.6	145.2
1949	9,157.3	471.0	897.7	99.7	4.4	1.2	541.6	44.4	10,601.0	616.3	485.6	59.2
1950	8,247.3	421.8	1,041.4	115.7	121.2	34.6	699.8	57.4	10,109.7	629.5	721.3	88.0
1951	8,366.3	379.6	964.9	107.2	133.0	34.3	519.7	42.6	9,983.9	563.7	938.4	115.8
1952	5,175.4	268.9	11,066.6	118.5	513.0	134.3	308.5	25.3	7,063.5	547.0	1,047.6	141.8
1953	5,644.5	265.4	434.5	48.3	97.1	24.8	249.2	20.4	6,425.3	358.9	1,378.5	169.6
1954	4,318.4	218.7	295.5	32.8	195.6	49.9	320.0	26.2	5,129.5	327.6	1,257.1	132.0
1955	6,469.7	353.9	525.2	58.4	30.5	7.3	125.6	10.3	7,151.0	429.9	963.8	118.5
1956	7,456.3	427.3	447.4	49.7	180.7	45.6	45.7	3.7	8,130.1	526.3	632.5	81.5
1957	5,863.0	335.4	390.5	46.2	239.7	64.9	32.1	2.7	6,525.3	449.2	739.9	96.7
1958	6,283.7	360.0	165.9	18.5	704.4	190.9	89.3	7.4	7,243.3	576.8	671.6	87.3
1959	4,562.2	265.6	119.5	15.1	633.2	184.1	42.9	3.5	5,357.8	468.3	623.8	103.0
1960	3,893.4	263.1	158.0	17.5	392.2	119.4	15.3	1.3	4,458.9	401.3	649.8	90.8
1961	4,043.8	246.1	379.1	37.2	157.6	40.6	16.9	1.3	4,597.4	325.2	602.2	98.4

**Table 22—Columbia River commercial landings of salmon and steelhead below Bonneville Dam, 1938-93
(in thousands)—(continued)**

Year	Chinook		Coho		Sockeye		Chum		Total salmon		Steelhead	
	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.
1962	5,322.3	300.9	582.5	62.8	39.3	10.5	48.1	3.9	5.0	378.1	715.2	95.1
1963	3,802.0	214.3	500.6	65.1	20.0	5.1	15.3	1.2	4,337.9	285.7	908.1	108.0
1964	3,838.3	226.6	1,943.6	203.7	16.6	5.0	23.8	1.9	5,822.3	437.2	372.1	49.1
1965	5,269.4	279.9	1,880.3	231.5	.3	.1	6.1	.5	7,156.1	512.0	405.6	51.1
1966	3,409.1	188.6	4,317.6	415.5	.6	.2	11.0	.9	7,738.3	605.2	378.3	44.2
1967	3,953.6	199.3	3,715.7	368.8	76.9	21.2	9.7	.9	7,755.9	590.2	309.7	34.3
1968	3,330.8	172.8	912.7	125.1	72.4	20.3	3.3	.3	4,319.2	318.5	340.5	35.5
1969	4,411.8	227.2	1,624.9	190.1	62.0	16.2	4.0	.3	6,102.7	433.8	348.6	34.1
1970	5,504.8	299.4	5,608.0	520.8	42.7	13.0	8.0	.6	11,163.5	833.8	194.9	19.9
1971	4,765.9	256.4	2,191.5	264.3	208.1	54.9	5.9	.5	7,171.4	576.1	238.9	25.5
1972	4,342.8	228.6	1,177.5	131.3	186.9	51.8	16.0	1.3	5,723.2	413.0	343.5	33.5
1973	6,835.2	349.5	1,823.2	183.7	9.8	2.3	18.0	1.4	8,686.2	536.9	337.4	25.0
1974	2,386.3	118.4	2,391.0	261.0	0	0	10.7	.9	4,788.0	380.3	68.8	6.2
1975 ^a	3,918.2	182.4	1,530.7	156.6	0	0	5.7	.5	5,454.6	339.5	0	0
1976	3,023.9	153.0	1,298.4	168.4	.3	.1	16.9	1.2	4,339.5	322.7	0	0
1977	3,511.5	183.2	309.0	39.0	0	0	2.3	.2	3,822.8	222.4	0	0
1978	2,433.8	123.5	1,074.1	132.7	.1	.1	20.4	1.5	3,528.3	257.7	0	0
1979	2,033.2	108.1	1,065.8	127.6	.1	.1	1.6	.1	3,100.6	235.8	0	0
1980	2,342.9	116.4	1,120.6	150.1	0	0	3.1	.2	3,466.6	266.7	0	0
1981	764.5	38.7	461.9	59.8	0	0	18.5	1.4	1,244.9	99.9	0	0
1982	1,935.3	97.6	1,574.3	201.7	0	0	0	1.8	3,531.9	301.1	0	0
1983	624.6	33.2	44.4	7.1	0	0	0	.2	671.0	40.5	0	0

**Table 22—Columbia River commercial landings of salmon and steelhead below Bonneville Dam, 1938-93
(in thousands)—(continued)**

Year	Chinook		Coho		Sockeye		Chum		Total salmon		Steelhead	
	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.
1984	1,211.9	74.4	1,612.6	201.5	31.8	9.1	22.1	1.8	2,878.4	286.8	0	0
1985	1,298.4	74.5	1,632.4	190.0	111.6	31.9	7.5	.7	3,049.9	297.1	0	0
1986	27,442.0	175.9	6,724.0	981.0	6.7	1.8	20.2	1.8	9,495.1	1,160.5	0	0
1987	6,219.0	343.0	1,299.7	167.8	107.5	28.3	14.1	1.3	7,640.3	540.4	0	0
1988	7,248.2	342.1	2,645.5	363.0	61.4	17.5	30.2	2.5	9,985.3	725.1	0	0
1989	3,257.9	146.9	2,668.3	389.2	0	0	17.3	1.3	5,943.5	537.4	0	0
1990	1,300.2	64.2	494.3	75.2	0	0	9.4	.8	1,803.9	140.2	0	0
1991	994.7	55.7	2,685.5	409.2	0	0	4.2	.4	3,684.4	465.3	0	0
1992	426.6	24.0	299.0	57.8	0	0	6.9	.7	732.5	82.5	0	0
1993	337.0	19.7	262.0	36.1	0	0	0.5	.1	599.5	55.8	0	0

^a Sale of steelhead by non-Indians prohibited since 1975.

Sources: WDFW 1994 and ODFW 1994.

**Table 23—Columbia River commercial landings of salmon and steelhead above Bonneville Dam, 1938-93
(in thousands)**

Year	Chinook		Coho		Sockeye		Chum		Steelhead		Total	
	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.
1938	1,670.7	86.3	1.1	0.2	99.1	32.6	6.0	0.5	349.1	43.1	2,126.0	162.7
1939	1,494.0	79.4	1.4	.2	89.8	29.6	20.2	1.7	233.7	28.9	1,839.1	139.8
1940	2,356.2	123.5	.8	.1	196.8	64.7	.8	.1	472.7	58.3	3,027.3	246.7
1941	4,339.4	230.2	22.6	3.2	128.0	42.1	0	0	486.4	60.1	4,976.4	335.6
1942	3,573.3	184.1	1.8	.3	56.0	18.4	1.0	.1	376.4	46.4	4,008.5	249.3
1943	2,050.2	105.1	0.7	.1	28.4	9.3	0	0	283.3	35.0	2,362.6	149.5
1944	1,862.5	99.8	3.6	.5	21.4	7.0	0	0	376.1	46.4	2,263.6	153.7
1945	1,378.4	71.4	1.2	.2	3.9	1.3	0	0	347.5	42.9	1,731.0	115.8
1946	2,670.4	137.4	1.2	.2	35.2	11.6	0	0	413.0	50.9	3,119.8	200.1
1947	3,412.4	175.5	13.3	1.9	143.6	47.2	0	0	349.7	43.2	3,919.0	267.8
1948	3,647.1	201.8	1.4	.2	55.0	18.1	0	0	388.4	47.9	4,091.9	268.0
1949	1,623.7	87.7	1.5	.2	19.6	6.5	3.4	.3	328.4	40.6	1,976.6	135.3
1950	2,171.5	112.8	6.6	.9	48.0	15.8	0.4	.1	223.9	27.6	2,450.4	157.2
1951	1,663.1	95.4	3.1	.4	36.4	12.0	12.6	1.0	268.8	34.4	1,984.0	143.2
1952	2,087.0	118.0	7.4	1.1	95.7	31.5	.1	0	414.3	57.3	2,604.5	207.9
1953	1,285.3	79.7	23.0	3.3	49.1	16.2	0	0	519.8	64.1	1,877.2	163.3
1954	994.3	80.4	7.9	1.1	47.8	17.5	0	0	193.7	17.4	1,243.7	116.4
1955	2,112.5	151.8	73.6	10.5	169.9	52.4	0	0	356.2	47.8	2,712.2	262.5
1956	722.3	57.7	12.6	1.8	106.4	35.7	0	0	182.5	27.4	1,023.8	122.6
1957	55.9	3.7	.2	.1	.5	.2	0	0	1.1	.1	57.7	4.1
1958	150.4	11.7	1.7	.2	19.1	6.3	0	0	28.4	4.1	199.6	22.3

**Table 23—Columbia River commercial landings of salmon and steelhead above Bonneville Dam, 1938-93
(in thousands)—(continued)**

Year	Chinook		Coho		Sockeye		Chum		Steelhead		Total	
	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.
1959	32.1	2.2	.2	0.1	2.6	0.9	0	0	4.7	0.5	39.6	3.7
1960	34.6	2.4	1.1	.2	1.9	0.6	0	0	7.6	0.7	45.2	3.9
1961	116.4	7.5	3.5	.5	.4	.1	.4	.1	10.1	1.5	130.8	9.7
1962	145.0	9.9	17.5	2.5	12.4	3.8	0	0	.1	<.1	175.0	16.2
1963	544.1	36.8	.5	.1	28.8	8.9	0	0	64.8	6.4	638.2	52.2
1964	645.7	42.7	19.9	2.5	51.6	15.8	<.1	<.1	48.9	6.5	766.1	67.5
1965	873.5	55.6	21.5	3.2	22.6	5.8	0	0	104.5	13.2	1,022.1	77.8
1966	203.1	12.4	71.5	8.3	16.6	4.2	0	0	14.7	2.1	305.9	27.0
1967	1,020.5	63.3	102.2	13.6	118.2	34.5	0	0	135.9	15.9	1,376.8	127.3
1968	766.3	47.2	49.5	7.6	17.2	5.0	.1	<.1	93.4	10.4	926.5	70.2
1969	1,364.1	90.7	38.4	7.8	42.5	11.3	0	0	146.4	14.8	1,591.4	124.6
1970	956.9	57.1	137.6	15.5	13.0	4.1	0	0	116.9	13.5	1,224.4	90.2
1971	1,201.3	75.1	86.4	13.1	77.5	21.3	0	0	228.6	25.9	1,593.8	135.4
1072	1,341.8	90.1	61.9	8.7	88.7	26.1	<.1	<.1	323.6	28.6	1,816.0	153.5
1973	1,717.2	104.1	81.6	11.1	6.1	1.4	<.1	<.1	296.7	27.9	2,101.6	144.5
1974	1,251.5	72.5	41.7	6.8	.2	<.1	0	0	116.4	13.1	1,409.8	92.4
1975	2,668.3	140.6	50.7	5.7	0	0	0	0	69.5	7.3	2,788.5	153.6
1976	2,562.8	135.4	30.2	4.0	.2	<.1	0	0	86.6	9.6	2,679.8	149.0
1977	1,176.9	72.4	7.6	1.0	.5	.1	0	0	425.7	35.2	1,610.7	108.7
1978	1,240.6	65.6	22.8	3.7	<.1	<.1	0	0	249.2	20.4	1,512.6	89.7
1979	1,193.1	62.9	31.0	3.9	<.1	<.1	<.1	<.1	68.6	9.2	1,292.7	76.0

**Table 23—Columbia River commercial landings of salmon and steelhead above Bonneville Dam, 1938-93
(in thousands)—(continued)**

Year	Chinook		Coho		Sockeye		Chum		Steelhead		Total	
	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.	Lb.	No.
1980	729.5	33.9	1.9	0.3	<.1	<.1	0	0	65.6	7.3	797.0	41.5
1981	974.9	56.4	11.3	1.8	<.1	<.1	0	0	98.0	10.0	1,084.2	68.2
1982	1,100.8	57.7	25.9	4.3	.5	.1	0	0	96.5	9.4	1,223.7	71.5
1983	414.3	24.5	1.0	.2	6.5	1.8	<.1	<.1	156.7	18.5	578.5	45.0
1984	857.1	53.5	8.7	1.6	78.7	22.5	0	0	908.4	75.1	1,852.9	152.7
1985	1,348.3	76.9	42.3	5.2	175.8	49.4	<.1	<.1	766.2	85.5	2,332.6	217.0
1986	1,984.8	107.1	96.1	16.8	17.1	4.3	0	0	683.8	72.0	2,781.8	200.2
1987	2,797.8	140.5	13.7	2.3	149.0	39.5	0	0	753.8	79.1	3,714.3	261.4
1988	3,290.9	146.9	38.0	5.2	119.6	31.0	0	0	764.8	78.5	4,213.3	261.6
1989	2,862.4	128.1	14.8	2.5	.1	<.1	0	0	591.0	60.9	3,468.3	191.5
1990	1,795.1	83.8	6.9	1.0	<.1	<.1	0	0	331.0	32.6	2,133.0	117.4
1991	999.8	51.2	44.7	6.7	<.1	<.1	0	0	307.4	37.0	1,351.9	94.9
1992	525.7	29.2	4.8	1.0	<.1	<.1	0	0	465.2	51.9	995.7	82.1
1993	540.7	31.1	9.4	0.9	<.1	<.1	0	0	263.1	27.6	813.2	59.6

Sources: WDFW 1994 and ODFW 1994.

Table 24—Columbia River commercial landings of salmon and steelhead by treaty Indian fishers using dip nets at Celilo Falls, 1938-56^a

Year	Chinook	Coho ^b	Sockeye	Steelhead	Total
			<i>In thousands</i>		
1938	1,311.5	—	86.5	262.9	1,660.9
1939	1,087.5	—	71.6	186.8	1,345.9
1940	1,616.5	—	155.4	340.9	2,112.8
1941	3,038.2	—	106.2	320.5	3,464.9
1942	2,464.6	—	47.9	274.0	2,786.5
1943	1,548.3	—	27.5	214.7	1,790.5
1944	1,273.4	—	16.3	303.5	1,593.2
1945	941.9	—	3.8	302.1	1,247.8
1946	1,927.1	—	22.9	345.3	2,295.3
1947	2,120.6	—	119.6	245.6	2,485.8
1948	2,600.0	—	51.6	188.3	2,839.9
1949	1,011.5	—	12.6	211.6	1,235.7
1950	1,516.8	—	45.4	156.1	1,718.3
1951	1,474.8	—	32.3	255.9	1,763.0
1952	1,790.7	—	88.2	407.0	2,285.9
1953	1,120.8	—	48.5	500.7	1,670.0
1954	570.5	—	45.0	180.7	796.2
1955	1,475.6	—	168.6	338.9	1,983.1
1956	634.6	—	105.6	170.7	910.9
Total ^c					32,520.0

^a The dipnet fishery at Celilo Falls ended in 1957 when the falls was inundated by the construction of The Dalles Dam.

^b Coho landings were usually less than 500 fish annually.

^c Average is 1,712.

Sources: WDFW 1994 and ODFW 1994.

Appendix E

Table 25—Columbia River commercial catch of white sturgeon, 1889-1939

Year	Zones 1-5 (below Bonneville Dam)	Zone 6 (above Bonneville Dam)	Total
<i>Thousands of pounds</i>			
1889	—	—	1746.7
1890	—	—	3,084.9
1891	—	—	3,562.0
1892	—	—	5,466.8
1893-94	—	—	ND
1895	—	—	4,704.5
1896-98	—	—	ND
1899	—	—	73.3
1900-03	—	—	ND
1904	—	—	137.7
1905-14	—	—	ND
1915	—	—	134.9
1916-22	—	—	ND
1923	—	—	182.9
1924	—	—	ND
1925	—	—	231.4
1926	—	—	209.1
1927	—	—	211.5
1928	—	—	147.5
1929	—	—	159.6
1930	—	—	129.4
1931	—	—	112.9
1932	—	—	71.4
1933	—	—	84.5
1934	—	—	79.1
1935	—	—	72.8
1936	—	—	131.3
1937	—	—	127.3
1938	28.5	39.1	67.6
1939	45.7	28.2	73.9

ND = no data.

Sources: PSMFC 1992, WDFW 1994, and ODFW 1994.

**Table 26—Columbia River white and green sturgeon commercial landings, 1938-93
(in thousands)**

Year	White sturgeon						Green sturgeon,	
	Zones 1-5 ^a		Zone 6		Zones 1-6		total	
	<i>Lb.</i>	<i>No.</i>	<i>Lb.</i>	<i>No.</i>	<i>Lb.</i>	<i>No.</i>	<i>Lb.</i>	<i>No.</i>
1938	28.5	—	39.1	—	67.6	—	10.8	—
1939	45.7	—	28.2	—	73.9	—	16.1	—
1940	54.2	—	29.7	—	83.9	—	15.3	—
1941	60.6	—	24.0	—	84.6	—	10.1	—
1942	58.5	—	36.7	—	95.2	—	5.5	—
1943	86.0	—	30.1	—	116.1	—	6.1	—
1944	178.5	—	58.5	—	237.0	—	11.1	—
1945	195.6	—	70.5	—	266.1	—	19.0	—
1946	211.9	—	99.6	—	311.5	—	16.9	—
1947	215.7	—	159.4	—	375.1	—	11.8	—
1948	388.1	—	187.3	—	575.4	—	11.3	—
1949	249.2	—	142.6	—	391.8	—	18.9	—
1950	266.8	—	60.3	—	327.1	—	33.0	—
1951	225.5	—	31.9	—	257.4	—	22.3	—
1952	233.4	—	37.5	—	270.9	—	35.1	—
1953	322.7	—	23.9	—	346.6	—	34.7	—
1954	293.5	—	17.6	—	311.1	—	30.1	—
1955	202.8	—	20.1	—	222.9	—	70.8	—
1956	227.6	—	16.3	—	243.9	—	50.7	—
1957	303.6	—	8.1	—	311.7	—	112.8	—
1958	240.4	—	19.7	—	260.1	—	76.6	—
1959	167.5	—	35.9	—	203.4	—	192.2	—
1960	173.1	4.3	11.0	.2	184.1	4.5	71.3	1.8
1961	174.0	4.4	9.3	.2	183.3	4.6	119.2	3.0
1962	196.5	4.9	4.1	.1	200.6	5.0	65.3	1.6
1963	207.8	5.2	4.2	.1	212.0	5.3	50.3	1.2
1964	135.8	3.4	3.8	.1	139.6	3.5	30.0	.8
1965	150.1	3.8	7.9	.2	158.0	4.0	32.4	.8

**Table 26—Columbia River white and green sturgeon commercial landings, 1938-93
(in thousands)—(continued)**

Year	White sturgeon						Green sturgeon,	
	Zones 1-5 ^a		Zone 6		Zones 1-6		total	
	<i>Lb.</i>	<i>No.</i>	<i>Lb.</i>	<i>No.</i>	<i>Lb.</i>	<i>No.</i>	<i>Lb.</i>	<i>No.</i>
1966	221.2	5.5	5.0	.1	226.2	5.6	70.9	1.8
1967	151.1	3.8	8.6	.2	159.7	4.0	46.1	1.1
1968	141.1	3.5	10.6	.2	151.7	3.7	24.7	.6
1969	293.4	7.5	16.6	.4	310.0	7.9	68.4	1.7
1970	250.0	6.3	15.3	.4	265.3	6.7	51.1	1.3
1971	280.2	7.2	31.3	.7	311.5	7.9	52.4	1.3
1972	297.5	7.6	30.5	.7	328.0	8.3	46.2	1.1
1973	389.5	10.7	41.5	1.1	431.0	11.8	34.5	1.3
1974	345.0	10.7	26.6	.5	371.6	11.2	121.8	3.1
1975	454.5	14.0	29.3	0.6	483.8	14.6	42.9	1.3
1976	732.7	22.8	24.4	0.6	757.1	23.4	89.5	3.0
1977	320.7	9.7	20.2	0.6	340.9	10.3	23.5	0.8
1978	288.5	9.8	20.7	0.7	309.2	10.5	48.7	1.7
1979	533.8	20.5	38.8	1.3	572.6	21.8	36.8	1.2
1980	263.2	9.4	53.4	1.8	316.6	11.2	44.6	1.7
1981	419.9	14.9	70.4	2.0	490.3	16.9	5.1	0.2
1982	353.0	11.6	44.8	1.3	397.8	12.9	24.4	0.8
1983	398.6	12.4	48.7	1.4	447.3	13.8	18.6	0.7
1984	524.4	17.5	88.3	2.8	612.7	20.3	84.5	2.7
1985	270.4	8.4	168.5	5.0	438.9	13.4	41.0	1.6
1986	373.9	11.6	322.1	9.5	696.0	21.1	180.6	6.0
1987	307.0	9.7	384.1	11.1	691.1	20.8	145.7	4.9
1988	217.1	6.8	136.6	4.1	353.7	10.9	114.1	3.3
1989	162.0	5.0	126.7	3.5	288.7	8.5	47.8	1.7
1990	176.2	5.3	115.5	3.4	291.7	8.7	64.9	2.2
1991	120.6	3.8	46.7	1.5	167.3	5.3	89.0	3.2
1992	172.4	6.2	54.1	1.6	226.5	7.8	62.3	2.2
1993	218.9	8.1	61.6	2.0	280.5	10.1	66.4	2.2

^a Includes Youngs Bay (1979 to present) and Washington (1980-82) terminal landings.

Sources: WDFW 1994 and ODFW 1994.

Table 27—Columbia River Shad commercial landings, 1938-93 (in thousands)

Year	Zones 1 -5		Zone 6		Zones 1-6	
	<i>Pound</i>	<i>Number</i>	<i>Pound</i>	<i>Number</i>	<i>Pound</i>	<i>Number</i>
1938	168.0	44.8	1.7	0.4	169.7	45.2
1939	350.7	93.5	2.6	.7	353.3	94.2
1940	349.7	93.2	14.7	3.9	364.4	97.1
1941	376.1	100.3	5.0	1.3	381.1	101.6
1942	509.3	135.8	9.6	2.6	518.9	138.4
1943	321.4	85.7	2.2	.6	323.6	86.3
1944	589.8	157.2	3.3	.9	593.1	158.1
1945	877.8	234.1	32.2	8.6	910.0	242.7
1946	1,428.7	380.9	14.0	3.7	1,442.7	384.6
1947	1,291.2	344.3	6.1	1.6	1,297.3	345.9
1948	394.5	105.2	.9	.2	395.4	105.4
1949	429.7	114.5	7.2	1.9	436.9	116.4
1950	631.9	168.5	1.2	.3	633.1	168.8
1951	406.2	108.3	.3	.1	406.5	108.4
1952	342.4	91.3	.3	.1	342.7	91.4
1953	275.8	73.5	0	0	275.8	73.5
1954	246.4	65.7	0	0	246.4	65.7
1955	285.0	76.0	0	0	285.0	76.0
1956	245.4	65.4	.1	0	245.5	65.4
1957	150.1	40.0	0	0	150.1	40.0
1958	193.4	51.6	0	0	193.4	51.6
1959	135.6	36.2	0	0	135.6	36.2
1960	160.9	42.9	9.4	2.5	170.3	45.4
1961	405.9	108.2	.3	.1	406.2	108.3
1962	883.5	235.6	10.9	2.9	894.4	238.5
1963	799.7	213.2	59.6	15.9	859.3	229.1
1964	251.8	67.1	53.5	14.2	305.3	81.3
1965	327.2	87.2	27.7	7.4	354.9	94.6
1966	770.6	205.5	15.8	4.2	786.4	209.7
1967	831.8	221.8	21.4	5.7	853.2	227.5
1968	305.7	81.5	5.1	1.4	310.8	82.9

Table 27—Columbia River Shad commercial landings, 1938-93 (in thousands)—(continued)

Year	Zones 1 -5		Zone 6		Zones 1-6	
	<i>Pound</i>	<i>Number</i>	<i>Pound</i>	<i>Number</i>	<i>Pound</i>	<i>Number</i>
1969	170.8	45.5	8.0	2.1	178.8	47.6
1970	228.1	59.1	22.6	6.4	250.7	65.5
1971	155.9	40.3	24.1	6.7	180.0	47.0
1972	216.7	55.3	16.8	4.9	233.5	60.2
1973	191.9	49.0	18.8	4.8	210.7	53.8
1974	180.7	45.9	14.5	3.6	195.2	49.5
1975	239.9	64.5	29.8	8.5	269.7	73.0
1976	232.8	60.9	71.1	19.4	303.9	80.3
1977	241.2	61.9	2.1	.6	243.3	62.5
1978	441.6	113.6	18.7	5.6	460.3	119.2
1979	468.2	120.3	24.8	7.9	493.0	128.2
1980	88.9	23.2	.7	.2	89.6	23.4
1981	66.7	21.8	0	0	66.7	21.8
1982	291.4	75.0	6.0	1.5	297.4	76.5
1983	270.2	85.0	1.2	.3	271.4	85.3
1984	57.1	18.1	8.8	3.1	65.9	21.2
1985	111.1	35.4	0	0	111.1	35.4
1986	308.5	88.2	2.4	.7	310.9	88.9
1987	313.6	108.7	36.4	12.3	350.0	121.0
1988	326.4	108.5	59.0	19.2	385.4	127.7
1989	143.8	51.6	.3	.1	144.1	51.7
1990	450.2	167.8	.5	.2	450.7	168.0
1991	120.8	43.1	<.1	<.1	120.8	43.2
1992	395.2	141.4	.8	.3	396.0	141.7
1993	405.2	144.7	2.8	1.0	408.0	145.7

Sources: WDFW 1994 and ODFW 1994.

Table 28—Partial Walleye sport catch estimates for Bonneville, The Dalles, and John Day pools, 1981-93^a

Year	Bonneville pool	The Dalles pool	John Day pool	Survey total
1981	0	2,062	164	2,226
1982	NS	NS	NS	NS
1983	NS	NS	463	463
1984	NS	NS	349	349
1985	NS	NS	186	186
1986	NS	NS	291	291
1987	NS	1,660	NS	1,660
1988	394	3,480	NS	3,874
1989	1,066	7,556	1,718	10,340
1990	1,351	NS	3,088	4,439
1991	NS	NS	2,207	2,207
1992	100	1,000	1,780	2,880
1993	82	2,200	2,746	5,028

NS = pool not surveyed.

^a Partial catch estimates based on results of limited creel surveys conducted during predator-prey and sturgeon research programs.

Sources: WDFW 1994 and ODFW 1994.

Appendix F

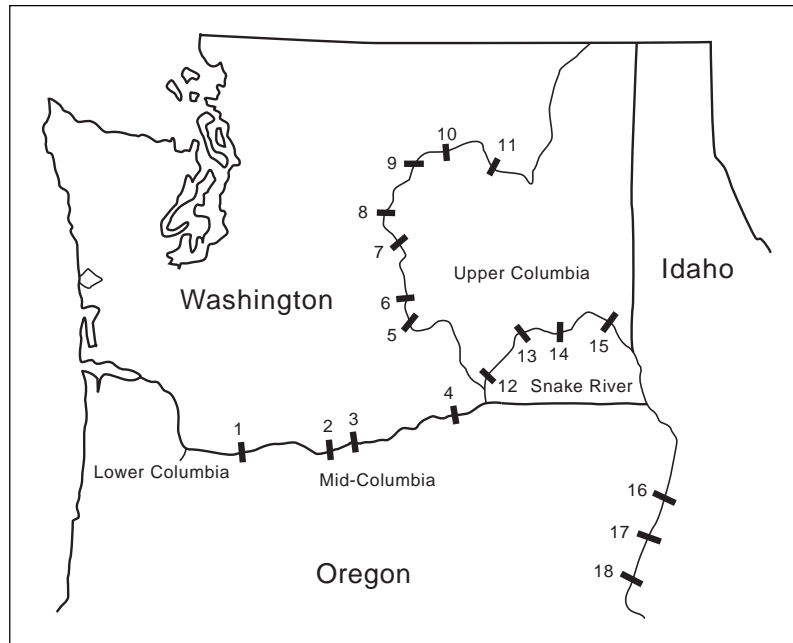


Figure 4—Major dams on the Columbia and Snake Rivers. Numbers in the map correspond to the dams in the first column of the accompanying table.

Dam	Year in service	Miles to mouth	Gross head (feet)	Miles of reservoir	Operator	Adult fish passage
1. Bonneville	1938	146	65	45	Corps of Engineers	Yes
2. The Dalles	1957	192	85	31	Corps of Engineers	Yes
3. John Day	1968	216	105	76	Corps of Engineers	Yes
4. McNary	1953	292	75	61	Corps of Engineers	Yes
5. Priest Rapids	1959	397	82	18	Grant County PUD	Yes
6. Wanapum	1963	416	84	38	Grant County PUD	Yes
7. Rock Island	1933	453	54	21	Chelan County PUD	Yes
8. Rocky Reach	1961	474	93	42	Chelan County PUD	Yes
9. Wells	1967	515	72	30	Douglas County PUD	Yes
10. Chief Joseph	1955	545	177	51	Corps of Engineers	No
11. Grand Coulee	1941	597	343	151	Bureau of Reclamation	No
12. Ice Harbor	1961	334	100	32	Corps of Engineers	Yes
13. Lower Monumental	1969	366	100	29	Corps of Engineers	Yes
14. Little Goose	1970	395	100	37	Corps of Engineers	Yes
15. Lower Granite	1975	432	98	39	Corps of Engineers	Yes
16. Hells Canyon	1967	571	210	22	Idaho Power Company	No
17. Oxbow	1961	597	120	12	Idaho Power Company	No
18. Brownlee	1958	609	272	57	Idaho Power Company	No

Sources: WDFW 1994 and ODFW 1994.

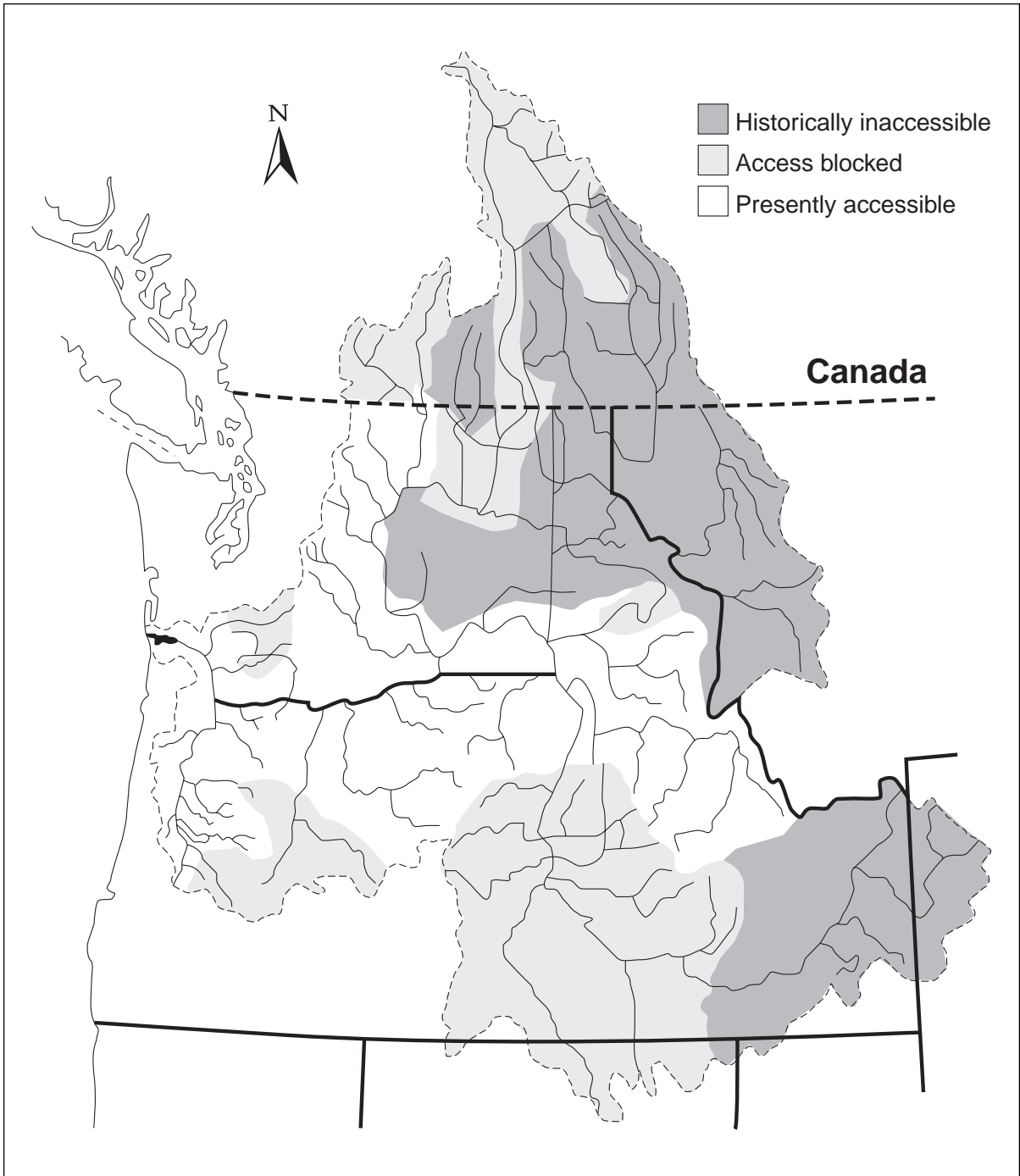


Figure 5—Basin areas accessible to salmon. Sources: WDFW 1994 and ODFW 1994.

Table 29—Dams in salmonid habitat in the basin by river reach

Area	Hydropower dams	Multipurpose dams	Total dams
Columbia River below Bonneville Dam	17	19	36
Columbia River above Bonneville Dam to Snake River mouth	6	8	14
Columbia River between Snake River and Chief Joseph Dam	4	10	14
Columbia above Chief Joseph Dam	15	18	33
Snake River below Hells Canyon Dam	0	9	9
Snake River above Hells Canyon Dam	16	14	30
Total basin	58	78	136

Source: NPPC 1986.

Appendix G

Table 30—Fish hatcheries in the basin^a

Hatchery name	River	Year and operator	Species
Big Canyon	Wallowa River	1988 ODFW ^a	ChS
Bonifer	Umatilla River	1984 Umatilla Tribe	ChF
Carson	Wind River	1937 USDI FWS ^b	ChS
Cascade	Eagle Creek (Col. River)	1958 ODFW	ChF, coho
Crooked River	South Fork Clearwater River	1990 IDFG ^b	ChS
Dworshak	North Fork Clearwater River	1969 USDI FWS	ChS
East Bank	Upper Columbia River	1989 WDF ^b	ChF, coho
Entiat	Entiat River	1942 USDI FWS	ChS
Hells Canyon	Snake River	1965 IDFG	ChS
Imnaha	Imnaha River	1982 ODFW ^b	ChS
Irrigon	Mid-Columbia River	1985 ODFW	ChF
Klickitat	Klickitat River	1951 WDFW	ChF, coho
Kooskia	South Fork Clearwater River	1966 USDI FWS	ChS
Leavenworth	Icicle Creek	1938 USDI FWS	ChS
Little White Salmon	Lower White Salmon River	1898 USDI FWS	ChF, ChS, coho
Lookingglass	Lookingglass Creek	1982 ODFW	ChS
Lyon's Ferry	Snake River	1983 WDF	ChS, ChF
McCall	South Fork Salmon River	1976 IDFG	ChR
Minthorn	Umatilla River	1986 Umatilla Tribe	ChF, coho
Oxbow	Herman Creek	1938 ODFW	ChF, coho
Oxbow	Snake River	1962 IDFG	Steelhead
Pahsimeroi	Pahsimeroi River	1970 IDFG	ChR
Powell	Lochsa River	1989 IDFG	ChS
Priest Rapids	Upper Columbia River	1963 WDF	ChF
Rapid River	Rapid River	1964 IDFG	ChS
Red River	South Fork Clearwater River	1987 IDFG	ChS
Ringold	Upper Columbia River	1966 WDF	ChS
Rocky Reach	Upper Columbia River	1961 WDF	ChF, coho
Round Butte	Deschutes River	1972 ODFW	ChS

Table 30—Fish hatcheries in the basin (continued)^a

Hatchery name	River	Year and operator	Species
Sawtooth	Salmon River	1985 IDFG	ChS
Spring Creek	Mid-Columbia River	1901 USDI FWS	ChF
Three-Mile	Umatilla River	1988 ODFW	ChF, ChS, coho
Tucannon	Tucannon River	1971 WDW ^b	ChS
Warm Spring	Warm Springs River	1977 USDI FWS	ChS
Wells	Upper Columbia River	1967 WDF	ChR
Willard	Lower White Salmon River	1967 WDFW	Coho
Winthrop	Methow River	1942 USDI FWS	ChS

^aBasin salmon hatcheries = 37.

^bIDFG = Idaho Department of Fish and Game; ODFW = Oregon Department of Fish and Wildlife; USDI FWS = U.S. Fish and Wildlife Service; WDF = Washington Department of Fisheries; WDW = Washington Department of Wildlife; WDFW = Washington Department of Fish and Wildlife; Ch F = fall chinook; Ch S = spring chinook; Ch R = summer chinook.

Sources: WDFW 1994 and ODFW 1994.

Appendix H

Table 31—Important Columbia River fishery management events

Year	Event
1818	United States and Britain agree on joint occupancy of Oregon country.
1843	Oregon Provisional Government established.
1846	Treaty between the United States and Great Britain set at Forty-Ninth Parallel.
1848	Treaty between the United States and Mexico.
1853	Washington Territory created.
1855	Treaties between the United States and some Columbia River Indian tribes signed.
1859	Oregon Statehood.
1861	Commercial fishing became an important industry.
1866	Salmon canning began. Washington passed its first salmon fishing gear regulation.
1877	Washington established first closed fishing periods (Oregon followed in 1878).
1878	Oregon Fish Commission established. Oregon passed its first gear regulation.
1879	First fish wheel on the Columbia River.
1883	Peak harvests of Columbia River salmon.
1887	Oregon established a three-person State Board of Commissioners to enforce fish and game laws. First fish hatchery established in Oregon.
1889	Montana Statehood. Washington Statehood.
1890	Idaho Statehood. Wyoming Statehood. Washington Department of Fisheries and Game established.
1893	State Game and Fish Protector position established in Oregon (beginning of combined fish and game administration in Oregon).
1895	Washington State Fish Commission created.
1897	Washington established closed season for sturgeon March 1 through November 1 (Oregon followed in 1899).
1898	Oregon split fish and game programs and created a Board of Fish Commissioners comprised of governor, secretary of state, and fish commissioner. A Board of Game Commissioners followed in 1899.
1899	Beginning of joint Oregon and Washington fishery management (joint committees of the two legislatures met in an effort to agree on Columbia fishing regulations). Chinese sturgeon lines (snagging setlines) prohibited. Sturgeon minimum commercial size set at 48 inches.
1901	Oregon established the Master Fish Warden position.
1903	Washington established a game code and county commissioners appointed game wardens.
1909	Sturgeon allowed to be taken at times and in areas open to commercial salmon fishing. Beginning of consistent Oregon and Washington seasons. Upper deadline established at mouth of Deschutes River.

Table 31—Important Columbia River fishery management events (continued)

Year	Event
1911	Oregon's Fish and Game boards combined to form the Board of Fish and Game Commissioners comprised of three members appointed by the governor.
1912	Troll salmon fishing began off the mouth of the Columbia.
1913	Position of Washington Chief Game Warden created.
1915	Washington regulation of game, game fish, and food fish combined under the authority of the State Game Warden. Oregon abolished Board of Fish and Game Commissioners and replaced with Fish and Game Commission, with the governor chair of three-member commission. Legislatures of Oregon and Washington created the Columbia River Fish Compact for joint regulation of Columbia River commercial fisheries.
1917	Purse seines prohibited in the Columbia River.
1918	United States Congress ratified the compact and agreement between Oregon and Washington covering concurrent jurisdiction of Columbia River fisheries.
1920	Oregon replaced the 1915 body with Board of Fish and Game Commissioners.
1921	Oregon established separate fish (three members) and game (five members) commissions with members to be appointed by the legislature and later by the governor. Washington abolished the State fish commission and replaced it with a Department of Fisheries and Game. Oregon landings of salmon, shad, and sturgeon taxed.
1923	Whip seines prohibited in the Columbia River. Oregon fish dealers required to report purchases to the state.
1927	Fish wheels prohibited in Oregon (followed by the Washington prohibition in 1935). Commercial fishing prohibited in Willamette River.
1932	Washington legislature separated food fish and game fish management and created the Department of Fisheries under an appointed director and the Department of Game under a six-person commission. United States Army Corps of Engineers completes master plan for 10 Columbia River dams.
1934	Commercial take or sale of steelhead in Washington prohibited. Fish and Wildlife Coordination Act gave Secretaries of Agriculture and Commerce authority to provide technical assistance and to cooperate with other Federal and state agencies.
1935	Haul (drag) seines, traps, and set nets prohibited in Washington (followed by the Oregon prohibition in 1949—effective September 14, 1950). Fish wheels prohibited in Washington.
1937	Oregon and Washington fisheries officials permitted to change seasons (formerly only the state legislatures could change seasons). Bonneville Power Administration created.
1938	Bonneville Dam completed. Commercial fishery prohibited 5 miles below (Beacon Rock) and 15 miles above the dam. Mitchell Act required fish and wildlife mitigation in water resource projects.
1941	Grand Coulee Dam completed.
1946	Fish and Wildlife Coordination Act amended to require Federal and state agencies to consult on water resource projects.

Table 31—Important Columbia River fishery management events (continued)

Year	Event
1948	Staggered season for the area above Bonneville Dam (season opened and closed later than that in effect below the dam). Idaho, Oregon, and Washington fish agencies sign agreement with U.S. Fish and Wildlife Service to repair damage to fish by upriver developments. Pacific States Marine Fisheries Commission (PSMFC) established by Congress.
1949	Haul (drag) seines, traps, and set nets prohibited in Oregon (effective September 14, 1950). Lower Columbia River Fisheries Development Program appropriation.
1950	Sturgeon maximum size for all fisheries set at 72 inches. Sturgeon minimum size first established for sport fisheries set at 30 inches.
1951	Oregon's Master Fish Warden position changed to State Fisheries Director.
1953	Special shad-only season first established (in the area of Camas and Washougal).
1957	Celilo Falls inundated by The Dalles Dam ending the tribal fishery.
1958	Fish and Wildlife Coordination Act amended to require "equal consideration" for fish and wildlife conservation in water-development projects.
1964	Last summer commercial salmon season for zones 1-5.
1965	Last summer commercial salmon season for zone 6.
1967	Hells Canyon Dam completed.
1968	Commercial fishing reestablished by states above Bonneville Dam exclusively for treaty Indian fishers. Law suit <i>United States v. Oregon</i> filed. Governors of Oregon, Washington, and Idaho established the Columbia River Fisheries Advisory Council composed of the fish and game directors of the three states.
1969	Zone 6 fishing area (Bridge of the Gods to mouth Umatilla River), river mouth closures, dam sanctuaries, and gear regulations established. <i>United States v. Oregon</i> decision (Belloni decision).
1971	<i>United States v. Washington</i> filed.
1974	<i>United States v. Washington</i> decision (Boldt decision) allocates salmon fishing 50-50 between treaty and nontreaty fishing. (Extended to Columbia River in 1975.)
1975	Oregon's separate fish and wildlife commissions merged forming the Oregon Department of Fish and Wildlife with a seven-member Oregon Fish and Wildlife Commission. Sale of steelhead in Oregon by non-Indians prohibited. Lower Granite Dam completed, last of 18 major main-stem Snake and Columbia dams finished 1933-75.
1976	Limited entry system in effect in Washington. Congress passes Fishery Conservation and Management Act (later named the Magnuson Act).
1977	Court approves 5-year management and allocation agreement regarding upper Columbia fish runs. Four Columbia River treaty Indian tribes establish Columbia River Intertribal Fish Commission. Last spring commercial salmon seasons in zones 1-6.
1979	United States Supreme Court affirms Boldt decision in <i>United States v. Washington State Passenger Fishing Vessel Association</i> .

Table 31—Important Columbia River fishery management events (continued)

Year	Event
1980	Congress passes the Northwest Electric Power Planning and Conservation Act. Limited entry system in effect in Oregon
1985	United States - Canada Pacific Salmon Interception Treaty signed.
1988	Court approves the <i>United States v. Oregon</i> Columbia River Fish Management Plan. Sturgeon setline fishing below Bonneville Dam phased out under Washington legislative statute. Last commercial sockeye seasons for zones 1-6 .
1990	“Salmon Summit.” Snake River salmon proposed for listing under Endangered Species Act.
1991	Snake River sockeye salmon listed as an endangered species. Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean concluded (United States, Russia, Japan, and Canada).
1992	Snake River wild spring and summer and fall chinook salmon listed as a threatened species. United Nations Moratorium on High Seas Drift Net Fishing.
1993	Washington legislature passed merger of Washington’s Department of Fisheries and Department of Wildlife into the Washington Department of Fish and Wildlife.
1994	Snake River wild spring and summer and fall chinook listed as endangered species.

Sources: Modified from WDFW 1994 and ODFW 1994.

Appendix I

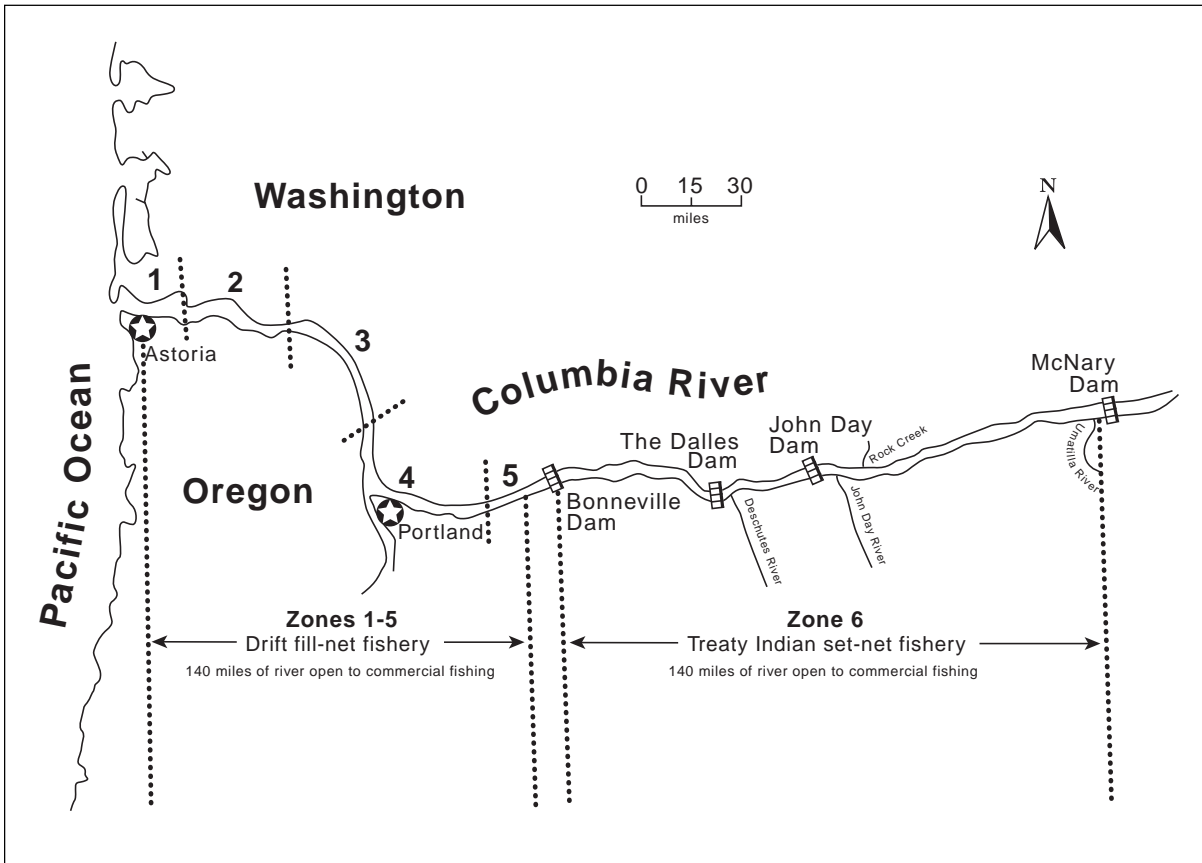


Figure 7—The Columbia River below McNary Dam showing areas open to commercial fishing. Sources: WDFW 1994 and ODFW 1994.

Table 32—Commercial fishing zones and areas on the Columbia River

Area	Description
Zone 1	Easterly of a line projected from the knuckle of the south jetty on the Oregon bank to the inshore end of the north jetty on the Washington bank, and westerly of a line projected from a beacon light at Grays Point on the Washington bank to the flashing 4-second red buoy "44" off the easterly tip of Tongue Point on the Oregon bank.
Zone 2	Easterly of a line projected from a beacon light at Grays Point on the Washington bank to the flashing 4-second red buoy "44" off the easterly tip of Tongue Point on the Oregon bank, and westerly of a line projected from the 4-second flashing green light "81" on the Washington bank to a boundary marker on the easterly end of the Beaver Terminal Pier in Oregon, including all waters of Grays Bay, those waters of Deep River downstream of the Highway 4 bridge, all waters of Seal Slough, those waters of Grays River downstream of a line projected between fishing boundary markers on both banks at the Leo Reisticka farm, and those waters of Elokomin Slough and Elokomin river downstream of the Highway 4 bridge.
Zone 3	Easterly of a line projected from the 4-second flashing green light "81" on the Washington bank to a boundary marker on the easterly end of the Beaver Terminal Pier in Oregon, and westerly of a line projected true west from the east or upstream bank of the Lewis River mouth in Washington.
Zone 4	Easterly of a line projected true west from the east or upstream bank of the Lewis River in Washington, and westerly of a line projected true north from Rooster Rock on the Oregon bank, and those waters of Camas Slough downstream of the westernmost powerline crossing at the Crown Zellerbach mill.
Zone 5	Easterly of a line projected true north from Rooster Rock on the Oregon bank, and westerly of a line projected from a deadline marker on the Oregon bank to a deadline marker on the Washington bank, both such deadline markers located about 5 miles downstream from Bonneville Dam.
Area 2S	From a downstream boundary of a true north/south line through flashing red 4-second light "50" near the Oregon bank to an upstream boundary of a straight line from a deadline marker on the Oregon bank to a deadline marker on the Washington bank, both such deadline markers located about 5 miles downstream from Bonneville Dam.
Washougal Reef shad area	Area lying within a line commencing at the green 6-second equal-interval light about 3/4 mile east of the Washougal Woolen Mill pipeline and projected westerly to the Washougal blinker light (light "50"); thence continuing westerly to the green 4-second blinker light on the east end of Lady Island; thence easterly and northerly along the shoreline of Lady Island to the State Highway 14 bridge; thence easterly across State Highway 14 bridge to the mainland.
Youngs Bay terminal salmon fishing area	Waters of Youngs Bay and river upstream from an imaginary line running parallel to and 150 feet upstream from the new Highway 101 bridge to deadline markers at the mouth of the Battle Creek Slough except for those waters southerly of a line from the Visual-Omnirange (VOR) at the Port of Astoria Airport through buoy 11 to a marker on the opposite bank.
Big Creek terminal salmon fishing area	Calendar and Big Creek sloughs east from boundary markers at the west end of Minaker Island, upstream to deadline markers about 1/4-mile east of the mouth of Big Creek.
Zone 6	Three-pool area between Bonneville and McNary Dams.

Sources: WDFW 1994 and ODFW 1994.

Appendix J

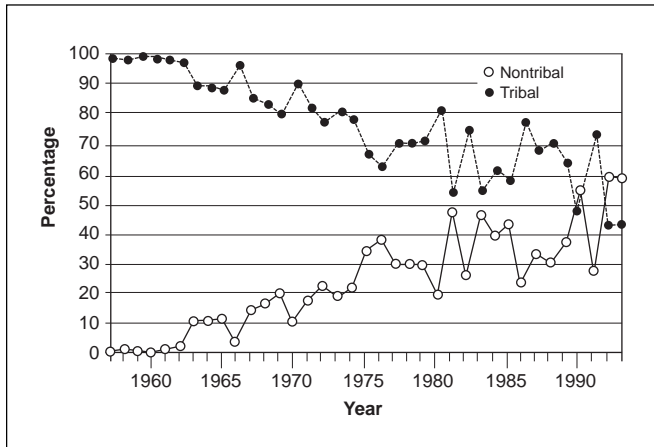


Figure 8—Tribal and nontribal percentages of Columbia River commercial landings of salmon and steelhead. Sources: WDFW 1994 and ODFW 1994.

Table 33—Treaty commercial fishery in the basin (zone 6) 1980 to present^a

Year	Chinook	Coho	Sockeye	Steelhead	White sturgeon	Shad	Walleye	Total, all species ^c
<i>Thousands of dollars</i>								
1981	974.9	12.2	0	119.6	69.0	0		1,175.7
1982	704.5	23.2	.7	107.1	45.2	.9		881.7
1983	356.3	.7	4.4	120.7	48.7	.2		531.0
1984	1,028.5	8.4	85.0	953.8	120.1	.7		2,196.5
1985	1,213.5	28.8	170.5	360.1	235.9	0		2,008.8
1986	1,607.7	72.1	19.7	382.9	521.8	.3		2,604.5
1987	4,504.5	16.6	219.0	829.2	672.2	1.5		6,243.0
1988	6,483.1	69.2	246.4	1,093.7	266.4	5.9		8,164.7
1989	1,831.9	8.9	.1	319.1	269.9	.1	6.1	2,436.1
1990	2,082.3	5.6	0	268.1	242.6	.1	2.2	2,600.9
1991	569.9	29.5	0	187.5	110.7	0	3.2	900.8
1992	467.9	3.2	0	307.0	121.2	.1	5.2	904.6
1993	362.3	7.4	0	134.1	108.4	.4	4.2	616.8
Avg.	1,707.0	22.0	57.0	399.0	218.0	.8	4.0 ^b	2,408.0
Avg., 1993 (\$)	2,119.0	27.0	71.0	495.0	270.0	1.0	5.0	2,988.0

^a Ex-vessel value \$1,000 – nominal dollars unless elsewhere indicated.

^b 5-year average.

^c Rounding errors may affect some totals.

Sources: WDFW 1994 and ODFW 1994.

Appendix K

Table 34—Nontreaty Columbia River commercial landings 1980 to present^a

Year	Chinook	Coho	Sockeye	White sturgeon	Shad	Total all species
<i>Thousand of dollars</i>						
1981	1,307.3	512.7	0	449.3	16.7	2,286.0
1982	1,935.1	1,353.9	0	381.2	64.1	3,734.3
1983	843.2	47.1	0	462.4	45.9	1,398.6
1984	1,745.1	1,854.4	37.0	723.7	12.6	4,372.8
1985	1,687.9	1,371.2	128.5	416.4	21.1	3,625.1
1986	2,524.7	6,724.0	7.6	590.8	64.8	9,911.9
1987	8,644.4	2,443.4	164.5	491.2	62.7	11,806.2
1988	13,771.6	5,820.1	111.7	388.6	52.2	20,144.2
1989	2,899.5	2,294.7	0	290.0	28.8	5,513.0
1990	2,197.3	578.3	0	354.2	72.0	3,201.8
1991	1,502.0	2,121.5	0	223.1	27.8	3,874.4
1992	618.6	269.1	0	274.1	71.1	1,232.9
1993	347.1	214.9	0	260.5	64.8	887.3
Avg.	3,078.7	1,969.6	34.6	408.1	46.5	5,537.6
Basin (%)	95.0 ^b	<10 ^c	100.0 ^d	<5 ^e	70.0 ^f	NA
Basin avg. value	2,925.0	197.0	35.0	20.0	33.0	3,210.0
Basin avg. value in 1993 dollars	3,632.0	244.0	42.0	24.0	40.0	3,985.0

NA = not available.

^a Ex-vessel value \$1,000 – nominal dollars unless elsewhere indicated.

^b Based on USDE and others 1994d, appendix O.

^c Author's estimate based on USDE and others 1994b, appendix C-1 table 19.

^d All sockeye in lower basin are from above Bonneville.

^e Author estimate based on PSMFC 1992.

^f Author estimate based on WDFW 1994 and ODFW 1994.

Sources: Derived from WDFW 1994 and ODFW 1994.

Appendix L

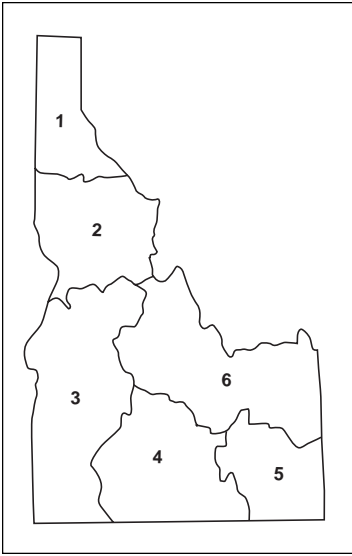


Figure 9a—Wildlife management regions in Idaho. Source: USDI FWS 1989a.

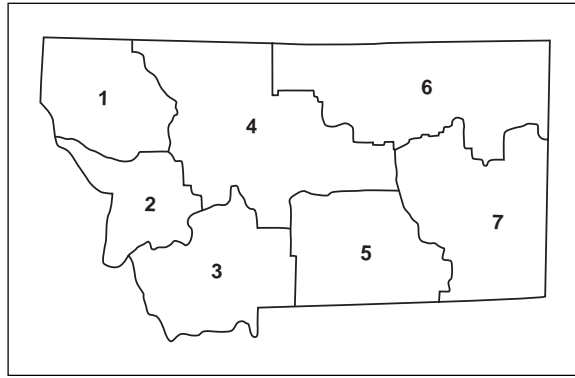


Figure 9b—Wildlife management regions in Montana. Source: USDI FWS 1989b.

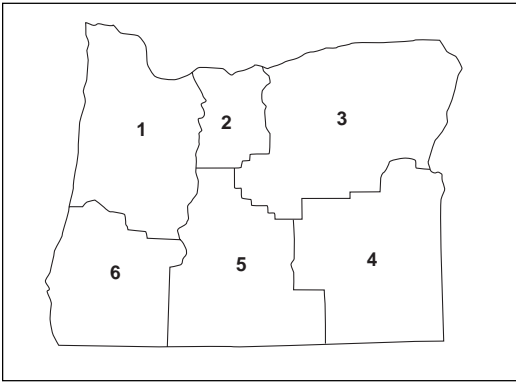


Figure 10a—Wildlife management regions in Oregon. Source: USDI FWS 1989c.

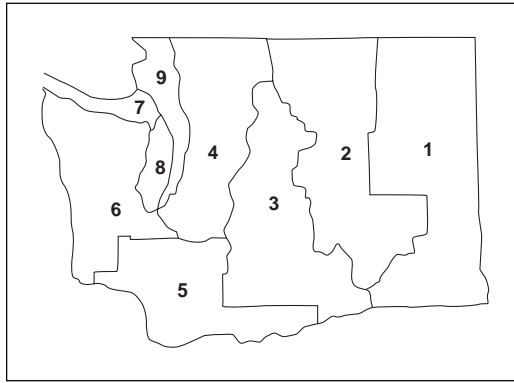


Figure 10b—Wildlife management regions in Washington. Source: USDI FWS 1989d.

Table 35—Freshwater fisheries-associated recreation in the basin, 1991

Parameter	Idaho	Montana	Oregon	Washington	Total no.
Total anglers:	365,000	342,000	605,000	681,000	1,993,000
Resident no.	232,000	164,000	457,000	626,000	1,479,000
Resident (%)	64	48	76	92	74
Nonresident no.	133,000	178,000	147,000	56,000	514,000
Nonresident (%)	36	52	24	8	26
Basin anglers: ^a	365,000	135,774	225,060	397,023	1,122,857
Resident no.	232,000	68,430	178,022	329,926	808,378
Resident (%)	64.0	50.7	79.1	83.1	72
Nonresident no.	133,000	67,344	47,037	67,097	314,478
Nonresident (%)	36	49.6	20.1	16.9	28
Total days fishing:	3,157,000	3,156,000	6,490,000	8,583,000	21,386,000
Resident no.	2,495,000	1,872,000	5,817,000	8,285,000	18,469,000
Resident (%)	79	59	90	97	86
Nonresident no.	662,000	1,284,000	674,000	298,000	2,918,000
Nonresident (%)	21	41	10	3	14
Basin days fishing:	3,157,000	959,424	1,518,660	4,617,654	10,252,738
Resident no.	2,495,000	767,539	1,131,401	4,128,182	8,522,122
Resident (%)	79.0	80.0	74.5	89.4	83.1
Nonresident no.	662,000	191,885	387,259	489,472	1,730,616
Nonresident (%)	21	20.0	25.5	10.6	16.9
Total fishing expenditures (\$1,000) ^b	145,456	71,200	461,297	1,009,309	1,687,262
Total anglers	365,000	342,000	717,000*	995,000*	2,419,000
Basin anglers	365,000	135,774	225,060	397,023	1,122,857
Basin (%) num	100	39.7	31.4	39.9	46.4
Basin fishing expenditures (\$1,000)	145,456	28,266	144,847	404,714	723,283**

* = Total freshwater and saltwater anglers for Oregon and Washington (USDI FWS 1993, table 60); ** = sum of total weightings.

^a Basin values assume the pattern and distribution of activities remains proportional to 1985 data (USDI FWS 1989a, 1989b, 1989c, 1989d, table 23; USDI FWS 1993, table 65).

^b Assigns same value to all types of fishing. Basin values for salmon, freshwater (cold and warm), and resident vs. nonresident not distinguished in original source (USDI FWS 1993, table 68).

Table 36—Freshwater fisheries associated recreation in the basin in Idaho, 1985

Parameter	Total	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
Anglers:	455.0	69.5	44.0	170.6	109.6	80.9	128.1
Resident no.	278.4	28.3	39.3	122.6	63.7	55.7	86.0
Resident (%)	61.2	40.7	89.3	71.9	58.1	68.9	67.1
Nonresident no.	176.7	41.2	(4.7)	48.1	46.0*	25.2	42.1
Nonresident (%)	38.8	71.7	10.7	28.1	41.9	31.1	32.9
Days fishing	6,622.4	1,118.2	439.0	1,927.7	954.6	874.5	1,308.7
Fishing trips	5,617.4	699.6	367.2	1,769.1	842.2	801.6	1,127.9
Resident no.:							
DF	5,104.6	530.7	409.6	1,786.2	629.1	742.6	1,006.7
FT	4,618.8	466.3	346.2	1,659.4	555.5	711.8	879.9
Resident (%):							
DF	77.1	47.5	93.3	92.7	65.9	84.9	76.9
FT	82.2	66.7	94.3	93.8	66.0	88.8	78.0
Nonresident no.:							
DF	1,517.9	587.5	—	141.6*	325.5*	132.0	302.0
FT	998.6	233.4	—	109.8*	286.7*	89.0	258.0
Nonresident (%):							
DF	22.9	52.5	6.7*	7.2*	34.1	15.1	23.1
FT	17.8	33.3	5.7*	6.2*	34.0	11.2	22.0

* = estimate based on small sample size.

— = sample size too small to report data reliably.

Source: USDI FWS 1989a, table 23.

Table 37—Freshwater fisheries associated recreation in the basin in Montana, 1985

Parameter	Total	Region 1	Region 2	Basin	Basin (%)
Anglers:	371.6	99.1	48.4	147.5	39.7
Resident no.	212.4	47.2	27.1	74.3	35.0
Resident (%)	62.5	47.6	56.0	50.4	
Nonresident no.	139.2	51.9	21.3	73.2	
Nonresident (%)	37.5	52.4	44.0	49.6	
Days fishing	4,952.1	1,110.6	393.7	1,504.3	30.4
Fishing trips	3,908.3	893.0	310.7	1,203.7	30.8
Resident no.					
DF	3,602.5	899.7	283.7	1,183.4	32.8
FT	3,146.4	822.1	240.6	1,062.7	29.6
Resident (%):					
DF	72.7	81.0	72.1	80.0	
FT	80.5	92.0	77.4	88.3	
Nonresident no.:					
DF	1,349.7	211.0	110.1	321.1	23.8
FT	762.0	70.9	70.2	141.1	18.5
Nonresident (%):					
DF	27.3	19.0	27.9	20.0	
FT	19.5	8.0	22.6	11.7	

* = estimate based on small sample size.

Source: USDI FWS 1989b, table 23.

Table 38—Freshwater fisheries associated recreation in the basin in Oregon

Parameter	Total	Region 2	Region 3	Region 4	Region 5	Basin	Basin (%)
Anglers:	943.3	72.4	87.9	23.1*	167.2	350.6	37.2
Resident no.	647.5	62.3	58.3	(3.7) ^a	153.1	277.4	35.1
Resident (%)	68.6	86.0	66.3	16.0	91.6	79.1	
Nonresident no.	295.9	(10.1)	29.7	19.4	14.2	73.4	
Nonresident %	31.4	14.0	33.7	84.0	8.4	20.9	
Days fishing	14,091.3	711.1	605.6	113.4*	1,869.8	3,299.9	23.4
Fishing tips	12,031.9	595.4	469.4	90.6*	1,472.6	2,628.0	21.8
Resident no.							
DF	11,675.8	612.0	528.3	28.2	1,290.4	2,458.9	21.1
FT	10,794.2	506.4	425.6	25.7	913.3	1,877.0	17.4
Resident (%):							
DF	82.9	86.0	87.2	24.9	69.0	74.5	
FT	89.7	85.1	90.7	28.4	62.0	71.4	
Nonresident no.:							
DF	2,415.5	(99.1)	77.4*	85.2*	579.5*	841.2*	34.8
FT	1,237.7	(89.0)	43.9*	64.9*	559.4*	757.2*	61.2
Nonresident (%):							
DF	17.1	14.0	12.8	75.1	31.0	25.5	
FT	10.3	14.9	9.3	71.6	38.0	28.6	

* = estimate based on a small sample size.

^a Parentheses mean sample size too small to report data reliably. Numbers shown are subtracted from resident estimates. This was not done in source document.

Source: USDI FWS 1989c, table 23.

Table 39—Freshwater fisheries associated recreation in the basin in Washington, 1985

Parameter	Total	Region 1	Region 2	Region 3	Region 5 ^a	Total basin	Basin (%)
Anglers:	1,306.9	171.5	258.3	91.9	181.2	702.9	53.8
Resident no.	1,025.1	152.6	231.0	91.7	108.8	584.1	57.0
Resident (%)	78.4	89.0	89.4	99.8	60.0	83.1	
Nonresident no.	281.8	19.0	27.4*	.2	72.4	119.0	42.2
Nonresident (%):	21.6	11.0	10.6	.2	40.0	26.9	
Days Fishing	21,133.5	1,997.8	5,093.4	477.3	1,812.4	9,380.0	44.4
Fishing Trips	19,233.5	1,754.9	4,476.1	251.2	1,668.7	9,150.9	42.4
Resident no.:							
DF	19,543.3	1,827.4	4,937.3	477.3	1,590.1	8,832.1	45.2
FT	17,969.1	1,597.9	4,373.9	250.3	1,490.4	7,712.5	42.9
Resident (%):							
DF	92.5	91.5	96.9	100.0	87.7	89.4	
FT	93.4	80.0	97.7	99.6	89.3	84.3	
Nonresident no.:							
DF	1,590.2	170.4	156.1*	—	222.3	548.8	34.5
FT	1,264.5	157.0	102.3*	—	178.3	437.6	55.1
Nonresident (%):							
DF	7.5	8.5	3.1*	—	12.3	10.6	
FT	6.6	20.0	2.3*	—	10.7	15.8	

* = estimate based on small sample size; — = sample size too small to report data reliably.

^a Region 5 includes Columbia River recreational fishing below Bonneville Dam almost to the mouth of the river. Thus, it considerably overstates the amount of recreation occurring in the basin for that region.

Source: USDI FWS 1989d, table 23.

Table 40—Saltwater fishing

Parameter	Oregon	Washington	Total
Anglers:	225,000	504,000	729,000
Resident no.	157,000	430,000	587,000
Resident (%)	70	85	81
Nonresident no.	68,000	73,000	141,000
Nonresident (%)	30	15	19
Days fishing:	1,072,000	3,557,000	4,629,000
Resident no.	894,000	3,303,000	4,197,000
Resident (%)	83	93	91
Nonresident no.	177,000	254,000	431,000
Nonresident (%)	17	7	9

Source: USDI FWS 1993, table 67.

Table 41—Primary nonconsumptive fisheries oriented recreation in the basin, 1991

Parameter	Idaho	Montana	Oregon	Washington	Total no.
Total participants:	382,000	558,000	882,000	1,058,000	2,880,000
Residents	194,000	173,000	479,000	800,000	1,646,000
Residents (%)	51	31	54	76	57
Nonresidents	188,000	384,000	402,000	258,000	1,232,000
Nonresidents (%)	49	69	46	24	43
Basin participants:	382,000	221,526	328,104	569,204	1,500,834
Percent of total	100	39.7	37.2	53.8	52.1
Fish related participation ^a	49,660	28,798	26,248	102,457	207,163
Percentage	13	13	8	18	14
			(1,000 of dollars)		
Total expenditure:	68,017	102,205	362,111	511,218	1,043,551
Trip related	39,563	34,174	119,014	298,941	491,692
Equipment	25,171	63,986	227,909	178,044	495,110
Other	2,283	4,045	8,449	34,232	49,009
Basin expenditure (%)	100	39.7	37.2	53.8	49.7
			(1,000 of dollars)		
Basin NC total	68,017	40,575	134,705	275,035	518,332
Fish related (%)	13*	13	8	18	14.4
			(1,000 of dollars)		
Basin fish related NC expenditures	8,842	5,275	10,776	49,506	74,399

* = estimated; NC = nonconsumptive.

^a Fish-related nonconsumptive recreation is calculated assuming the rate for primary residential (USDI FWS 1989a, 1989b, 1989c, 1989d, table 28) activities in 1985 for each state is representative of primary nonresidential activities. Total attributable to the basin in the state is assumed to be the same proportion as fisheries in the basin in the state.

^b Nonconsumptive expenditure data derived by applying fish related percentage of primary residential activity based on 1985 data (USDI FWS 1989a, 1989b, 1989c, 1989d, table 28) to total expenditure data.

Source: USDI FWS 1993, table 71 and table 73.

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