LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

ANADROMOUS FISH ECONOMIC ANALYSIS

Some of the major dams in the basin.

Foster Wheeler Environmental Corporation
and
U.S. Army Corps of Engineers

October 1999

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prepared by

Hans D. Radtke
Shannon W. Davis
and
Rebecca L. Johnson

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PREFACE

This report is about possible economic consequences related to changes in anadromous fish harvests from alternative hydrosystem actions being considered for the four lower Snake River dams. The report is organized in parts to provide the reader different content levels. Part 1 contains an abstract that presents the most telling of background and analysis results; summary information about anadromous fish production, economic consequences, and the validity of the results; and, references for all report parts. However, Part 1 is brief and contains very little explanation of methodology. Part 2 provides a more thorough description of anadromous fish production and harvest management in the Columbia River Basin and describes the harvest user groups along the U.S. West Coast, Alaska, and British Columbia. The economic analysis results for modeling alternative hydrosystem actions for the four lower Snake River dams are covered in Part 3. Part 4 describes the potential consequences for four cases of anadromous fish production and harvest management policies for the entire Columbia River Basin.

While there is substantial discussion about Columbia River Basin production and economic contribution to fisheries, the report's description should only be considered an overview of the situation. The authors have attempted to describe relevant and important trends and influences on the economic aspects of fisheries. However, it is recommended that references be consulted for any additional information. A bibliography is provided for this purpose.

A more thorough analysis was used to model the economic consequences of the alternative hydrosystem actions for the four lower Snake River. The risk and uncertainty chapter in Part 1 deals with how changes in modeling assumptions and data may affect model results. Several factors that contribute to the analysis model input and results sensitivity are discussed. The explanations of risk and uncertainty are not an exhaustive treatment of data variability and methodological error propagation.

Oversight and monitoring for the analysis of anadromous fish harvest economic consequences was provided by the Drawdown Regional Economic Workgroup (DREW). A subcommittee of DREW, called the A-Fish Subcommittee, met regularly during the conduct of the study and the A-Fish Subcommittee chairman presented interim study results at DREW meetings. The Northwest Power Planning Council's (NPPC) Independent Economic Analysis Board (IEAB) served as technical reviewers for all of the DREW workgroups.

The authors were assisted in the analysis and report development by many other researchers and government representatives. Foremost were the members of the DREW A-Fish Subcommittee and the NPPC IEAB. Biologists and economists from the National Marine Fisheries Service (NMFS) were extremely cooperative in providing data and interpretations. The individuals that have been especially helpful include:

Steve Freese, Economist, NMFS; Chairman, DREW A-Fish Subcommittee
Phil Meyer, Economist, Private Consultant
Mike Matelywich, Fisheries Director, Columbia River Intertribal Fish Commission

Terry Morlan, Economist, NPPC
Elliot Rosenberg, Regional Economist, U.S. Environmental Protection Agency
Matt Dadswell, Economist, Foster Wheeler Environmental Corporation
Tom Cooney, Biologist, NMFS
Lynne Krasnow, Biologist, NMFS
Jack Richards, Economist, NPPC IEAB
Ed Sheets, Private Consultant
Ed Woodruff, Economist, U.S. Army Corps of Engineers

The authors' interpretations and conclusions should prove valuable for study purpose, but no assurances can be given that the described results will be realized. Government legislation and policies, market circumstances, and other situations can affect the basis of assumptions in unpredictable ways and lead to changes in study conclusions. The methodologies used to determine contributions were adopted with the understanding that technically sound and defensible approaches would be used. Where judgment was necessary, conservative interpretation was to be employed. Because this philosophy was strictly adhered to in all aspects of the report, the authors represent that the descriptions presented herein are reasonable estimates.

While reviewers and members of the study advisory subcommittee, as well as the study sponsor's staff and many other contributors, provided comments, the authors take sole responsibility for study results.

Hans D. Radtke
Shannon W. Davis
Rebecca L. Johnson

ABSTRACT

The U.S. Army Corps of Engineers (Corps) is examining the economic, social, and biological effects of alternative hydrosystem actions for operating, changing juvenile fish transportation and passage procedures, or breaching the lower four dams on the Snake River. This study is one element of the examination and covers the economic evaluation from changed harvests of anadromous fish (major salmon and steelhead species only) originating in the Snake River in particular with a more general assessment of anadromous fish harvests and management in the entire Columbia River Basin.

Historically, the Columbia River Basin salmon and steelhead provided a basis for trade and economic expansion. The Northwest Power Planning Council (NPPC) has concluded that an annual fish run size of up to 16 million is the most reasonable estimate of Columbia River Basin historic runs. If these runs were available today, a 50 percent harvest rate could support a $500 million (personal income that includes multiplier effects) fishing industry annually. Western expansion and economic development changed the salmon and steelhead production capability of the Columbia River Basin, as well as harvest patterns. Production of outgoing smolts has become dependent on artificial propagation. Once only a terminal fishery (fish adults harvested inriver), Columbia River Basin produced salmon are now being harvested throughout their migration routes from California to Alaska.

The overall effect of hatchery fish on the survival of certain wild anadromous species has led the National Marine Fisheries Service (NMFS) to place a cap on the total hatchery releases in the Columbia River System. Because hatchery and wild fish cannot always be separated during harvesting, hatchery production and harvest management directly affect wild runs. The low rate of returning wild spawners in recent years has raised concerns about the eventual extinction of wild anadromous fish stocks in the Snake River system. For example, during the early 1990's, every two wild spring chinook salmon spawners from the Snake River system returned about 1.2 spawners. This may be due to a variety of factors: harvesting methods, habitat alterations, hatchery production, hydrosystem operations, ocean conditions.

The possible effects from alternative hydrosystem actions on the Snake River anadromous fish stocks only include the causation factors considered in an external modeling process. Readers are directed to the many publications from the committee based process called Plan for Analyzing and Testing Hypotheses (PATH) for understanding forecasts of harvests and returning spawners related to the hydrosystem actions. The PATH modeled the survival of about 52 percent (recent ten year average) of the Snake River wild spring and summer chinook stocks, all of the wild fall chinook stocks, and none of the summer steelhead stocks to determine the effects of the hydrosystem actions. The PATH also did not model any hatchery origin stocks. It was necessary to expand the PATH results to represent all Snake River stocks as well as perform the economic evaluation. The PATH results are presented as a range of probabilities for exceeding anadromous fish survival and recovery standards. The point estimates selected for the economic evaluation were the median percentile results (referenced as "likely") spring and summer chinook "equal weights" scenario and fall chinook "base case" scenario.

The four hydrosystem actions for improving survival of Snake River anadromous fish stocks are: maintain current operations or base case (Action A1), emphasize transportation of smolts around dams (Action A2), improve the dam’s smolt bypass facilities (Action A3), and restore the natural river in the lower Snake River reach taking eight years to implement (Action A4). These actions, intended to increase wild anadromous fish survival, would also increase the survival of Snake River hatchery originating fish. The economic evaluation not only considered commercial and recreational harvesting of wild and hatchery originating fish, but also sales of hatchery returns for egg, carcass, and food fish sales.

The economic values for changed harvests from the hydrosystem actions are expressed as net economic values. The economic values for anadromous fish harvests from the entire Columbia River Basin are expressed as both net economic values and regional economic impacts. Using Corps accounting stances, the former are National Economic Development (NED) benefits and the latter are Regional Economic Development (RED) benefits.

The anadromous fish forecasts provide a simulation of where, how many, what species, and which user group (commercial, recreational, treaty, hatchery surplus sales) is doing the harvests of stocks that will be affected by the hydrosystem actions. While the forecast of fish harvests is a complete accounting, the summary economic evaluation information presented in this report omits one user group. The economic evaluation of inriver recreational harvest will be provided by analyzing general recreation and tourism.[1]

The changed economic value (NED benefits) measured by annual average equivalent values (AAEV) over a project life of 100 years between base case and other hydrosystem actions using the most current Corps discount rate (6 7/8 percent) ranges between $0.16 million and $1.59 million in 1998 dollars (Table 1). If a zero percent discount rate is used for valuing future generation benefits, then the changed values (NED AAEV benefits) may be as high as $3.49 million for one of the actions. Action A4 has the highest changed values. Table 2 shows the annualized economic value (NED AAEV benefits) range by fisheries. The "high" modeling results are interesting in that Action A1 for some fisheries is greater than other proposed project actions. Not considering the inriver recreational fishery, most of the economic values (NED AAEV benefits) would be generated from the inriver treaty fishery (Table 2) contributed by fall chinook (Figure 1).

The economic evaluation also describes what may be at risk if major changes or curtailment takes place in all anadromous fish production and harvest management in the entire Columbia River Basin. Four policy cases were taken into consideration, ranging from the present continued very low run levels through runs that would be double those experienced in the 1980's. The regional economic impacts (RED benefits) from averaging the contribution from fisheries to economies wherever harvests occur in the 1980’s is $108 million (personal income, 1998 dollars) per year (Table 3). The early 1990’s average dropped to $38 million per year.

1. The methods used to provide for the economic evaluation of this user group and fishery are different from those used to evaluate the other anadromous fish fisheries and may not be directly comparable.

Table 1
Changed Annualized Economic Value (NED Benefits) Between Base Case and Other Hydrosystem Actions for Various Discount Rates

Hydrosystem Actions	0% Amount	0% Order	4 6/8% Amount	4 6/8% Order	6 7/8% Amount	6 7/8% Order
Annual Average Equivalent Value (Year 0 to Year 100)						
A2 less A1	$0.20	2	$0.18	2	$0.16	3
A3 less A1	$0.19	3	$0.17	3	$0.16	2
A4 less A1	$3.49	1	$2.06	1	$1.59	1

Notes: 1. NED benefits measured by annual average equivalent values over a 100 year project life in millions of 1998 dollars.
2. Evaluation is for all modeled anadromous fish species and includes harvests and hatchery surplus utilization. The evaluation excludes the economic values for inriver recreational fishing.
3. The analysis is based on PATH results' "base case" scenario for fall chinook and "equal weights" scenario for spring/summer chinook using "likely" (50th percentile) modeling output.
4. See text for explanation of hydrosystem action descriptions.

Source: Study.

If it is possible to attain the NPPC's goal for doubling the runs experienced in the 1980's, then the regional economic impacts (RED benefits) may be as high as $233 million per year. The economic loss to the nation in lost economic value (NED benefits) would be as high as $160 million per year for the doubling the runs policy. Projecting over 100 years from what is at stake for anadromous fish production in the Columbia River Basin, the net-present-value at the current social discount rate used by the Corps may be as high as $2.0 billion (NED benefits). Another way of considering these policy cases' effects, is that it would be the value for eliminating most hatchery programs and thereby most harvesting of salmon and steelhead originating in the Columbia River Basin. The burden of these reductions would be felt all along the U.S. West Coast, Alaska, British Columbia and inland throughout the Columbia River Basin.

Columbia River Basin anadromous fish production has shifted from upper river wild origin stocks (upper river wild origin was estimated to be 77 percent of runs during pre-development time periods) to lower river hatchery origin stocks (upper river wild and hatchery origin is estimated to be 42 percent of runs in the 1980's). Production has changed from mostly wild spring and summer chinook (fall chinook estimated to be 14 percent pre-development run size) to hatchery fall chinook (hatchery origin fall chinook estimated to be 34 percent of 1980's hatchery and wild run size) and coho. The production by watersheds and stocks and the geographic areas receiving benefits from production are shown in Figure 2. The Columbia River inland region only receives about 46 percent of the regional economic impacts (RED benefits) from Columbia River Basin production. Because fall chinook and coho have large ocean fisheries, the effect of shifting production to the lower river stocks has resulted in a

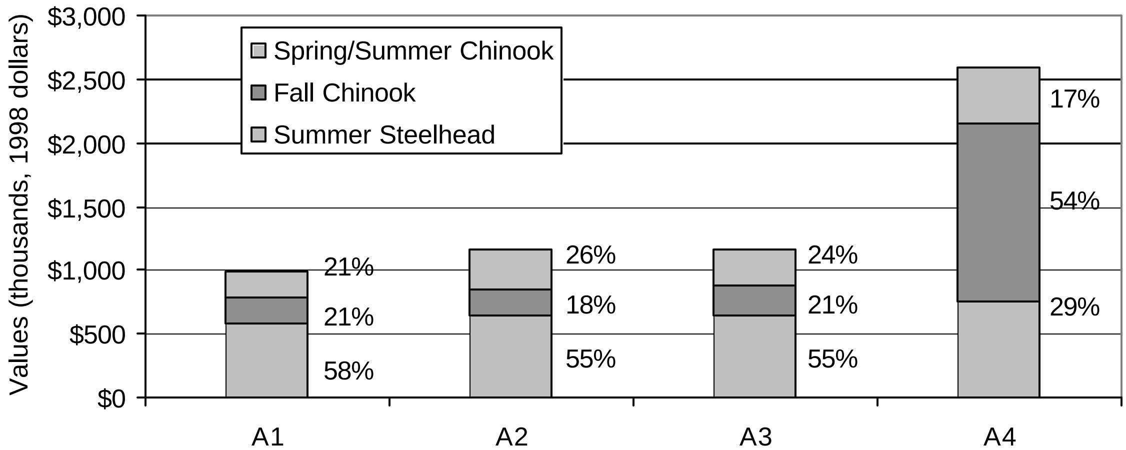
Table 2
Ranges of Annualized Economic Value (NED Benefits) by Fishery For Each
Hydrosystem Action Using "Low", "Likely", and "High" Modeling Results

Anadromous Fish	A1 Low	A1 Likely	A1 High	A2 Low	A2 Likely	A2 High	A3 Low	A3 Likely	A3 High	A4 Low	A4 Likely	A4 High
Commercial												
Ocean												
Alaska	$6.15	$12.72	$26.35	$6.15	$12.72	$26.35	$6.85	$14.56	$30.54	$31.99	$69.48	$136.12
British Columbia	$25.93	$53.66	$111.09	$25.93	$53.66	$111.09	$28.90	$61.41	$128.77	$134.89	$292.97	$573.99
WA Ocean	$7.02	$14.53	$30.08	$7.02	$14.53	$30.08	$7.83	$16.63	$34.87	$36.53	$79.34	$155.44
WA Puget Sound	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.01
Oregon	$2.14	$4.43	$9.17	$2.14	$4.43	$9.17	$2.39	$5.07	$10.63	$11.13	$24.18	$47.38
California	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.02
Subtotal Ocean	$41.24	$85.34	$176.70	$41.24	$85.34	$176.70	$45.97	$97.68	$204.82	$214.55	$465.99	$912.95
Inriver												
Non-treaty	$21.50	$45.76	$96.49	$23.09	$51.36	$110.14	$24.26	$52.75	$113.84	$120.47	$223.36	$409.35
Treaty Indian	$293.52	$702.77	$2,003.61	$323.81	$795.22	$2,062.65	$323.18	$789.90	$1,992.09	$564.64	$1,287.11	$2,771.28
Hatchery Returns	$8.77	$137.06	$522.24	$28.98	$198.78	$613.34	$25.47	$188.48	$567.35	$206.31	$480.92	$990.32
Subtotal Inriver	$323.79	$885.59	$2,622.34	$375.88	$1,045.36	$2,786.14	$372.92	$1,031.12	$2,673.27	$891.43	$1,991.39	$4,170.95
Subtotal Commercial	$365.02	$970.93	$2,799.04	$417.12	$1,130.70	$2,962.84	$418.89	$1,128.80	$2,878.09	$1,105.97	$2,457.38	$5,083.90
Recreational												
Ocean												
Alaska	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
British Columbia	$3.11	$6.44	$13.32	$3.11	$6.44	$13.32	$3.47	$7.37	$15.44	$16.18	$35.14	$68.84
WA Ocean	$6.78	$14.03	$29.04	$6.78	$14.03	$29.04	$7.55	$16.05	$33.66	$35.26	$76.58	$150.04
WA Puget Sound	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
Oregon	$1.70	$3.51	$7.26	$1.70	$3.51	$7.26	$1.89	$4.02	$8.42	$8.82	$19.15	$37.53
California	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
Subtotal Ocean	$11.59	$23.98	$49.65	$11.59	$23.98	$49.65	$12.92	$27.44	$57.55	$60.28	$130.93	$256.51
Total Commercial and Recreational	$376.61	$994.91	$2,848.68	$428.70	$1,154.68	$3,012.48	$431.81	$1,156.25	$2,935.64	$1,166.25	$2,588.31	$5,340.41

Notes:
1. NED benefits measured by annual average equivalent values over a 100 year project life using 6 7/8% discount rate in thousands of 1998 dollars.
2. Evaluation is for all modeled anadromous fish species and includes harvests and hatchery surplus utilization. The evaluation excludes the economic values for inriver recreational fishing.
3. PATH results fall chinook Action A1 is the same as Action A2. Fall chinook is the only significantly harvested species in ocean fisheries.
4. "Low", "likely," and "high" modeling results correspond to PATH results for 25th, 50th, 75th percentile modeling outputs, respectively.
5. The analysis is based on PATH results' "base case" scenario for fall chinook and "equal weights" scenario for spring/summer chinook.
6. Total and subtotals may not equal sum of values due to rounding.

Source: Study.

Figure 1
Annualized Economic Values (NED Benefits) by Anadromous Fish Species for Each Project Action



Notes:
1. NED benefits measured by annual average equivalent values over a 100 year project life using 6 7/8% discount rate in thousands of 1998 dollars.
2. Evaluation is for all modeled anadromous fish species and includes harvests and hatchery surplus utilization. The evaluation excludes the economic values for inriver recreational fishing.
3. PATH results fall chinook Action A1 is the same as Action A2. Fall chinook is the only significantly harvested species in ocean fisheries.
4. The analysis is based on PATH results' "base case" scenario for fall chinook and "equal weights" scenario for spring/summer chinook using "likely" (50th percentile) modeling output.

Source: Study.

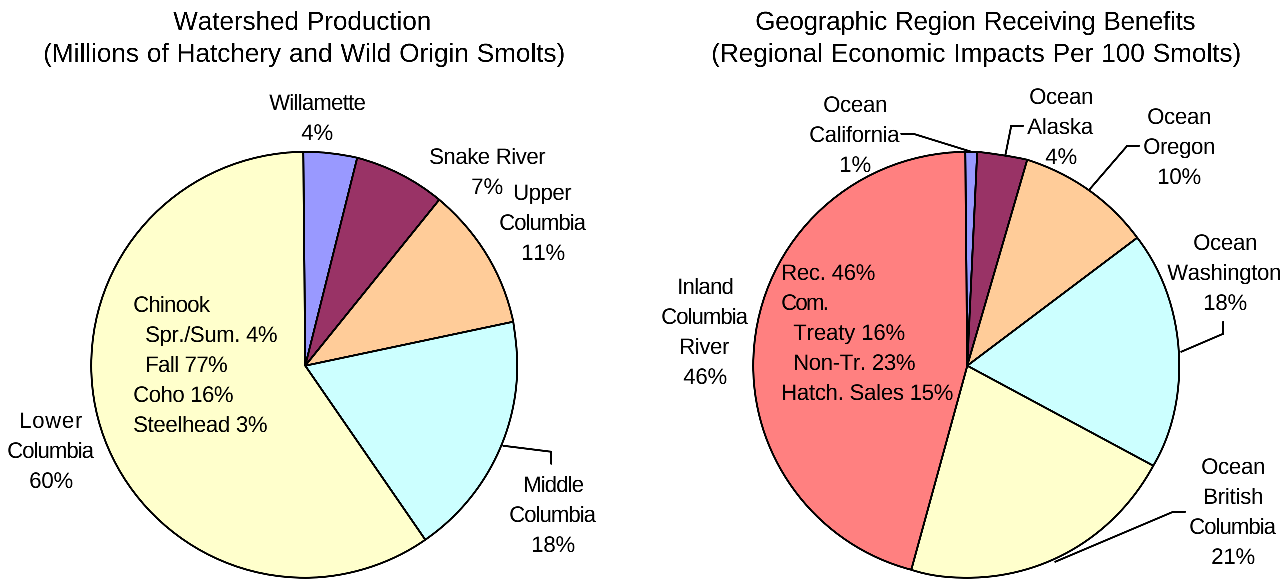
Table 3
Potential Economic Values (RED and NED Benefits) Per Year For Four Cases of Columbia River Basin Anadromous Fish Production and Harvest Management Policies

Policy		RED Benefits			NED
Case	Assumptions	Commercial	Recreational	Total	Benefits
I	Hatchery production at NMFS cap; SAR and harvests 30 yr historical average	$49.43	$33.36	$82.79	$55.33
II	Hatchery production, SAR, harvests at 1980's historical average	$60.45	$47.08	$107.53	$74.04
III	Policy for "doubling the runs;" SAR adjusted to meet policy using NMFS cap hatchery production	$131.69	$101.58	$233.27	$159.92
IV	Hatchery production, SAR, harvests early 1990's historical average	$24.04	$13.59	$37.63	$24.59

Notes:
1. RED and NED benefits measured per year in millions of 1998 dollars.
2. SAR is smolt-to-adult survival rate. Adults are harvests and returns to hatcheries for hatchery origin anadromous fish. Adults are harvests and spawners plus prespawning mortality for wild origin anadromous fish.
3. Commercial includes ocean treaty and non-treaty harvests from California to Alaska, inriver treaty, inriver non-treaty harvests, and hatchery surplus sales. Recreational includes ocean, inriver mainstem, and inriver tributary.
4. Total and subtotals may not equal sum of values due to rounding.

Source: Study.

Figure 2
Shares of Columbia River Basin Anadromous Fish Production and Geographic Regions Receiving Regional Economic Impacts (RED Benefits) From the Production



Notes: 1. Wild and hatchery origin smolt production is representative of the 1980's.
2. The regional economic impacts for the inland Columbia River region include inriver treaty and non-treaty commercial fisheries, inriver recreational fisheries, and hatchery return sales.

Source: NMFS (1995) and Study.

larger share of economic value from anadromous fish being exported out of the Columbia River inland region.

The economic valuation estimates are very sensitive to assumptions of survival rates and harvest management regimes. Future harvest management for higher smolt-to-adult survival rates may allow higher harvests, thereby increasing the overall economic values generated by anadromous fish produced in the Columbia River Basin. However, changing management regimes that moves recreational harvest shares to especially inriver commercial user groups decreases gains in economic value. The anadromous fish forecasting analysis resulted in a large share of summer steelhead destined to the Snake River watershed escaping fisheries and returning to hatcheries as surplus. The default use of this surplus is for food fish, egg, and carcass sales. There may be fishery management opportunities to convert these sales to harvests.

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PART 4. POTENTIAL ECONOMIC VALUES FOR FOUR CASES OF COLUMBIA RIVER BASIN ANADROMOUS FISH PRODUCTION AND HARVEST MANAGEMENT POLICIES

PART 1

EXECUTIVE SUMMARY AND REFERENCES

CHAPTER I. INTRODUCTION

A. Study Purpose

The U.S. Army Corps of Engineers (Corps) has initiated a study to examine the engineering, economic, social, and biological effects of alternative hydrosystem actions for operating the four Corps dams on the lower Snake River for improved salmon migration. The four dams are Lower Granite, Little Goose, Lower Monumental, and Ice Harbor located in southeast corner of the State of Washington. The alternatives being considered are:

- Maintain the existing system of juvenile fish bypass systems, juvenile fish transportation, spill for fish at the dams, and release of water from storage dams to augment river flows and aid juvenile fish migration. This includes improvements such as extended length guidance screens in the juvenile fish bypass systems to guide a greater percentage of fish away from turbine intakes and into the bypass system. This hydrosystem action is referred to as base case or Action A1.

- Construct major improvements to the dams and maximize the juvenile fish transportation system. One improvement possibility is surface-oriented juvenile fish bypass systems to provide a potentially more efficient and less stressful means for diverting juvenile fish before they dive down toward the turbine intake area. Other possible major system improvements are turbine modifications to reduce injury to fish that go through the turbines; gas abatement measures to allow more spill with less gas supersaturation; and fish guidance improvements. The hydrosystem action for maximizing juvenile fish transportation without the surface-oriented bypass system is referred to as Action A2. Including surface-oriented improvements is Action A3.

- Draw down, or breach, the four lower Snake River dams to return to natural river level. This would entail removing the earthen portion at each of the dams to create a channel around the dams and provide a 140 mile free flowing stretch of river. Power production at the dams would cease, and there would be no commercial navigation on the lower Snake River. It is assumed the breaching alternative would take eight years to implement. The breaching alternative is referred to as Action A4.

The purpose of this report is only to provide information about the economic effects from the alternative hydrosystem actions. Other economic, social, and biological effects being provided by other researchers are referenced as needed. The report describes the economic evaluation (expressed as net economic values, or the National Economic Development (NED) accounting stance used by the Corps) from changes to harvests of anadromous fish originating in the Snake River Basin due to alternative hydrosystem actions. This report also discusses the economic values (expressed as both regional economic impacts, or the Regional Economic Development (RED) accounting stance used by the Corps, and net economic values from harvesting anadromous fish produced in the entire Columbia River Basin.

B. Study Approach

The study included the development of models to forecast fish harvests and to relate harvest activity to economic values. The committee based process called Plan for Analyzing and Testing Hypotheses (PATH) provided estimates of some Snake River wild salmon stock harvests resulting from the alternative hydrosystem actions. It was necessary to expand fish run size, harvest (both ocean and inriver), and spawner count information provided by PATH to represent all major salmon and steelhead stocks. This report describes the methods and results for the expansion as well as the economic evaluation.

The economic evaluation of harvesting is modeled quite differently for commercial and recreational fisheries. It was necessary to compile commercial fishing economic data about ex-vessel values (price paid to harvesters for their catch), primary processing prices, recovery rates, and costs of harvesting and processing for different species, gear, geographic areas, and user groups. Anadromous fish from the Snake River are commercially harvested by different means (troll - hand and power; net - gillnet, purse seine, and dip net) in different ocean areas (southeast Alaska, Canada, Washington, Oregon, and Northern California), Columbia River estuary, main stem of the Columbia River, as well as its main tributaries. Primary seafood processing is included in order to evaluate the contribution at different stages of processing. For example, troll salmon are usually dressed and sold directly to processors. Net fish are usually sold to a fish buyer in the round. A tender, for a margin of 10 to 18 cents per pound, gathers the salmon and delivers them to the processors. Hatchery fish that escape harvesting return as hatchery surpluses. The surpluses are sold for eggs, carcasses, and sometimes food fish. The funds are usually returned to hatcheries for offsetting operating and capital improvement costs. A portion of these costs are expenditures made in local economies. Available information on recreational fishing (success rates, trip expenditure patterns by trip mode, such as guided trips, etc.) associated with lower Snake River anadromous fish runs was also compiled and synthesized. The direct costs of commercial and recreational fishing and hatchery surplus sales were then related to economic values for regional economies or the national economy.

Study results are presented in terms of "regional economic impacts" and "net economic value." and, while the same basic information on costs and expenditures is used to derive these estimates, it is emphasized that these estimates are quite different measures. Regional economic impacts are derived from the economic activity (direct, indirect, and induced) generated in local areas. It is important because it is an indication of household personal income and jobs gained or lost. Regional economic impacts are expressed as personal income, employment, and business sales. Net economic value usually defines the value that someone, some group, or the nation may receive resulting from an activity, over and above the cost of that activity. Both economic value and regional economic impacts are calculated over a 100 year project life. Annualized future values are discounted to Year 0 using various interest rates. The current Corps rate is 6 7/8 percent, while the current Bonneville Power Administration rate is 4 6/8 percent. Indian tribes generally do not discount future generation benefits, i.e. they use a zero percent interest rate. Values are annualized using the Corps definition for annual average equivalent values. All values are in 1998 dollars.

The anadromous fish forecasts provide a simulation of where, how many, what species, and which user group (commercial, recreational, treaty, hatchery surplus sales) is doing the harvests of stocks that will be affected by the hydrosystem actions. While the forecast of fish harvests is a complete accounting, the summary economic evaluation information about Snake River hydrosystem actions presented in this report omits one user group. The economic evaluation of inriver recreational harvest will be provided by analyzing general recreation and tourism. The methods used to provide for the economic evaluation of this user group and fishery are different from those used to evaluate the other anadromous fish recreational fisheries. To give a more complete depiction of the sensitivity associated with data and modeling assumptions, the inriver recreational user group is included in the risk and uncertainty analysis. The assessment of economic values from production in the entire Columbia River Basin always includes this user group.

The economic analysis for the alternative hydrosystem actions evaluates all major anadromous fish stocks originating in the Snake River Basin. The major anadromous fish stocks are defined to be spring/summer and fall chinook salmon *(Oncorhynchus tshawytscha)* and summer steelhead *(O. mykiss)*. Other anadromous fish, such as shad *(Alosa sapidissima)*, sturgeon *(Acipenser transmontanus and A. medirostris)*, coho salmon *(O. kisutch)*, sockeye salmon *(O. nerka)*, etc., would not have fisheries significantly changed by the hydrosystem actions. All utilization of both wild and hatchery originating stocks was considered. This includes commercial and recreational harvests, as well as sales of hatchery egg, carcass, and surplus fish. The economic analysis for the entire Columbia River Basin adds coho salmon and winter steelhead to the Snake River list of major anadromous fish stocks.

C. Report Outline

This report is organized in four parts for the convenience of the reader. The location of economic value measurements in the report contents is shown in Table 1.I.1.

Part 1 contains an abstract, the executive summary, the risks and uncertainties in results for changing analysis assumptions, and references cited in all parts. The study purpose, approach, and report outline is given in Chapter I, Part 1. The changing patterns of the Columbia River Basin salmon and steelhead production and harvesting are discussed in Chapter II, Part 1. Salmon and steelhead are migratory and know no jurisdictional bounds. Their migration routes carry them from far inland in the Columbia River Basin to as far as Alaska and south to California. Historic and international agreements on their harvests have been reached and are continually negotiated. A brief overview of these agreements is provided in Chapter III, Part 1. A discussion of fisheries economic evaluation methods used in this study is presented in Chapter IV, Part 1. Salmon and steelhead typically reproduce in fresh water and spend a greater part of their adult life in the ocean. In their migratory route, they are exposed to a variety of predators. Survival rates from production to harvest are an important component of

Table 1.I.1
Location of Economic Value Measurements in Report Contents

	Report Contents				
Economic Value Measurement	Abstract	Part 1 (Summary)	Part 2 (Columbia River Basin Production)	Part 3 (Hydrosystem Actions' Economic Values)	Part 4 (Columbia River Basin's Economic Values)
1. Net Economic Value (NED Benefits)					
a. Snake River Hydrosystem Actions	3	3		3	
b. Columbia River Policy Cases	3	3			3
c. Historical Trends					
2. Regional Economic Impacts (RED Benefits)					
a. Snake River Hydrosystem Actions				3	
b. Columbia River Policy Cases	3	3			3
c. Historical Trends			3		
3. Inriver Recreational					
a. Snake River Hydrosystem Actions				3	
b. Columbia River Policy Cases	3	3			3
c. Historical Trends			3		
4. Risk and Uncertainty					
a. Snake River Hydrosystem Actions	3	3		3	
b. Columbia River Policy Cases		3			
c. Historical Trends			3		

Notes: 1. Inriver recreational economic values for Snake River hydrosystem actions will be provided by analyzing general recreation and tourism. However, to give a more complete evaluation of the effect of the hydrosystem actions, this fishery's economic values are included in the risk and uncertainty chapter and in Part 3. The methods used to analyze this fishery are different than the analysis of general recreation and tourism and results may not be comparable.

2. The risk and uncertainty chapter discusses sensitivities for modeling assumptions using different PATH result scenarios, and explains unresolved modeling issues. The high-low range of harvest forecasts for Snake River hydrosystem actions is discussed in Part 3.

Source: Study.

how many adult fish will be available for harvest. Survival rates and contribution to fisheries are discussed in Chapter V, Part 1 to provide a basis for the economic evaluations. Commercial and recreational fishing for Columbia River Basin anadromous fish stocks generates a significant amount of personal income and has national benefits. These economic value estimates for changed harvests due to alternative lower Snake River dams hydrosystem actions are presented in Chapter VI, Part 1. Chapter VII, Part 1 contains the potential economic values for four cases of Columbia River Basin anadromous fish production and harvest management policies. A discussion of the risk uncertainties in modeling outcomes due to the data and modeling assumptions is included as Chapter VIII, Part 1.

Part 2 contains background information about historical anadromous fish runs and harvests. The information should prove especially helpful in understanding the complexity of Columbia River anadromous fish harvest management.

Economic values are calculated for the expected change in harvestable anadromous fish runs from the alternative hydrosystem actions. These economic values are included in Part 3 of this report.

This report also describes the potential economic value to the Pacific Northwest region and to the nation that may result from four cases of anadromous fish production and harvest management policy. The broader overview of what net economic value and contributions to regional personal income and jobs may result from the four cases is presented in Part 4. Part 4 descriptions may be viewed as what is at risk if the Columbia River Basin anadromous fish survival rates, and therefore harvestable fish runs, are not improved.

CHAPTER II. CHANGING PATTERN OF ANADROMOUS FISH PRODUCTION

A. Columbia River Basin

To the Indians living along the Columbia River, salmon were their lifeblood, essential to their subsistence, their culture, and their religion. A focal point of this great salmon fishery for many centuries was Wy-am, one of the longest continuously occupied sites on the North American continent. Located near Celilo Falls on the Columbia River, the Wy-am area, before the Dalles Dam in 1957, was a commercial center during the fishing season. In autumn, as many as 5,000 people would gather to trade, feast, and participate in games and religious ceremonies.

The history of Columbia River salmon harvest has been one of transition from spears and dip nets, to seine and gillnets, to diesel engines and ocean trolling poles. Historically, harvesters waited until salmon returned to the Columbia River. Today, salmon produced in the Columbia River system are harvested from California to Alaska by trolling gear and by nets set to harvest other species of salmon.

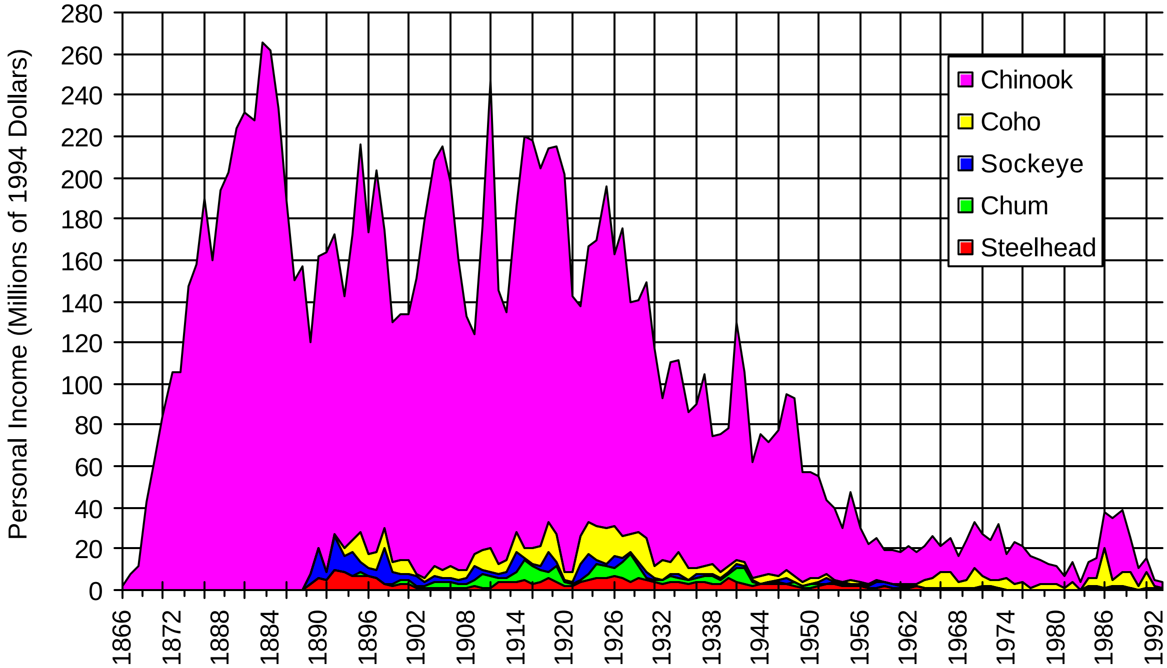
Salmon played a key role in developing the West by European settlers. As early as 1828, various trading companies were purchasing and exporting salmon caught by the Indians on the Columbia River. The first commercial use of fishery products in Oregon was the packing of salmon. Development of the canning process in the mid 1800's created a huge demand for salmon. The total harvested pounds of salmon and steelhead in the early 1890's ranged from 21 million pounds to 33 millions pounds. During the late 1880's and early 1920's, the salmon gillnet fishery in the Columbia River pumped a substantial amount of income into communities on the lower Columbia River, such as Astoria. At today's prices, these runs contributed as much as $260 regional economic impacts (RED benefits) into the lower Columbia communities per year (Figure 1.II.1).

When salmon became scarcer and gas powered engines allowed fishermen to venture out farther into the ocean, trolling for salmon became an attractive alternative. As ocean fisheries developed, a majority of the fish produced in the Columbia River Basin were harvested in marine waters from California to Alaska. The effect of economic development, hatchery production, and mixed stock, open access fisheries has been to reduce the total, and change the species and stock composition, of returning salmon to the Columbia River.

In more recent times, the Columbia River Basin produced around 20 million pounds until the late 1940's. Since then, the total poundage harvested commercially generally declined to the very low level in 1993, when a total of just over one million pounds of salmon was harvested in the Columbia River (Radtke and Davis, August 1994). As fish numbers have declined, so have the revenues received by fishermen.

Artificial salmon propagation in the Columbia River Basin was initiated in the late 1800's when managers realized that "...the increased demand for fish and the growing scarcity of the same will call for more aid toward artificial propagation in order to keep up the supply." (Cone

Figure 1.II.1
Historical Columbia River Estimated Regional Economic Impacts (RED Benefits)



Sources: Landing data are from NPPC (1986), fish size and ex-vessel price are from ODFW (1995), and regional economic impacts (RED benefits) per pound in 1994 U.S. dollars are from Radtke (May 1997).

1995, p.114). Most of the early hatcheries were built for enhancement of returning salmon numbers. As the waters of the Columbia River were used to develop the Pacific Northwest, artificial propagation was used to mitigate for the detrimental effects of dam construction and water withdrawal projects.

The Pacific Salmon Treaty (PST) between the United States and Canada emphasized increased artificial propagation in order to satisfy allocation demands for salmon. In the late 1980's, under the NPPC's goal of "doubling the salmon runs," the emphasis for operating the Columbia River power system was also on increasing hatchery production.

Two major factors took place since the 1980's that may be changing the optimistic emphasis on artificial propagation. One is the Endangered Species Act (ESA), and the other is the changing survival rates of salmon in the ocean environment. The concern about certain wild salmon and steelhead stocks and the overall effect of hatchery fish on the survival of these stocks has led to the National Marine Fisheries Service (NMFS) placing a "ceiling" or "cap" on total hatchery releases in the Columbia River system.

The NMFS cap for smolt production from the Columbia River Basin is 197 million. The cap is to protect the salmon runs that have been declared threatened or endangered. The cap in effect requires reduction in smolt production and limits future growth of hatchery releases to those that have been identified as supplemental to wild production. The supplementation policy relies on increased species specific programs that utilize stocks that clearly represent wild stocks. Also present in this policy are habitat based policies that aim to increase overall productivity of anadromous runs.

Estimates of pre-development salmon run size depend on historical catch records and in some cases historic habitat availability. The Northwest Power Planning Council (NPPC), in order to assess the salmon and steelhead loses attributable to hydropower development and operations, developed estimates of "pre-development" run sizes (NPPC 1986, p.1). They concluded that up to 16 million fish run size is probably the most reasonable estimate of Columbia River historic salmon and steelhead runs (NPPC 1986, pp.14-17). At recent prices, the commercial ex-vessel value of the pre-development salmon and steelhead runs, at a 50 percent exploitation rate, would be about $272 million for the Columbia River Basin. The runs in today's economy could generate about $500 million in regional economic impacts (RED benefits) for harvesters, processors, and supporting industries.

B. Snake River Watershed

The four lower Snake River dams were planned in the 1950's for economic development reasons. The planning evaluation in 1951 pointed to "technical difficulties involved in maintaining that large portion of the Columbia salmon resources produced in the Snake River if Ice Harbor and the other three lower Snake River dams are constructed at the present time." (McKernon 1951). The evaluation estimated that about 135,000 fall and spring chinook salmon spawn in the Snake River and its tributaries each year, 2,000 silver [coho] salmon, and 65,000 steelhead trout. From these, some 200,000 adults, approximately 12 million pounds, are landed annually. "Between one half and one billion salmon and steelhead eggs are deposited in the Snake River drainage each year. Our problem would be a hatchery or hatcheries capable of spawning, hatching, and rearing this colossal number of fingerlings. . . Further, the races involved are among the most difficult to rear in a hatchery." (McKernon 1951).

The four dams were built and problems have developed in maintaining wild origin anadromous fish production. In the most recent five year average (1991 to 1995), the escapement past the upper most of the four dams (Lower Granite Dam) was about 16,000 fall and spring chinook (40 percent wild origin), 83,000 summer steelhead (15 percent wild origin), and coho salmon are now extinct. This escapement contributed to about 62,000 adult harvests. In recent years, for every two natural spawners, about 1.2 spawners return in subsequent cycles (Smith 1998). The low returning natural spawners have raised concerns about maintaining any natural anadromous fish stocks in the Snake River.

CHAPTER III. SALMON MANAGEMENT ON THE U.S. WEST COAST

A. International Understandings and Agreements

There are a host of salmon treaties and agreements that affect salmon of the Columbia River system. These can be categorized as *international understandings*, such as the 1992 International North Pacific Fisheries Commission Convention (Shepard and Argue, February 1998), the United Nations Convention on the Law of the Sea which entered into force in November 1994, the PST between the United States and Canada, *harvest management agreement processes* such as the Pacific Fishery Management Council (PFMC), *agreements to rebuild the stocks* such as the Northwest Power Planning Act, *court decisions* that have defined the obligations to Northwest Indian Tribes, and most recently *federal mandates to protect salmon* stocks under the ESA. The forecast of future anadromous fish run sizes produced from the Snake River and the entire Columbia River system used in this study has taken into consideration the international understandings for assumptions about salmon production, allocation agreements, and protection of natural runs.[1]

B. U.S. Endangered Species Act

The purpose of the ESA is to provide a means whereby the ecosystems upon which endangered species and threatened species depend, may be conserved to provide a program for the conservation of such species, and to take steps as may appropriate to achieve the purposes of various international treaties and conventions. The ESA is a process for listing, protection and recovery of certain species, subspecies, and distinct populations. Alaska and West Coast salmon fisheries impact the following Columbia River anadromous fish species that are currently (as of September 1999) listed under the ESA:

<u>Chinook</u>
Snake River spring/summer (threatened);
Snake River fall (threatened);
Lower Columbia River (threatened);
Upper Willamette River (threatened);
Upper Columbia River (threatened);

<u>Coho</u>
Lower Columbia River/Southwest Washington (candidate);

<u>Chum</u>
Columbia River (threatened);

---

1. The PST was being renegotiated during the study, so applicable provisions of the new agreement were not included in modeling assumptions.

Sockeye
Snake River (endangered);

Steelhead
Upper Columbia River (endangered);
Lower Columbia River (threatened);
Snake River Basin (threatened);
Upper Willamette River (threatened); and
Middle Columbia River (threatened).

In addition to the Columbia River stocks, several other Oregon and Washington coast and Puget Sound chinook and coho salmon and steelhead species are listed. Guidance for the management of all listed stocks will affect future harvest management of Columbia River anadromous fish fisheries. NMFS issues biological opinions for listed stocks that require fisheries management practices to meet objectives to avoid jeopardizing the recovery of the listed stocks. The PFMC and the North Pacific Fishery Management Council (NPFMC), through the State of Alaska, develop management plans to achieve the stock recovery plans. Similarly the Columbia River fisheries are under a court order to have the Columbia River Fish Management Plan (CRFMP) consistent with stock recovery plans.

The NMFS 1995 Federal Columbia River Power System (FCRPS) Biological Opinion (NMFS 1995) concluded that major changes were needed to significantly increase salmon survival. NMFS called for a detailed evaluation of alternative configurations and operations of the four federal hydroelectric projects on the lower Snake River. The purpose of the evaluation was to determine the likelihood that drawdown of these four dams, or some other alternative such as expansion of the juvenile fish transportation program, would result in the survival and recovery of Snake River salmon and steelhead. The Corps initiated the evaluation with the Lower Snake River Juvenile Salmonid Migration Feasibility Study. The Corps in-turn requested that the NMFS summarize available information on the potential effects of the hydrosystem actions on anadromous salmon and steelhead runs originating within the Snake River system. The NMFS evaluated the adequacy of PATH results to show the potential effects. Because the effect of any hydrosystem action would be embedded in the broader relationship between fish and their environment, hydrosystem actions also were evaluated by NMFS (1999) in the context of factors that might occur outside the direct control of the hydrosystem (such as hatcheries output and changes in habitat, harvest, and ocean conditions). The NMFS (1999) conclusions pertaining to the adequacy of PATH results have been incorporated into this study.

CHAPTER IV. METHODS FOR THE ECONOMIC EVALUATION AND ANADROMOUS FISH HARVEST FORECAST

A. Economic Evaluation Methods

This study's overall goal is to calculate the economic values from harvesting those Columbia and Snake River anadromous fish stocks that are assisted by removal or change in the operation of four dams on the lower Snake River. While this study specifically analyzes the economic effects of changes in wild and hatchery originating Snake River stocks, it is possible that production and harvest management policies may affect other anadromous fish runs in the Columbia River Basin. The economic values for anadromous fish harvest from the entire Columbia River Basin are presented as well.

The two basic economic terms used in this report are "regional economic impact" and "net economic values." Regional economic impact includes direct, indirect, and induced effects. This is a measure of how many jobs are effected by fishing and how much many is spent by fishing. The fishing costs, or expenditures, are the source of household income associated with use of the fish. These are commonly called the RED's (Regional Economic Development benefits) for a Corps accounting stance. Net economic values includes the economic value above costs and is a measure of the national benefits received by those that fish. This is commonly called the NED's (National Economic Development benefits) for a Corps accounting stance.

Regional economic impacts and net economic values are two distinct measures, and each is useful for different purposes. Regional economic impacts are important in assessing the distributional impacts of the different allocation possibilities. Net economic values are important if the goal is to allocate society's resources efficiently. It may often be the case that society will want to invest in a less valuable resource because the local area or economy that holds that resource is in need of economic development. Nevertheless, having the information on net economic value will tell society how much they are giving up in order to achieve the redistribution of economic activity or development.

Another way of measuring the special appreciation of anadromous fish is called existence value. This measure is provided by analyzing general recreation and tourism and is not included in this report. It is important that the reader distinguish between the two different types of economic valuation measures (regional economic impacts and net economic values) that are described in this report. They should not be mixed or compared to each other.

The regional economic impacts are based on input/output (I/O) models that translate direct fishing expenditures and hatchery costs into total personal income. The I/O models have been constructed for the Pacific Northwest states and Alaska with the use of the IMPLAN model.[1] An I/O model for British

1. The commercial fisheries regional economic impact analysis used methods from Hans Radtke and William Jensen, who developed a fisheries economic assessment model (FEAM) for the West Coast Fisheries Development Foundation. The analysis of regional economic impacts for ocean recreational charter boats and ocean recreational private boat fishermen are based on the same methods used by the Pacific Fishery

Columbia is from Radtke (May 1997). On the commercial side, representative budgets from the fish harvesting sector and the fish processing sector, as well as a price and cost structure for processing are used to estimate the impacts of changes. On the recreational side, a charter operator budget and recreational fishermen destination expenditures provide the basic data. Hatchery costs are proxied using sales of hatchery surpluses. The individual expenditure categories are used as I/O model inputs to estimate the total community income impacts.

Estimates of net economic value of commercial and recreational anadromous fishing are made using available studies and procedures developed by management agencies, such as Oregon Department of Fish and Wildlife (ODFW), PFMC, and the NMFS. Commercial fisheries evaluations use ex-vessel value of the fish as a proxy indicator for the value. Seventy percent of ex-vessel revenue is used as an indicator of net value. The remaining 30 percent represents additional expenses of harvesting and primary processing required to produce a consumer product from Columbia River Basin anadromous fish runs. Recreational fisheries evaluation uses a benefit-transfer approach for an angler day value. The basis of a benefit-transfer approach is that other similar situations for fishing experiences are correctly evaluated and are directly comparable to another situation. Specific uses in selective areas may have different values. The reader is cautioned that other harvest analysis may have relied on different data and studies for determining recreational use benefits that may be inconsistent with the analysis presented in this report. The analysis does not include non-use economic values that may be derived from cultural or existence considerations.

B. Anadromous Fish Harvest Forecast Methods

The possible effects from alternative hydrosystem actions on the Snake River anadromous fish stocks examined in this report only includes the causation factors considered in an external modeling process. Readers are directed to the many publications from the committee based process called PATH for understanding forecasts of harvests and returning spawners related to the hydrosystem actions. The NMFS (1999) provides a biological evaluation of PATH results to estimate the recovery probabilities of ESA listed stocks.

The PATH process intended to identify, address, and (to the maximum extent possible) resolve uncertainties in the fundamental biological issues surrounding recovery of endangered spring/summer chinook, fall chinook, and summer steelhead stocks in the Columbia River Basin. The PATH modeled the survival of some of the Snake River wild spring and summer chinook stocks and fall chinook stocks to determine the effects of the hydrosystem actions.

Management Council and are documented in annual reports about the Review of Ocean Salmon Fisheries. Analysis methods used to evaluate the inriver recreational fisheries are described by The Research Group (1991).

The objectives of PATH were to:

- determine the overall level of support for key alternative hypotheses from existing information and propose other hypotheses and/or model improvements that are more consistent with these data (retrospective analyses);
- assess the ability to distinguish among competing hypotheses from future information, and advise institutions on research, monitoring, and adaptive management experiments that would maximize learning; and
- advise regulatory agencies on management actions to restore endangered salmon stocks to self-sustaining levels of abundance (prospective and decision analyses).

PATH developed a quantitative decision analysis framework for spring/summer chinook and a preliminary framework for fall chinook. The process also developed a qualitative analysis for summer steelhead using comparisons of the likely effects of actions on spring/summer chinook as a guide to the probable response of summer steelhead. The PATH decision analysis focused on the probability to which alternative hydrosystem actions contributed to preventing extinction and aiding recovery of stocks either listed or proposed for listing.

It was necessary to expand the PATH results to represent all Snake River stocks. Information contained in PATH results is limited to seven index stocks for Snake River spring/summer chinook, a comprehensive review of Snake River fall chinook, and a narrative description about how smolt-to-adult survival rates (SAR) between Snake River spring/summer chinook and steelhead are correlated. For spring/summer chinook and fall chinook, the information includes numbers of fish harvested in the ocean, river mainstem, and tributaries; harvest rates for ocean and mainstem based on ocean escapement (estimated adult fish counts at the entrance of the Columbia River to the Pacific Ocean); harvest rates for tributaries based on Lower Granite (LWG) Dam escapement (estimated adult fish counts passing over LWG Dam); and, numbers of spawners. Results are reported in five year increments starting with Year 5, i.e. five years after an improvement is implemented.

Uncertainty information is also contained in released PATH results.[1] Table 1.IV.1 describes the PATH results selected for the point estimates used in the economic analysis.

1. The PATH analyses directly incorporated potential effects of key uncertainties. Each action was analyzed across a range of assumptions reflecting alternative biological considerations, survival responses, and variations in future climate effects. As a result, the projected effects of any given action on Snake River salmon runs generated by the PATH analyses were not simple point estimates. Summary statistics were used to compile across the large number of model runs necessary to capture possible combinations of key assumptions in a balanced way. In addition to expressing projections in terms of numbers of fish, PATH also summarized results in the context of the relative probability of exceeding survival and recovery criteria. Projected numbers of fish and harvest were summarized in terms of a standard set of fractions or percentiles of the total number of combinations run for each action (10th, 25th, 50th, 75th and 90th percentiles). For example, if the harvest reported at the 25th percentile was 100 fish, that means that 25% of the model runs for that particular action resulted in a harvest of 100 fish or less. If, for that same action, the harvest reported at the 75th percentile was 500, that means that 75% of the runs for that action resulted in a projected harvest of 500 or less. Each set of percentiles has several scenarios. Spring/summer chinook has a set for "unweighted upper bound," "unweighted lower bound," "equal weights," and "four expert weighing schemes." Fall chinook has a "base

Table 1.IV.1
Release Dates and Scenarios Selected From PATH Results Used in the Economic Analysis

Actions		PATH Results' Release Dates and Scenarios Assumptions	
Identifier	Improvements	Spring/Summer Chinook /1	Fall Chinook /2
A1	Current operations under 1995 Biological opinion	Results released October 1998	Same as fall chinook A2
A2	A1 plus maximize transportation w/o surface bypass collectors	Results released October 1998	Results released November 1998
A3	A2, but also use surface bypass collectors	Results released November 1998	Results released November 1998
A4	Natural river drawdown of four Snake River dams	Results released October 1998	Results released November 1998

Notes: 1. "Likely" point estimates for spring/summer chinook harvest and spawner estimates are based on the PATH results "equal weight" scenario, median percentile outputs. Fall chinook harvest and spawner estimates are based on the PATH "base case" scenario, 50th percentile outputs. A range from "low" to "high" estimates were based on the 25th and 75th percentiles, respectively.
2. Summer steelhead harvests and spawner estimates are based on ratio changes to spring and summer chinook stocks.

Source: Study.

To generate the hydrosystems management actions' effects on all Snake River originating anadromous fish, study assumptions were used for certain life-cycle modeling factors that were in addition to those included in the PATH process. A generalized life-cycle representation for Snake River salmonids is shown on Figure 1.IV.1. The reasons that further analytical work was required include:

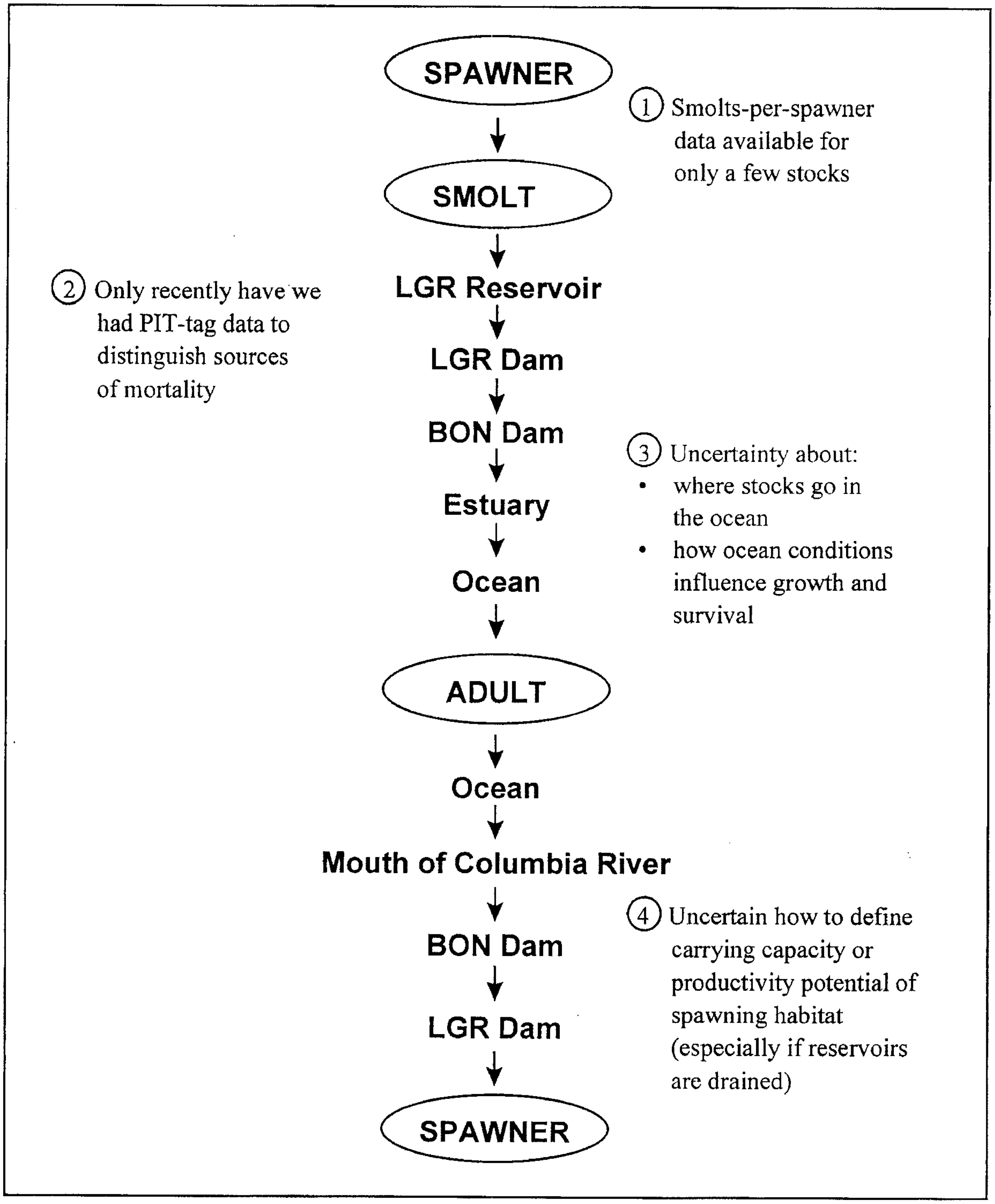
- PATH results did not include Year 0 information for any of the reported stocks. It is necessary to know the change in present conditions to Year 5 (first PATH forecast year) in order to estimate changes in stocks that are not accounted for in PATH results.
- PATH results for spring/summer chinook need to be expanded from the reported seven index wild stocks to all wild stocks.
- Hatchery production needs to be added to PATH results for spring/summer chinook and fall chinook wild stocks.

case," "conservative case," and "liberal case." For example, runs averaged across assumption sets that gave relatively optimistic projections ('best case' or 'unweighted upper bounds') or relatively pessimistic projections ('worst case' or 'unweighted lower bounds'). For any given action the difference between these two perspectives gives a good indication of the effects of uncertainty. The spring/summer chinook results were also summarized after weighting key assumptions based on the opinions solicited from a scientific review panel (personal communication, Tom Cooney, July 1999).

- Summer steelhead hatchery and wild production are not included in PATH results.

The assumptions used to expand PATH results should not be considered an attempt to develop a separate life-cycle model. Wherever possible, PATH modeling factors were reused as proportions in the expansion methods. The assumptions for the life-cycle modeling factors by species are shown in Table 1.IV.2.

Figure 1.IV.1
Straight-Line Representation of a Generalized Life-Cycle for Snake River Salmonids



Note: Annotations show examples of points in the life cycle where empirical data are missing or incomplete.
Source: NMFS (1999).

Table 1.IV.2
Additional Biological Assumptions Needed to Expand PATH Results for Use in the Anadromous Fish Economic Analysis

Life-Cycle/ Modeling Factors	Spring/Summer Chinook
Smolt downstream passage mortality	Nan
Ocean incidental mortality	Nan
Ocean harvest	Nan
Run size total - wild	For Year 0, 1986-95 average from Table 2, Tab 1 and 2, TAC (1997). Future years calculated at the same percentage change as PATH results for index stock's ocean escapement. PATH results ocean escapement calculated using mainstem harvest divided by mainstem harvest rates.
Run size total - hatchery	Nan
Total adults - wild	Mainstem harvest + tributary harvest + pre-spawning mortality after LWG + spawners
Total adults - hatchery	For Year 0, hatchery smolt production goals in 1998 from Smith (1998) times SAR recent year averages in various CWT Missing Production Group Annual Reports (Fuss et al. 1994 and Garrison et al. 1995). For future years, hatchery production held constant and hatchery SAR same changes as wild SAR.
Mainstem harvest - wild	For Year 0, same proportion as PATH results index stocks. For future years, PATH results expanded to represent total production.
Mainstem harvest - hatchery	Proportion of PATH results for mainstem harvest to total wild adults.
Tributary harvest - wild	PATH results expanded to represent total production.
Tributary harvest - hatchery	Proportion of PATH results for index stock's tributary harvest to total wild adults
Upstream passage mortality	Nan
LWG Dam escapement - wild	(tributary harvest + spawners) ÷ 0.9. The 10% LWG prespawning mortality factor is from Marmorek (personal communication 1999).
LWG Dam escapement - hatchery	Nan
Pre-spawning mortality - wild	10% of LWG escapement
Female fraction fecundity - wild and hatchery	Female fraction 50% and fecundity 3,500
Smolt capacity and egg survival rates - wild	Smolt carrying capacity and density dependent egg-smolt survival rate
Smolt capacity and egg survival rates - hatchery	67% fecundity

Note: 1. Nan - No assumption needed; SAR - smolt-to-adult survival rate; CWT - coded wire tag; LWG Dam - Lower Granite Dam.
2. Fecundity is the number of fertilized eggs that can be attributed to a spawning pair.

Source: Study.

Table 1.IV.2 (cont.)

Life-Cycle/ Modeling Factors	Fall Chinook	Summer Steelhead
Smolt downstream passage mortality	Nan	Nan
Ocean incidental mortality	Nan	Nan
Ocean harvest	PATH results	Nan
Run size total - wild	For Year 0, 1986-95 average from Table 9, Tab 3, TAC (1997).	For Year 0, 1986-95 average (length method) for A and B runs Tables 12 and 13, Tab 8, TAC (1997). Future years, 37% s/s chinook SAR changes.
Run size total - hatchery	Nan	Nan
Total adults - wild	Total harvest + spawners + hatchery supplements. Pre-spawning mortality assumed to be zero.	Mainstem harvest + tributary harvest + pre-spawning mortality after LWG + spawners
Total adults - hatchery	For Year 0, hatchery smolt production goals in 1998 from Smith (1998) times SAR recent year averages in various CWT Missing Production Group Annual Reports (Fuss et al. 1994 and Garrison et al. 1995). For future years, hatchery production held constant and SAR same changes as wild SAR.	For Year 0, hatchery smolt production goals in 1998 from Smith (1998) times SAR recent year averages in various CWT Missing Production Group Annual Reports (Fuss et al. 1994 and Garrison et al. 1995). For future years, hatchery production held constant and SAR same changes as 37% wild spring/summer chinook SAR.
Mainstem harvest - wild	For Year 0, Table 9, Tab 3, TAC (1997). For future years, PATH results.	Table 12 and 13, Tab 8, TAC (1997).
Mainstem harvest - hatchery	Proportion of PATH results for mainstem harvest to total wild adults.	Table 12 and 13, Tab 8, TAC (1997).
Tributary harvest - wild	PATH results	Table A1d, Tab 8, TAC (1997).
Tributary harvest - hatchery	Nan	Table A1d, Tab 8, TAC (1997).
Upstream passage mortality	Nan	Nan
LWG Dam escapement - wild	Tributary harvest + spawners + supplements, i.e., zero assumed pre-spawning mortality.	For Year 0, 1986-95 average (length method) for A and B runs, Table 12, Tab 8, TAC (1997). Future years calculated as same percentage change as PATH results calculated LWG escapement
LWG Dam escapement - hatchery	Nan	Nan
Pre-spawning mortality - wild	Zero assumed pre-spawning mortality.	10% of LWG escapement
Female fraction fecundity - wild and hatchery	Female fraction 50% and fecundity 3,500	Female fraction 50% and fecundity 2,500
Smolt capacity and egg survival rates - wild	Smolt carrying capacity and density dependent egg-smolt survival rate varying from 15% in Year 5 to 2% in Year 25+	Varying from 15% in Year 5 to 2% in Year 25+
Smolt capacity and egg survival rates - hatchery	67% fecundity	67% fecundity

Note: 1. Nan - No assumption needed; SAR - smolt-to-adult survival rate; CWT - coded wire tag; LWG Dam - Lower Granite Dam.

2. Fecundity is the number of fertilized eggs that can be attributed to a spawning pair.

Source: Study.

CHAPTER V. SURVIVAL RATES AND CONTRIBUTION TO FISHERIES

Pacific Northwest states, the federal government, tribes, municipalities, and private businesses have funded hatchery salmon and steelhead production for more than 100 years. This activity has been continually viewed as a solution to persistent problems of habitat loss and overfishing. From the earliest efforts until well into the 1960's, most production relied primarily on release of salmon fry with a gradual shift toward holding fish to fingerling size for stocking. By the 1960's, hatchery programs began holding fish for release as full term smolts.

Hatchery smolt production costs are only one component of the unit cost of a harvested adult. The unit cost of production allows an evaluation of a hatchery to control costs and reflect one part of the efficiency of an operation. However, smolts are not sold or caught, only harvestable adults. Therefore, the number of adults surviving gives a better evaluation of individual hatcheries and of the hatchery program in general. The number of returning wild spawners is also crucial to the survival of the species and to contribution to any harvests.

There are three basic distribution patterns of Columbia River Basin produced salmon: north turning fish (fall chinook), south turning fish (coho), and some that tend to migrate in either direction (some of the above). Steelhead tend to scatter and migrate as far as Russian waters. Harvest rates by geographic area depend on migration patterns, as well as historic fishing patterns, and on international and historic treaties and management policies. The same reports used in calculating survival rates are used to calculate historic geographic and gear harvest shares. The distributional assumptions are that future harvests will reflect recent historical catches. These assumptions, however, depend on present Columbia River, U.S. - Canada, and Indian treaty allocations.[1]

Historical information is available on the survival of hatchery reared salmon and steelhead releases and some test wild reared anadromous fish. For this study, a survival rate is defined to be hatchery releases divided by adults that subsequently show up in fisheries or hatchery returns.[2] Analogous survival rate for wild origin fish is the ratio of downstream migrating smolts and harvests plus spawner escapement. The wild origin survival rate definition is similar to "SAR2" discussed by Petrosky and Shaller (1998). The Bonneville Power Administration funds the collection of survival rate and catch rate information on Columbia River Basin produced salmon (Fuss et al. 1994 and Garrison et al. 1995).

As previously mentioned, the PATH results did not provide starting year information for the forecasts of fish harvests or spawners. PATH forecasts were in five year increments, starting with Year 5 and ending with Year 100. The PATH results also did not include SAR's, or fishery user group harvest allocations. The PATH results were only for wild origin stocks, and in the case of spring and summer

1. Harvest allocation treaties change. For example, the U.S. is presently negotiating with Canada on harvest allocations. It is not clear what new harvest allocations will result from these negotiations. For that reason, existing U.S. and Indian tribal agreements are the base used in allocating harvests. What may be available after these obligations are met is distributed according to historical harvest distributions.
2. Because recent hatchery practices mostly have released fish at smolt age, the survival rates are referenced in this study as smolt-to-adult survival rates or SAR.

chinook stocks, only seven index stocks were analyzed. Using Beamesderfer (1997) and TAC (1997) for the period 1986 to 1995, the study estimate for the share of PATH index spring/summer stocks is 52 percent of all wild stocks.

A starting point was needed to determine changes to existing SAR's, and to determine relationships of the seven wild stocks analyzed by PATH to all stocks. The 1986 to 1995 ten year average was adopted to provide the Year 0 information for run size, SAR's, and harvest rates. This period has the following average SAR's for hatchery stocks: 0.25 percent for spring/summer chinook, 0.6 percent for fall chinook, and 0.8 percent for summer steelhead.

The beginning SAR's for wild stocks were determined using a spawner-recruit function between Year 5 and Year 10 using PATH information.[1] Because the PATH information resulted in an extremely high rate of change in SAR's during the early forecast years, study assumptions included the introduction of supplemental fish into the model to better pattern spawner-recruit relationships. This is a plausible explanation, because there are presently test programs for out-planting first generation hatchery rearings at early ages rather than releasing multi-generation hatchery smolts at migrating ages. Figure 1.V.1 shows the results from the modeling assumptions on SAR's over the project life. The previous chapter explains other species-by-species life cycle modeling assumptions used to pattern the wild non-index stocks and all hatchery stocks after PATH stocks.

The economic evaluation depends on the user group and geographic area accomplishing the harvests. Table 1.V.1 shows the 1986 to 1995 average inriver harvest rates, based on run size measured at ocean escapement. The inriver and ocean user group distributions used in the modeling are shown in Table 1.V.2. These tables need to be carefully interpreted if compared, because of the basis of the shares. Treaty rights are for 50 percent of the harvestable fish, regardless of the geographic area. This means that harvest rates for species caught in the ocean, such as fall chinook, will have a greater inriver harvest share. Treaty harvests have consistently fallen below the treaty right share for composite (wild and hatchery) Snake River summer steelhead. To provide for a realistic transition to this distribution, a 25 year trend was used. This means that summer steelhead recreational mainstem (about 10,000 fish) and tributary harvest (about 40,000 fish) are held relatively constant during the 25 year transition period. After the transition period, both treaty and recreational harvests grow proportionally.

Run sizes can be measured at ocean escapement or at other geographic locations. The major anadromous fish stock's wild origin run size measured at escapement past the upper most dam on the lower Snake River over a recent historical period (1964-1996) and forecasts over the

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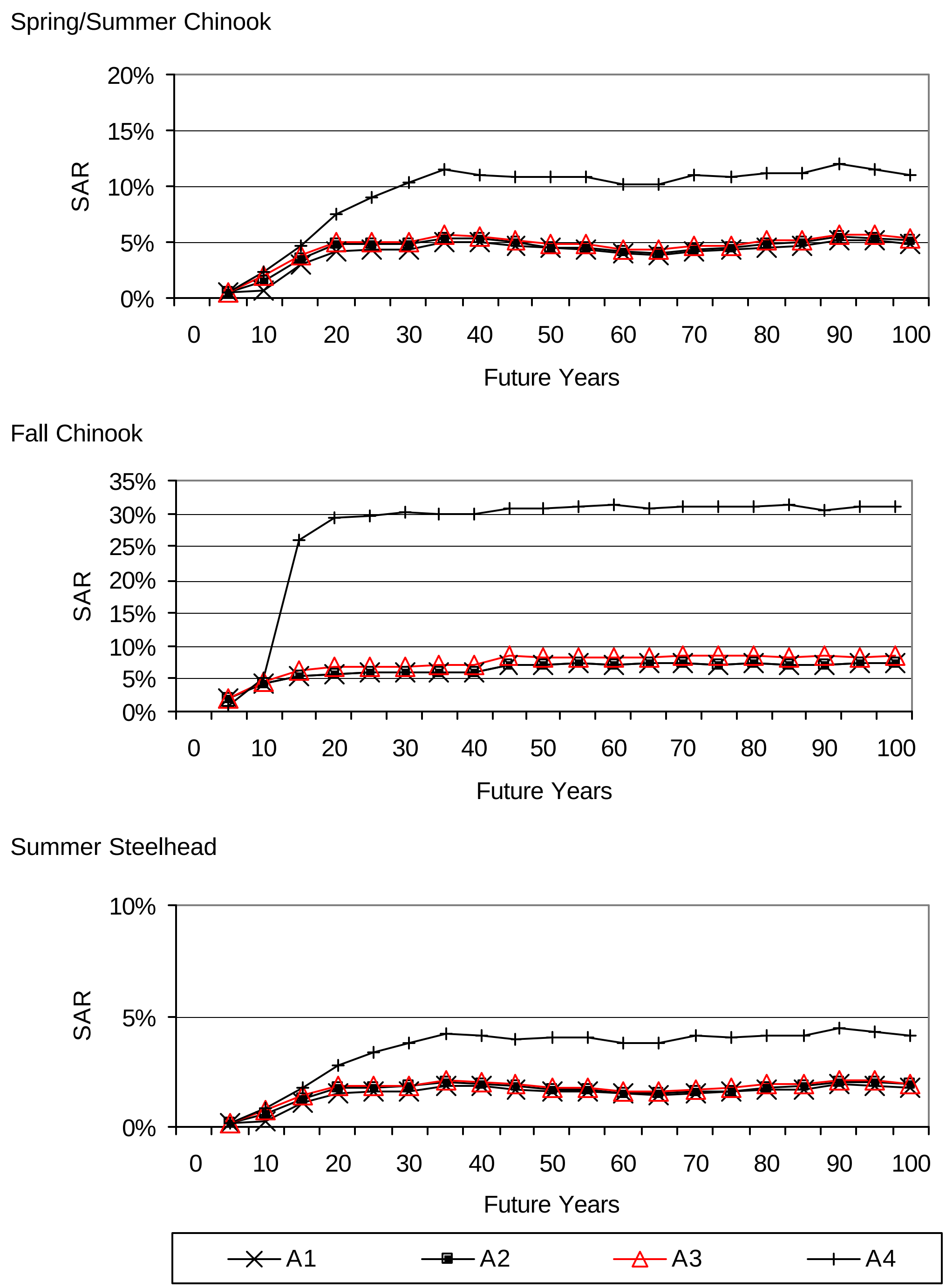
1. Insufficient PATH information existed to calculate an age structure SAR. Instead, a ratio of PATH wild origin stocks' adult to previous five year smolt production was used as an indicator SAR. The movement of the Year 0 hatchery rate was then tied to the PATH indicator SAR rate of change. Smolt production was calculated using a density dependent egg-to-smolt relationship and the number of spawners five years previous. Readers are directed to Williams et al. (1998), Petrosky and Shaller (1998), and Shaller (1999) for a more rigorous treatment of Snake River stock survival rate discussions.

Figure 1.V.1
Snake River Wild Origin Fish Smolt-to-Adult Survival Rate
Indicators by Hydrosystem Actions During Project Period



Notes: 1. The Y-axis maximums are different for each species.
2. Smolt-to-adult rates are referenced as indicators because they are not based on age structures. The indicator rates are spawners, prespawning mortality, and harvest divided by smolts produced five years previous expressed as a percent. Smolts are calculated using a density dependent egg-to-smolt relationship and the number of spawners five years previous.
3. Summer steelhead rates are based on changes to spring/summer chinook changes.

Source: Study.

Table 1.V.1
Snake River Anadromous Fish Inriver Harvests and Harvest Rates for 10-year Average, 1986-1995

		Existing Inriver Harvest and Harvest Rates									
		Mainstem								Tributary	
	Ocean	Commercial Non-Treaty		Recreational		Treaty Indian		LWG Escapement		Recreational	
Species/Stock	Escapement	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Snake River											
Fall Chinook											
Wild	1,813	--	--	--	--	419	23.1%	381	21.0%	--	--
Hatchery	4,458	--	--	--	--	1,108	24.9%	1,679	37.7%	--	--
Total	6,271	803	12.8%	159	2.5%	1,527	24.3%	2,060	32.8%	--	--
Spring Chinook											
Wild	8,657	--	--	--	--	561	6.5%	5,126	59.2%	--	--
Hatchery	19,865	--	--	--	--	1,363	6.9%	12,234	61.6%	--	--
Total	28,522	506	1.8%	364	1.3%	1,924	6.7%	17,360	60.9%	--	--
Summer Chinook											
Wild	3,073	0	0.0%	--	--	78	2.5%	2,294	74.6%	--	--
Hatchery	2,856	0	0.0%	--	--	89	3.1%	1,972	69.0%	--	--
Total	5,929	0	0.0%	3	0.0%	167	2.8%	4,265	71.9%	--	--
Summer Steelhead											
Wild	21,187	0	0.0%	0	0.0%	4,115	19.4%	16,225	76.6%	0	0.0%
Hatchery	105,598	0	0.0%	10,733	10.2%	25,972	24.6%	72,795	68.9%	40,248	38.1%
Total	126,785	0	0.0%	9,846	7.8%	29,636	23.4%	89,020	70.2%	40,248	31.7%

Notes:
1. Averages are based on 1986 through 1995 period.
2. Harvest rates based on ocean escapement.
3. Upriver refers to mainstem escapement from the lower Columbia River into either the Upper Columbia River or the Snake River.
4. All references to specific tables and tabs are found in TAC 1997.
5. Recreational mainstem and tributary harvest are assumed to be illegal and zero for wild fall chinook, spring chinook, and summer chinook after 1990 and for summer steelhead after 1984.
6. Fall chinook
   a. Total fall chinook harvest from commercial, recreational, and treaty user groups is from Table 8 Tab 3. The assumption is made that catch in zone 6 is treaty.
   b. Ocean and LWG escapement is from Tables 8 and 9 Tab 3.
   c. Treaty harvest of wild fall chinook is from Table 9 Tab 3. Hatchery is the residual of total and wild.
7. Spring chinook
   a. Total ocean escapement is the total upriver run size times the proportion of Snake River spring chinook from Tables 1 and 2 Tab 1.
   b. Wild ocean escapement and LWG escapement are from Tables 2 and 3 Tab 1.
   c. Hatchery ocean escapement is the residual between total and wild.
   d. Hatchery LWG escapement is from Table 3 Tab 1.
   e. Total commercial and total recreational Snake River harvests are estimated using upriver spring chinook mainstem harvest by user group and applying the proportion of mainstem escapement to Snake River.
   f. Treaty harvest of wild mainstem Snake River spring chinook is from Table 2 Tab 1. It is assumed that harvest in zone 6 are treaty harvest only. Total harvest is estimated using harvest of upriver spring chinook and proportion to Snake River spring chinook. Treaty harvest of hatchery spring chinook is the residual of total and wild.
8. Summer chinook
   a. Wild ocean escapement and LWG escapement is from Table 2 Tab 2.
   b. Hatchery ocean escapement and LWG escapement is from Table 3 Tab 2.
   c. Total recreational mainstem harvest of summer chinook is estimated from harvest of upriver summer chinook and proportion Snake River summer chinook.
   d. Non-treaty commercial harvest in zones 1-5 for wild and hatchery summer chinook is zero. Table 1 Tab 2. Incidental non-retention excluded.
   e. Treaty harvest of wild summer chinook is from Table 2 Tab 2. This assumes zone 6 harvest is treaty only.
   f. Treaty harvest of hatchery summer chinook is from Table 3 Tab 2. This assumes zone 6 harvest is treaty only.
9. Summer steelhead
   a. Non-treaty commercial harvest is assumed to be zero.
   b. LWG escapement is from Tables 12 through 15 Tab 8. Lower Granite counts of group A and B were summed (based on the length method).
   c. Total tributary harvest is from Tables A1c and A1d.
   d. Wild and hatchery ocean escapement is from Tables 12 through 15 Tab 8. Lower Granite with no mainstem fishery counts of group A and B were summed (based on the length method). This provides a minimum run size.
   e. Mainstem harvest rates are assumed to equal mainstem harvest rates for total upriver summer steelhead stocks. Tab 8 Table 4.

Source: TAC 1997.

Table 1.V.2
Assumptions for Anadromous Fish User Group Distributions by Species and Geographic Area

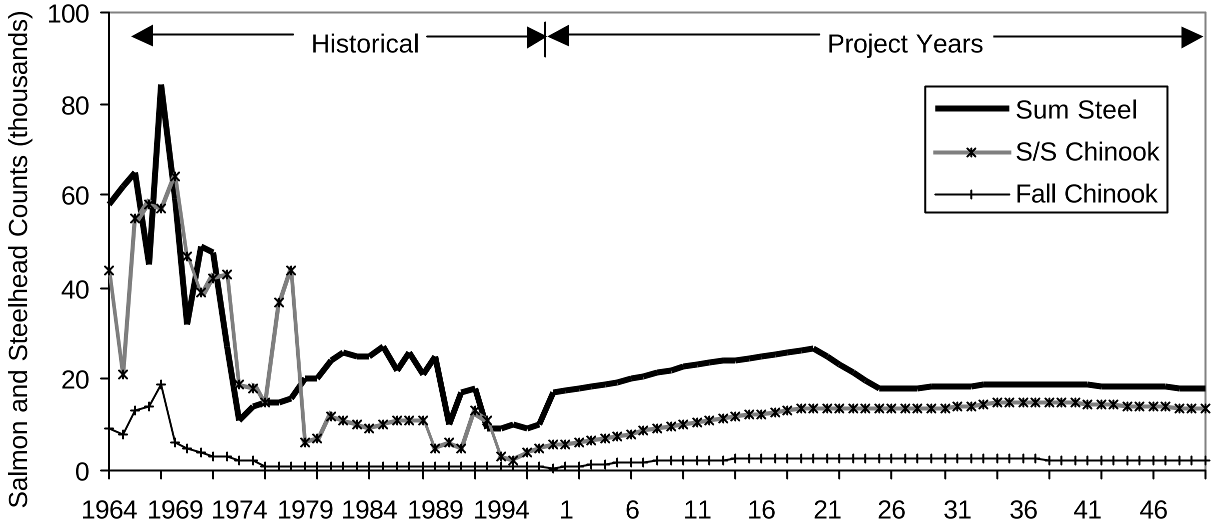
Geographic Area/User Group	Anadromous Species: Chinook Spring/Summer	Chinook Fall	Summer Steelhead
Ocean Harvest			
Alaska			
a) Commercial	0.000%	11.663%	0.000%
b) Sport	0.000%	0.002%	0.000%
British Columbia			
a) Commercial	0.000%	48.506%	0.000%
b) Sport	0.000%	3.880%	0.000%
Subtotal Alaska/B.C.	0.000%	64.051%	0.000%
Washington ocean			
a) Commercial	0.000%	19.027%	0.000%
b) Sport	0.000%	8.456%	0.000%
Washington Puget Sound			
a) Commercial	0.000%	0.002%	0.000%
b) Sport	0.000%	0.002%	0.000%
Oregon			
a) Commercial	0.000%	6.343%	0.000%
b) Sport	0.000%	2.115%	0.000%
California			
a) Commercial	0.000%	0.002%	0.000%
b) Sport	0.000%	0.002%	0.000%
Subtotal WOC Ocean	0.000%	35.949%	0.000%
Subtotal Ocean	0.000%	100.000%	0.000%
In-river Harvest			
Treaty Year 0	50.000%	62.219%	37.200%
Year 5	50.000%	62.219%	39.760%
Year 10	50.000%	62.219%	42.320%
Year 15	50.000%	62.219%	44.880%
Year 20	50.000%	62.219%	47.440%
Year 25-100	50.000%	62.219%	50.000%
Non-treaty			
Mainstem	(less treaty)		(less treaty)
a) Freshwater sport	77.000%	2.874%	100.000%
b) Commercial non-Treaty	17.000%	34.491%	0.000%
c) Other in-river	6.000%	0.416%	0.000%
Tributary			
a) Freshwater sport	100.000%	0.000%	100.000%
Returns to Hatcheries			
Requirement to Carcass	100.000%	100.000%	100.000%
Surplus			
a) Carcass and egg sales	50.000%	50.000%	50.000%
b) Food fish	50.000%	50.000%	50.000%

Notes:
1. Expressed as percent of fish harvested by the geographical fisheries.
2. See text narrative on survival rates and contribution to fisheries for explanation of distributional assumptions.
3. Results assume 50% for treaty harvest and zero ocean harvests for spring/summer chinook and summer steelhead.
4. Treaty harvest percent of fish is based on all inriver harvestable fish (mainstem and tributary). It is assumed that all treaty harvest are in the mainstem.
5. Non-treaty mainstem harvest for spring/summer chinook and summer steelhead, represent the distribution of the remaining mainstem harvestable fish by user group.
6. Non-treaty harvest for fall chinook represent shares of total inriver harvest.

Source: Study.

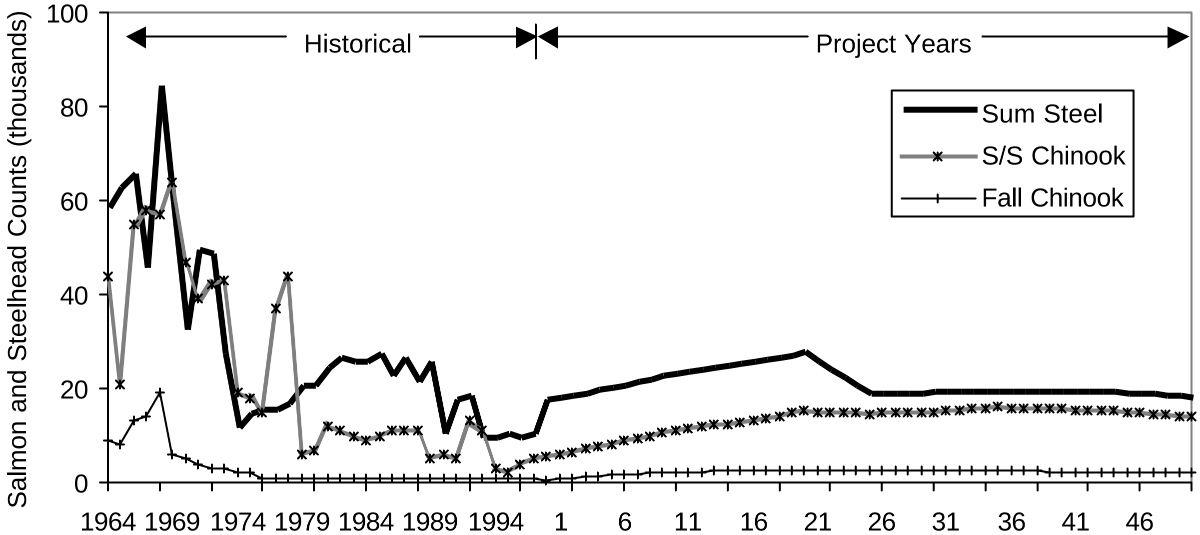
first 50 years of project life for each hydrosystem action are shown in Figures 1.V.2a through 1.V.2d. This means ocean and inriver harvests as well as other river passage mortalities have been accounted for in the wild run sizes. The forecasts show rapid recovery during early project period and minor fluctuations in later years. The fluctuations, as explained by PATH documentation, are due to ocean regime shifts. The forecasted wild origin run sizes are less than about one third pre-dam historical levels.

Figure 1.V.2a
Historical and Project Year Wild Origin Stock Run Counts at Snake River Uppermost Dam, Action A1



Note: Adult wild salmon and steelhead counts at the uppermost dam on the Snake River below Lewiston (Ice Harbor Dam 1964-68, Lower Monument Dam 1969, Little Goose Dam 1970-74, Lower Granite Dam 1970-74).
Source: Study and IDFG (1998).

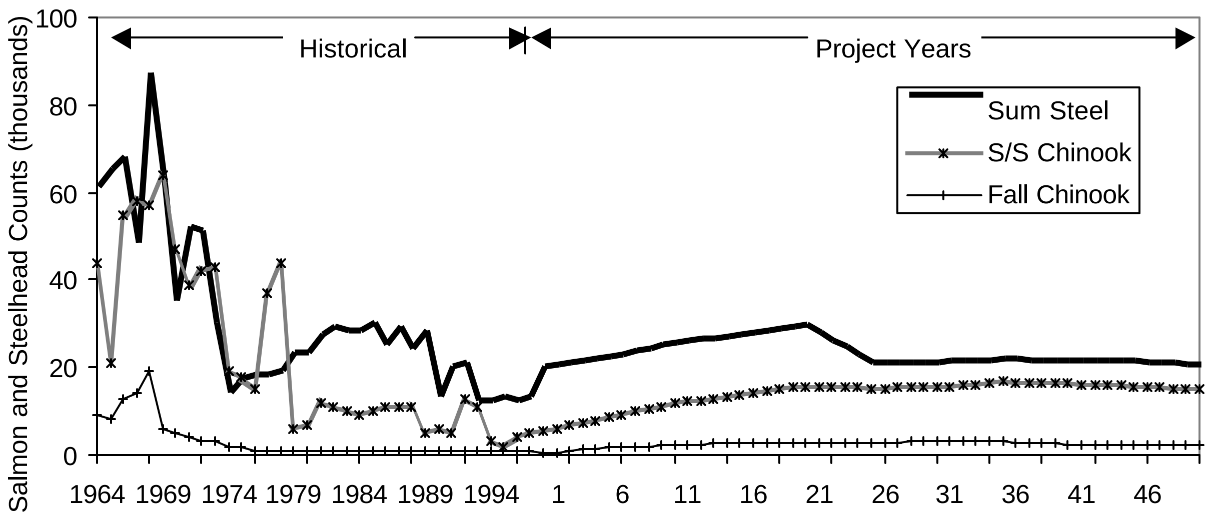
Figure 1.V.2b
Historical and Project Year Wild Origin Stock Run Counts at Snake River Uppermost Dam, Action A2



Note: Adult wild salmon and steelhead counts at the uppermost dam on the Snake River below Lewiston (Ice Harbor Dam 1964-68, Lower Monument Dam 1969, Little Goose Dam 1970-74, Lower Granite Dam 1970-74).

Source: Study and IDFG (1998).

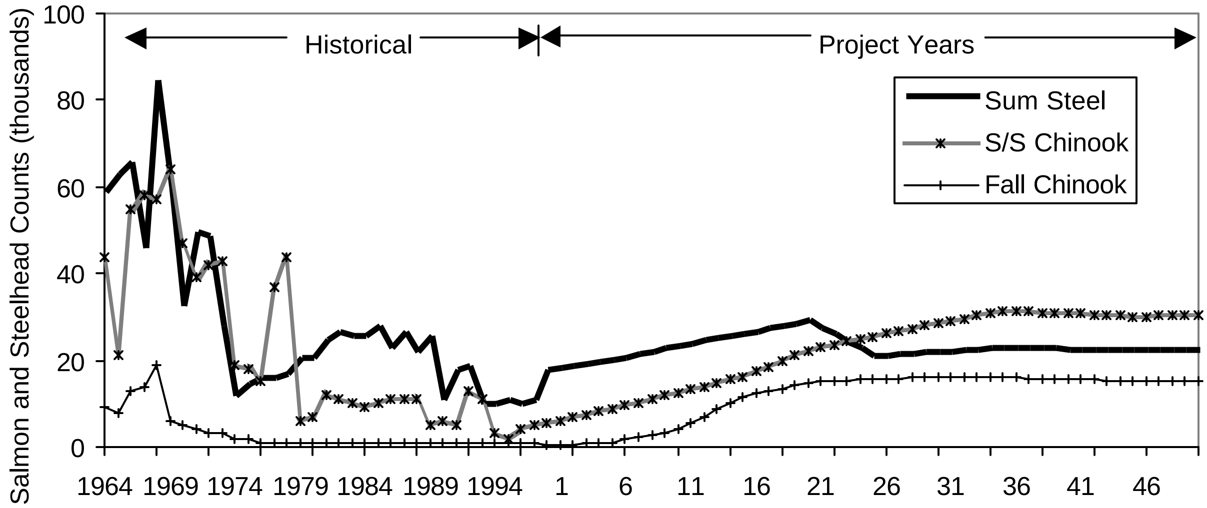
Figure 1.V.2c
Historical and Project Year Wild Origin Stock Run Counts
at Snake River Uppermost Dam, Action A3



Note: Adult wild salmon and steelhead counts at the uppermost dam on the Snake River below Lewiston (Ice Harbor Dam 1964-68, Lower Monument Dam 1969, Little Goose Dam 1970-74, Lower Granite Dam 1970-74).

Source: Study and IDFG (1998).

Figure 1.V.2d
Historical and Project Year Wild Origin Stock Run Counts
at Snake River Uppermost Dam, Action A4



Note: Adult wild salmon and steelhead counts at the uppermost dam on the Snake River below Lewiston (Ice Harbor Dam 1964-68, Lower Monument Dam 1969, Little Goose Dam 1970-74, Lower Granite Dam 1970-74).

Source: Study and IDFG (1998).

CHAPTER VI. ECONOMIC EVALUATION OF CHANGED ANADROMOUS FISH HARVESTS DUE TO ALTERNATIVE LOWER SNAKE RIVER DAMS HYDROSYSTEM ACTIONS

The economic evaluation of changed anadromous fish stocks due to hydrosystem actions relies on available methods and data. The PATH provided information for some wild index stocks which were expanded to represent all stocks using abbreviated life cycle modeling procedures. Historical harvest distribution patterns were used as a base and then modified for future expected management regimes.

The forecast of fish available for harvest in the ocean and inriver is distributed to user groups within constraints of international understandings and Columbia River tribal treaty agreements. The previous chapter described the study assumptions for user group allocations. The economic values per commercial fish harvested and per recreational day used in this analysis are presented by species and geographic location in Table 1.VI.1. Commercial economic values (NED benefits) are based on ex-vessel values. Seventy percent of ex-vessel revenue is used as an indicator of net economic value. The recreational fishery value uses a benefit transfer approach to develop a value per angler day. This value is then multiplied by the number of angler days required to catch a fish. Angler days were determined using catch per unit effort (CPUE) data based on recent periods, which were then adjusted for abundance levels.[1]

The economic evaluation of inriver recreational harvest will be provided by analyzing general recreation and tourism.[2] To give a more complete depiction of the sensitivity associated with data and modeling assumptions, the inriver recreational user group is included in the risk and uncertainty analysis.

The changed economic value (NED benefits) measured by annual average equivalent values (AAEV) over a project life of 100 years between base case and other hydrosystem actions using the most current Corps discount rate (6 7/8 percent) ranges between $0.16 million and $1.59 million in 1998 dollars (Table 1.VI.2). If a zero percent discount rate is used for valuing future generation benefits, then the changed values (NED AAEV benefits) may be as high as $3.49 million for one of the actions. Action A4 has the highest changed values. Table 1.VI.3 shows the annualized economic value (NED AAEV benefits) range by fisheries for three discount rates. The "high" modeling results are interesting in that Action A1 for some fisheries is greater than other proposed project actions. Not considering the inriver

1. The CPUE to determine angler days used recent period catch rates. Ocean recreational composite CPUE rates are one day per fish, Columbia River mainstem is two days per fish, and Snake River tributary is 5.88 days per fish. CPUE is influenced by fishing motivational factors and fishery management techniques. For example, all existing recreational steelhead fishing is selective for hatchery origin fish. If future wild origin abundance levels allow retention, then the CPUE (expressed as days per fish) will decrease. Modeling assumptions for CPUE incorporated decreasing tributary CPUE (expressed as days per fish) with increasing abundances.
2. The methods used to provide for the economic evaluation of this user group and fishery are different from those used to evaluate the other anadromous fish fisheries and may not be directly comparable.

Table 1.VI.1
Economic Value (NED Benefits) Assumptions by Species and Fishery

	Commercial	Recreational
Spring/Summer Chinook		
Ocean		
Alaska	33.83	
British Columbia	34.30	
Washington ocean	23.68	
Washington Puget Sound	21.19	
Oregon	21.65	
California	22.33	
Columbia Basin inland		
Mainstem	49.95	51.43
Tributary		63.23
Other	0.00	
Food fish	26.87	
Carcass and egg sales	0.00	
Fall Chinook		
Ocean		
Alaska	33.83	51.43
British Columbia	34.30	51.43
Washington ocean	23.68	51.43
Washington Puget Sound	21.19	51.43
Oregon	21.65	51.43
California	22.53	51.43
Columbia Basin inland		
Mainstem	23.53	51.43
Tributary		
Other	0.00	
Food fish	18.25	
Carcass and egg sales	1.23	
Summer Steelhead		
Ocean		
Alaska		
British Columbia	11.44	
Washington ocean		
Washington Puget Sound		
Oregon		
California		
Columbia Basin inland		
Mainstem	9.99	52.85
Tributary		63.23
Other		
Food fish	8.73	
Carcass and egg sales	1.23	

Notes: 1. Average 1998 dollars per fish (commercial fisheries) and angler day (recreational fisheries).
2. Carcass sales assume $0.10 per pound for whole body dressed weight.
Source: Study.

Table 1.VI.2
Changed Annualized Economic Value (NED Benefits) Between Base Case and Other Hydrosystem Actions for Various Discount Rates

Hydrosystem Actions	Discount Rates 0% Amount	0% Order	4 6/8% Amount	4 6/8% Order	6 7/8% Amount	6 7/8% Order
Annual Average Equivalent Value (Year 0 to Year 100)						
A2 less A1	$0.20	2	$0.18	2	$0.16	3
A3 less A1	$0.19	3	$0.17	3	$0.16	2
A4 less A1	$3.49	1	$2.06	1	$1.59	1

Notes:
1. NED benefits measured by annual average equivalent values over a 100 year project life in millions of 1998 dollars.
2. Evaluation is for all modeled anadromous fish species and includes harvests and hatchery surplus utilization. The evaluation excludes the economic values for inriver recreational fishing.
3. The analysis is based on PATH results' "base case" scenario for fall chinook and "equal weights" scenario for spring/summer chinook using "likely" (50th percentile) modeling output.
4. See text for explanation of hydrosystem action descriptions.

Source: Study.

recreational fishery, most of the economic values (NED AAEV benefits) would be generated from the inriver treaty fishery (Table 1.VI.3) contributed by fall chinook (Figure 1.VI.1). Annualized economic values (NED AAEV benefits) generated per year by species for wild and hatchery origin fish over the life of the project for each hydrosystem action are shown in Figures 1.VI.2a through 1.VI.2c.

The anadromous fish forecasting analysis resulted in a large share of summer steelhead destined to the Snake River watershed escaping fisheries and returning to hatcheries as surplus. The default use of this surplus is for food fish, egg, and carcass sales. There may be fishery management opportunities to convert these sales to harvest opportunities. Changing fish forecasting assumptions to realize this opportunity is described in the risk and uncertainty chapter.

Table 1.VI.3a
Ranges of Annualized Economic Value (NED Benefits) by Fishery For Each Hydrosystem Action Using "Low", "Likely", and "High" Modeling Results

	A1			A2			A3			A4		
Anadromous Fish	Low	Likely	High	Low	Likely	High	Low	Likely	High	Low	Likely	High
Commercial												
Ocean												
Alaska	$6.15	$12.72	$26.35	$6.15	$12.72	$26.35	$6.85	$14.56	$30.54	$31.99	$69.48	$136.12
British Columbia	$25.93	$53.66	$111.09	$25.93	$53.66	$111.09	$28.90	$61.41	$128.77	$134.89	$292.97	$573.99
WA Ocean	$7.02	$14.53	$30.08	$7.02	$14.53	$30.08	$7.83	$16.63	$34.87	$36.53	$79.34	$155.44
WA Puget Sound	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.01
Oregon	$2.14	$4.43	$9.17	$2.14	$4.43	$9.17	$2.39	$5.07	$10.63	$11.13	$24.18	$47.38
California	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.02
Subtotal Ocean	$41.24	$85.34	$176.70	$41.24	$85.34	$176.70	$45.97	$97.68	$204.82	$214.55	$465.99	$912.95
Inriver												
Non-treaty	$21.50	$45.76	$96.49	$23.09	$51.36	$110.14	$24.26	$52.75	$113.84	$120.47	$223.36	$409.35
Treaty Indian	$293.52	$702.77	$2,003.61	$323.81	$795.22	$2,062.65	$323.18	$789.90	$1,992.09	$564.64	$1,287.11	$2,771.28
Hatchery Returns	$8.77	$137.06	$522.24	$28.98	$198.78	$613.34	$25.47	$188.48	$567.35	$206.31	$480.92	$990.32
Subtotal Inriver	$323.79	$885.59	$2,622.34	$375.88	$1,045.36	$2,786.14	$372.92	$1,031.12	$2,673.27	$891.43	$1,991.39	$4,170.95
Subtotal Commercial	$365.02	$970.93	$2,799.04	$417.12	$1,130.70	$2,962.84	$418.89	$1,128.80	$2,878.09	$1,105.97	$2,457.38	$5,083.90
Recreational												
Ocean												
Alaska	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
British Columbia	$3.11	$6.44	$13.32	$3.11	$6.44	$13.32	$3.47	$7.37	$15.44	$16.18	$35.14	$68.84
WA Ocean	$6.78	$14.03	$29.04	$6.78	$14.03	$29.04	$7.55	$16.05	$33.66	$35.26	$76.58	$150.04
WA Puget Sound	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
Oregon	$1.70	$3.51	$7.26	$1.70	$3.51	$7.26	$1.89	$4.02	$8.42	$8.82	$19.15	$37.53
California	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
Subtotal Ocean	$11.59	$23.98	$49.65	$11.59	$23.98	$49.65	$12.92	$27.44	$57.55	$60.28	$130.93	$256.51
Total Commercial and Recreational	$376.61	$994.91	$2,848.68	$428.70	$1,154.68	$3,012.48	$431.81	$1,156.25	$2,935.64	$1,166.25	$2,588.31	$5,340.41

Notes:
1. NED benefits measured by annual average equivalent values over a 100 year project life using 6 7/8% discount rate in thousands of 1998 dollars.
2. Evaluation is for all modeled anadromous fish species and includes harvests and hatchery surplus utilization. The evaluation excludes the economic values for inriver recreational fishing.
3. PATH results fall chinook Action A1 is the same as Action A2. Fall chinook is the only significantly harvested species in ocean fisheries.
4. "Low", "likely," and "high" modeling results correspond to PATH results for 25th, 50th, 75th percentile modeling outputs, respectively.
5. The analysis is based on PATH results' "base case" scenario for fall chinook and "equal weights" scenario for spring/summer chinook.
6. Total and subtotals may not equal sum of values due to rounding.

Source: Study.

Table 1.VI.3b
Ranges of Annualized Economic Value (NED Benefits) by Fishery For Each
Hydrosystem Action Using "Low", "Likely", and "High" Modeling Results

	A1			A2			A3			A4		
Anadromous Fish	Low	Likely	High	Low	Likely	High	Low	Likely	High	Low	Likely	High
Commercial												
Ocean												
Alaska	$6.42	$13.71	$28.66	$6.42	$13.71	$28.66	$7.33	$15.94	$33.65	$39.67	$84.82	$163.84
British Columbia	$27.07	$57.80	$120.87	$27.07	$57.80	$120.87	$30.91	$67.22	$141.87	$167.30	$357.68	$690.88
WA Ocean	$7.33	$15.65	$32.73	$7.33	$15.65	$32.73	$8.37	$18.20	$38.42	$45.30	$96.86	$187.10
WA Puget Sound	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.02
Oregon	$2.23	$4.77	$9.98	$2.23	$4.77	$9.98	$2.55	$5.55	$11.71	$13.81	$29.52	$57.03
California	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.02
Subtotal Ocean	$43.05	$91.93	$192.24	$43.05	$91.93	$192.24	$49.16	$106.91	$225.66	$266.09	$568.91	$1,098.88
Inriver												
Non-treaty	$23.38	$52.57	$110.98	$25.38	$59.30	$127.02	$27.08	$61.25	$132.53	$155.22	$287.02	$514.37
Treaty Indian	$309.67	$821.38	$2,175.04	$341.58	$920.20	$2,246.11	$341.37	$911.40	$2,177.94	$677.23	$1,601.70	$3,238.98
Hatchery Returns	$7.26	$167.65	$556.91	$30.41	$237.63	$658.06	$27.33	$223.90	$609.53	$269.56	$605.58	$1,154.79
Subtotal Inriver	$340.31	$1,041.60	$2,842.92	$397.36	$1,217.13	$3,031.18	$395.77	$1,196.55	$2,920.00	$1,102.01	$2,494.30	$4,908.14
Subtotal Commercial	$383.36	$1,133.53	$3,035.17	$440.42	$1,309.06	$3,223.43	$444.92	$1,303.46	$3,145.66	$1,368.10	$3,063.21	$6,007.02
Recreational												
Ocean												
Alaska	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
British Columbia	$3.25	$6.93	$14.50	$3.25	$6.93	$14.50	$3.71	$8.06	$17.02	$20.07	$42.90	$82.86
WA Ocean	$7.08	$15.11	$31.59	$7.08	$15.11	$31.59	$8.08	$17.57	$37.08	$43.73	$93.49	$180.59
WA Puget Sound	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
Oregon	$1.77	$3.78	$7.90	$1.77	$3.78	$7.90	$2.02	$4.39	$9.28	$10.94	$23.38	$45.17
California	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
Subtotal Ocean	$12.10	$25.83	$54.01	$12.10	$25.83	$54.01	$13.81	$30.04	$63.40	$74.76	$159.84	$308.75
Total Commercial and Recreational	$395.46	$1,159.36	$3,089.18	$452.51	$1,334.89	$3,277.44	$458.74	$1,333.50	$3,209.06	$1,442.87	$3,223.05	$6,315.78

Notes:
1. NED benefits measured by annual average equivalent values over a 100 year project life using 4 6/8% discount rate in thousands of 1998 dollars.
2. Evaluation is for all modeled anadromous fish species and includes harvests and hatchery surplus utilization. The evaluation excludes the economic values for inriver recreational fishing.
3. PATH results fall chinook Action A1 is the same as Action A2. Fall chinook is the only significantly harvested species in ocean fisheries.
4. "Low", "likely," and "high" modeling results correspond to PATH results for 25th, 50th, 75th percentile modeling outputs, respectively.
5. The analysis is based on PATH results' "base case" scenario for fall chinook and "equal weights" scenario for spring/summer chinook.
6. Total and subtotals may not equal sum of values due to rounding.

Source: Study.

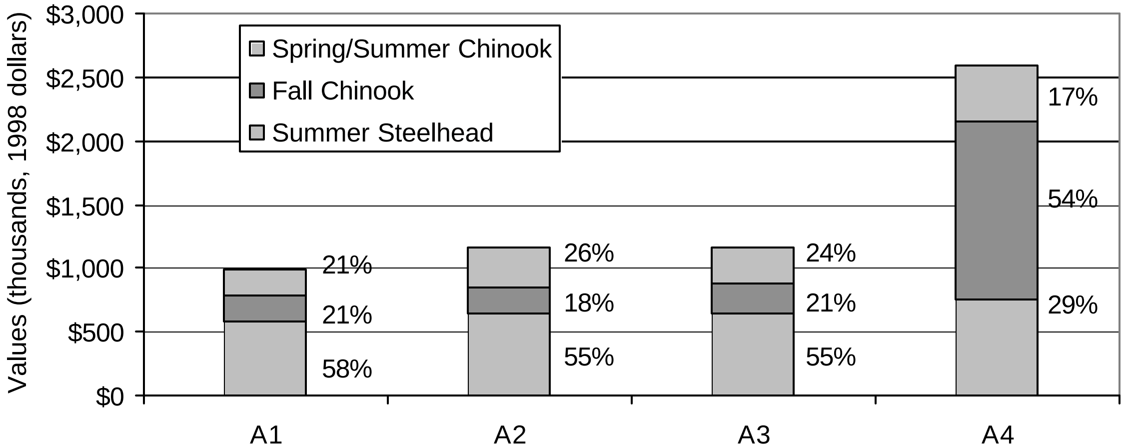
Table 1.VI.3c
Ranges of Annualized Economic Value (NED Benefits) by Fishery For Each
Hydrosystem Action Using "Low", "Likely", and "High" Modeling Results

	A1			A2			A3			A4		
Anadromous Fish	Low	Likely	High	Low	Likely	High	Low	Likely	High	Low	Likely	High
Commercial												
Ocean												
Alaska	$7.83	$16.97	$35.34	$7.83	$16.97	$35.34	$9.35	$20.41	$42.62	$61.71	$126.69	$235.99
British Columbia	$33.00	$71.55	$149.01	$33.00	$71.55	$149.01	$39.43	$86.08	$179.70	$260.20	$534.22	$995.10
WA Ocean	$8.94	$19.38	$40.35	$8.94	$19.38	$40.35	$10.68	$23.31	$48.66	$70.47	$144.67	$269.48
WA Puget Sound	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.01	$0.03
Oregon	$2.72	$5.91	$12.30	$2.72	$5.91	$12.30	$3.25	$7.10	$14.83	$21.48	$44.09	$82.14
California	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.01	$0.03
Subtotal Ocean	$52.48	$113.81	$237.00	$52.48	$113.81	$237.00	$62.72	$136.91	$285.82	$413.87	$849.71	$1,582.76
Inriver												
Non-treaty	$30.77	$74.27	$152.91	$33.77	$83.38	$174.65	$37.31	$87.20	$186.39	$263.24	$479.50	$817.23
Treaty Indian	$381.49	$1,190.57	$2,663.95	$414.35	$1,291.15	$2,756.41	$416.17	$1,272.42	$2,708.91	$1,071.46	$2,616.35	$4,671.95
Hatchery Returns	$7.40	$255.19	$635.86	$37.97	$343.14	$761.36	$37.13	$319.21	$709.59	$468.72	$967.27	$1,602.86
Subtotal Inriver	$419.65	$1,520.04	$3,452.72	$486.10	$1,717.67	$3,692.42	$490.61	$1,678.83	$3,604.88	$1,803.42	$4,063.12	$7,092.04
Subtotal Commercial	$472.13	$1,633.85	$3,689.72	$538.58	$1,831.48	$3,929.42	$553.33	$1,815.74	$3,890.71	$2,217.29	$4,912.82	$8,674.80
Recreational												
Ocean												
Alaska	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.01	$0.01	$0.02	$0.03	$0.06
British Columbia	$3.96	$8.58	$17.87	$3.96	$8.58	$17.87	$4.73	$10.32	$21.55	$31.21	$64.07	$119.35
WA Ocean	$8.63	$18.70	$38.95	$8.63	$18.70	$38.95	$10.31	$22.50	$46.97	$68.02	$139.64	$260.11
WA Puget Sound	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.01	$0.01	$0.02	$0.03	$0.06
Oregon	$2.16	$4.68	$9.74	$2.16	$4.68	$9.74	$2.58	$5.63	$11.75	$17.01	$34.93	$65.06
California	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.01	$0.01	$0.02	$0.03	$0.06
Subtotal Ocean	$14.75	$31.98	$66.59	$14.75	$31.98	$66.59	$17.62	$38.47	$80.31	$116.28	$238.74	$444.71
Total Commercial and Recreational	$486.88	$1,665.82	$3,756.31	$553.33	$1,863.46	$3,996.01	$570.95	$1,854.21	$3,971.02	$2,333.57	$5,151.56	$9,119.50

Notes:
1. NED benefits measured by annual average equivalent values over a 100 year project life using 0% discount rate in thousands of 1998 dollars.
2. Evaluation is for all modeled anadromous fish species and includes harvests and hatchery surplus utilization. The evaluation excludes the economic values for inriver recreational fishing.
3. PATH results fall chinook Action A1 is the same as Action A2. Fall chinook is the only significantly harvested species in ocean fisheries.
4. "Low", "likely," and "high" modeling results correspond to PATH results for 25th, 50th, 75th percentile modeling outputs, respectively.
5. The analysis is based on PATH results' "base case" scenario for fall chinook and "equal weights" scenario for spring/summer chinook.
6. Total and subtotals may not equal sum of values due to rounding.

Source: Study.

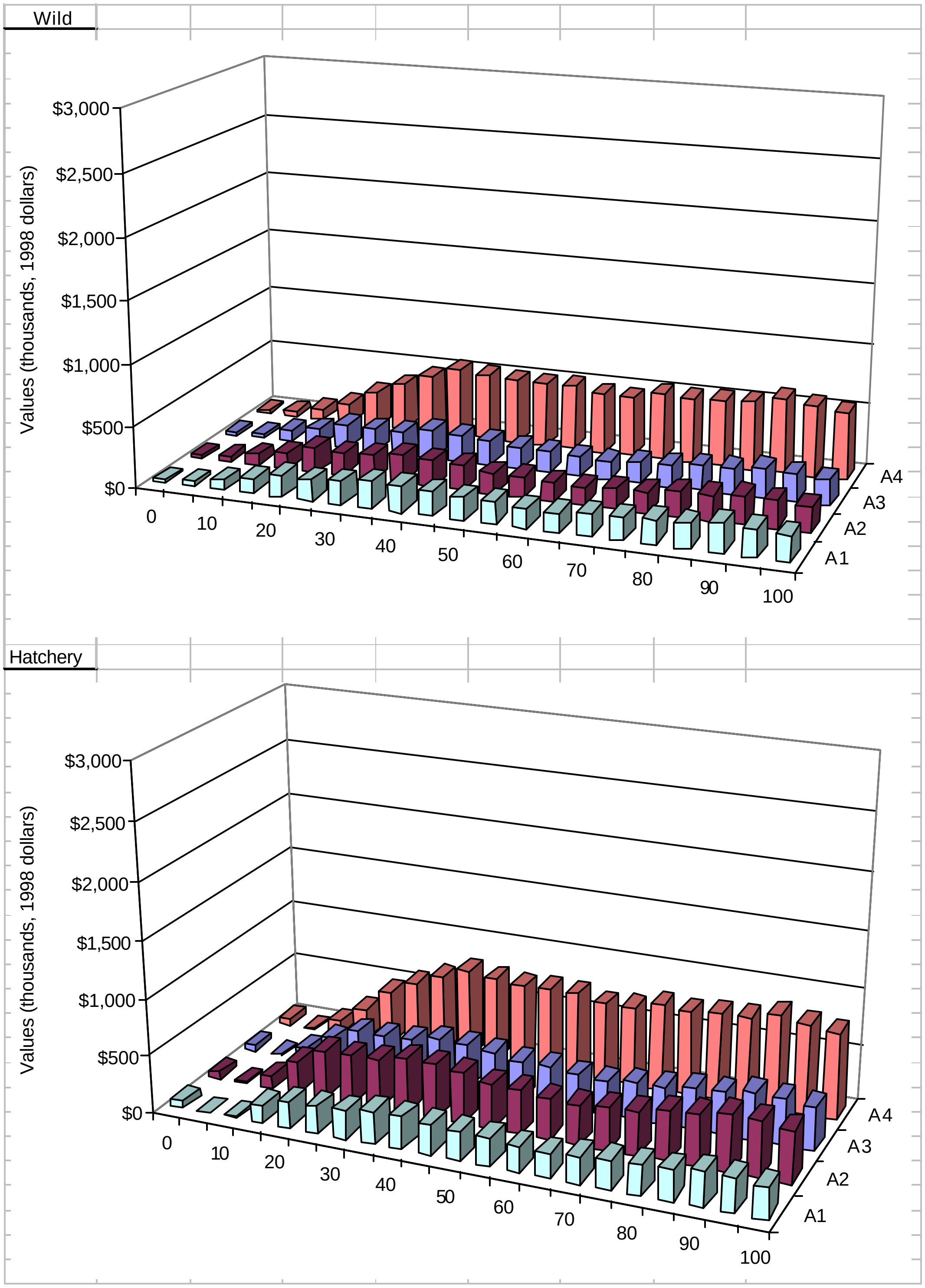
Figure 1.VI.1
Annualized Economic Values (NED Benefits) by Anadromous Fish Species for Each Project Action



Notes:
1. NED benefits measured by annual average equivalent values over a 100 year project life using 6 7/8% discount rate in thousands of 1998 dollars.
2. Evaluation is for all modeled anadromous fish species and includes harvests and hatchery surplus utilization. The evaluation excludes the economic values for inriver recreational fishing.
3. PATH results fall chinook Action A1 is the same as Action A2. Fall chinook is the only significantly harvested species in ocean fisheries.
4. The analysis is based on PATH results' "base case" scenario for fall chinook and "equal weights" scenario for spring/summer chinook using "likely" (50th percentile) modeling output.

Source: Study.

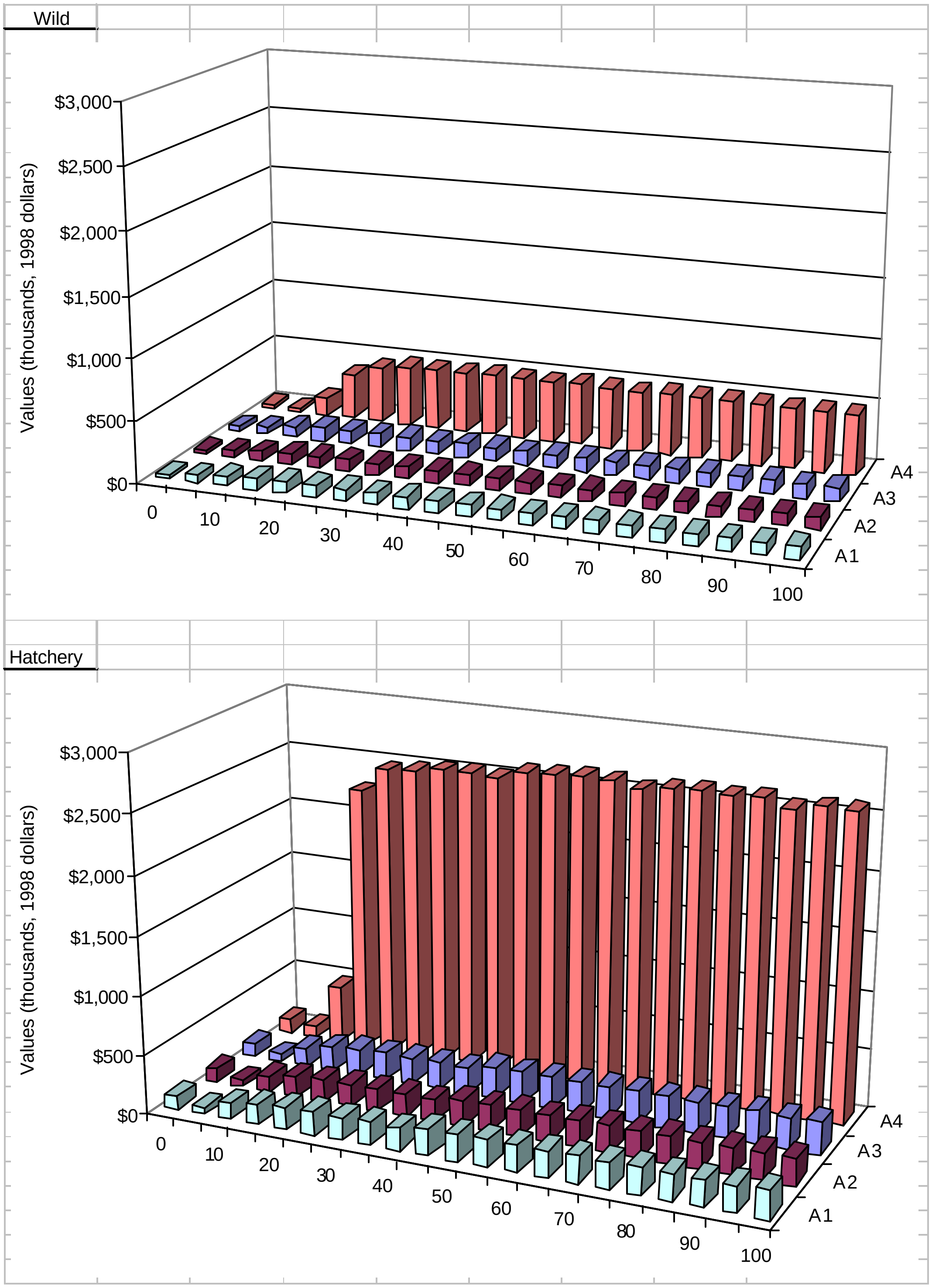
Figure 1.VI.2a
Economic Values (NED Benefits) for Spring/Summer Chinook
by Project Action Using "Likely" Modeling Results



Note: 1. Recreational inriver fisheries are excluded from the analysis.
2. NED benefits are based on PATH results fall chinook "base case" and spring/summer chinook "equal weights".

Source: Study.

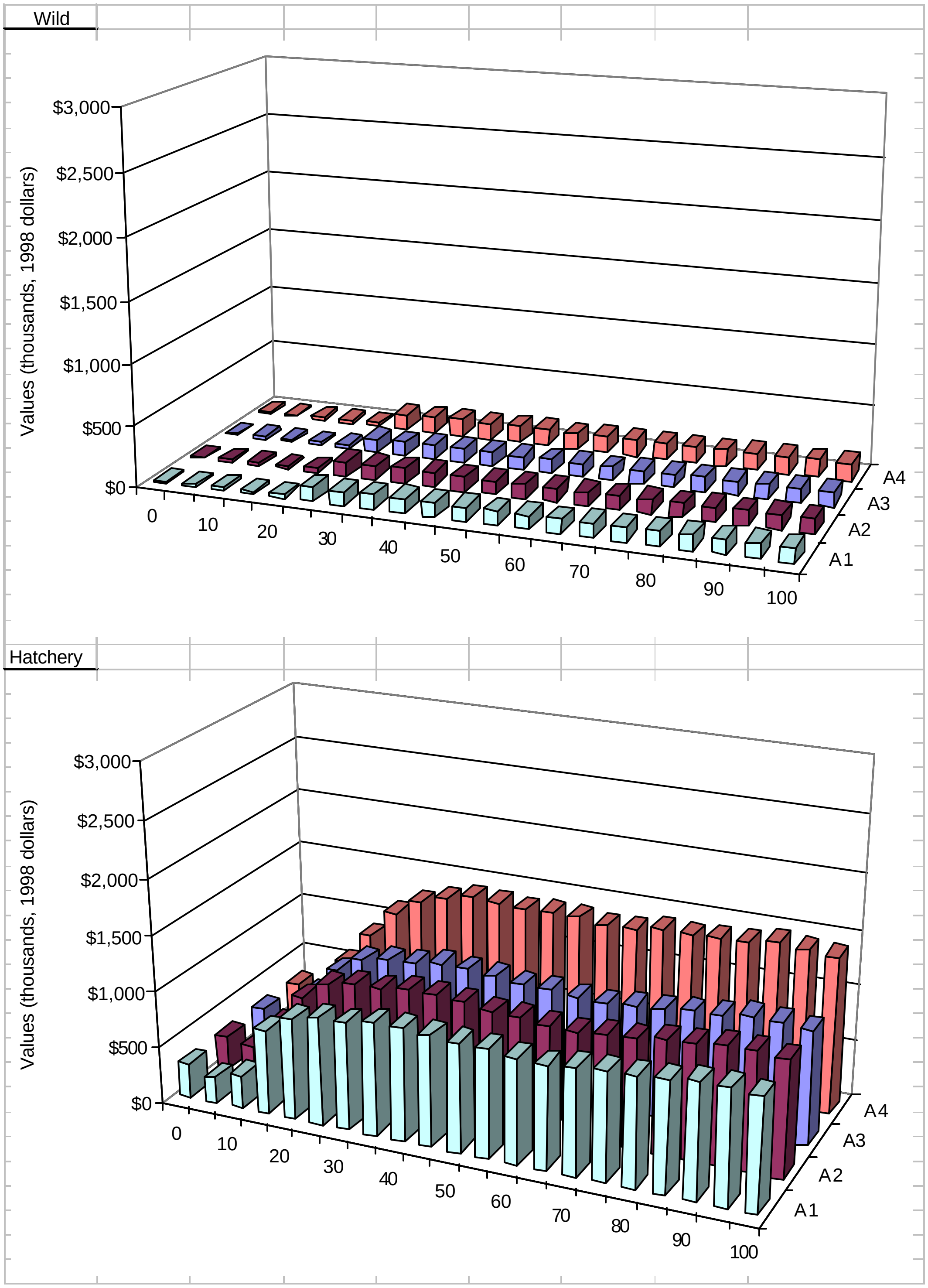
Figure 1.VI.2b
Economic Values (NED Benefits) for Fall Chinook
by Project Action Using “Likely” Modeling Results



Note: 1. Recreational inriver fisheries are excluded from the analysis.
2. NED benefits are based on PATH results fall chinook "base case" and spring/summer chinook "equal weights".

Source: Study.

Figure 1.VI.2c
Economic Values (NED Benefits) for Summer Steelhead
by Project Action Using "Likely" Modeling Results



Note: 1. Recreational inriver fisheries are excluded from the analysis.
2. NED benefits are based on PATH results fall chinook "base case" and spring/summer chinook "equal weights".

Source: Study.

CHAPTER VII. POTENTIAL ECONOMIC VALUES FOR FOUR CASES OF COLUMBIA RIVER BASIN ANADROMOUS FISH PRODUCTION AND HARVEST MANAGEMENT POLICIES

The recent low rate of returning wild spawners has raised concerns about maintaining and recovering wild anadromous fish species in the Snake River system. In broader context, the economic values that may be at risk, if major changes or curtailment take place in production and harvest management on the Snake River, are all harvests of Columbia River anadromous fish. To model the economic effects for this curtailment, four production and harvest management policy cases were used.[1] These policy cases ranged from present low run levels to double the runs experienced in the 1980's. The four cases were specifically designed to show a range of economic values (NED and RED benefits) that may be lost if a harvest curtailment occurs. Table 1.VII.1 describes the periods and assumptions used to devise the policy cases and describes the economic values. Figure 1.VII.1a and 1.VII.1b graphically show the economic values. The size of the fish in the graphic is proportionally correct to the economic value for each species.

The ability to harvest salmon has an important economic value to people of the Pacific Northwest and to the nation. Historically, salmon have been a part of the economy and culture of the people of the Pacific Northwest. To the Indians living along the Columbia River, salmon were their lifeblood, essential to their subsistence, their culture, and their religion. Salmon today also play an important part in the lives of most citizens of the Pacific Northwest. These values can be defined as option or existence values. These may be considerable, but are not included in these evaluations. The fishing values in this section only estimate commercial and recreational economic value of what may show up in economies. The economic value of non-use (option or existence value) placed on these fish runs may be much higher than the values that can be shown as contributing to economies.

The economic loss to the nation in lost economic value (NED benefits) would be as high as $160 million per year for the doubling the runs policy. Projecting over 100 years from what is at stake for anadromous fish production in the Columbia River Basin, the net-present-value at the current social discount rate used by the Corps may be as high as $2.0 billion (NED benefits). The regional economic impacts (RED benefits) from averaging the contribution from fisheries to economies wherever harvests occur in the 1980’s is $108 million (personal income, 1998 dollars) per year. The early 1990’s average dropped to $38 million per year. If it is possible to attain the NPPC’s goal for doubling the runs experienced in the 1980’s, then the regional economic impacts (RED benefits) may be as high as $233 million per year.

1. These four policy cases may be viewed as situations or goals for Columbia River anadromous fish management that could be at risk if salmon and steelhead recovery programs in the Columbia River Basin are not successful. The four policy cases have nothing to do with Snake River alternative hydrosystem actions. The four policy cases simply portray different situations that either have occurred in the past or hypothetically may occur in the future.

Table 1.VII.1
Potential Economic Values (RED and NED Benefits) Per Year For Four Cases of
Columbia River Basin Anadromous Fish Production and Harvest Management Policies

Policy Case	Assumptions	RED Benefits			NED Benefits
		Commercial	Recreational	Total	
I	Hatchery production at NMFS cap; SAR and harvests 30 yr historical average	$49.43	$33.36	$82.79	$55.33
II	Hatchery production, SAR, harvests at 1980's historical average	$60.45	$47.08	$107.53	$74.04
III	Policy for "doubling the runs;" SAR adjusted to meet policy using NMFS cap hatchery production	$131.69	$101.58	$233.27	$159.92
IV	Hatchery production, SAR, harvests early 1990's historical average	$24.04	$13.59	$37.63	$24.59

Notes:
1. RED and NED benefits measured per year in millions of 1998 dollars.
2. SAR is smolt-to-adult survival rate. Adults are harvests and returns to hatcheries for hatchery origin anadromous fish. Adults are harvests and spawners plus prespawning mortality for wild origin anadromous fish.
3. Commercial includes ocean treaty and non-treaty harvests from California to Alaska, inriver treaty and non-treaty harvests, and hatchery surplus sales. Recreational includes ocean, inriver mainstem, and inriver tributary.
4. Total and subtotals may not equal sum of values due to rounding.

Source: Study.

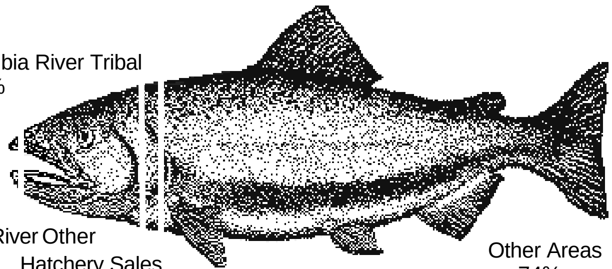
Another way of considering these policy cases' effects, is that it would be the value for eliminating most hatchery programs and thereby most harvesting of salmon and steelhead originating in the Columbia River Basin. The burden of these reductions would be felt all along the U.S. West Coast, Alaska, British Columbia and inland throughout the Columbia River Basin.

Columbia River Basin anadromous fish production has shifted from upper river wild origin stocks (upper river wild origin was estimated to be 77 percent of runs during pre-development time periods) to lower river hatchery origin stocks (upper river wild and hatchery origin is estimated to be 42 percent of runs in the 1980's). Production has changed from mostly wild spring and summer chinook (fall chinook estimated to be 14 percent pre-development run size) to hatchery fall chinook (hatchery origin fall chinook estimated to be 34 percent of 1980's hatchery and wild run size) and coho. The production by watersheds and stocks and the geographic areas receiving benefits from production are shown in Figure 1.VII.2. The Columbia River inland region only receives about 46 percent of the regional economic impacts (RED benefits) from Columbia River Basin production. Because fall chinook and coho have large ocean fisheries, the effect of shifting production to the lower river stocks has resulted in a

Figure 1.VI.1a
Net Economic Value (NED Benefits) in West Coast Geographic Areas Attributable to Columbia River Produced Salmon (Hatchery and Wild) Under Four Cases

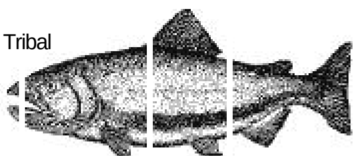
Net Economic Value: I NMFS Cap; II 1980's Average; III "Doubling of Runs"; IV Early 1990's

Coho



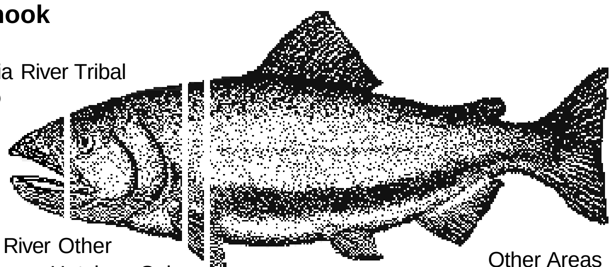
Total Smolts Released (millions)	Net Economic Value	
37.18	I.	$18.69
37.18	II.	$21.92
37.18	III.	$44.82
30.91	IV.	$5.55

Spring/Summer Chinook



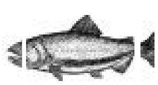
Total Smolts Released (millions)	Net Economic Value	
39.13	I.	$6.60
39.13	II.	$6.97
39.13	III.	$21.52
36.78	IV.	$1.85

Fall Chinook



Total Smolts Released (millions)	Net Economic Value	
227.60	I.	$23.56
227.60	II.	$29.49
227.60	III.	$64.72
200.22	IV.	$13.81

Steelhead



Total Smolts Released (millions)	Net Economic Value	
28.63	I.	$6.48
28.63	II.	$15.66
28.63	III.	$28.88
25.15	IV.	$3.39

Total

	Net Economic Value	
	I.	$55.33
	II.	$74.04
	III.	$159.92
	IV.	$24.59

Note: 1. NED benefits expressed in millions of 1998 dollars.

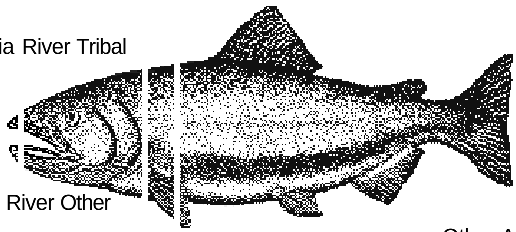
2. Columbia River other includes inriver commercial and recreational fisheries.
Source: Study.

Figure 1.VI.1b

Regional Economic Impacts (RED Benefits) in West Coast Geographic Areas Attributable to Columbia River Produced Salmon (Hatchery and Wild) Under Four Cases

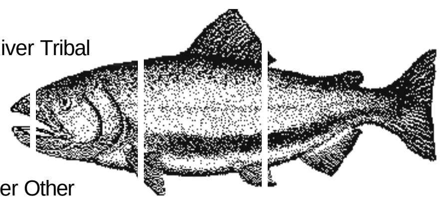
Total Personal Income: I NMFS Cap; II 1980's Average; III "Doubling of Runs"; IV Early 1990's

Coho



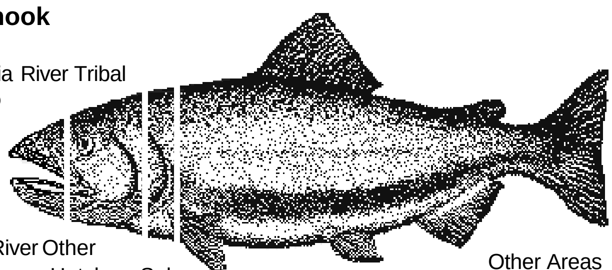
Case	Total Smolts Released (millions)	Total Personal Income
I.	37.18	$24.40
II.	37.18	$28.61
III.	37.18	$58.46
IV.	30.91	$7.25

Spring/Summer Chinook



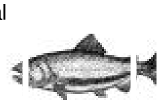
Case	Total Smolts Released (millions)	Total Personal Income
I.	39.13	$11.09
II.	39.13	$11.72
III.	39.13	$33.82
IV.	36.78	$3.03

Fall Chinook



Case	Total Smolts Released (millions)	Total Personal Income
I.	227.60	$40.25
II.	227.60	$50.18
III.	227.60	$109.08
IV.	200.22	$23.68

Steelhead



Case	Total Smolts Released (millions)	Total Personal Income
I.	28.63	$7.05
II.	28.63	$17.01
III.	28.63	$31.90
IV.	25.15	$3.67

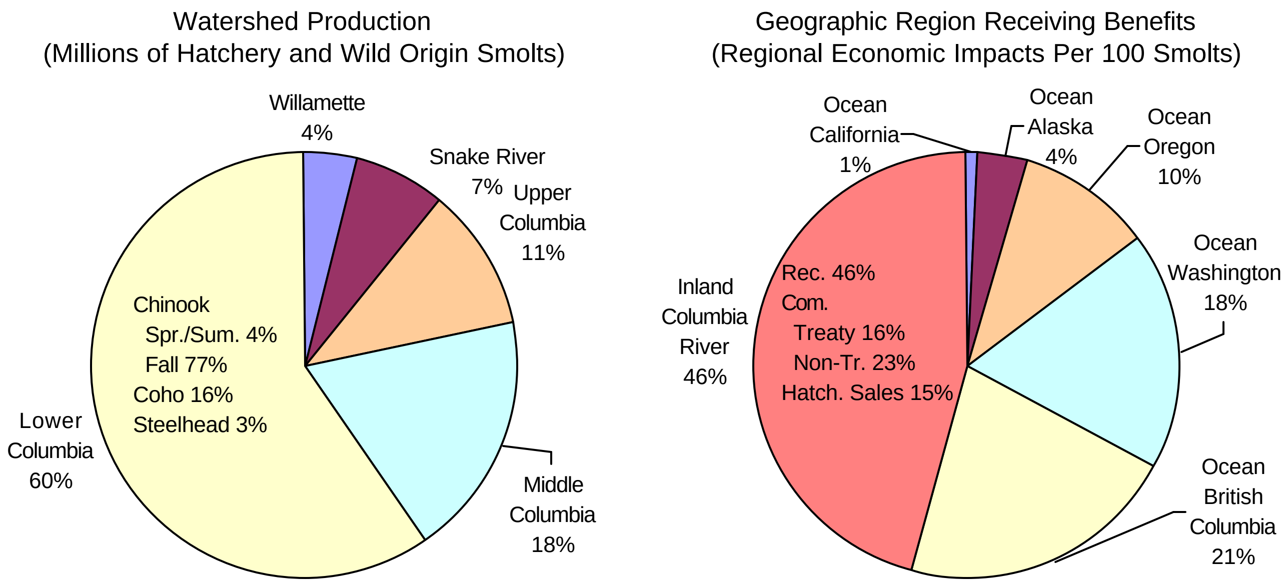
Total

Case	Total Personal Income
I.	$82.79
II.	$107.53
III.	$233.27
IV.	$37.63

Note:
1. RED benefits are expressed as personal income in millions of 1998 dollars.
2. Columbia River other includes inriver commercial and recreational fisheries.

Source: Study.

Figure 1.VII.2
Shares of Columbia River Basin Anadromous Fish Production and Geographic Regions Receiving Regional Economic Impacts (RED Benefits) From the Production



Notes: 1. Wild and hatchery origin smolt production is representative of the 1980's.
2. The regional economic impacts for the inland Columbia River region include inriver treaty and non-treaty commercial fisheries, inriver recreational fisheries, and hatchery return sales.

Source: NMFS (1995) and Study.

larger share of economic value from anadromous fish being exported out of the Columbia River inland region.

CHAPTER VIII. RISK AND UNCERTAINTY IN MODELING THE ECONOMIC VALUES

The economic values from the Columbia River Basin anadromous fish runs are determined using forecasted harvests throughout their migration routes. The actual harvestable fish depends on the productivity of the inland water system as well as the ocean system. Inland water system production factors can include harvesting methods, habitat alterations, hatchery production, hydrosystem operations, and ocean conditions. Strategies for recovery can address manmade factors, the more immediate remedies being harvesting methods, hydrosystem operations, and hatchery production. A short discussion of the variability in economic analysis results due to these remedy factors follows. The factors are explained in terms of markets, smolt-to-adult survival rates, and harvest management. Additional sections in this chapter discuss how the economic analysis results change based on using different PATH results' scenarios and a section about unresolved analysis issues is included.

Recreational inriver fisheries' economic values are included in the sensitivity analysis, since much of the discussion concerns effects of harvest management and the recreational inriver fishery is the highest contributor to economic values. The values may be different from those provided in the general recreation and tourism analysis for this fishery. However, this chapter is only to discuss sensitivity of results. Therefore, the change to the fishery's economic value should be relatively proportional, no matter what the estimated value.

A. Markets

1. Commercial Fishing

For centuries, salmon have sustained the people of the Pacific Northwest. They were an important food source, cultural symbol, and means of trade for American Indians. As western development took place, salmon runs provided jobs and income to harvesters, cannery workers, and related industries throughout the region. As water based economic development took place in the Pacific Northwest, natural based production was supplemented by artificial propagation.

Artificial propagation was at first limited to egg incubation. For some salmon species, in order to increase egg-to-adult survival rates, the propagation process included fry and later smolt releases. Smolt production may cost $0.50 to $1.00 per smolt. The high cost of smolt production combined with low overall survival rates of free ranging salmon (salmon ranching) has led to growing salmon in cages (salmon farming) where smolts will survive at about 80 to 90 percent. The farming process is now producing about 50 percent of the world salmon market. The price of salmon for the fresh and frozen market is now generally set by farmed salmon. These prices are dependent on markets but also on the main ingredient in farming salmon, the feed costs. There are a range of substitutes available; therefore, no dramatic changes are expected in the price level of commercial salmon produced from the Columbia Basin.

More variation may be expected in utilization of a substantial portion of the anadromous fish that return as "surplus" and are not harvested. For wild fish, this is presently not a problem. However, in some cases, returns to hatcheries over and above what is needed for propagation are a resource that could provide additional benefits to the Pacific Northwest region.

According to lower Columbia River processors, about 50 percent of the fall returning fish and 100 percent of the summer returning fish could be utilized for developed markets (personal communication with processor facility operators, April 1999). Development of markets would include the traditional fresh and frozen markets, as well as value added products, such as ready to purchase fillet steaks and ready to eat portions. Other specialty products may also include canned and smoked products. Egg production for the Japanese market may also have a significant potential (Radtke and Davis, January 1996).

The model's existing assumptions assume 50 percent of hatchery return surplus goes to egg and carcass sales and 50 percent for food fish. The change in analysis results for hydrosystem actions for developed markets (zero percent carcass sales and 100 percent utilization for food fish) is about a $180 thousand gain in NED AAEV for Action A4 (Table 1.VIII.1 and Figure 1.VIII.1). This would only be about a one percent NED AAEV increase with the higher utilization. Changing the analysis results for a zero percent hatchery utilization results in a $400 thousand loss in NED AAEV for Action A4.

Without any hatchery utilization for food fish, the benefits under the four policy cases analyzed for the entire Columbia River Basin range from $35.7 to $220.4 million in regional economic impacts and $23.4 to $152.3 million in net economic value (Table 1.VIII.2). These benefits would be increased ($38.2 to $239.7 million in personal income; $24.9 to $163.6 million in net value) by developing products and markets to utilize 50 percent of the fall fish and 100 percent of the spring/summer fish.

2. Recreational Angling

Since World War II, there has been a steady increase in outdoor activity in the West. Between 1945 and the early 1970's, recreation activity on public lands grew by more than 10 percent per year, driven by rapid population growth, increased affluence, improvements in cars and interstate highways, decreased real gasoline prices, increased air travel, and the decline of the average work week to 40 hours and five days (Walsh 1986).

Population growth and the proportion of that population having a degree of affluence are the most significant factors contributing to the increases in recreation activity (English et al. 1993). The significant population increases expected for the West indicated major increases in recreation activity related to public resources (Haynes and Horne, April 1996).

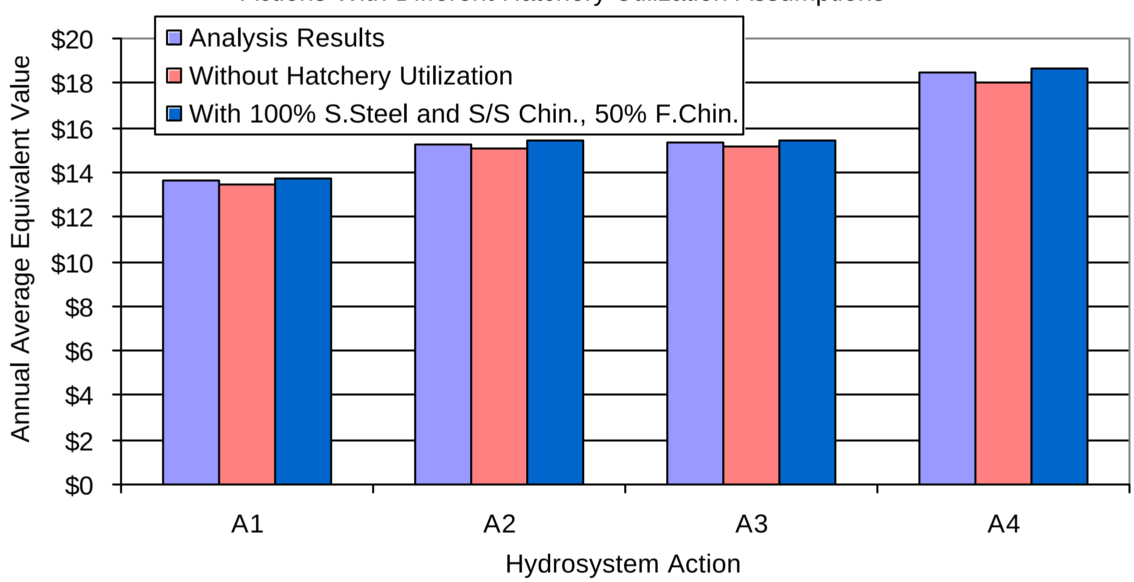
In general, the assumption of one fish per day is used in this evaluation of the benefits of recreational angling in ocean fishing. Past studies of ocean salmon fishing suggest the success of one fish per day is a reasonable representation of historical trends. Since salmon/steelhead fishing has been curtailed inland during the last few years, no clear studies of motivation

Table 1.VIII.1
Annualized Economic Value (NED Benefits) For Alternative Hydrosystem Actions With Different Hatchery Utilization Assumptions

	Hydrosystem Action			
Category	A1	A2	A3	A4
Analysis Results				
AAEV	$13.59	$15.27	$15.33	$18.46
Hatchery Utilization: 0% for Steelhead, Spring/Summer Chinook, and Fall Chinook				
AAEV	$13.49	$15.10	$15.17	$18.05
Difference from analysis results	($0.10)	($0.16)	($0.15)	($0.41)
Hatchery Utilization: 100% for Steelhead and Spring/Summer Chinook and 50% for Fall Chinook				
AAEV	$13.68	$15.41	$15.46	$18.64
Difference from analysis results	$0.09	$0.14	$0.13	$0.18

Note: NED benefits measured by annual average equivalent value over a 100 year project life in millions of 1998 dollars.
Source: Study.

Figure 1.VIII.1
Annualized Economic Value (NED Benefits) For Alternative Hydrosystem Actions With Different Hatchery Utilization Assumptions



Note: NED benefits measured by annual average equivalent value over a 100 year project life in millions of 1998 dollars.
Source: Study.

Table 1.VIII.2
Economic Value Per Year Generated Under Four Production and Harvest Management Cases With Different Hatchery Utilization Assumptions

	I. NMFS Cap	II. 1980's Average	III. "Doubling of Runs"	IV. Early 1990's
Analysis Results				
Regional economic impacts	$82.8	$107.5	$233.3	$37.6
Net economic value	55.3	74.0	159.9	24.6
Without Hatchery Utilization				
Regional economic impacts	76.8	100.0	220.4	35.7
Net economic value	51.8	69.6	152.3	23.4
Difference analysis results impacts	(6.0)	(7.5)	(12.9)	(2.0)
Difference analysis results value	(3.5)	(4.4)	(7.6)	(1.2)
With 100% Hatchery Utilization for Steelhead and Spring Chinook and 50% for Fall Chinook and Coho				
Regional economic impacts	86.1	111.7	239.7	38.2
Net economic value	57.1	76.4	163.6	24.9
Difference analysis results impacts	3.3	4.1	6.5	0.6
Difference analysis results value	1.8	2.3	3.7	0.3

Note: Regional economic impacts and net economic value in millions of 1999 dollars.
Source: Study.

factors, such as fishing success rates needed to attract anglers, have been completed. The ODFW utilizes a one fish per day success rate for ocean fishing and up to two days per fish success rates for inland fishing (personal communication, Chris Carter, ODFW, March 1999). The State of Idaho conducts annual surveys of anglers (Bowler, July 1999). For tributaries above the Columbia River/Snake River confluence, a two days per fish success rate for wild, non-retained, and hatchery retained fish has been experienced. For retained steelhead only, the days per fish ratio has been 5.88. A study by Reading (1999) suggests that in Idaho the average success rate for anadromous fish is one fish for about 6.5 days of fishing. Future demand for outdoor recreation suggests that a success rate of as low as 10 days per fish may be enough to attract anglers to fish for anadromous fish in some inland waters.

Using a range of success rates or catch per unit effort (CPUE) provides a wide range of potential benefits related to the anadromous resources of the Columbia Basin. The change in analysis results for hydrosystem actions is considerable. Changing to a success rate of three days per fish slightly lowers the NED AAEV benefits (Table 1.VIII.3 and Figure 1.VIII.2), because model assumptions use a tributary summer steelhead CPUE of 5.88 in Year 0 trended to a CPUE of two over 30 years. Changing the success rate to 10 days per fish increases NED AAEV benefits by about double.

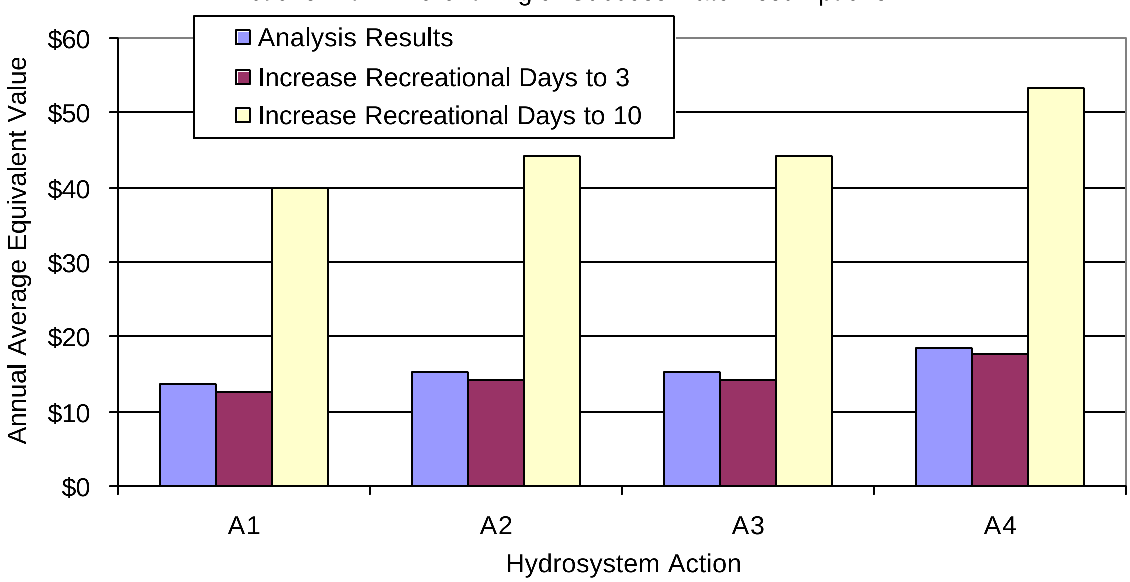
Lowering the success rates from the base case of one day per fish in the ocean and up to two days per fish in the river to three or 10 days increases the benefits substantially (Table 1.VIII.4) for the four policy cases analyzed for the Columbia River Basin. An increase to

Table 1.VIII.3
Annualized Economic Value (NED Benefits) For Alternative Hydrosystem Actions with Different Angler Success Rate Assumptions

	Hydrosystem Action			
Category	A1	A2	A3	A4
Analysis Results				
AAEV	$13.59	$15.27	$15.33	$18.46
Recreational Inland: Success Rate 3				
AAEV	$12.64	$14.08	$14.10	$17.78
Difference from analysis results	($0.95)	($1.18)	($1.23)	($0.68)
Recreational Inland: Success Rate 10				
AAEV	$39.82	$44.25	$44.29	$53.24
Difference from analysis results	$26.22	$28.99	$28.96	$34.78

Note: NED benefits measured by annual average equivalent value over a 100 year project life in millions of 1998 dollars.
Source: Study.

Figure 1.VIII.2
Annualized Economic Value (NED Benefits) For Alternative Hydrosystem Actions with Different Angler Success Rate Assumptions



Note: NED benefits measured by annual average equivalent value over a 100 year project life in millions of 1998 dollars.
Source: Study.

Table 1.VIII.4
Economic Value Per Year Generated Under Four Production and Harvest Management Cases With Different Angler Success Rate Assumptions

	I. NMFS Cap	II. 1980's Average	III. "Doubling of Runs"	IV. Early 1990's
Analysis Results, Success Rate 1				
Regional economic impacts	$82.8	$107.5	$233.3	$37.6
Net economic value	55.3	74.0	159.9	24.6
Increase Recreational Inland Success Rate to 3				
Regional economic impacts	94.4	125.0	271.3	42.5
Net economic value	65.6	89.9	194.2	29.0
Difference analysis results impacts	11.6	17.4	38.1	4.9
Difference analysis results value	10.3	15.8	34.3	4.4
Increase Recreational Inland Success Rate to 10				
Regional economic impacts	152.0	219.0	477.8	67.9
Net economic value	117.5	176.6	382.9	52.2
Difference analysis results impacts	69.3	111.5	244.5	30.3
Difference analysis results value	62.2	102.6	222.9	27.6

Notes: 1. Regional economic impacts and net economic value in millions of 1999 dollars.
2. Success rate expressed as days per fish.
Source: Study.

three days per fish for all recreational fisheries may increase the personal income generated to $271.3 million ($194.2 million in net economic value). An increase to 10 days per fish increases these potential numbers to $477.8 million and $382.9 million. This is about two times the benefit from all harvests that is presently generated or what may be potentially generated under the four policy cases.

B. Smolt-to-Adult Survival Rates

Smolt production and resulting adult harvests are the base for evaluating fishery benefits. The four policy cases evaluated for the entire Columbia River Basin included best estimates of survival rates experienced for a 30 year average (Case I), 1980's average (Case II), and the early 1990's (Case IV). Case III uses a hypothetical survival rate necessary to double harvests when hatchery production is at the NMFS cap. The 1980's actual runs survival rates could be considered the base (Table 1.VIII.5). The increased survival rates needed for the "doubling of the runs" objective may come from increased survival rates of hatchery and wild fish or from increasing runs of wild fish. The survival rates of the 1990's have generally been about one half to one third of what the runs were in the 1980's and are only about 15 to 30 percent of what they need to be to achieve the doubling of the runs objective.

Table 1.VIII.5
Smolt-to-Adult Survival Rate Assumptions Used For Four Cases of
Production and Harvest Management Policy in the Columbia River Basin

	Snake River	Upper Columbia	Middle Columbia	Lower Columbia	Willamette	Weighted Average
Coho						
I. NMFS Cap (1970's-1990's Actual)	NA	1.20%	1.20%	2.50%	1.20%	2.33%
II. 80's Actual Runs	NA	1.49%	1.49%	2.90%	1.49%	2.72%
III. Run Doubling Objective	NA	2.98%	2.98%	5.80%	2.98%	5.43%
IV. Early 90's Runs	NA	0.15%	0.15%	1.00%	0.40%	0.90%
Spring/Summer Chinook						
I. NMFS Cap (1970's-1990's Actual)	0.37%	0.37%	0.37%	0.97%	0.97%	0.65%
II. 80's Actual Runs	0.39%	0.39%	0.39%	1.01%	1.02%	0.69%
III. Run Doubling Objective	0.79%	0.79%	0.79%	2.03%	2.04%	1.37%
IV. Early 90's Runs	0.10%	0.10%	0.10%	0.35%	0.35%	0.22%
Fall Chinook						
I. NMFS Cap (1970's-1990's Actual)	0.60%	0.60%	0.60%	0.32%	NA	0.41%
II. 80's Actual Runs	0.73%	0.73%	0.73%	0.38%	NA	0.49%
III. Run Doubling Objective	1.45%	1.45%	1.45%	0.77%	NA	0.99%
IV. Early 90's Runs	0.40%	0.40%	0.40%	0.25%	NA	0.30%
Steelhead						
I. NMFS Cap (1970's-1990's Actual)	0.70%	0.70%	0.70%	0.40%	0.40%	0.62%
II. 80's Actual Runs	1.56%	1.56%	1.56%	0.89%	0.89%	1.38%
III. Run Doubling Objective	3.11%	3.11%	3.11%	1.78%	1.78%	2.76%
IV. Early 90's Runs	0.50%	0.50%	0.50%	0.20%	0.20%	0.42%

Notes:
1. Rates expressed as representative percents of hatchery reared smolts released divided by adults contributing to fisheries plus adults returning to hatcheries. Survival rates are best estimates based on information provided by the "Annual Coded Wire Program - Missing Production Groups" annual reports (Fuss et al. 1994 and Garrison et al. 1995).
2. Survival rate assumptions for the "Run Doubling Objective" case are the survival rates that would be required to meet the objectives.

Source: Study.

There are indications that ocean conditions during the last decade have been poor, as far as anadromous fish survival. Ocean conditions are, however, only one of several natural and human caused factors that affect total survival. In the period 1996-1998, up to 195 million hatchery smolts were released in the Columbia Basin system. In addition, another 136 million wild smolts were produced. Therefore, about 331 million smolts per year entered the Columbia Basin. Out of this total, about 100 million smolts entered the Columbia estuary (Pollard, April 1999). This is a 70 percent loss of smolts in the upriver system. In the lower estuary, avian predation accounts for significant mortality. "If the level of avian predation in 1999 is again in the 12 to 35 million range . . ." (Pollard, April 1999), then up to 80 percent of smolts produced in the Columbia system would have died before entering the ocean system.

In order to produce the harvestable numbers of the 1980's, an overall ocean survival rate of four percent would be required. In order to reach the "doubling of runs" objective, a 7.5 percent ocean survival rate would be required. There is speculation, based on limited research, that wild fish survive at higher rates. One study suggests that wild fall chinook in the lower Columbia River survive "at an average rate that may be as high as 12 times greater than the average of Columbia River hatchery stocks" (McIsaac 1990). A recovery plan for wild fish, that also will increase downstream passage survival of hatchery smolt production, would have to result in total harvestable numbers evaluated under the "doubling of the runs" scenario.

The PATH results did not generate SAR's as modeled outputs. It was possible to generate an indicator SAR using the five year increment outputs of harvests and spawners. These SAR's are referenced as indicator rates because insufficient information about age-structures, interdam mortality, and other factors was available to determine a more precise rate. The wild component indicator SAR's by species and hydrosystem action are shown in Table 1.VIII.6. The wild component indicator SAR's are not exactly comparable to hatchery component SAR's mentioned above, but generally show the large increase necessary to attain the PATH results' forecasted spawners. In general, there must be a seven fold increase in the indicator SAR's for spring/summer chinook and a two to three fold increase for fall chinook between the initial Project years and at Project Year 50, in order for spawners to be at the forecasted level. Obviously, economic values will be significantly affected by a lesser improvement.

Table 1.VIII.6
Wild Smolt-to-Adult Survival Indicator Rates by Species and
by Hydrosystem Actions for Selected Project Years

	Survival Rate Indicators	
	Project Year 5	Project Year 50
Spring/Summer Chinook		
A1	0.468%	4.422%
A2	0.514%	4.495%
A3	0.537%	4.788%
A4	0.557%	10.850%
Fall Chinook		
A1	1.889%	7.195%
A2	1.889%	7.195%
A3	1.877%	8.385%
A4	0.940%	30.850%
Summer Steelhead		
A1	0.173%	1.636%
A2	0.190%	1.663%
A3	0.199%	1.772%
A4	0.206%	4.014%

Note: Project year survival rate indicators are adult spawners and pre-spawning mortality plus harvest divided by smolts produced five years previous expressed as a percent.

Source: Study and Petrosky and Schaller (1998).

C. Harvest Management

1. Hatchery Production

It is assumed that hatchery management is based on past mitigation agreements and that hatchery release goals are defined by the present NMFS cap on hatchery releases. The role of supplementation hatcheries is not specifically included in the evaluation.

If natural resource based recreation increases as discussed earlier, a challenge to management may be to convert hatchery surplus to inland recreational angling. The interplay between the conversion of hatchery surplus to recreational fishing and using different CPUE is shown in Table 1.VIII.7 and Figure 1.VIII.3. The CPUE, expressed as days per fish, generally decreases with increasing abundances. This is because increasing abundances generally mean harvest management will allow a more liberal bag limit (i.e., five fish per week rather than two). If the CPUE is changed to be slightly lower than the existing analysis, shifting hatchery surpluses will increase NED AAEV by about 40 percent.

The allocation shift may increase regional annual personal income as much as $541.4 million ($499.9 million in net economic value) for the entire Columbia River Basin production (Table 1.VIII.8). This, of course, assumes that hatchery surplus fish may be caught without affecting other objectives, such as endangered species recovery.

Making hatchery surplus Snake River stocks available to recreational anglers will similarly have a large effect (Table 1.VIII.8). Regional economic impacts would double at success rates of one day per fish and be 15 times higher at success rates of 10 days per fish.

Under the NMFS cap, hatchery releases are to be below 197 million smolts per year. "The total hatchery production in 1999 is projected to be in the range of 140 to 150 million smolts, down from the 185 to 195 million range of 1996 to 1998 releases. These reductions are due to ESA concerns, fiscal cutbacks and the failure of some hatchery programs to receive sufficient spawning escapement in the last two years." (Pollard, April 1999). This is in effect a 25 percent reduction in hatchery releases. Unless wild fish production increases, a reduction of about 25 percent in economic benefits could be anticipated if this reduction in hatchery releases continues. The other expectation may be that decreased hatchery releases increases wild fish survival and that the reduction in hatchery releases increases the number of returning wild spawners, which in turn increases overall production.

2. User Group Allocations

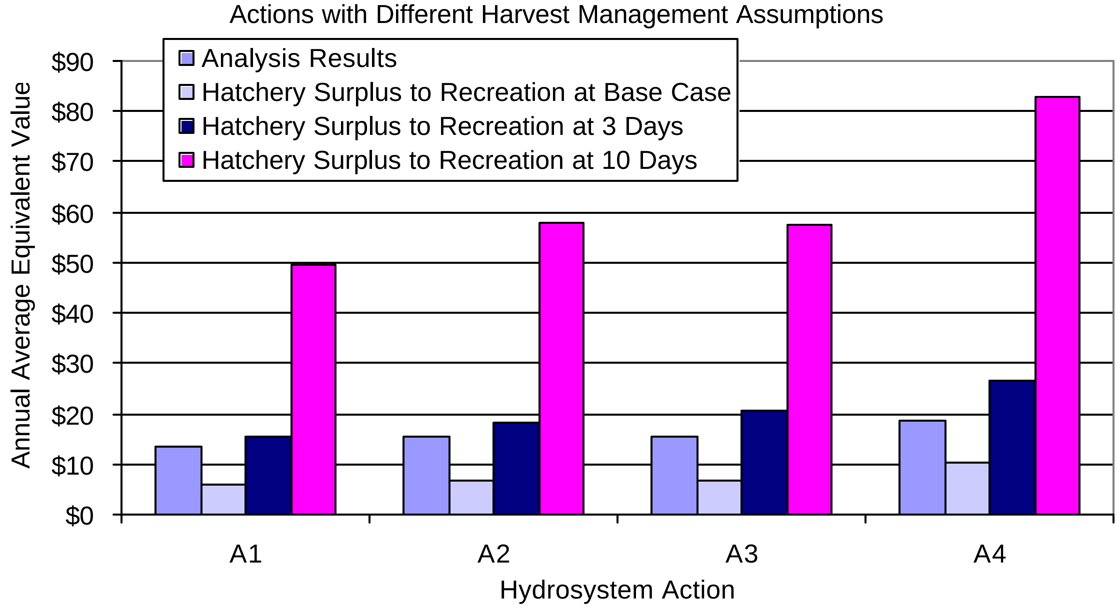
There are a host of salmon treaties and agreements that affect salmon of the Columbia River system. This report assumes that international and treaty agreements will not change. Under the four scenarios, the allocation to any of the historical harvesters changes only if spawning requirements and treaty obligations are met. There are no treaties on allocation of salmon harvests between commercial and recreational harvesters, only user group allocation

Table 1.VIII.7
Annualized Economic Value (NED Benefits) For Alternative Hydrosystem Actions with Different Harvest Management Assumptions

	Hydrosystem Action			
Category	A1	A2	A3	A4
Analysis Results				
AAEV	$13.59	$15.27	$15.33	$18.46
Convert Hatchery Surplus to Inland Recreational: Success Rate 1				
AAEV	$5.75	$6.66	$6.64	$10.22
Difference from analysis results	($7.85)	($8.60)	($8.69)	($8.24)
Convert Hatchery Surplus to Inland Recreational: Success Rate 3				
AAEV	$15.49	$18.04	$20.71	$26.40
Difference from analysis results	$1.90	$2.78	$5.38	$7.94
Convert Hatchery Surplus to Inland Recreational: Success Rate 10				
AAEV	$49.59	$57.88	$57.49	$83.05
Difference from analysis results	$35.99	$42.61	$42.16	$64.59

Note: NED benefits measured by annual average equivalent value over a 100 year project life in millions of 1998 dollars.
Source: Study.

Figure 1.VIII.3
Annualized Economic Value (NED Benefits) For Alternative Hydrosystem Actions with Different Harvest Management Assumptions



Note: NED benefits measured by annual average equivalent value over a 100 year project life in millions of 1998 dollars.
Source: Study.

Table 1.VIII.8
Economic Value Per Year Generated Under Four Production and Harvest Management Cases With Different Harvest Management Assumptions

	I. NMFS Cap	II. 1980's Average	III. "Doubling of Runs"	IV. Early 1990's
Analysis Results				
Regional economic impacts	$82.8	$107.5	$233.3	$37.6
Net economic value	55.3	74.0	159.9	24.6
Convert Hatchery Surplus to Inland Recreation at Base Case Success Rate				
Regional economic impacts	95.4	127.2	271.7	41.9
Net economic value	68.6	94.7	199.8	28.9
Difference analysis results impacts	12.6	19.7	38.5	4.2
Difference analysis results value	13.3	20.7	39.9	4.3
Convert Hatchery Surplus to Inland Recreation at Success Rate 3				
Regional economic impacts	122.9	166.2	352.5	51.9
Net economic value	93.1	130.0	272.7	37.9
Difference analysis results impacts	40.2	58.7	119.3	14.2
Difference analysis results value	37.7	56.0	112.8	13.3
Convert Hatchery Surplus to Inland Recreation at Success Rate 10				
Regional economic impacts	259.1	371.5	774.6	102.2
Net economic value	215.8	319.0	659.8	83.7
Difference analysis results impacts	176.3	263.9	541.4	64.6
Difference analysis results value	160.5	245.0	499.9	59.1

Notes: 1. Regional economic impacts and net economic value in millions of 1999 dollars.
2. Success rate expressed as days per fish.

Source: Study.

agreements. Any future reallocation of such harvests may result in a shift of economic benefits between users or regions, and may also change the total benefits generated.

The situation for shifting Snake River production between user groups is complicated because of the overriding influence of summer steelhead contributions to fisheries. There is very little non-treaty commercial use for steelhead. Spring/summer chinook do not have a significant ocean commercial fishery and have not had a viable river gillnet fishery since the late 1980's. Therefore, converting all species from recreational to commercial fisheries will have little effect for increasing economic values from commercial fisheries (Table 1.VIII.9 and Figure 1.VIII.4).

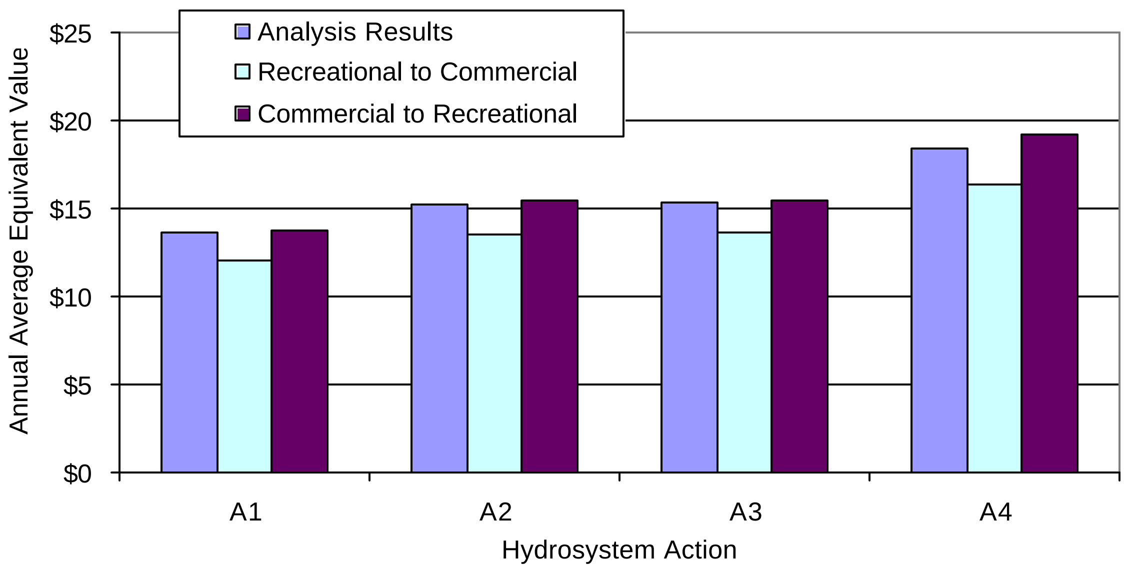
A total allocation from recreational harvest to commercial may decrease personal income generated in the region between $8.1 million and $64.7 million (net economic value from $9.2 to $71.6 million) for the entire Columbia River Basin production (Table 1.VIII.10). A shift from commercial to recreational use (assuming a one fish per day success rate) may increase annual regional economic impacts by $7.3 to $55.1 million (net economic value from $13.1 to $80.3 million) for the entire Columbia River Basin production.

Table 1.VIII.9
Annualized Economic Value (NED Benefits) For Alternative Hydrosystem Actions With Different User Group Allocations

Category	Hydrosystem Action A1	A2	A3	A4
Analysis Results				
AAEV	$13.59	$15.27	$15.33	$18.46
Convert Recreational to Commercial				
AAEV	$12.02	$13.54	$13.60	$16.34
Difference from analysis results	($1.58)	($1.73)	($1.72)	($2.12)
Convert Commercial to Recreational				
AAEV	$13.73	$15.41	$15.49	$19.24
Difference from analysis results	$0.14	$0.15	$0.16	$0.78

Note: NED benefits measured by annual average equivalent value over a 100 year project life in millions of 1998 dollars.
Source: Study.

Figure 1.VIII.4
Annualized Economic Value (NED Benefits) For Alternative Hydrosystem Actions With Different User Group Allocations



Note: NED benefits measured by annual average equivalent value over a 100 year project life in millions of 1998 dollars.
Source: Study.

Table 1.VIII.10
Economic Value Per Year Generated Under Four Production and Harvest Management Cases With Different User Group Allocations

	I. NMFS Cap	II. 1980's Average	III. "Doubling of Runs"	IV. Early 1990's
Analysis Results				
Regional economic impacts	$82.8	$107.5	$233.3	$37.6
Net economic value	55.3	74.0	159.9	24.6
Convert Recreational to Commercial				
Regional economic impacts	61.7	75.2	168.6	29.5
Net economic value	32.3	39.5	88.3	15.3
Difference analysis results impacts	(21.1)	(32.3)	(64.7)	(8.1)
Difference analysis results value	(23.0)	(34.6)	(71.6)	(9.2)
Convert Commercial to Recreational				
Regional economic impacts	104.2	133.2	288.4	44.9
Net economic value	86.7	111.6	240.2	37.6
Difference analysis results impacts	21.4	25.6	55.1	7.3
Difference analysis results value	31.3	37.6	80.3	13.1

Note: Regional economic impacts and net economic value in millions of 1999 dollars.
Source: Study.

D. PATH Results' Scenarios

The PATH process developed a large set of simulations based on different harvest management, smolt-to-adult survival rates, and other modeling factors. The combinations of assumptions were categorized under several scenario titles, including "equal weights" and "experts." The latter refers to a panel of four experts (called the Science Review Panel or SRP), which provided weights to seven different hypotheses about life-cycle modeling factors (Marmorek and Peters 1998). Each of the four simulations that resulted from the weighting was averaged to be the mean-of-expert results. The PATH results' scenario for mean-of-expert only applies to spring and summer chinook. The NMFS suggests that the expert panel approach be disregarded in favor of using new data and standard statistical methods (NMFS, April 1999, p.11).

The simulations made to satisfy the weighting schemes by the SRP were greatly anticipated, because the research would be used to validate or reject the PATH process. While the mean-of-expert scenario is not used in the analysis, the scenario can be useful for showing the range that occurs when using a different base to calculate the economic consequences. Table 1.VIII.11 shows the NED AAEV for the fall chinook base case scenario and spring and summer chinook mean-of-experts scenario. The equal weights scenario results have slightly higher changed NED AAEV for most hydrosystem actions.

Table 1.VIII.11
Changed Annualized Economic Value (NED Benefits) Between Base Case and Other Hydrosystem Actions Using Different PATH Scenarios

PATH Scenerio/ Hydrosystem Action	Discount Rates 0% Amount	Order	4 6/8% Amount	Order	6 7/8% Amount	Order
AAEV Equal Weights						
A2 less A1	$0.97	2	$1.56	3	$1.67	3
A3 less A1	$0.86	3	$1.59	2	$1.73	2
A4 less A1	$8.65	1	$5.81	1	$4.87	1
AAEV Mean of Experts						
A2 less A1	-$0.64	3	-$0.35	3	-$0.26	3
A3 less A1	-$0.04	2	$0.40	2	$0.51	2
A4 less A1	$8.36	1	$5.35	1	$4.35	1
Difference						
A2 less A1	$1.61		$1.92		$1.93	
A3 less A1	$0.90		$1.19		$1.22	
A4 less A1	$0.30		$0.46		$0.51	

Notes: 1. NED benefits measured by annual average equivalent value over a 100 year project life in millions of 1998 dollars.
2. Negative values mean the base case (Action A1) benefits are greater than the hydrosystem actions being compared.

Source: Study.

The hydrosystem action ranking from highest values to lowest values does change with the mean-of-expert simulations. For the zero percent discount rate, Actions A3 and A2 reverse order with the mean-of-expert scenario. The dam breaching action (Action A4) is the highest order for both scenarios.

E. Unresolved Issues

There were several data, model development, and research coordination issues remaining to be resolved at the time of this report's completion. These issues included the following.

- PATH result releases. The PATH results used in this report's analysis were based on the most recent available. The PATH is continuing to investigate the effects of hydrosystem actions and new PATH results are forthcoming. The new results will reflect improve modeling assumptions and methods.
- Fish forecast modeling procedures used to expand PATH results. PATH information for calculated SAR and Year 0 may be available in future PATH result releases. This information will preclude some study modeling assumptions used in this report for these

factors. Some analysts have commented that the assumptions for starting SAR's and Year 0 abundances using the most recent ten year period that complete information is available (1986 to 95) is too high. Other analysts commented that, with a 100 year forecast horizon, a longer period base average was required.

- PATH result scenarios. The analysis for this report and the analysis for the recreation and tourism report used the PATH spring and summer chinook scenario results called "equal-weights." The analysis for tribal circumstances used the PATH spring and summer chinook scenario results called "mean-of-experts." Some analysts argue that PATH results based on the expert opinions about key PATH model assumptions reflects better science and should be used by all researchers. The NMFS (1999) recommends that the expert opinion PATH results be disregarded.
- Economic methods used to evaluate fisheries. For estimating net economic value for commercial harvests, the analysis for this report relies on an accepted approach used by other agencies. The PFMC and others use a percentage of the ex-vessel value as a proxy. There is disagreement among analysts on what the size of this percentage should be. If the amount of additional fish that can be harvested is small, then it could be harvested with no additional effort or capacity to the commercial fishery. In this situation, then 100 percent of the ex-vessel value represents the net economic value. However, if the additional amount of fish made available by the project causes fishermen to use more fuel, labor, or other factors of production, then some lower percentage of ex-vessel value should be used as a proxy for net economic value. The analysis used in this report assumes a 70 percent ex-vessel value as a proxy to account for contribution from the harvest sector, processing sector, and other affected businesses. However, some analysts argue that the percentage should be higher to account for the use of labor from areas such as tribal areas where there are high levels of unemployment, because the opportunity cost of such labor is zero. In such instances, relationships would have to be made specific to each fishery (troll, gillnet, non-tribal and tribal).
- Coordination with the recreation and tourism analysis. The analysis for general recreation and tourism used different data and methods. The results may not be directly transferable for comparison or roll-up to results presented in this report. In particular, the recreational and tourism analysis assumptions concerning angler trip length, trip expenditures, success rates, and angler day benefits are different. The general recreation and tourism analysis also assumes success rates are steady state (do not vary with increasing run sizes) and it is assumed that survey results applicable to the lower Snake River area apply to mainstem Columbia River recreational fishing. Better alignment of anadromous fish analysis and general recreation and tourism analysis could be achieved with adjustments to the angler motivation and choice modeling variables, geographic study areas, and data used for model specification.
- Expressing economic values. The analysis used in this report contains calculated regional economic impacts (RED benefits) for Pacific Northwest states, British Columbia, and Alaska. Other analysis calculates regional economic impacts (RED benefits) associated with inland counties. The two are not additive. To avoid confusion, there needs to be consistent geographic resolution between the analyses.

- Future fisheries management regimes. This report's analysis is based on current management regimes in determining harvest levels, fishery effects, and allocations among user groups. Several treaties, court decisions, and other governance understandings are being considered for changes. For example, the PST is currently being negotiated. It is expected that this treaty will soon be adopted, and accordingly, that the results of the PST should be incorporated into this report's analysis.
- Treaty harvest rights. This report's harvest forecast distributional assumptions for ocean and inriver treaty commercial fisheries includes ceremonial and subsistence (C&S) harvests. There is concern that double counting may result if C&S harvests are itemized in separate tables in other analyses.

Unresolved issues when related research is being undertaken by separate researchers is not uncommon. Based on further discussion between researchers and comments from the public, appropriate analytical revisions may need to be completed to make results consistent across all study elements.

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PART 2

OVERVIEW OF ANADROMOUS FISH PRODUCED IN THE COLUMBIA RIVER BASIN AND ECONOMIC EVALUATION METHODS

CHAPTER I. INTRODUCTION

The U.S. Army Corps of Engineers (Corps) has initiated a study to examine the engineering, economic, social, and biological effects of alternative hydrosystem actions for operating the four Corps dams on the lower Snake River for improved salmon migration. The four dams are Lower Granite, Little Goose, Lower Monumental, and Ice Harbor located in southeast corner of the State of Washington. This report only provides information about one aspect of the effects of the alternative hydrosystem actions. The report describes the economic evaluation expressed as regional economic impacts, or the Regional Economic Development (RED) accounting stance used by the Corps, and net economic values, or the National Economic Development (NED) accounting stance used by the Corps, from changes to harvests of anadromous fish originating in the Snake River Basin due to alternative hydrosystem actions. Discussion is also offered in this report for the economic values from harvesting anadromous fish produced in the entire Columbia River Basin. The other Corps reports for economic, social, and biological effects are referenced as needed.

This report is organized in four parts for the convenience of the reader. Part 1 contains an abstract, the executive summary, the risks and uncertainties in results for changing analysis assumptions, and references cited in all parts.

Part 2 contains background information about how to accomplish an economic evaluation and information about historical anadromous fish runs and harvests. The information should prove especially helpful in understanding the complexity of Columbia River anadromous fish harvest management. A discussion of fisheries economic evaluation methods used in this study is presented in Chapter II, Part 2. The changing patterns of the Columbia River Basin salmon and steelhead production and harvesting are discussed in Chapter III, Part 2. Salmon and steelhead are migratory and know no jurisdictional bounds. Their migration routes carry them from far inland in the Columbia River Basin to as far as Alaska and south to California. Historic and international agreements on their harvests have been reached and are continually negotiated. A brief overview of these agreements is provided in Chapter IV, Part 2. Salmon and steelhead typically reproduce in fresh water and spend a greater part of their adult life in the ocean. In their migratory route, they are exposed to a variety of predators. Survival rates from production to harvest are an important component of how many adult fish will be available for harvest. Survival rates and contribution to fisheries are discussed in Chapter V, Part 2 to provide a basis for the economic evaluations. Chapter VI, Part 2 gives a historical perspective for the economic value of Columbia River Basin fisheries.

Commercial and recreational fishing for Columbia River Basin anadromous fish stocks generates a significant amount of personal income and has national benefits. These economic value estimates for changed harvests due to alternative lower Snake River dams hydrosystem actions are presented in Part 3.

This report also describes the potential economic value to the Pacific Northwest region and to the nation that may result from four cases of anadromous fish production and harvest management policies. The broader overview of what net economic value and contributions to regional personal income and jobs may result from the four cases is presented in Part 4. Part 4 descriptions may be viewed as what is at risk if the Columbia River Basin anadromous fish survival rates, and therefore harvestable fish runs, are not improved.

The economic analysis for the alternative hydrosystem actions evaluates all major anadromous fish stocks originating in the Snake River Basin. The major anadromous fish stocks are defined to be spring/summer and fall chinook salmon *(Oncorhynchus tshawytscha)* and summer steelhead *(O. mykiss)*. Other anadromous fish, such as shad *(Alosa sapidissima)*, sturgeon *(Acipenser transmontanus and A. medirostris)*, coho salmon *(O. kisutch)*, sockeye salmon *(O. nerka)*, etc., would not have fisheries significantly changed by the hydrosystem actions. All utilization of both wild and hatchery originating stocks was considered. This includes commercial and recreational harvests, as well as sales of hatchery egg, carcass, and surplus fish. The economic analysis for the entire Columbia River Basin adds coho salmon and winter steelhead to the Snake River list of major anadromous fish stocks.

CHAPTER II. METHODS USED TO CALCULATE REGIONAL ECONOMIC IMPACTS AND NET ECONOMIC VALUE

A. Background

The study's overall goal is to evaluate the economic contributions and values from harvesting those Columbia and Snake River anadromous fish stocks that are assisted by removal or change in the operation of four dams on the lower Snake River. This study specifically analyzes the economic effects of changes in wild Snake River stocks related to changes in salmon migration resulting from water flows in the lower Snake River. Other anadromous runs in the Snake and Columbia River Basin may also be affected by changes in water flows and management practices in hatchery production and harvest allocations. The economic contribution of the wild Snake River fish stocks as well as the total Columbia River Basin anadromous production is measured in terms of direct earnings and indirect/induced personal income. The economic contribution expenditure budgets serve as a base to develop estimates of benefit (net economic value) for anadromous fish harvesting and primary processing.

The economy of the Pacific Northwest (Alaska and British Columbia are included in this definition, as are other of the Pacific Northwest states) is highly dependent on its natural resources. The natural resources provide raw materials for manufacturing processes, such as the production of lumber and plywood, and commercial fish processing among other things. The natural resources also attract recreation seekers who are both residents and from all over the world. In addition to the users of the natural resources, people who never touch or view the resources also place a value on them. They are people who may only wish to use the resource themselves or hope their relatives will be able to experience it. Methods to measure these economic values and dependence is complex. This report explains how only one aspect of the natural resources - fishing - is important to people and how it contributes to the economy. It also explains how management and other policy issues involving fisheries are related within the context of the economic measurements.

The two basic economic terms used in this report are "economic valuation" and "economic impact." Net economic valuation attempts to measure the benefits received by those that fish and the value people place on fishing. There also may be economic values to "nonusers," i.e. preservation or existence values to people who don't actually visit the Pacific Northwest. Regional economic impact considers how many people participate in fishing and how much they spend while fishing. The separate estimates are necessary to determine both the benefits and economic contributions to the economy. This report does not address the costs of providing the resources or services. Neither are the economic impacts included of the provision of fish resources. Generally, only the end products are valued, such as a recreational fishing day or a commercial fish harvested.

The following sections describe the different types of market and nonmarket economic values and regional economic impacts, and discuss applications and methodological concerns of economic information when applied to allocation issues.

B. Measuring Economic Values

1. Economic Valuation

Economic value is only one of many ways to describe the "worth" of some resource or service. The fishery resource provides an excellent example of this. Native salmon have many different types of value. A biologist may say that the values of the native fish are their genetic contribution to the survival of the species. An angler may say that the value of the native fish is in their challenge and fight, and the sense of accomplishment at having landed one. A nutritionist may find no difference in the value of native and hatchery fish, both providing the same calories, protein, etc. All of these people would be describing some aspect of the value of native fish, but none would be describing the economic value.

Economic value is very precisely defined as the relative value of a good or service, or what someone would be willing to give up (pay) in exchange for that good or service. This definition describes an anthropocentric view of value, that is, value to people. Therefore, for a fishery resource to have economic value, people must be willing to give up other valuable resources (which can be represented by money) in order to have the fishery resource. Clearly this makes economic value a function of peoples, preferences and their ability to pay (income).

When measuring economic value, it is not necessary to know why people value a resource (e.g. for nutritional reasons, for biological reasons, for recreation reasons), but rather how much they value it relative to other things. This makes it clear that economics is the appropriate tool when the objective is to allocate scarce resources. (A scarce resource is defined as a resource that people desire and need and of which there is a limited amount. A resource such as air may not fit this definition unless clean air becomes polluted.) For example, if something of value must be given up to save native fish populations, society needs to know whether the native fish are worth more than what must be given up. Information about the biological, nutritional, or recreational value of fish will certainly affect people's willingness to pay for the resource, but the economist does not need to know the motives behind people's willingness to pay in order to make socially efficient resource allocations. The calculation for social efficiency requires information on the total value of resources, that value being the result of many different motives. While recognizing that total value is the goal, there are methodological issues related to the measurement of economic value that have led to a distinction between different types of economic value.

a. Use Value

People may value a particular resource such as the fishery because they either use the resource currently, or they intend to use it at some time in the future. Current and future use value can be either direct or indirect. An example of direct use value would be the willingness of anglers to pay for access to the salmon in the Pacific fisheries. This may be actual price paid, which may be market price or any price that may not signal a "market clearing" price; an angler may be willing to pay more than he is being charged on the market. An example of indirect use value would be the willingness of a reader to pay for a magazine account of a fishing trip to the Pacific Northwest. In both cases, someone had to actually use the site or resource in order for something of value to be produced.

Since the anadromous fish of the Columbia/Snake River Basins contribute to the overall ocean stocks, some of the use value of these fish is actually realized in the ocean fishery. In a sense, there is a derived demand for the habitat of Pacific Northwest rivers since they are an input into the ocean fishery "product."

The willingness to pay for future use of the resource is called option price. This price represents the expected value of the future trip (expected consumer surplus), plus (or minus) any "option value." The option value represents any additional (or less) willingness to pay (above expected consumer surplus) for the option of future use, when future use is uncertain. Some have described option value as a kind of insurance premium, to guarantee that the resource will be available when, and if, future use is desired.

b. Non-Use Value (Intrinsic Value)

There are some people who are willing to pay for a resource, even though they never intend to use it. This type of Non-use value is called existence value, because people are willing to pay to ensure that a resource exists, knowing that they will never actually use the resource. The motive for existence value may be that people want to ensure that a resource exists for future generations to enjoy. Some economists have separated this type of existence value into a separate category called bequest value, but it is clearly a subset of existence value.

c. Which Value to Measure?

It is likely that the fishery resource of the Pacific Northwest provides all of the above types of values to society. The decision about which ones to focus on for measurement is a function of the resource allocation question being asked. For example, if a particular fishery resource is not threatened with extinction, there is no need to measure the existence value of that resource. Since society would not be deciding whether to allocate scarce resources to save the fishery, the existence value is not relevant. If the policy decision under consideration is whether to invest resources to increase the fish populations, then the values which are measured must correspond to only the increase in fish numbers. In other words, total use value would not be the appropriate value to compare with the value of the resources necessary to increase the population by some incremental amount. Given the different types of policy decisions which might be relevant, as well as the fact that the existence of some Pacific Northwest fish populations may be in question, measurement of total and marginal values are likely to be useful to decision makers.

2. Regional Economic Impacts

The economic value of the fishery resource has been defined as people's willingness to give up resources of value (money) to have the fishery resource. This is commonly called net economic value or NEV (net economic value above costs) or NED's (National Economic Development accounts). A common mistake that is often made is to include the costs associated with using the fishery resource (e.g. travel costs, lodging costs, equipment) as part of the economic value of the resource. These associated costs, or expenditures, are instead the source of local or regional economic impacts associated with use of the fishery. These are commonly called the RED's (Regional Economic Development accounts).

Since economic values are used to allocate scarce resources, the economic value must represent the value of the fishery resource itself, and not the value of the related travel and equipment items. For example, suppose the fishery was threatened by a hydropower development and policy makers wanted to know whether the anglers could "buy out" the hydropower interests, All of the money spent on travel and equipment is no longer available to be used to buy out the competing hydropower interests. However, the money that is left over, after all the costs of angling have been paid, is the net willingness to pay (consumer surplus) for the fishery resource (or site) itself. and could be used to buy out the hydropower interests.

Another way to view the difference between economic value and economic impacts is to consider economic value as the net loss to society if the resource was no longer available. Suppose that a specific river fishery was no longer available to anglers, and they had to either fish somewhere else or engage in some other activity. The money spent on travel and equipment would not be lost to society - in fact it could be spent on travel and equipment or some other commodities in some other location. But the value anglers received from fishing that specific river would be lost. It must be assumed that one river's fishing was preferred over (had greater value than) the other rivers or activities, or the anglers wouldn't have chosen the one site in the first place. Their net willingness to pay for the chosen fishery would be a loss to society. Their expenditures or associated impacts on income or jobs would be a loss to the economy of the preferred river, but would be a gain to some other local economy. Economic impacts, therefore, describe the local or regional effects on jobs and income associated with any specific area chosen as the point of interest.

The above example should make it clear why local economies are often more concerned about economic impacts than economic values, especially when the economic values are in the form of consumer surplus. If anglers are willing to pay some amount of money over and above their costs, but don't actually have to pay, the consumers get to take that surplus or value home with them in their pockets. It is not immediately obvious to local businesses that the consumer surplus generated from any specific fishery has any impact on the local economy. On the other hand, money spent on lodging, food, supplies, guides, etc., has a direct impact on local businesses.

It is clear that net economic value and regional economic impacts are two distinct measures, and each is useful for different purposes. Net economic values are important if the goal is to allocate society's resources efficiently. Regional economic impacts are important in assessing the distributional impacts of the different allocation possibilities. It may often be the case that society will want to invest in a less valuable resource because the local area or economy that holds that resource is in need of economic development. Nevertheless, having the information on economic value will tell society how much they are giving up in order to achieve the redistribution of economic activity or development.

a. Input/Output Models

Economic input/output (I/O) models are used to estimate the impact of resource changes or to calculate the contributions of an industry to a regional economy. The basic premise of the I/O framework is that each industry sells its output to other industries and final consumers and in turn purchases goods and services from other industries and primary factors of production. Therefore, the economic performance of each industry can be determined by changes in both final demand and the specific inter-industry relationships.

I/O models can be constructed using surveys of a regional economy. The disadvantages of the survey model approach are its complexity and high cost. Construction of a survey data I/O model involves obtaining data on the sectorial distribution of local purchases and sales to final demand of every sector of the economy, and on the imports purchased and exports sold by each sector.

Another approach uses secondary data to construct estimates of local economic activity. The models developed for this project utilize one of the best known secondary I/O models available. The U.S. Forest Service has developed a computer system called IMPLAN which can be used to construct county or multi-county I/O models for any region in the U.S. The regional I/O models used by the Forest Service are derived from technical coefficients of a national I/O model and localized estimates of total gross outputs by sectors. IMPLAN adjusts the national level data to fit the economic composition and estimated trade balance of a chosen region. Areas that are any combination of single counties can be constructed using IMPLAN. The IMPLAN model is now being offered for general use by the Minnesota IMPLAN Group (Olson et al. 1993). Estimates of economic impacts and economic value of composite stocks harvested throughout the Pacific Northwest (including Canada and Alaska) are determined by the information made available on contributions of Columbia River stocks to fisheries. These composites are determined by the survival rates (from egg to adult) and the method and geographical location of harvests. The Fishery Economic Assessment Model (FEAM)[1], based on 1994 technical coefficients, is used to estimate economic impacts of salmon harvests.[2] The price and cost information in the FEAM is also used to calculate economic value of commercially harvested salmon. The FEAM model process is outlined in Figure 2.II.1.

1. Fishery Economic Assessment Model (FEAM) was developed for the West Coast Fisheries Development Foundation by Hans Radtke and William Jensen in 1986. Current models are available from Radtke or Jensen. The FEAM model uses IMPLAN generated coefficients to estimate specific expenditure to personal income impact relationships.
2. The available IMPLAN models are generally three to four years behind calendar years. This is due to data availability and the time it takes to prepare the models. Unless very dramatic changes take place in a regional economy, the sector coefficients will not change dramatically from year to year.

Figure 2.II.1
The Fisheries Economic Assessment Model (FEAM) Process

- Based on IMPLAN
- Construct I/O coefficients for fishing related expenditures
- Species data
- Harvest data
- Primary processing data
- Economic impacts
  - Personal income
  - Full time job equivalents
- Geographic areas
  - Alaska
  - Canada
  - Washington
  - Oregon
  - California

Source: Study.

i. Imports and Exports

One way of measuring the contribution of a particular economic activity is to look at the amount of goods and services it sells and buys outside the local economy. A local economy has exports and imports similar to state or national exports and imports. Timber harvested and processed in Forks and shipped to Los Angeles is an export that benefits the local economy. The wind surfer from Seattle brings money to the Hood River area economy. Recreational activities are called exports when they bring in "outside" money. Exports from the local economy stimulate local economic activity.

However, the money brought into a local economy does not all stay in the local economy. This is particularly true for the smaller regional economies which are not economically self-sufficient. Many of the goods and services consumed in the local economy must be brought in from the outside. They are the imports to the local economy. The money that flows out of the local economy to pay for these imports is referred to as leakage.

In larger, more industrial diverse economies, there are fewer "leakages" of economic activity due to purchases from outside the region, and as a result, the multiplier effects are larger. In smaller, less diverse economies where more goods and services are purchased outside the region, regional impacts are smaller. For this reason, state impacts will almost always be larger than impacts for regions within the state.

The amount that a commercial fisherman spends to prepare a consumer-ready product for market, or a recreational fisherman spends to take part in a fishery, has an important impact on the local and regional economy. In addition, purchases made by the harvester, processor, or tourist-related businesses will cause suppliers to purchase additional inputs in the form of labor, more inventory, and other items. As workers and entrepreneurs receive wages, salaries, and profits from these activities, they spend money in the local area for a variety of goods and services. The total effect on the local economy depends upon the amount of the original dollar expenditures and the amount which is spent for subsequent purchases within the local economy. This effect is closely tied to the total expenditures, types of expenditures, and structure of the economy. So as not to confuse the size of economies between different areas, when comparisons are made between geographic areas, it makes more sense to use similar coefficients, such as state coefficients. (In comparisons between areas such as Alaska, Canada, Washington, or Oregon the state coefficients are probably the most appropriate to use. This is so that the size of the coefficients do not become the critical point in any policy comparisons.) The area of contribution chosen should therefore depend on the purpose of the comparisons.

ii. Basic Sectors

Since imports take money out of the economy, it is important for the smaller economies to have some exporting sectors. In the I/O jargon, these are called "basic sectors." The dollars brought in by basic or exporting sectors begin the multiplier process. The basic sectors stimulate a local economy by originating the multiplier effect. When people talk about a change in the economic base of an area, they are referring to a change in the basic business sectors.

Sectors other than basic sectors generally do not generate "new dollars", but rather operate on the circulation of dollars already present in the economy. Therefore, nonbasic sectors do not initiate a multiplier effect themselves, but instead contribute to the multiplier effect of basic sectors by preventing leakage. For communities on the Pacific coast, the basic sectors are often resource-based. Examples of basic and nonbasic sectors are (not necessarily in any order of importance):

Basic Sector Examples	Nonbasic Sector Examples
Fish harvesting/processing	Medical services
Logging and timber processing	Movie theaters
Tourism and recreation	Grocery stores
Transfer payments	Banking services

Transfer payments include such things as social security payments, retirement payments, and non-local government salaries. Activities such as fishing, being a form of recreation, would be considered a basic sector industry for that portion of expenditures made by anglers whose residence is other than in the area they are fishing.

b. Multipliers and Coefficients

i. Output (Sales) Multipliers

How is the effect of a dollar of export sales multiplied in a local economy? Suppose an industry increases export sales by $1,000. If the economy has an output multiplier of 2.49, total business sales through the county are expected to increase by a total of $2,490 as a result of the $1,000 increase in exports and the $1,490 in local sales generated by these exports. (The 2.49 is used as an example only. The actual output multiplier may be different.)

Figure 2.II.2 demonstrates how local respending of the export payment by businesses and households creates this multiplier effect. The process begins when a dollar enters the local economy, in this case as the result of an export sale (column A). The dollar will be respent by the exporting firm in order to purchase inputs (goods, services, labor, taxes, profits, etc.) to meet the increased export demand (column B). Sixty cents of the dollar will be received by local businesses and households, but $0.40 will leak out in the form of nonlocal purchases. Thus, in addition to the initial dollar, business respending has generated an additional $0.60 of business activity within the economy. Of the $0.60 that is locally received, $0.38 will be respent within the county, and the rest ($0.22) will leak out (column C). This process continues until the amount remaining in the local economy is negligible (columns D, E, F). Thus, greater leakage at any round of respending leads to a smaller multiplier.

In order to determine the total value, the initial dollar is added to the sum of the local respending. In this example, the multiplier equals 2.49 ($1.00 initial change + $0.60 + $0.38 +$0.20 + $0.12 + $0.08 and so on until it approaches $2.49). Thus, $2.49 of local business activity will be generated for each dollar that enters the local economy. The same process can be used to explain a decrease in export sales.

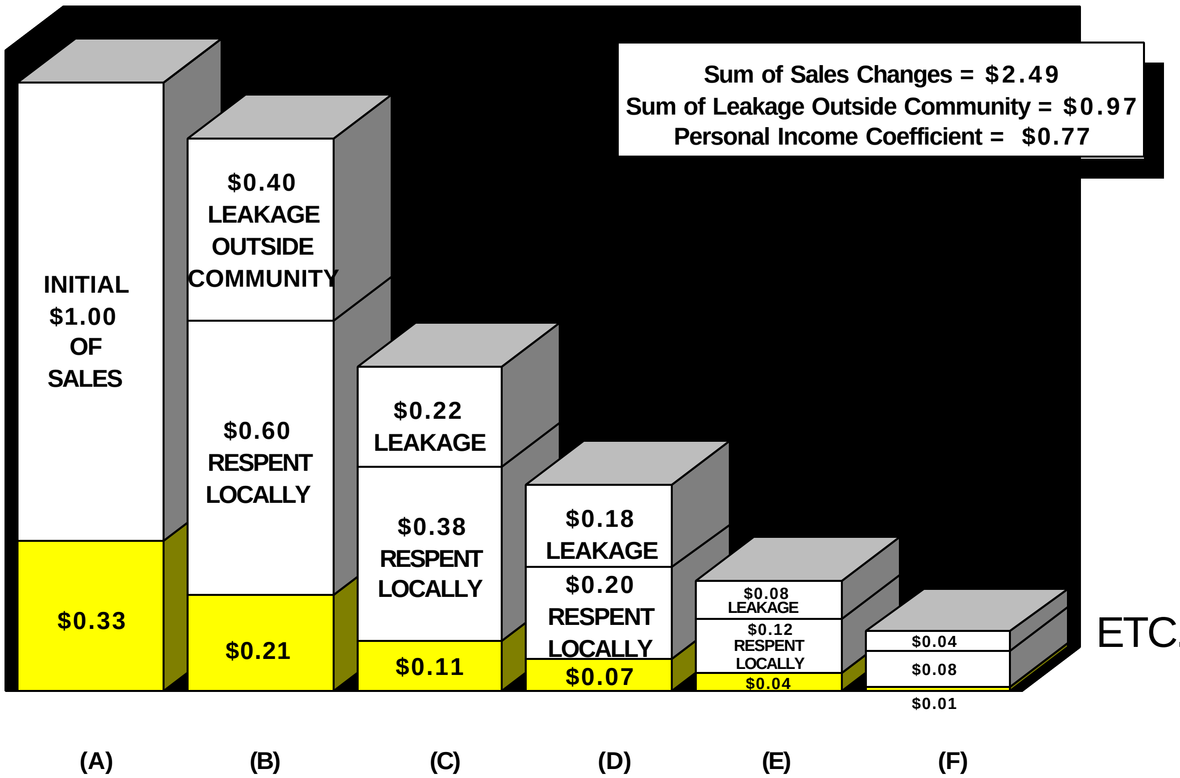
The output (sales) multiplier calculates how much money is "stirred up" in the economy, but it does not mean that someone in the local area is making a wage or profit from this money. The differences between output multipliers and income coefficients are often confused, leading to misuse. People, especially decision-makers, need to know and understand what type of multiplier or coefficient is being used in the assessment of the economics of proposed policy decisions.

ii. Personal Income Coefficients

A more useful measurement of the contribution of a sector's activity is the amount of local personal income that is directly and indirectly generated from an increase in sales. The distribution of the amount of local personal income generated is the shaded part of the output (sales) multiplier.

The "personal income coefficient" measures the income generated as a result of a change in sales. In the first round of export sales, $0.33 of local personal income is generated. The other $0.67 in the initial round goes to purchase supplies and services from other industries.

Figure 2.II.2
Output (Sales) Multiplier and Personal Income Coefficient



Note: The shaded portion of the output (sales) that goes to households in terms of wages, salaries, and profits is called personal income.

Source: Radtke and Davis (August 1994).

These industries also create wages, salaries, and profits. As these sales work through the economy, a total of $0.77 of personal income is generated from every $1 of increase in sales.

The size of the personal income coefficient is largely determined by the amount of personal income generated by the first round. In an industry that is very labor intensive, the output (sales) multiplier may not be very large while the income coefficient is above average. On the other hand, if the industry goes through several transactions but is not very labor intensive throughout the process, the output (sales) multipliers may be large and the income coefficient small.

The impacts estimated in this report are effects on total personal income, the amount that is retained as household income (salaries, wages, and proprietary income). Because many jobs in the fishing industry are not full-time, an employment figure could be misleading. A full-time equivalent employment figure can be calculated by dividing the total personal income figure by a representative annual personal income average. In the Pacific Northwest, a $20,000 to $25,000 per year wage or salary is a fair representative of a full-time equivalent job.

C. Regional Economic Impacts Model Application

I/O models have been constructed for the Pacific Northwest coastal counties with the use of the IMPLAN model. On the commercial side, representative budgets from the fish harvesting sector (Figure 2.II.3a) and the fish processing sector, as well as a price and cost structure for processing are used to estimate the impacts of changes. On the recreational side, a charter operator budget and recreational fishermen destination expenditures (Figure 2.II.3b) provide the basic data. The individual expenditure categories are used as input into the IMPLAN I/O model to estimate the total community income impacts.

1. Commercial Fishing Regional Economic Impacts

Representative budgets from the fish harvesting sector and the fish processing sector, as well as price and cost for processing are used to estimate the impacts or contributions of commercial salmon fishing (for more detail see Carter and Radtke 1986). The commercial fisheries data were developed by Hans Radtke and William Jensen in connection with a project to develop a fisheries economic assessment model for the West Coast Fisheries Development Foundation. For illustrative purposes, Figure 2.II.4 displays example regional impact estimates for two species (chinook and coho) by gear.

For example, gillnet-caught fall bright chinook command $1.50 per pound. The yield on this dressed fish, when it is marketed fresh, is 80 percent. The sales price for the primary product for the fisherman is $2.94 per pound. The community income received from this one pound is $2.86; people in the State outside the local area, that supply goods or services to local area, will receive another $0.50, for a total of $3.36. The total state income generated by one pound of salmon harvested and processed in the Pacific Northwest is $3.36. The average weight of these chinook is 18.4 pounds. Thus, the total state level impact per landed chinook is $61.74. For a troll caught fish landed at $2.30 per pound (round weight), the income impact per fish may be $52.44. The harvesting and processing of hatchery fish may generate $2.24 per pound or $41.22 per fish, especially if additional processing, such as canning or smoking, takes place. For fresh fish sales, because there is less labor involved, this impact may only be $29.52 per fish. The economic impact of a commercially harvested salmon depends on many factors, as shown on Figure 2.II.5.

In some remote areas, "direct selling" to consumers is taking place. In these cases, the consumer travels to rural areas on the Columbia River to purchase a salmon/steelhead from tribal harvesters. Usually, wholesale (only harvesting and primary processing) and retail margins are not included in impact analysis. The reasoning is that these sales would take place in the area of analysis regardless of production. In this case, where the consumer travels to the point of harvesting/selling, these margins may be included for community level impact analysis, but not at the state level.

For example, a $0.50 ex-vessel price ($0.63 dressed) would increase by about $0.65 by the primary processor, another $0.20 by the wholesaler, and another $0.65 by the retailer, for a total of $2.12 per pound. The direct sales of salmon to consumers on the Columbia in 1997

Figure 2.II.3a
Commercial Fishing Expenditures

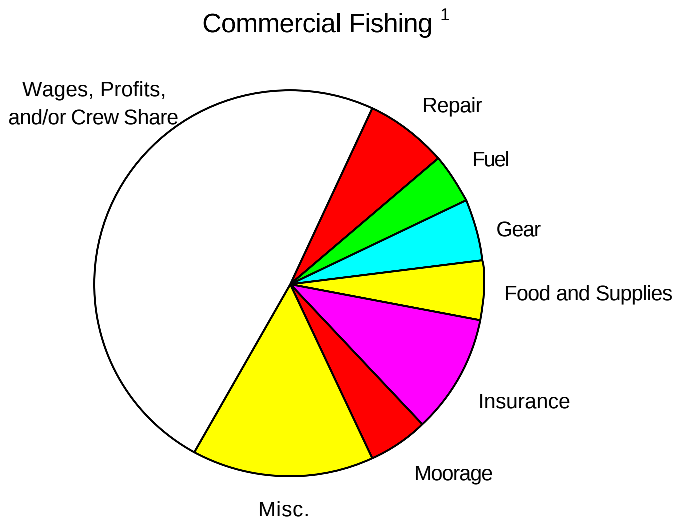
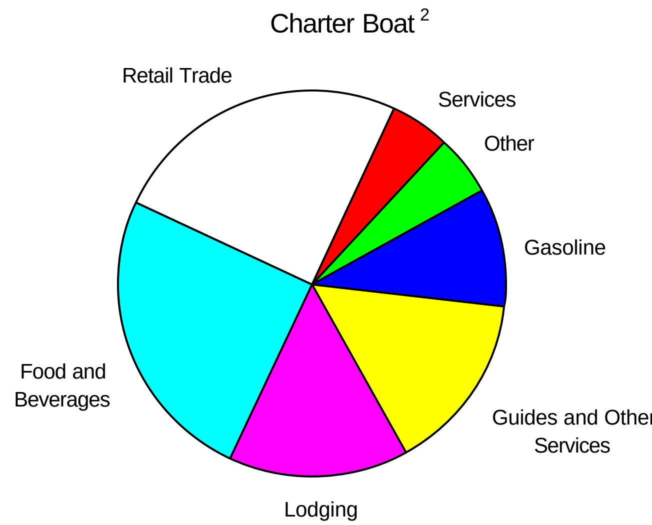


Figure 2.II.3b
Charter Boat Angler Expenditures



Sources: 1. Radtke and Jensen. 1986.
2. The Research Group. 1991.

was reported to be between $1.75 and $2.00 per pound. Depending on the expenditure patterns of the harvester/retailers' direct sales, the local impacts would most likely be similar to the impact estimates developed by the FEAM for harvesting and primary processing.

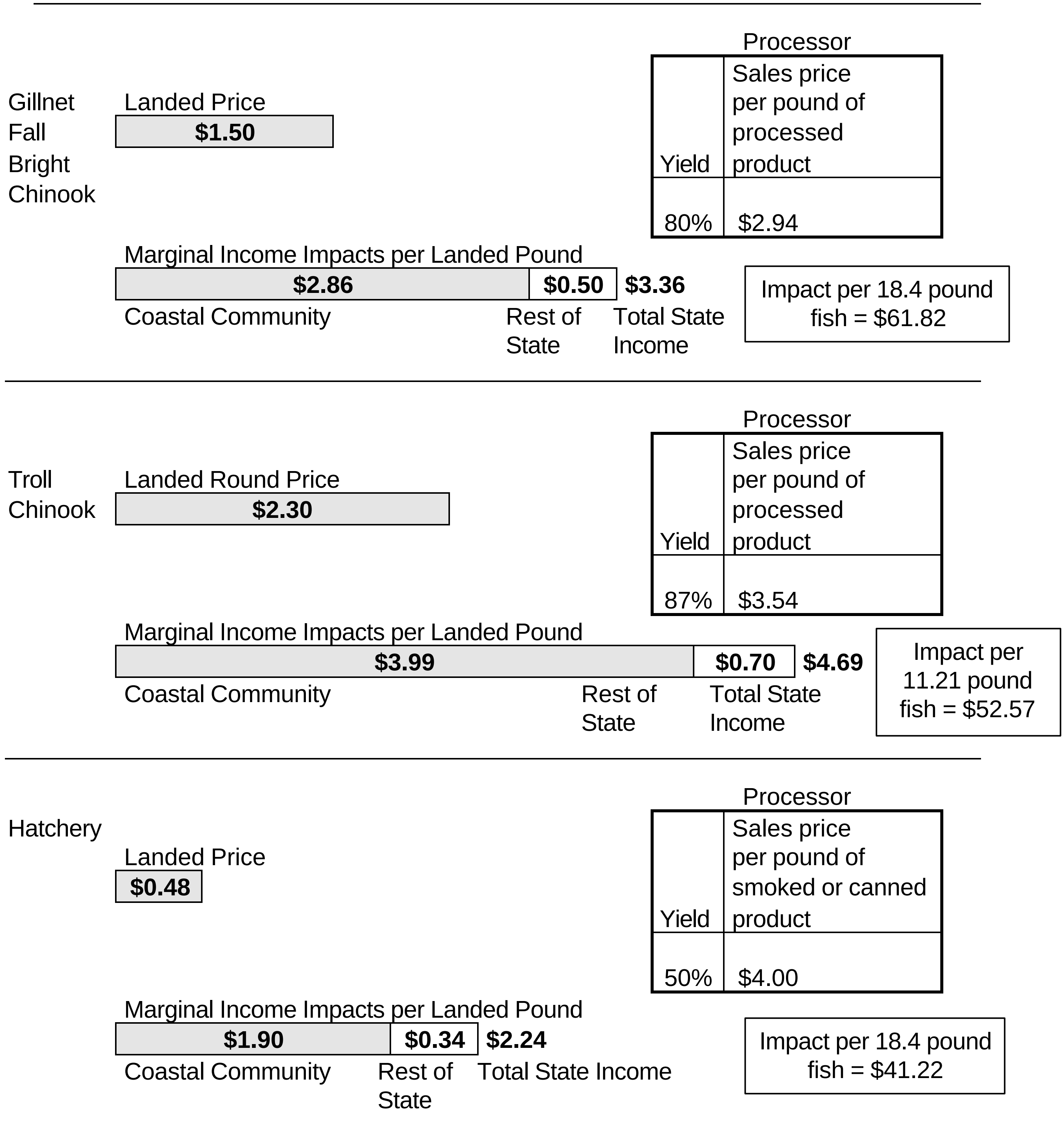
Changes in any of these factors will result in a change in the total income impact of salmon landed in an area.

2. Recreational Fishing Regional Economic Impacts

In 1991, a comprehensive survey to compile information about angler characteristics, expenditures, and preferences of recreational anglers was completed for the Oregon Department of Fish and Wildlife (ODFW) (The Research Group 1991). This study completed estimates of economic impacts for seven management zones, eight species categories, and four water types. The economic impact estimates were completed with the same process of disaggregating the IMPLAN model and estimating impacts relating to specific expenditure categories. This study is the basis for the Pacific Fishery Management Council (PFMC)'s annual economic impact of the salmon fisheries (PFMC 1998). These estimates were developed by the State of Oregon and are used by the Pacific Council to estimate regional impacts from California to Washington. The assumption in this report is that these estimates also reflect, in a general way, the economic impacts of salmon harvested in Canada and Alaska.

The estimates of economic contributions to Pacific Northwest personal income associated with recreationally-fished ocean salmon are shown in Figure 2.II.6. Factors affecting this include

Figure 2.II.4
Representative Community and State Personal Income Impacts of Salmon Per Pound



Source: Study and Radtke and Davis (August 1994).

Figure 2.II.5
Factors Affecting Income Generated from Commercial Fishing

Commercial Fishing

- Purchase patterns of fishing businesses (landed price per pound)
- Yield of product
- Type of finished product
- Purchase patterns of processors (sales price of processed product)
- Spending patterns in local economy
- Size of local or regional economy

Source: Radtke and Davis (August 1994).

the means of fishing, expenditures patterns, and success ratios (Figure 2.II.7). It is also important to have legal access to the fish during the time they become available in any specific area. It is assumed there will be access to these fish when they return.

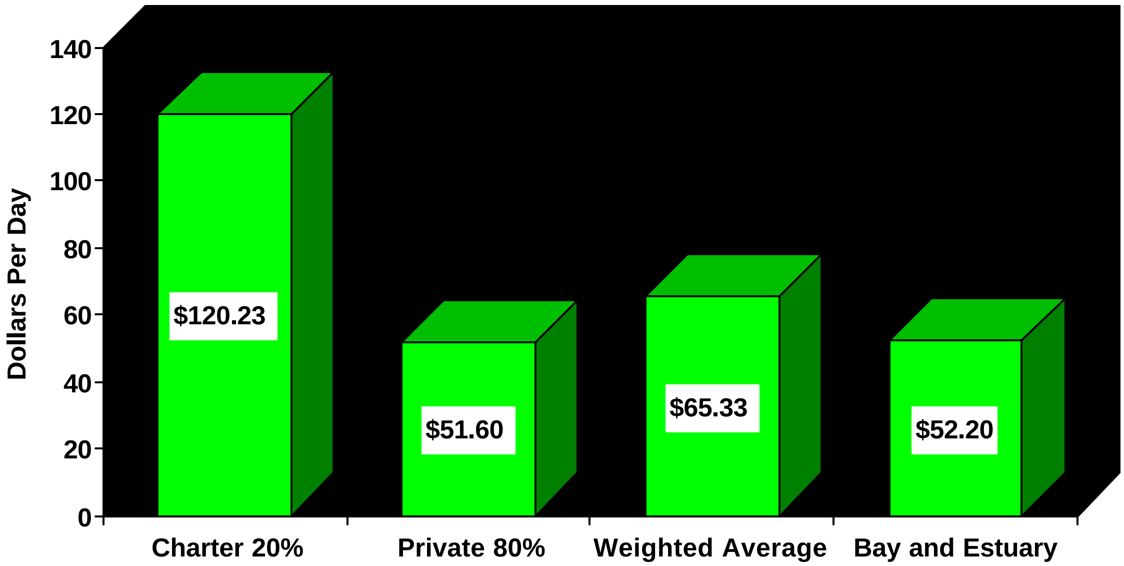
The commercial fishing unit estimates are for personal income impacts per fish. The recreational fishing unit estimates are for personal income impacts per recreational fishing day.

Since 1980, the success rate in ocean salmon fisheries in the PFMC jurisdiction has been about one fish per day (Radtke and Davis, April 1994). Therefore, the coastal community impact for the destination expenditures for charter boat patrons plus the charter boat fee is $102.20 per day (state impacts are $120.23) (Figure 2.VI.6). A weighted average for the two means of fishing is $55.53 per day for local income impacts (state income impacts are $65.32) based on an 80/20 private/charter split. This may range widely depending upon area and species. Unless otherwise documented, a one fish per angler day is a reasonable success rate to use. This is based on a historical average for most salmon fisheries that average about one fish per day.

As a general guideline, the economic impacts per salmon/steelhead harvested recreationally in this study is $60 per day at the state level and $50 per day at the community level. For ocean fishing, one fish per day success rates are used. Within the Columbia Basin, the success rates vary from species to species and by geographic area. Chris Carter, Economist for the ODFW (Carter, March 1999), utilizes a one fish per day success rate for ocean fishing and up to two days per fish success rates for inland fishing.[1] For tributaries above the Columbia/Snake

1. There are intuitive reasons that give support to the argument that anglers prefer large chinook and that it would take smaller success rates to entice anglers to fish for chinook. There are no studies available to support this reasoning. For this reason, the same impacts per fish (coho or chinook) are used in this paper. Historical data suggest that each recreational fish "supports," on the average, roughly one day of recreational fishing (Radtke

Figure 2.II.6
Typical Personal State Income Impacts Per Day and Percent of
Total Effort From Salmon Recreational Fishing (1997 Dollars)



Notes: The percentage of charter/ private boats are assumed to represent the actual charter/private boat harvest of salmon in the Pacific Ocean (and Columbia River terminal area).
Source: PFMC (1998) and Seger (1996).

confluence, two days per non-retained fish success rates are utilized (Bowler, July 1999). For steelhead retained, the fish per day success rate is 5.88 days. The steelhead surveys were used as an indicator for future salmon fisheries in Idaho.

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and Davis, April 1994). It is tempting to conclude that each additional recreational fish caught in the ocean would produce a community income of $65.33 (Figure 2.IV.6). Depending on the circumstances, this could be an incorrect inference. The number of salmon made available to recreational fishing may result in large amounts of fish being available to the recreational fishery. As a result of such large increases, the recreational fish limit may have to be increased. With such an increased bag limit, and supposing the average catch per day increased to three salmon, the income impact per average recreational salmon is reduced because fewer recreational days were "supported" per sport allocated fish. If it can be clearly shown that additional numbers of fish can be released to attract additional angler days, then the average impacts used may be used as an estimate of total impacts. For calculating income impacts of chinook, the means of harvesting may not matter a great deal as long as the angler success rate remains at about one fish per day. That is because the economic impacts per chinook salmon harvested commercially or recreationally are about $50 to $60 per day. The point could even be made that it would be more beneficial to harvest chinook (especially spring chinook) commercially if the bag limits and success rates are higher than one fish per day. The same case could not be made for coho salmon, since a commercially caught coho will generate about $15 if harvested commercially versus about $50 to $60 if caught by the recreational fishing industry.

D. Net Economic Value Model Applications

Estimates of net economic value of commercial and recreational anadromous fishing are made using available studies and procedures developed by management agencies, such as ODFW,

Figure 2.II.7
Factors Affecting Income Generated by Recreational Fishing

Recreational Fishing

- Means of fishing (charter, private)
- Expenditure patterns
- Success ratio (average fish per day)
  -
- Spending patterns in local economy
- Size of local or regional economy

Source: Radtke and Davis (August 1994).

PFMC, and the National Marine Fisheries Service (NMFS). Estimates of net value utilized in this report should be viewed as general values. Specific uses in selective areas may change these values.

1. Commercial Fishery Net Economic Value

To compute the net economic benefits from commercial fishing the costs of harvest (fuel, repairs, labor, etc.) should be subtracted from the gross revenues (ex-vessel price). Because the fishing season is of short duration, most fishing boats are not limited to salmon fishing. The investment in boat and gear is also used for other fisheries. Also, at low levels of total salmon harvest and with small incremental changes in salmon production, it is often argued that any increased harvest could be taken with almost the same amount of labor, fuel, ice, etc. as before. Since the current fisheries (both the harvesting sector and processing sector) are greatly overcapitalized, in use of fixed and operating capital as well as labor, this is a plausible assumption. This assumption implies that almost no additional costs are involved and gross benefits are close to net benefits.

Generally, any valuation of salmon species involves a geographic area and a salmon species for which there are many substitutes. In such cases, the demand curve is relatively flat. That is, if consumers are faced with a rise in the price of one type of salmon in one area, they will simply shift their consumption to an alternative salmon product. In such cases, there are no extra benefits that could be counted resulting from consumers' willingness to pay different prices for a specific salmon product. Therefore, most economic valuations involving salmon will center on the benefits that a producer receives from the harvesting and processing of salmon.

The assumption of full employment is implicit in most benefit and cost analysis. But unemployment and excess fishing capacity, both transitory and chronic, seem to prevail in many Pacific coastal communities dependent on commercial fishing. Changes in markets or fishing opportunities may make it necessary for people and capital to change occupations and/or locations. Various factors make it difficult for this to happen quickly enough to prevent a period of unemployment and idle capacity.

The Water Resources Council (1979) suggests that when "idle boats" are available, the only incremental costs of increased harvest will be the operating costs.[1]

Rettig and McCarl (1984) make recommendations on the calculations of commercial fisheries NEV's. Their recommendations range from 50 to 90 percent of ex-vessel prices.[2] Because primary processing is an integral part of producing salmon, a portion of the primary processor margins are also used to calculate the net economic value of commercial fishing. Huppert and Fluharty (October 1996) utilized only the harvesting ex-vessel price and concluded that "All of these estimates are at or below the 50 percent net earnings rates suggested by Rettig or McCarl." (Rettig and McCarl 1984). (Processor margin is the difference between their purchase price, ex-vessel price, and their sales price.)

In periods of reductions, the 90 percent rule would be appropriate. However, if the total salmon harvest increases, it might not be appropriate to use the 90 percent level. A more appropriate level might be the 50 percent level (the lower level recommended by Rettig and McCarl (1984)). In a situation where new resources (capital and labor) were needed to harvest and process a greater amount of salmon, the actual additional costs of harvesting and processing would have to be deducted from the ex-vessel price and the processors' margin in order to arrive at the NEV of additional salmon harvest.[3]

Because it is difficult to collect data on the commercial salmon fishing industry for specific areas and specific gears and almost impossible to compare such estimates on a wide geographic and industry basis, a general guidance may be to present information on ex-vessel basis (properly defined so as to be comparable) and on a first level primary processing basis. (This being the minimal amount of processing required to move the fish out of the region - dressing, icing, packing, etc.) The first level processor basis should be used because in many areas tendering costs and other costs and incentives of specific fisheries may not reflect the actual ex-vessel prices. It may also be argued that the first level processing in any area is inseparable from the harvesting component.

A portion of the ex-vessel and ex-processor prices are therefore used as measures to facilitate guidelines in any of net value of commercial salmon fishing. Specific fisheries with acceptable data can

1. The estimates of "net value" of tribal harvest may be conservative. This conservative approach may be balanced by assumption of ex-vessel prices that may be received by in-river tribal harvests (Water Resources Council 1979).
2. In many small coastal communities, there are no substitutes for the processor involved in the primary processing of salmon. Much of the salmon is partially processed on board the boat. For these reasons, the harvesting and primary processing is included. Wholesale and retail margins are not included. The basic reason is that demand curve is expected to be flat, thereby no appreciable "surplus." For retailers selling seafood, there are also a host of substitutes available.
3. Note: Chronic underemployment of human and capital resources on tribal lands may result in very low incremental costs resulting from increased harvest opportunity. Other studies have suggested that the average cost increase with increased harvest opportunities may be two to nine percent (Barclay and Morley 1977). A two percent cost was utilized by Meyer in the Elwha Study (Meyer et al. 1995).

be investigated to determine the net value of the fishery. For this analysis, in order not to complicate the presentation, a 70 percent margin is used to represent an "average" NEV for most commercial salmon harvested. The 70 percent margin is applied over a range of annual prices. The remaining 30 percent represents additional expenses of harvesting and primary processing required to produce a consumer product from Columbia River Basin anadromous fish runs.

2. Recreational Fishery Net Economic Value

This section summarizes available information on the economic values of sportfishing for Columbia and Snake River anadromous fish. While there are many studies of anadromous sportfishing values in other locations, there are relatively few studies directly linked to Columbia or Snake River salmon. This report reviews past studies, including their scope and limitations, and reports the most current economic values available.

a. Review of Previous Valuation Studies

There have been a number of studies of the economic value of fishery resources, both ocean and inland. The proceedings from the 1988 AERE conference on the economic value of marine and sport fisheries (AERE 1988) contain a number of papers on this topic, as well as references to many more. Most of the journal literature is concerned with theoretical and methodological issues related to estimating nonmarket economic values, but most also contain an empirical application to a particular fishery resource. Few of the studies, however, are directly relevant to Columbia and Snake River fisheries.

Studies that have been done in the Pacific Northwest include the early study by Brown, Singh, and Castle (1965) on salmon and steelhead fishing in Oregon, and the follow-up studies by Brown and his colleagues (Brown et al. 1976 and Sorhus et al. 1981). The 1977 data collected by Sorhus, et al (1981), has since been used by Strong (1983) and Loomis (1989) in other applications. Loomis, Provencher, and Brown (1990) also estimated regional travel cost models for Oregon coastal streams using this same data set. A version of the Loomis, et al, model is available in a PC program called "GAMEFISH" that allows the user to estimate the effect of changes in fish catch on net economic value (Loomis and Provencher 1986).

Other Pacific Northwest fishery studies include the study by Johnson, Shelby, and Moore (1989) on the Chetco River winter fishery, studies by Meyer (1982), Meyer, Brown, and Hsiao (1983), and Olson, Richards, and Scott (1990) on the Columbia River fishery, a study of Washington steelhead anglers by Demirelli (1988), a recent study of Snake River steelhead fishing by Normandeau Associates (1998), and the work by Bergland and Brown (1988) on ocean salmon fishing. A study on the Rogue River produced economic values for different fishing seasons (Olson and Richards 1992).

None of the previous studies provide exactly the information needed for making management decisions on the Columbia and Snake River systems. However, they do provide some reference points for comparison. Studies from other regions provide a wealth of information on the theory and methods of economic valuation of fishery resources in general. Table 2.II.1 lists the economic values from selected studies in the Pacific Northwest. Values have been updated to 1998 dollars, and standardized to a value per day basis.

The values for salmon and steelhead range between $22 and $78 per day. The values for ocean salmon fishing range between $32 and $89 per day. The earliest study was done in 1962, and the most recent was done in 1998 on the Snake River. Both the TCM and the CVM have undergone methodological refinement over this time period, which makes it difficult to precisely compare estimates between studies.

Using previous studies (i.e., benefit transfer) to estimate a single value for salmon or steelhead in the Columbia and Snake River systems is problematic for a number of reasons. Previous studies likely used methodologies that have since been improved, would have had assumptions and conditions that aren't currently relevant to the Columbia/Snake system, and socioeconomic and demographic variables could have changed significantly over time. Despite these limitations, the range of values from these studies is relatively small (within $56 of each other), and could be used for lower and upper bounds in a benefit-cost analysis. If the decision from the benefit-cost analysis did not change from the lower to the upper bound, then the analyst could feel relatively confident in the value estimates. If a single value was required (instead of a range), then it would be preferable to focus on studies that were most relevant to the Columbia and Snake River systems. For steelhead, that would be reference numbers 70 (TCM and CVM), 58, 64, 50, 54, and 19. The average value across those studies is $52.85. For salmon, the most relevant studies would be reference numbers 64, 58, and 50, and the average value is $51.43. These average values show that steelhead are slightly higher valued than salmon, which is consistent with studies where both salmon and steelhead have been valued using the same methodology in the same location.

b. Anadromous Fish Values

A few studies report values for both salmon and steelhead (Table 2.II.2). These are noteworthy because they allow a comparison of salmon vs. steelhead values in situations where the study date and method are the same. In all cases, the value of steelhead is greater than the value of salmon per day. Offsetting this higher value for steelhead is the fact that more anglers fish for salmon vs. steelhead. In Oregon in 1989, there were 582,872 salmon angler days, and 359,179 steelhead angler days (The Research Group 1991). Figure 2.II.8 shows that, in Oregon, the steelhead catch has been declining since 1984, while the salmon catch has been generally rising. The economic value of salmon and steelhead in any given river will be a function of the value of the species and the number of anglers fishing for each.

c. Net Economic Value Discussion and Conclusions

The values in this report should be used with caution. Many studies in other locations will not have angling characteristics that are similar to those found in the Columbia and Snake River systems. However, they can give a starting point to discuss sportfishing values in these rivers. More precise estimates would require a major data collection and analysis effort.

The sportfishing values of the Columbia and Snake Rivers represent the economic benefits to salmon and steelhead anglers for the opportunity to fish in these rivers. Some of the past studies estimated these values when anadromous fish and substitute rivers were fairly abundant. Current fish stocks may be much lower, and future policies could close some of the substitute rivers, making the remaining rivers more valuable. The location of rivers closed and left open will affect the relative value of different rivers.

These sportfishing values only represent use value of the salmon and steelhead resource. There are also option and existence values to consider. The more endangered the salmon or steelhead runs are on any river, the more important these nonuse values become. In cases where the overall runs of salmon become endangered, nonuse values can easily be greater than use values. Previous studies have estimated existence values for salmon on the Columbia River and the Elwha River.

The values in this section include both river and ocean fishing values. A large part of the value of river fish runs comes from their contribution to ocean stocks. Both the recreational and commercial value of ocean fishing have to be considered when assessing the total value of anadromous fish in any river.

As in estimating economic impacts, a one fish per day is used as a proxy for valuing anadromous fish produced in the Columbia River Basin and harvested in the ocean. The general guideline is that, for recreational use value, $52.85 for steelhead and $51.43 for salmon per day (and therefore per fish) represents the value that recreational anglers place on an anadromous fish produced in the Columbia River Basin. When there was additional information, this was utilized. For inland fishing below the confluence of the Snake/Columbia, consideration is given to Chris Carter's value estimates (Carter, March 1999), which basically use a success rate of one fish per day for ocean fishing and coho inland fishing. For inland fishing, the rate varies from about one day per fish for coho to two days per fish for steelhead and spring chinook. (Estimates of days per fish are based on Carter's economic value assumptions of $50 per fish for coho, $75 per fish for fall chinook, and $100 per fish for steelhead and spring chinook.) For tributary fishing, according to the results from Loomis (1999), the value of a day of fishing in the studies is $63.23.

Table 2.II.1
Salmon and Steelhead Values - Selected Studies

	LOCATION	REF#;DATE	METHOD	$1998 per day /1
Steelhead				
	Idaho	70;1986	TCM	22.77
	Oregon	73;1983	TCM	27.41
	Idaho	70;1986	CVM	32.33
	Oregon	11;1983	TCM	34.64
	Oregon	12;1980	TCM	35.86
	Rogue	57;1992	CVM	38.69
	Oregon	38;1986	TCM	43.39
	OR/WA	58;1990	CVM	43.72
	OR/WA	64;1984	TCM	44.23
	Columbia R.	58;1990	CVM	58.30
	Oregon	50;1983	TCM	69.34
	Idaho	54;1998	TCM	73.57
	Washington	19;1988	TCM	78.54
Salmon				
	Oregon	38;1986	TCM	20.99
	Oregon	12;1980	TCM	25.50
	Rogue	57;1992	CVM	29.97
	OR/WA	64;1984	TCM	32.44
	Alaska	28;1991	CVM	37.57 -69.70
	OR/WA	58;1990	CVM	41.16
	B.C.	14;1987	CVM	58.04
	Columbia R.	58;1990	CVM	61.99
	Oregon	50;1983	TCM	70.13
Ocean Salmon				
	B.C.	14;1984	CVM	32.16
	Oregon	64;1962	TCM	37.61
	Washington	17;1978	CVM	40.49
	Oregon	4;1988	TCM	50.02
	Oregon	50;1980	TCM	61.92
	OR/WA	58;1990	CVM	64.53
	Washington	64;1984	TCM	88.47
Salmon and Steelhead				
	Oregon	10;1965	TCM	37.61
	Chetco	33;1989	CVM	36.38
	Oregon	9;1976	TCM	55.43

Notes: 1. Based on gross domestic implicit price deflator.
2. See Table 2.II.3 for reference number mapping.

Table 2.II.2
Salmon vs. Steelhead Values - Selected Studies ($1998)

LOCATION	REF#;DATE	SALMON	STEELHEAD
Oregon	12;1980	25.50	35.86
Rogue	57;1992	29.97	38.69
OR/WA	64;1984	32.44	44.23
Idaho /1	26;1973	94.01	184.87
Oregon	38;1986	20.99	43.39
OR/WA	58;1990	41.16	43.72

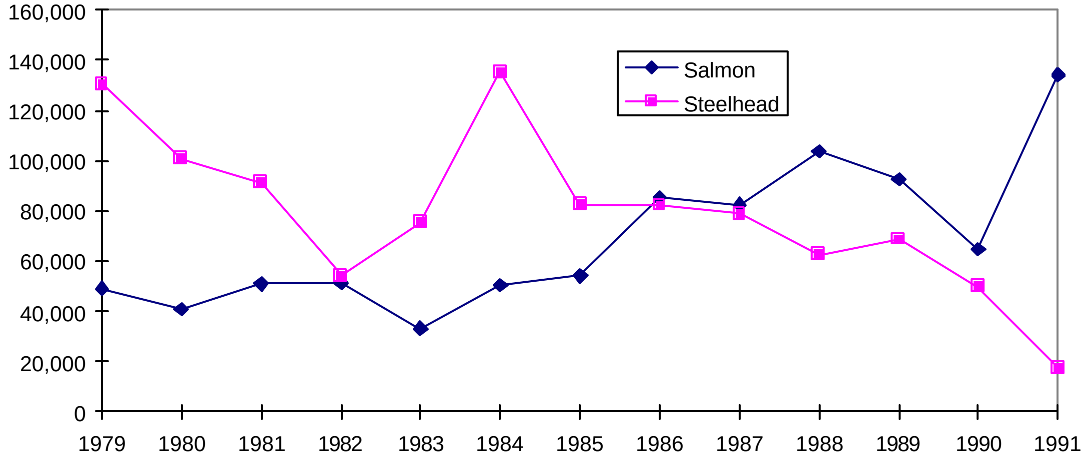
Notes:
1. This study is included in this table to show the relationship between salmon and steelhead values estimated within a single study, but is not included in the previous table because the methodology was not consistent with other studies.
2. See Table 2.II.3 for reference number mapping.

Table 2.II.3
Studies Used to Determine Benefit Transfer Unit Value

Ref. No.	Author	Ref. No.	Author
4	Bergland and Brown (1988)	33	Johnson et al. (1989)
9	Brown et al. (1976)	38	Loomis (1986)
10	Brown et al. (1965)	50	Meyer et al. (1983)
11	Brown et al. (1983)	54	Normandeau Associates (1998)
12	Brown et al. (1980)	57	Olsen, and Richards (1992)
14	Cameron and James (1987)	58	Olsen et al. (1990)
17	Crutchfield and Schelle (1978)	64	Riely (1988)
19	Demirelli (1988)	70	Sorg and Loomis (1986)
26	Gordon et al. (1973)	73	Strong (1983)
28	Hanneman and Carson (1991)		

Note: Full citation is included in References section.

Figure 2.II.8
Salmon and Steelhead Catch in Coastal Rivers


160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
Salmon
Steelhead

CHAPTER III. CHANGING PATTERN OF SALMON PRODUCTION

A. Historic Salmon Runs

To the Indians living along the Columbia River, salmon were their lifeblood, essential to their subsistence, their culture, and their religion. A focal point of this great salmon fishery for many centuries was Wy-am, one of the longest continuously occupied sites on the North American continent. Located near Celilo Falls on the Columbia River, the Wy-am area, before the Dalles Dam in 1957, was a commercial center during the fishing season. In autumn, as many as 5,000 people would gather to trade, feast, and participate in games and religious ceremonies. Here at salmon time were Indian goods to be traded for the prized dried salmon from half the continent. On hand were traders and goods, such as abalone shells and Wampum beads from California tribes, horses from the Nez Perce and Cayuse, slaves and dried clam meat from the chinook, and buffalo robes and native tobaccos from the plains tribes of the Rockies (Spranger and Anderson).

The abundance of salmon astonished Lewis and Clark when they first explored the region in 1805 and 1806. Many of the earliest accounts of the fishery were detailed in the diaries of these early explorers. They refer to the "stinking river," a sweet rotting smell that came from the salmon carcasses along the banks of the Columbia.

Before Oregon became a state, fishing played an important part in the economy. As early as 1828, various trading companies were purchasing and exporting salmon caught by the Indians on the Columbia River. The first commercial use of fishery products in Oregon was the packing of salmon. Development of the canning process in the mid 1800's created a huge demand for salmon. Scandinavian and French immigrants worked with gillnets, beach seines, and fish wheels to harvest the abundant fish. The lower Columbia became the West Coast center of the packing industry (West Coast Fisheries Development Foundation 1986). Smaller canning projects developed on the coastal river systems, like the Umpqua.

In the 1860's, the process of canning salmon was perfected, permitting the fish to be transported over long distances, stored for extended periods, and kept palatable for consumers. By the 1880's, as many as 55 canneries were operating on or near the Columbia. In 1883 a total of 43 million pounds of chinook was harvested (Spranger and Anderson). At this time, only the valuable chinook salmon was canned. The other species, coho, sockeye, and chum, as well as steelhead were not utilized by the canners.

As the 1893 Commissioner's Report states, "In the early years of the salmon-packing business on the Columbia chinook salmon were extremely abundant, comprising the bulk of the run and the pack; other varieties were unutilized. With the beginning of a decrease in the abundance of chinook salmon the small blueback salmon (sockeye) was brought more into notice . . . up to a comparatively recent date the steelhead, which has always occurred abundantly in the Columbia, was considered wholly unsuitable for packing. The same cause, however, which brought the blueback into use has led to the utilization of the steelhead. Recently the demand for canned salmon in certain sections of the country has called for a cheaper grade of fish, which has brought the neglected steelhead into prominence. The silver salmon, which does not enter the river until most of the canneries are closed, has also been canned in some quantities, and both it and steelhead have met with a ready sale that has yearly shown tendencies to greatly increase." (United States Commission of Fish and Fisheries 1895, pp.240-241).

The total harvested pounds of salmon and steelhead in the early 1890's ranged from 21 million pounds to 33 millions pounds. Chinook were generally about $1.00 per fish (in those years' prices), with other fish priced from $0.10 to $0.25 each. In the early 1890's the ex-vessel values were about $1 million. At today's prices, the ex-vessel value of these landings would be about $80 to $90 million.

In the late 1880's and early 1890's, the salmon canning industry was developing in Alaska. This and a nationwide general recession resulted in downward pressures on Columbia River harvested salmon prices. "For several years prior to 1880 the men had been receiving $1.00 each for chinook salmon . . . The men demanded $1.25 each for their fish, which, being refused, a general strike was begun which lasted throughout the month of April. After losing one month of the short salmon season, the men agreed to the price first offered . . . One dollar per fish was paid up to June 1, after which the canneries would give only $0.75 for chinooks." (United States Commission of Fish and Fisheries 1895, p.241).

In more recent times, the Columbia River produced around 20 million pounds until the late 1940's. Since then, the total poundage harvested commercially generally declined to the very low level in 1993, when a total of just over one million pounds of salmon was harvested in the Columbia River (Radtke and Davis, August 1994). As fish numbers have declined, so have the revenues received by fishermen.

Estimates of "pre-development" salmon run size depend on historical catch records and in some cases historic habitat availability. The Northwest Power Planning Council (NPPC), in order to assess the salmon and steelhead loses attributable to hydropower development and operations, developed estimates of "pre-European development" run sizes (NPPC, p.1). They concluded that up to 16 million fish run size is probably the most reasonable estimate of Columbia River historic salmon and steelhead runs (see Table 2.III.1) (NPPC, pp.14-17). At recent historical prices, the ex-vessel value of the pre-development salmon and steelhead runs, at a 50 percent exploitation rate, would be about $272 million for the Columbia River Basin (Table 2.III.1).

B. Columbia River Basin Salmon Fisheries

Salmon has been a significant and recurring source of protein for Oregonians. The abundant salmon runs of the Columbia supported a great trading center at Wy-am (Celilo Falls near The Dalles) for the Pacific Northwest Indians. The Indians netted and speared salmon from platforms and racks as the fish labored to get over the falls.

The development of commercial salmon harvesting did not begin until the 1850's and 1860's when canning of salmon was developed. As the canning process was perfected, the number of fish harvesters and methods of harvesting increased.

Table 2.III.1
Estimated Historic, Pre-Development Salmon and Steelhead Run Size of the Columbia River System and Resulting Annual Potential Ex-Vessel Revenues

Species	Total Number of Fish (thousands)	Average Weight per Fish in Pounds	Total Pounds (thousands)	Price	Ex-Vessel Revenues at 50% Harvest Rate (thousands)
Spring chinook	2,300	20	46,000	3.25	74,750
Summer chinook	4,600	20	92,000	3.25	149,500
Fall chinook	2,300	20	46,000	1.00	23,000
Coho	1,780	9.0	16,020	1.00	8,010
Sockeye	2,600	3.5	9,100	2.00	9,100
Chum	1,392	12	16,704	0.60	5,011
Steelhead	1,348	8.5	11,458	0.60	3,437
Total	16,320		237,282		272,808

Notes:
1. Total number of fish from: NPPC (1986), pp.18-19.
2. Price is representative price per pound. These represent recent years prices for salmon harvested in the Columbia River. In the world salmon market, regional salmon production should be considered a commodity. Spring and summer chinook having timing and quality characteristics that command attractive prices.
3. Ex-vessel revenues at 50 percent harvest rate in most years with healthy stocks is considered a sustainable harvest rate.

Source: Radtke and Davis (January 1996, p. C-28).

Most fish were caught with gillnets, which entangle the fish. On the lower Columbia, trap nets and purse seines were used to catch salmon. The fish entered the trap nets through a narrow opening and, unable to find their way out, were stranded at low tide and taken out by dipnet. By the 1880's, horse drawn seines were used. The nets could harvest thousands of pounds of fish; in 1921, one net caught 60,000 pounds in one hour (Spranger and Anderson). That calculates to 3,000 fish or about $3,000 of revenue. In these years, for an average worker, $1,000 per year was considered a lucrative income for one person.

Fish wheels were also used. Strategically located in the pathways of migrating salmon, the fish wheels used the swift river current to catch and deposit the fish into boxes. By 1899, 76 fish wheels were in operation on the Columbia River (Spranger and Anderson). A fish wheel could average 100,000 pounds of salmon per year (or up to 6,000 fish).

In 1912, a few gillnet boats equipped with gasoline engines began to follow salmon into the ocean. By 1915, an estimated 500 boats were working off the mouth of the Columbia. By 1920, at least 1,000 trollers were operating out of a number of coastal ports. There were no seasonal restrictions on ocean fishing and markets demanded a more steady supply of salmon than the river fisheries could provide (West Coast Fisheries Development Foundation 1986).

By 1943, the troll fishery hit an all-time low, with only 86,000 fish harvested. Fishery managers and legislators responded with increased gear restrictions, quotas, and increased hatchery construction.

As the salmon runs began to decline, the fishermen battled for their share. Each gear group claimed that its method of fishing was less harmful to the salmon runs than its competitor's. For example, fish wheels were outlawed in Oregon in 1926; seines were outlawed on the Columbia River in 1950. Gillnetting in all Oregon rivers except the Columbia was also eliminated in the 1950's. Today, troll fishing in the ocean, gillnetting on the Columbia, Indian gillnetting on the Columbia, and sport fishing in the Columbia and Oregon coastal rivers as well as open ocean are allowed under seasonal regulations.

During their life cycle, salmon range over a large and diverse land and seascape. De facto harvests of salmon can take place by not allowing the salmon cycle to be completed. Overharvesting by the early commercial fishing fleet took its toll on salmon abundance. Dams, urban development, and land management activities also restricted the salmon cycle and reduced the region's capacity to produce harvestable salmon. As restrictions on gear and geographic areas took place, fishing activity on Columbia River Basin produced fish developed in ocean waters off Oregon, Washington, California, British Columbia and Alaska. Some of these fisheries specifically target on Columbia River Basin produced fish; others harvest fish incidentally to targeting other salmon species. Other fisheries catch salmon incidentally to other marine species and most are discarded dead at sea.

C. Salmon Markets, Artificial Propagation, and Changing Harvests

1. Changing Salmon Markets[1]

In the past, the Sacramento River and the coastal areas of Washington, Oregon, and California were important for salmon production. The first canning operations in the western United States developed close to population centers in California. As the stocks of the Sacramento River were fished down, the California rivers polluted by the impact of gold miners, and as methods of canning were being developed, the Columbia River fish became attractive alternatives. At the peak, in 1883, nearly 630,000 cases of chinook were canned on the Columbia River (Cone 1995, p.107). This translates roughly to about 40 million pounds of gross weight or abut 2.0 million chinook salmon at 20 pounds average. This does not include the wasted salmon, due to congestion at the packing plants, etc. As was reported in oral history, "Every other night there would be them fish, beautiful big salmon, all washed and cleaned and ready . . . Then we would just have to go out and shovel them, often by the hundreds, back into the river (Cone 1995, p.115).

As canning and transportation methods advanced, the major West Coast salmon processing moved northward to Alaska. As for the Columbia, the declining abundance received another technological answer. Mr. W. A. Wilcox, an agent of the U. S. Fish Commission, who visited Portland on his regular tour of inspection of the region's fisheries, commented to the Oregonian in 1896, "The vast volume of fresh water coming down the Columbia will make it almost impossible ever to pollute it sufficiently to

1. Much of this section is from Radtke and Davis (January 1996, p. A-4).

drive away the salmon, and it is hardly possible that civilization will ever crowd its banks to an extent that will endanger that [salmon industry], so I suppose it is safe to say that Columbia River salmon will always continue to be a choice dish in all parts of the world . . . of course, the increased demand for fish and the growing scarcity of the same will call for more aid toward artificial propagation in order to keep up the supply." (Cone 1995, p.114).

The dam building period of the mid 1900's may not have affected the water purity, but it did affect the historical water flow with which specific species of salmon had evolved. The mix of salmon species and the timing of the runs were altered to the detriment of the Columbia River product. Instead of producing the bulk of salmon at the first of the season (spring chinook), the Columbia River fish now being produced were in greater competition with the salmon harvests in Alaska. The spring chinook that was traditionally harvested in the spring and summer is of high quality destined for specific markets. The change to late summer and fall harvests of fall chinook and other salmon species produced fish of lower quality and species that were also harvested in great quantities in other areas of the West Coast.

Salmon processing made great progress in the first sixty years after the first salmon cannery was built, but there was relatively little change in canning technology in the early 1900's. Canneries face two extremes of durability in their two principal markets: in their buying market they are faced with a highly perishable product and in their selling market a very durable one (Rubinstein 1966, p.18).

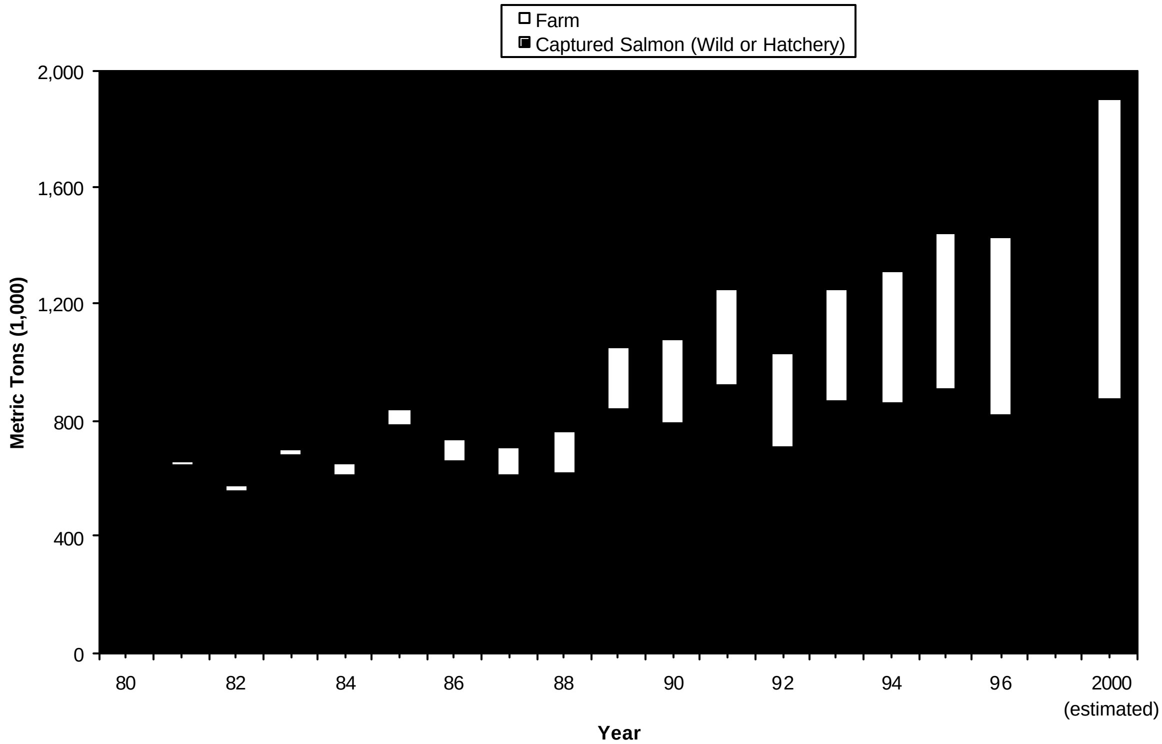
By 1888, a method of freezing was developed (Rubinstein 1966, p.17). As a direct method of presentation, it greatly increased the marketing capability of salmon, especially the highly desired chinook and sockeye species. In the last decade, as the use of ice and chilled seawater in harvesting boats, in tenders, and in processing is more common, marketing of fresh and quality frozen fish has dramatically improved. Coupled with speedier transportation systems, fresh and quality frozen fish are being shipped from any production area to markets throughout the world in a very short time. The new preservation and transportation methods improved the opportunities to market Columbia River fish throughout the world.

Since the early 1980's, improved captive salmon propagation procedures and transportation systems have allowed salmon aquaculture to supply the needs of the world market with a consistent supply of salmon. Salmon aquaculture, with its promise of consistent supply, is setting standards that have to be addressed by any other producers of salmon.

The world supply of salmon is going through dramatic changes. Captured salmon production has increased from about 600 thousand metric tons (mt) in 1980 to over 800 thousand mt in 1996. At the same time that captured salmon production increased, farmed salmon increased from no production in 1980 to over 700 thousand mt in 1996. Salmon supplies that were traditionally dependent on commercial harvests are changing toward farmed salmon production. Today's global salmon markets are characterized by strong competition and rapidly growing supplies of cultured product. Between 1980 and 1995, annual harvests of wild and farmed salmon increased from less than 600 thousand mt to over 1.4 million mt. Growth in total salmon production is forecast to continue, reaching over 1.8

million mt by the year 2000 (Figure 2.III.2). Farmed salmon production is expected to increase to one half of total production within the next five to 10 years.

Figure 2.III.2
World Salmon Supplies, 1980-2000



Source: Salmon Market Information Service (1995).

2. Changing Salmon Production

Salmon production may be described as coming from three sources. These are:

- Natural production
- Hatchery enhancement
- Farmed salmon

The U.S. and Canada have production from various levels in all of these sources. In the Sacramento-San Joaquin system, the commercial salmon harvest was as high as 12 million pounds (Western Water 1992). There was little control of this fishery, however, and over-fishing and industrial water based development caused a dramatic decline in salmon runs. Salmon hatcheries were established to mitigate for habitat destruction and for salmon run enhancement. The first California hatchery was established in 1872, the Baird Hatchery on the McCloud River. Today, almost all California chinook salmon production and about 70 to 75 percent of all Columbia River System salmon production is hatchery based (Washington Department of Fish and Wildlife (WDFW) and ODFW 1996).

As compensation for the loss of wild salmonid production, many artificial propagation hatcheries were built throughout the Columbia River Basin. Most of the salmon harvested on the west coast of North America come from Alaska waters. In Alaska, about 90 percent of all fish harvested are naturally produced fish (McNair and McGee 1994). Harvests in Alaska make up about 80 percent of all salmon harvested on the U.S.-Canada West Coast; therefore, about 75 to 85 percent of all salmon produced and harvested in the U.S. and Canada West Coast are naturally spawned.

Hatchery production may be used as a substitute for natural spawners. However, while commercial harvest may be increased significantly for some period, overall salmon production may also be decreased. Harvest rates based on the low number of returns necessary to seed another generation of hatchery fish can be too high to sustain natural production. Also, natural stock recruitment can be negatively affected by hatchery smolt releases (Anderson and Wilen 1985, pp.459-467), due primarily to natural selection process, competition for food, attraction of predators, and increased harvesting pressures. Basic, fundamental questions are being asked by scientists about the efficacy of hatchery programs and their effects on wild stocks. "It is now clear from synthesis of experience and from consideration of well-established biological knowledge that hatcheries have had demographic, ecological, and genetic impacts on wild salmon populations and have caused problems related to the behavior, health, and physiology of hatchery fish." (National Research Council 1996, pp.11-14).

Artificial salmon propagation in the Columbia River Basin was initiated in the late 1800's when managers realized that "...the increased demand for fish and the growing scarcity of the same will call for more aid toward artificial propagation in order to keep up the supply." (Cone 1995, p.114). Most of the early hatcheries were built for enhancement of salmon. As the waters of the Columbia River were used to develop the Pacific Northwest, artificial propagation was used to “mitigate” for the detrimental effects of the water projects.

Federal statutes such as the Federal Power Act and the Fish and Wildlife Coordination Act of 1934, were designed to provide mitigation for damage caused by water and other federal projects (WY-KAN-USH-MI WA-KISH-WIT 1995, pp.4-6). The Mitchell Act of 1938 is an example of these mitigation agreements. This Act funds a majority of mainstream Columbia River hatchery operations.

The Pacific Salmon Treaty (PST) between the United States and Canada also emphasized increased artificial propagation in order to satisfy allocation demands for salmon. And later, under the NPPC’s goal of "doubling the salmon runs," the emphasis is also on increasing hatchery production.

Two major factors took place since the 1980's that may be changing the optimistic emphasis on artificial propagation. One is the Endangered Species Act (ESA), and the other is the changing survival rates of salmon in the ocean environment. The concern about certain species or sub-species of salmon, and the overall effect of hatchery fish on the survival of these species, has led to the NMFS placing a cap on the total hatchery releases in the Columbia River system.

The NMFS cap for smolt production from the Columbia River Basin at 197 million smolts (Table 2.III.2) is to protect the salmon runs that have been declared threatened or endangered. The cap in effect requires reduction in smolt production and limits future growth of hatchery releases to those that have been identified as supplemental to wild production. "Supplementation is considered one of the major tools available to assist in rebuilding depressed Columbia River Basin salmon runs" (TAC 1997, p.6), with the caveat that "Ecological and genetic science suggests that artificial propagation must be carefully integrated into the functioning of the entire ecosystem." (Scientific Review Team 1999).

The early years of dam construction may have coincided with some very high survival rates of salmon smolts to harvestable adults. Survival rates for hatchery released coho were as high as eight percent in some of these years. They averaged about four percent in the 1980's, and are now less than one percent. Chinook survival rates, both fall and spring, have also decreased to fractions of what they had been in earlier years.

Table 2.III.2
Annual Cap Smolt Production for Unlisted Species in the Columbia River Basin
Established in NMFS Proposed Recovery Plan, March 1995

Agency	Spring Chinook	Fall Chinook	Coho	Steelhead	Chum	Sockeye	Sea-Run Cutthroat	Total
Snake River								
BPA	454,700							454,700
COE				2,300,000				2,300,000
USFWS	5,532,816	800,000		6,351,000				12,683,816
IDFG	3,000,000			1,800,000				4,800,000
Snake River Total	8,987,516	800,000		10,451,000				20,238,516
Non-Snake River								
SFWS	3,975,000			400,000				4,375,000
NMFS	10,241,700	75,984,750	21,836,000	2,434,250			126,975	110,623,675
COE	6,968,000	10,380,000		507,500				17,855,500
BPA	1,290,000	2,700,000		150,000				4,140,000
BIA						150,000		150,000
ODFW	800,000	900,000	2,868,450	729,250			15,000	5,312,700
WDFW	7,014,500	14,909,500	9,700,200	2,435,000	300,000	240,000	145,000	34,744,200
Non-Snake River Total	30,289,200	104,874,250	34,404,650	6,656,000	300,000	390,000	286,975	177,201,075
Basin Total	39,276,716	105,674,250	34,404,650	17,107,000	300,000	390,000	286,975	197,439,591

Notes: 1. Only the total production in the Snake River (20.2 million) and the total production in the Columbia River Basin (197 million) are specified in the production ceiling included in the proposed recovery plan (usually called the cap). The specie and geographic area of production estimates are made using current production levels.

2. Subsequent yearly hatchery releases change. For example, the 1998 hatchery releases are about 170 million total smolts. These releases are within the framework of the "cap."

Source: U.S. Department of Commerce (March 1995). (This table is not in the report, but was constructed from report data.)

As the cost considerations of hatchery production are included with environmental factors, the overall emphasis is shifting toward natural production, or hatchery operations that strive to "supplement" natural production. Supplementation strategies are based on increases in habitat productivity. Without increases in habitat productivity, the required supplementation budgets may double over the next 25 years (Smith 1999).

3. Changing Patterns in Salmon Harvests

The history of salmon harvests has been one of transition, from spears and dip nets, to improved and new technologies, such as diesel engines, entrapment nets, and trolling poles. The first canning operations in the western U.S. developed close to population centers in California. As the stocks of the Sacramento River were fished down, the Columbia River fish became more attractive. Most of these fish were harvested by nets (gillnets or seines) or fish wheels. As fish became scarcer and gas powered engines allowed fishermen to venture out farther into the ocean, trolling for salmon became an attractive alternative. As fishermen ventured farther into the ocean, salmon returning to their spawning areas were "intercepted." As a result, the river of production (spawning and rearing) is many times no longer the area of harvest. In most parts of Alaska, most salmon are harvested in or close to the river of production. Careful management assures that a sustainable level of spawners "escape" to each watershed. In the lower part of Alaska, fishing is allowed (including trolling) that targets on salmon produced from and returning to waters in Canada and the "lower 48." International conflicts arise over these "interceptions."

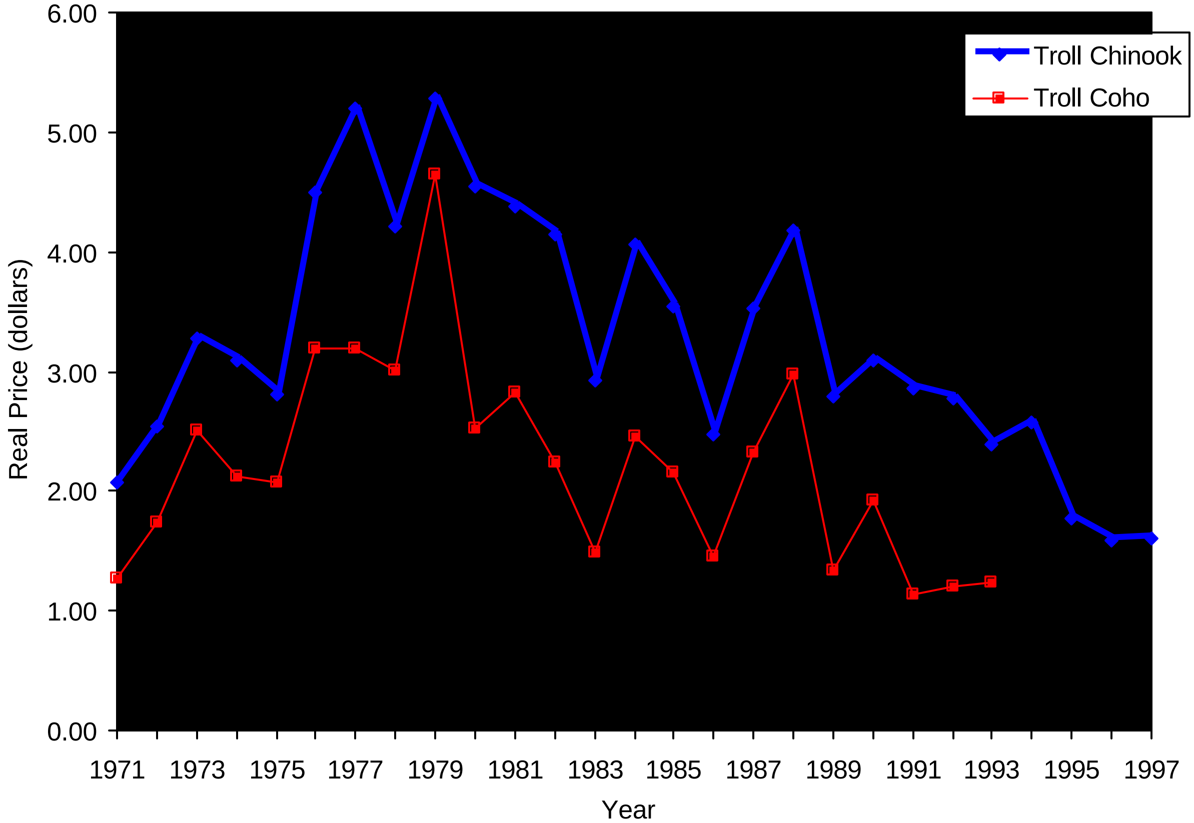
The spawning and production of salmon in a watershed may not be related to the level of harvest in a certain watershed. For example, between the 1870's and 1920's most of the fish produced in the Columbia River system were harvested in Columbia River waters. As ocean fisheries developed, a majority of the fish produced in the Columbia River Basin were harvested in marine waters from California to Alaska. Interestingly, this results in transferring economic investments in Columbia River anadromous fish production to distant economies.

4. Effect of Changing Markets, Production, and Harvests

The "squeeze" between Alaska's production of canned and frozen salmon and aquaculture's production of fresh salmon puts Columbia River salmon production into a price and market taker position. The real price of troll caught chinook salmon, for example, has decreased from $5 in the 1980's to less than $1.50 today (Figure 2.III.3). This is about a 70 percent decline in real prices at a time when most other seafood prices have remained constant. The change from the prized spring chinook to lower quality fall chinook does not allow Columbia River salmon production any competitive or market advantage. The effect of economic development, hatchery production, and mixed stock, open access fisheries has been to reduce the total, and the species composition, of returning salmon to the Columbia River. "Total runs have decreased from about 11 million fish returning per year,[1] before European settlement, to 2.9

1. The NPPC estimated that pre-European development runs were as high as 16 million fish (NPPC, March 1996).

Figure 2.III.3
1971-1997 Annual Commercial Troll Salmon Ex-Vessel Prices Trends
(Adjusted for Inflation, 1997 Base)

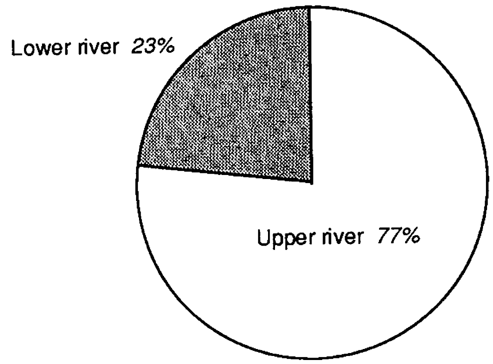


Notes: 1. Prices adjusted to real 1997 dollars using the gross national product implicit price deflator developed by the U.S. Bureau of Economic Analysis.
2. Prices are annual and species averaged and are for Oregon landings only.
3. Average prices for salmon include seasonal and size considerations.
4. Ex-vessel price is the amount paid to fishers at the time of fish delivery.

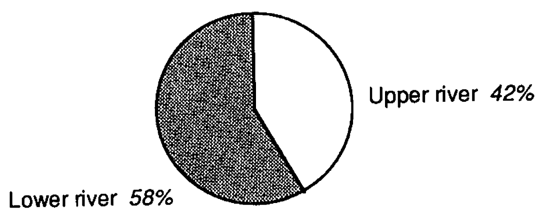
Source: Radtke and Davis (1999).

million fish (1977-1981 average); sockeye and chum have been mostly replaced; and upper river production of spring and summer chinook has been replaced by lower river returning fall chinook and coho" (Figures 2.III.4a to 2.III.4b) (Lee 1993). Because of unfavorable ocean conditions, such as El Niño events, total adult fish harvested or returning to the Columbia River Basin during the 1990's has been around one to 1.5 million fish.

Figure 2.III.4a
Distribution of Columbia River Salmon, Showing Abundance Above and Below the Site of Bonneville Dam (Area of Circles is Proportional to Estimated Population Sizes)



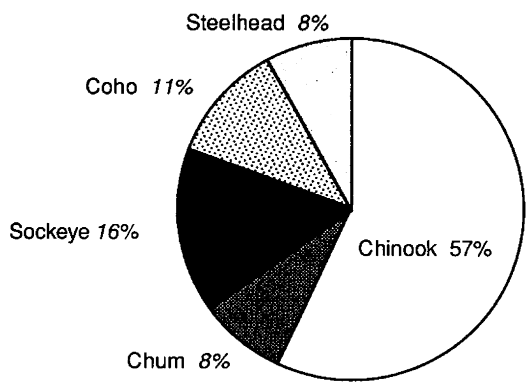
(a) Predevelopment: 11 million per year



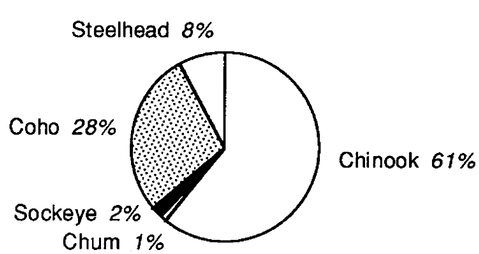
(b) 1977–1981 average: 2.9 million per year

Source: Lee (1993).

Figure 2.III.4b
Species Composition of Columbia River Salmon
(Area of Circles is Proportional to Estimated Population Sizes)



a. Predevelopment (before 1850): 11 million per year



b. 1977–1981 average: 2.9 million per year

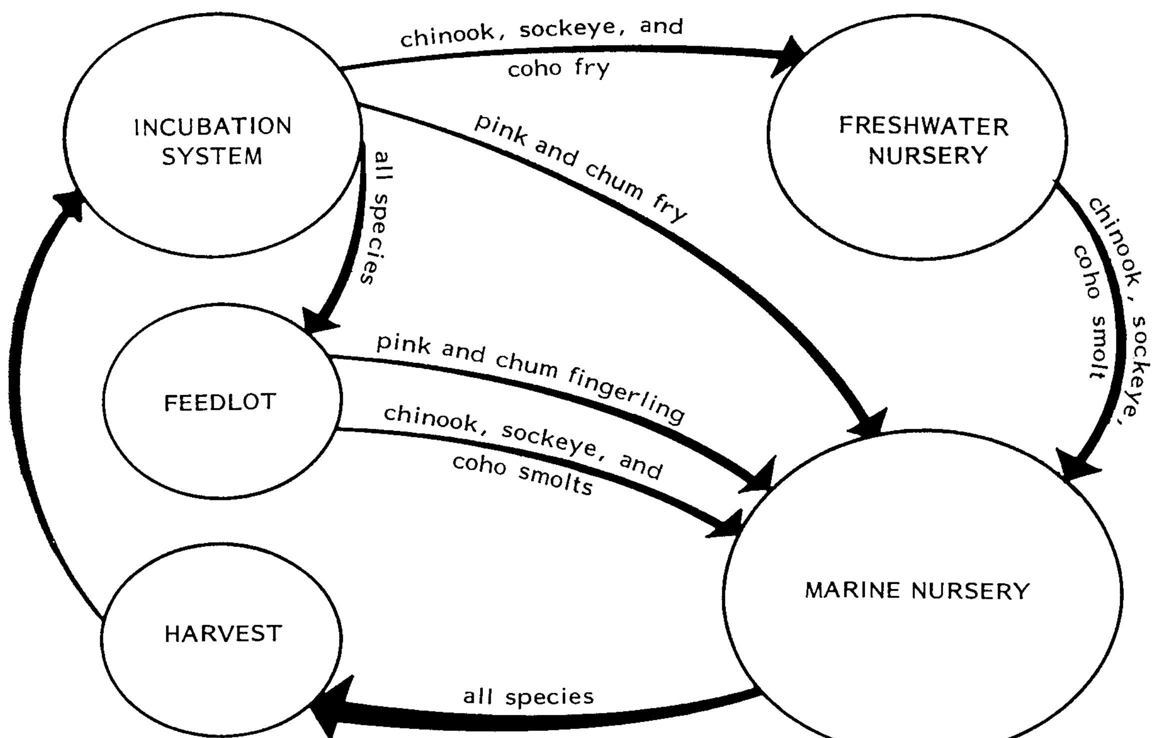
Source: Lee (1993).

CHAPTER IV. SALMON MANAGEMENT

A. Background

Salmon are fully migratory and know no jurisdictional or political bounds. They spawn in rivers and estuaries, then migrate as fingerlings into the marine system early in their life cycle, or feed and grow in freshwater for up to a year to migrate into the ocean as smolts weighing as much as 50 grams. Each of the major species of salmon (chinook, coho, sockeye, chum, pinks, and steelhead) have developed their own system of reliance on fresh or marine waters (Figure 2.IV.1).

Figure 2.IV.1
Processes of Ocean Ranching of Five Species of Pacific Salmon



Source: McNeil and Baily (July 1975).

Artificial propagation seeks to substitute for portions of this cycle. Pink and chums spend very little time in the incubation area and move to the marine nursery soon after the spawned egg moves into the "fish" cycle. Artificial propagation costs tend to be low, about $0.02 per "eyed" egg, and survival rates into fisheries may be very low and still return revenues greater than the cost of propagation. Other fish, such as coho or steelhead that require a longer period of time in fresh water (hatcheries) may cost as much as $0.60 per released smolt. Survival rates to fisheries are therefore an important consideration in artificial propagation management.

Salmon hatcheries were built in the Columbia River system to replace and/or increase natural production. Some of these hatcheries were built as mitigation for specific interruptions (such as dams), others were built for enhancement or economic development objectives. The operation of the mitigation hatcheries may therefore be secondary to the cost considerations of artificial propagation, and the consideration for these mitigation agreements seems to be the number of harvestable adults for any specific area or year.

The migration route of the salmon species and subspecies also varies. Fall chinook from the Columbia River system tend to migrate north through waters off Canada and Alaska, while coho that spawn in the lower Columbia River tend to migrate as far north as do fall chinook (Figure 2.IV.2). Steelhead are ocean wanderers that range as far as Russian waters in the Western Pacific.

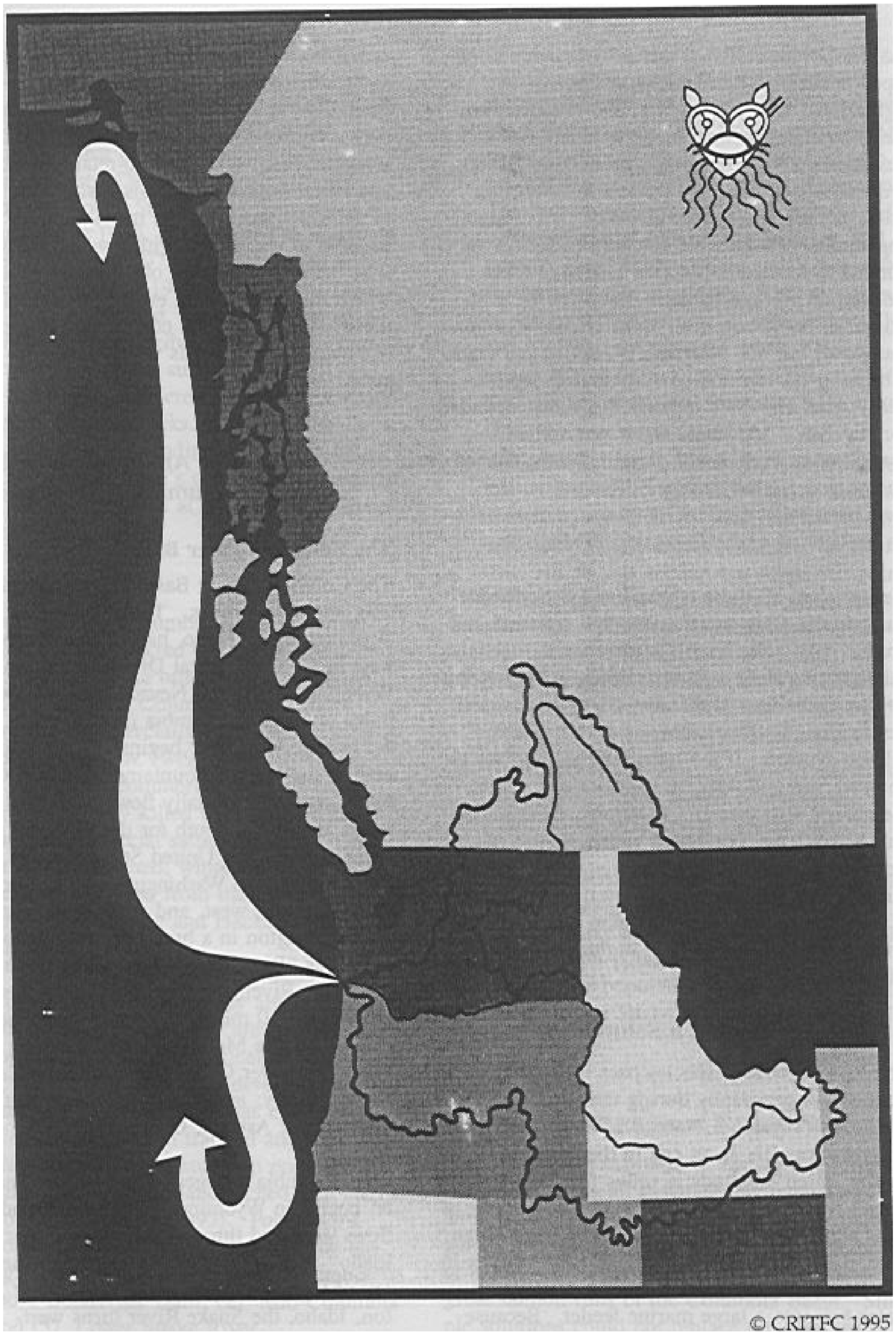
These wide-ranging migratory patterns have made salmon very susceptible to habitat changes and a variety of predators. With technological changes in marine transportation (boats and combustible engines) and fishing gear (monofilament nets and line) man has become the most effective predator in fresh as well as marine waters. The number of salmon that were taken in high seas fisheries after World War II became a concern to many countries. A general understanding has been reached through various international agreements and conventions of a prohibition against directed salmon fisheries in the open oceans or in the high seas (National Research Council 1996, p.262). There has developed an agreement against retention of salmon taken incidentally in fishing for other species. There is also a general agreement that those countries in whose waters salmon originate should receive the primary benefit from these fish.

Salmon harvested in any area are subjected to historical treaties or agreements. Such agreements may or may not be valid for future harvest allocations. The purpose of this chapter is to describe, in general form, some of the major treaties and agreements that affect the harvest of Columbia River Basin produced anadromous fish. Historical harvest patterns and anticipated treaty obligations will be used in estimating future harvest and therefore economic impacts (both regional economic impacts and estimated value impacts) of these harvests.

B. Treaties and Agreements

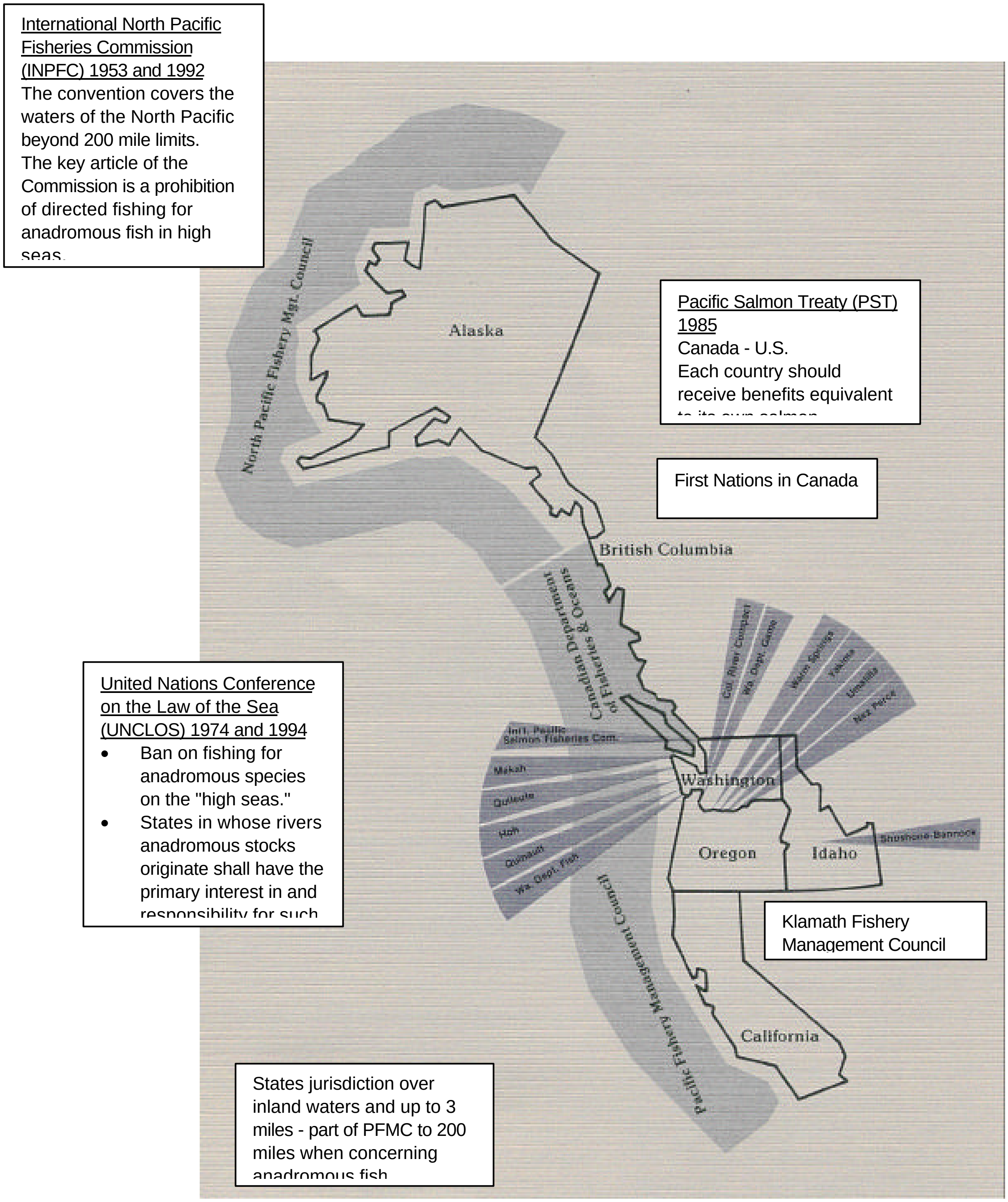
There are a host of salmon treaties and agreements that affect salmon of the Columbia River system. These can be categorized as *international understandings*, such as the 1992 International North Pacific Fisheries Commission (INPFC) Convention (Shepard and Argue, February 1998), the United Nations Convention on the Law of the Sea (UNCLOS) which entered into force in November 1994, the PST between the United States and Canada, *harvest management agreement processes* such as the PFMC, *agreements to rebuild the stocks* such as the Northwest Power Act, *court decisions* that have defined the obligations to Northwest Indian Tribes, and most recently *federal mandates to protect salmon* stocks under the ESA. Figure 2.IV.3 depicts some historical regulatory jurisdictions with partial authority over various stocks of salmon and steelhead production in the Columbia River.

Figure 2.IV.2
Habitat and Range of Columbia River Basin Anadromous Fish



Source: WY-KAN-USH-MI WA-KISH-WIT (1995).

Figure 2.IV.3
Regulatory Jurisdictions With Partial Authority Over Various Stocks of Salmon and Steelhead Produced in the Columbia River and Washington Conservation Areas



Source: NMFS (1984).

The following is a short discussion of some of the agreements, treaties, acts or mandates that affect or may affect the fish that are managed for harvest in any geographic region.

1. The Northwest Power Act of 1980[1]

The waters of the Columbia River system were the basis of a massive program to develop the Northwest. The Columbia River was "tamed" to provide subsidized electricity, irrigation, and navigation for industries and citizens of the west. Some of the costs of this development program began to be realized in the 1960's and 1970's. Demand for cheap power was forecast, and sections of the Pacific Northwest society believed that their historical share in salmon harvests was not being realized. The solution to these emerging issues was the Northwest Power Act of 1980.

"The Act was designed to solve a set of social problems by technological means….. As demand for power grew during the 1970's, more power plants seemed necessary to utilities….. Indian tribes and fishermen…were demanding that the damage to the Columbia's fish runs be repaired…. Congress sought to accommodate them all….. The claims of Indian tribes posed another threat to the region's power supply and economy. After their initial victories over fish harvest, the tribes filed more cases. Rulings in the lower courts suggested that the tribes might be awarded a right to enjoy a productive natural system." (Lee 1993, pp.31-32).

The Northwest Power Act had two principles to prove: that energy conservation made good business sense, and that the Columbia's salmon runs could be salvaged while preserving the dams and their economic benefits. Electric power consumers are obliged to find, through the Bonneville Power Administration, a program to "protect, mitigate, and enhance fish and wildlife to the extent affected by the development and operation of any hydro-electric project of the Columbia River and its tributaries." (Lee 1993, p.40).

In 1986 the council…..set the responsibility of present-day rate payers at between 8 and 11 million adult fish per year. The loss of this many fish, above and beyond the remaining 2.5 million returning to the river, could be ascribed to hydroelectric power generation…… The biological capability of the remaining habitat and technically feasible hatchery sites may fall well below 8 million fish." (Lee 1993, p.40). "The Columbia River Basin Fish and Wildlife Program has ". . . interim goal of doubling salmon populations over an unspecified time . . . Doubling populations while continuing to harvest at levels similar to those of recent years increases costs and biological risks; large scale reliance on hatcheries is unavoidable . . ." (Lee 1993, p.41).

"[The] requirement to share the catch equally between Indian and non-Indian harvesters forced the creation of a new set of institutional mechanisms to regulate fisheries. The Columbia River Basin program aimed at rebuilding *harvestable* populations of salmon - a goal that requires hatcheries. The Council continued, however, to defer to the authority of the fisheries management agencies and Indian tribes on matters concerning harvests. Supplementation thus promises effective use of existing and new

1. Much of this section is from Lee (1993).

hatchery capacity together with the hope of rebuilding wild stocks in their native streams and at population levels that will permit harvest." (Lee 1993, p.42).

The above discussion is included as a background to the NPPC's goal to "double the salmon runs." For a more detailed discussion on the legal aspects of the Columbia River Basin Fish and Wildlife Program, refer to WY-KAN-USH-MI WA-KISH-WIT (1995).

2. Pacific Salmon Treaty 1985

Because salmon have been intercepted in the high seas with gear such as large drift nets, a general agreement has been reached on the "area of origin concept" as it applies to anadromous fish stocks. The principle is that the benefits of enhancement should accrue principally to the nation that makes the enhancement investment. Incentives are therefore created for each country to conserve and enhance valuable salmon stocks by establishing fishery regimes which will substantially reduce the interception of each nation's stocks by the other nation.[1]

The concept is simple, but bogs down in detail of what constitutes a nation's waters. Does this include the three mile state waters or the 200 mile EEZ, or does the definition include only fresh water and river estuaries?

Provisions of the 1985 PST between the United States and Canada require that "each Party shall manage its fisheries and its salmon enhancement programs so as to…provide for each Party to receive benefits equivalent to the production of salmon originating in its waters." (Article III, paragraph 1b) Recognizing that it is not possible to fully eliminate interceptions of salmon by the two countries without unacceptably disrupting traditional fisheries of both countries, the Treaty nevertheless seeks to ensure that each country receives benefits *equivalent* to its own salmon production. The Treaty does not specify exactly how the "equity principle" is to be implemented, but rather leaves this task to the Pacific Salmon Commission (PSC), implementing body of the Treaty.[2] By fishing off each other's salmon stocks for some agreed upon quota, both countries have overfished the stocks. Alaska is advocating an "abundance based" fishery that takes into account the time that salmon "graze" in their waters. Canada maintains that a large share belongs to them based on the originating principle.

As of April 1998 negotiations are underway between Canada and the United States on the sharing of salmon that may intermingle in each other's waters. A recent historic sharing of salmon produced from the Columbia River system may provide an indication of Canadian salmon harvests of Columbia River system produced salmon.

For every ten coho and chinook salmon produced in Washington, Oregon and Idaho, six or more are harvested in Canada. Conversely, U.S. citizens of the Pacific Northwest harvest runs of sockeye and

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1. Comments made during the negotiation of the United Nations Law of the Sea Convention. Taken from Shepard and Argue (1988).
2. Taken from a paper prepared by U.S. participants for the Pacific Salmon Commission Workshop on Valuation Methodologies, held on September 23-25, 1991 at Kah-Nee-Ta, Oregon.

pink salmon which originate in Canada. Alaska fisheries also intercept chinook salmon from the lower Pacific Northwest and Fraser River (Canada) sockeye.

The central theme of the PST is that harvests and interceptions of each other's salmon may be controlled, and that naturally spawning salmon could be protected while at the same time increasing the abundance of hatchery produced salmon. Two major problems have emerged that may affect the success of the PST. One is the issue of equity and what constitutes “producing waters.” Alaska, as part of the U.S. delegation, argues that fish that migrate through its waters are “grazing” on its resources, and that the time the salmon spend in Alaskan waters should be counted as salmon “originating” in these waters. The second issue is the reliance on hatchery production. As ocean conditions have changed due to factors such as El Niño, salmon ocean survival has decreased to record historic lows. Expectations of increased harvests driven by increased hatchery capacity have not materialized, resulting in the carefully negotiated allocation agreements not being met.

The PSC determines the allowable total salmon to be harvested by the U.S. and Canada. Major provisions of the PST that affect Columbia River stocks.

- Southeast Alaska - Treaty quota of 263,000 chinook for the troll fishery
- Northern British Columbia - Treaty quota of 263,000 chinook for the troll fishery
- West Coast Vancouver Island - Treaty quota of 360,000 chinook and 1.8 million coho
- Georgia Strait Sport and Troll - Treaty quota of 275,000 chinook

The PSC’s primary function is to control harvest. Concurrent with catch restraints in PSC fisheries, the management agencies are required to “pass through” any fish saved by the curtailed PSC fisheries so that these fish would principally accrue to the spawning grounds. This “pass through” agreement requires certain restraints on the U.S. domestic fisheries not to intercept fish needed to rebuild the spawning population of depressed salmon runs in local rivers.

3. Pacific Fishery Management Council

The PFMC is the primary agency that manages the harvests of salmon in the waters off Washington, Oregon and California. The PFMC provides guidance to the U.S. Secretary of Commerce on the management of fisheries in waters off Washington, Oregon, and California. All fisheries of the Columbia River are established within the guidelines and constraints of the CRFMP, the ESA, and management agreements negotiated between the parties to U.S. v. Oregon.

The PFMC was established as one of eight regional councils in the U.S. that would regulate the fisheries in waters off the shores of the U.S. according to principles and objectives of the Magnuson Act of 1976. Fisheries are managed according to established Fisheries Management Plans (FMPs) that may be amended. A general description of the existing and proposed renewed salmon management plans as they relate to the Columbia River produced salmon follows.

a. Management Unit

Pacific Coast salmon are managed by the PFMC in accordance with Section 11.0 of the Pacific Coast Salmon Plan as revised in 1996.[1] The management unit includes those stocks of salmon of U.S. origin that are harvested in the exclusive economic zone (EEZ) off the coasts of Washington, Oregon, and California. Exceptions are those stocks which are managed there by another management entity with primary jurisdiction, (i.e. sockeye and pink salmon by the Fraser River Panel of the PSC in the Fraser River Panel Area (U.S.) between 49°N and 48°N latitude. Chinook and coho salmon are the main species caught in the ocean salmon fisheries operating off Washington, Oregon, and California. The catch of pink salmon in odd-numbered years is also significant. The management unit represents a coast wide aggregate of salmon stocks which are further broken down by species into principal stock components for ocean management purposes. The principal stock components represent a stratification by shared life-history traits, habit preference, and genetic similarities to facilitate greater management sensitivity to trends in regional abundance and increase the protection of the genetic diversity found within the coverage area. Table 2.IV.1 contains a complete listing of the principal stock components in the Salmon FMP.

Active management consideration is given to each principal stock component which is either significantly impacted by PFMC fisheries or listed under the ESA. The principal stock components which meet the exploitation rate criteria, represent populations where ocean impacts can directly effect the achievement of their management objectives. For listed principal stock components, the PFMC's annual harvest management plans are developed to be consistent with guidance provided by the NMFS regarding recovery plan objectives or proposed jeopardy standards. Principal stock components monitored as the result of ESA action, denote populations where harvest impacts may be of increased significance and need to be considered during the course of developing annual harvest management plans.

Although the FMP's management approach is focused on greater protection of natural stocks, hatchery stocks are also important contributors to the ocean fisheries. Within some principal stock components, hatchery stocks are an important management consideration and may be included as key stock or stock groups. Where hatchery stocks are designated as key stock or stock groups, management considerations for these stocks will be taken into account, but application of overfishing requirements do not extend to the hatchery stocks. A general description of the basic management considerations for each principal stock component from the Columbia River is provided below.

Table 2.IV.1
Principal Stock Components in the PFMC Salmon FMP

CHINOOK	COHO
Sacramento River Winter-Run	Central California Coast
Central Valley Spring-Run	Southern Oregon/Northern California Coast
Central Valley Fall/Late Fall-Run	North/Central Oregon Coast

1. Much of the material on the PFMC is from *Review of Ocean Salmon Fisheries* for Various Years, PFMC, Portland, Oregon.

Klamath River Southern Oregon/California Coast Oregon Coast Snake River Fall-Run Snake River Spring/Summer-Run Upper Columbia River Summer/Fall-Run Upper Columbia River Spring-Run Mid-Columbia River Spring-Run Lower Columbia River Upper Willamette River Washington Coast Puget Sound	Columbia River Southwest Washington Olympic Peninsula Puget Sound **PINK** Puget Sound

i. Columbia River - Coho

Coho salmon stocks originating from within the Columbia River represent this principal stock component. The freshwater fauna of this principal stock component is distinctive for its extensive estuarine habitat. Ocean distribution for these populations includes Oregon, Washington, and British Columbia coastal waters.

ii. Snake River Fall Run - Chinook

Populations of fall chinook returning to the Snake and Deschutes Rivers are included in this principal stock component. These populations exhibit ocean-type life history traits, with a more southerly migration pattern than the upper Columbia River populations. Tag recoveries occur from ocean fisheries spanning from California to Alaska. Ecologically, this region represents a high desert plain with annual rainfall varying between 25 to 50 cm.

iii. Snake River Spring/Summer Run - Chinook

Included in this principal stock component are stream-type chinook salmon populations from the upper reaches of the Snake River Basin. These populations emigrate to the ocean as yearlings, mature at ages four and five, and are rarely taken in ocean fisheries. Spawning occurs at elevations of above 1,000 meters in streams where winter snowpack is the major contributor to stream flows. Peak flows occur with spring melt in May or June lasting only two to three months.

iv. Upper Columbia River Summer/Fall Run - Chinook

All ocean-type chinook populations spawning in areas between McNary Dam and Chief Joseph Dam comprise this principal stock component. These populations generally mature at an older age than ocean-type chinook from the lower Columbia and Snake Rivers. This component exhibits a stronger northerly distribution pattern than the Snake River populations, contributing predominantly to ocean fisheries in British Columbia and Alaska.

v. Upper Columbia River Spring Run - Chinook

This principal stock component comprises stream-type chinook salmon populations spawning above Rock Island Dam, primarily in the river systems of the Wenatchee, Entiat and Methow. These populations exhibit classical stream-type life history strategies: yearling smolt emigration with only rare tag recoveries in coastal fisheries. Ecologically, these populations originate from drainages of the eastern Cascades, relying on snow melt for peak spring flows. These waters tend to be cooler and less turbid than the Snake and Yakima Rivers to the south. Spawning occurs at elevations between 500 and 1000 meters.

vi. Mid-Columbia River Spring Run - Chinook

Included in this principal stock component are stream-type chinook salmon spawning in the Klickitat, Deschutes, John Day, and Yakima Rivers. Stream-type life history traits are characterized by smolt emigration as yearlings. The majority of adults in this component spawn as 4-year-olds, with the exception that return to the upper tributaries of the Yakima River which return as 5-year-olds. These populations are genetically distinct from other stream-type populations in the basin. Streams in this region drain desert areas east of the Cascade range and are ecologically differentiated from the colder, less productive, glacial streams of the upper Columbia and from the generally higher elevation streams of the Snake River.

vii. Lower Columbia River - Chinook

All chinook salmon populations from the mouth of the Columbia River to the crest of the Cascade Range, excluding populations above Willamette Falls, are within this principal stock component. All of these stocks are considered ocean-type. These populations tend to mature at ages three and four, somewhat younger than the surrounding regions. Their ocean distribution is northerly, but with little contribution to the Alaska fishery.

viii. Upper Willamette River - Chinook

This principal stock component includes the spring chinook populations above the Willamette Falls. These populations have an unusual life history of sharing both the stream and ocean-type life history traits. This component attains maturity in its fourth and fifth year of life, with slightly more four-year-old fish. Ocean distribution is consistent with an ocean-type life history, considerable tag recoveries occur in the coastal fisheries of British Columbia and Alaska. Ecologically, the Willamette Valley experiences a rainshadow effect from Cascade Range which limits rainfall and produces peak flows in December and January. The Willamette Falls offered a narrow temporal window for upriver migration, which may have promoted isolation for the other Columbia River stocks.

b. Management Considerations

Outlined below is a general discussion of the management considerations associated with each primary ocean management area. Within these areas there is a presence of several different principal stock components requiring an integration of varying harvest objectives. For some of the principal stock components, achievement of the specific harvest objectives associated with ocean fisheries is also conditioned upon fulfilling federal trust obligations to Indian tribes with federally reserved fishing rights and inside non-Indian net and recreational fisheries needs. Each year specific regulatory measures are implemented that are intended to achieve a balance between the harvest objectives for the various ocean and inside fisheries. The following discussion identifies those components and ocean areas where harvest objectives related to treaty obligations and inside fishery needs are of significance.

i. South of Cape Falcon, Oregon Management Unit for Coho

Columbia River, Oregon and California coho are managed together within the framework of the Oregon Production Index (OPI) since these fish are essentially intermixed in the ocean fishery. These coho contribute to ocean fisheries off the southern Washington coast as well as to fisheries off the coasts of Oregon and northern California. Ocean fishery objectives for the OPI area address the following: (1) conservation and recovery of Oregon and California coastal coho; (2) the desire for viable fisheries inside the Columbia River; and (3) impacts on management objectives for other key stock or stock groups.

The OPI is used as a measure of the annual abundance of adult three-year-old coho salmon resulting from production in the Columbia River and in Oregon and California coastal basins. The index itself is simply the combined number of adult coho that can be accounted for within the general area from Leadbetter Point, Washington to as far south as coho are found. Currently, it is the sum of (1) ocean sport and troll fishery impacts in the ocean south of Leadbetter Point, Washington, regardless of origin; (2) Oregon and California coastal hatchery returns; (3) the Columbia River in-river runs; (4) Oregon coastal natural spawner escapement and (5) Oregon coastal inside fishery impacts. Most of the California production is from hatcheries which provide a very small portion of the total hatchery production in the OPI area.

ii. North of Cape Falcon, Oregon Management Unit for Coho

Management of ocean fisheries for coho north of Cape Falcon is complicated by an overlap of OCN stocks in the vicinity of the Columbia River mouth. Allowable harvests in the area between Leadbetter Point, Washington and Cape Falcon, Oregon will be determined by an annual blend of OCN and Washington coho management considerations including:

- Abundance of contributing stocks.
- Stock specific management objectives.
- Consultation standards of the ESA.
- Relative abundance of chinook and coho.

- Allocation considerations of concern to the PFMC.

Coho occurring north of Cape Falcon, Oregon are comprised of a composite of coho stocks originating in Oregon, Washington, and southern British Columbia. Ocean fisheries operating in this area must balance management considerations for stock specific management objectives for Southern Oregon/Northern California, Oregon Coast, Southwest Washington, Olympic Peninsula, and Puget Sound.

iii. South of Horse Mountain Management Unit for Chinook

Within this area, considerable overlap of chinook originating in Central Valley and northern California coastal rivers occurs between Point Arena and Horse Mountain. Ocean commercial and recreational fisheries are managed to address impacts on chinook stocks originating from the Central valley, California Coast, Klamath River, Oregon Coast, and the Columbia River. With respect to California stocks, ocean commercial and recreational fisheries operating in this area are managed to maximize natural production consistent with meeting the U.S. obligation to Indian tribes with federally recognized fishing rights, and recreational needs in inland areas.

iv. Horse Mountain to Humbug Mountain Management Unit for Chinook

Major chinook stocks contributing to this area originate in streams located along the Southern Oregon/California coasts as well as the Central Valley. The primary chinook run in this area is from the Klamath River system, including its major tributary, the Trinity River. Ocean commercial and recreational fisheries operating in this area are managed to maximize natural production of Klamath River fall and spring chinook consistent with meeting the U.S. obligations to Indian tribes with federally recognized fishing rights, and recreational needs in inland areas. Ocean fisheries operating in this area must balance management considerations for stock-specific management objectives for Klamath River, Central Valley, California Coast, Oregon Coast, and Columbia River chinook stocks.

v. Humbug Mountain to Cape Falcon Management Unit for Chinook

The major chinook stocks contributing to this area primarily originate in Oregon coastal rivers located north of Humbug Mountain, as well as from the Rogue, Klamath and Central Valley systems. Allowable ocean harvests in this area are an annual blend of management considerations for impacts on chinook stocks originating from the Central Valley, California Coast, Klamath River, Oregon Coast, Columbia River, and the Washington Coast.

vi. Cape Falcon to United States/Canada Border Management Unit for Chinook

The majority of the ocean chinook harvest in this area primarily originates from the Columbia River, with additional contributions from Oregon and Washington coastal areas. Bonneville Pool (tules) falls and lower Columbia River (tules) falls and springs (Cowlitz), all primarily of hatchery origin, comprise a majority of the ocean harvest between Cape Falcon, Oregon, and the U.S. - Canada border. Hatchery production escapement goals of these stocks are established according to long-range production programs and/or mitigation requirements associated with displaced natural stocks. Allowable ocean harvest in this area is a blend of management considerations for impacts on chinook stocks originating form the Oregon Coast, Columbia River, Washington Coast, and Puget Sound.

vii. Pink Salmon Management Unit

Ocean pink salmon harvests occur off the Washington coast and are predominantly of Fraser River origin. Pink salmon of Puget Sound origin represent a minor portion of the ocean harvest although ocean impacts can be significant in relation to the terminal return during years of very low abundance. The Fraser River Panel of the PSC manages fisheries for pink salmon in the Fraser River Panel Area (U.S.) north of 48° N latitude to meet Fraser River natural spawning escapement and U.S. - Canada allocation requirements. The PFMC manages pink salmon harvests in that portion of the EEZ which is not in the Fraser River Panel Area (U.S.) waters consistent with Fraser River Panel management intent. Pink salmon management objectives must address meeting natural spawning escapement objectives, allowing ocean pink harvest within fixed constraints of coho and chinook harvest caps and providing for treaty allocation requirements.

c. Recent Years Harvests of Major Columbia River Stocks

i. Lower Columbia River Spring Chinook

The 1997 minimum in-river run size of lower river adult spring chinook is estimated at 45,500 fish, improved over the 1996 return of 39,200 fish, but below the 1986-1990 average return of 131,500 fish. For 1997, the winter season commercial salmon fishery was closed because of the very poor runs of spring chinook that were projected to return to lower river areas. The early season mainstem lower river recreational fishery was closed on March 11 to provide maximum protection for depressed lower river spring chinook stocks.

ii. Upper Columbia River Spring and Summer Chinook

The 1997 in-river run size of adult spring chinook destined for areas above Bonneville Dam was 114,100 fish, over twice the 1996 return of 51,500, and over ten times the record low of 10,200 fish in 1995. Lower river fishery impacts on adult upriver spring chinook in 1997 were limited to incidental mortality in commercial fisheries, and ceremonial and subsistence fisheries. The in-river harvest impact rate on adult wild Snake River spring chinook was estimated at 7.3 percent in 1997, compared to 5.5 percent in 1996 and the 1986-1990 average impact rate of 10.7 percent.

Major fisheries targeting summer chinook in the Columbia River have been eliminated since 1964 due to chronically depressed status of this stock. In 1997, escapement of upriver spring chinook was 105,800, over twice the 1996 escapement of 48,700 and 92 percent of the interim goal of 115,000 adults. Escapement of upper Columbia River summer chinook was 27,600 adults, 78 percent above the 1996 escapement of 15,500 adults, but still far below the goal of 80,000 - 90,000 adults. The

1997 escapement of adult wild Snake River spring chinook at Lower Granite Dam was estimated at 1,400 fish, well below the 1986-1990 average return of 5,900 fish and the interim management goal of 25,000 adults.

iii. Columbia River Fall Chinook

Historically, four stocks have contributed significantly to the Columbia River fall chinook fisheries. These include two lower river stocks, lower Columbia River Hatchery (LRH) tules and Columbia River Wild (LRW) chinook, and two upper river stocks, Spring Creek Hatchery (SCH) tules and upriver bright (URB) chinook.

Total ocean escapement of all Columbia River fall chinook stocks was similar to the expected 1997 returns, with greater than expected returns of LRW stocks, but less than expected returns of the mid-Columbia River bright stocks. Ocean fisheries impacting the Columbia River Chinook stocks in 1997 were restricted by U.S. and Canada managers in order to provide needed conservation measures to protect and rebuild depressed chinook stocks. PFMC area and treaty Indian ocean chinook fisheries north of Cape Falcon were restricted in 1997.

4. Columbia River Compact

The challenges of salmon harvest management in the 1960's and 1970's resulted in jurisdictional guidelines for future Columbia River produced salmon harvests. The decision in the *U.S. versus Washington and Oregon* provides for an equal sharing of harvestable salmon between treaty and non-treaty entities (ODFW, October 1998). The judicial decision defines equal harvest sharing as 50/50 (50 percent treaty and 50 percent non-treaty) of the upriver destined chinook available for harvest in the ocean south of the Canadian border and in the mainstream of the Columbia River below Priest Rapids Dam. The management entity is the Columbia River Compact and the CRFMP (ODFW/WDFW, January 1998). The Columbia River Compact is the entity charged with congressional and statutory authority to adopt seasons and rules for Columbia River commercial fisheries. Member agencies are:

Oregon Department of Fish and Wildlife (ODFW)
Washington Department of Fish and Wildlife (WDFW)
Washington Fish and Wildlife Commission (WFWC)

In addition, the Columbia River treaty tribes have authority to regulate treaty Indian fisheries. When addressing commercial seasons for salmon, steelhead and sturgeon, the Compact must consider the effect of the commercial fishery on escapement treaty rights and sport fisheries, as well as the impact on species listed under the ESA.

"The harvest allocation provisions of this agreement apply only to the ocean fisheries south of the Washington/British Columbia border and the mainstem fisheries as herein defined unless otherwise expressly indicated." (ODFW 1998, p.5). The following are in-river management guidelines of the CRFMP.

a. Spring/Summer Chinook

Harvest of upriver spring chinook occurs primarily after mature fish return to freshwater. The ocean harvest rates are less than anticipated (two percent) when the plan was drafted. The current assessment is that upriver spring chinook are not known to be harvested significantly in ocean fisheries, probably due to timing and structure of fishing seasons.

The CRFMP provides that on runs between 50,000 and 112 percent of the Bonneville Dam management goal of 115,000, the mainstream harvest below Bonneville Dam is limited to 4.1 percent and in no event should exceed 5.0 percent of the upriver run. Treaty platform, gillnet, and ceremonial and subsistence (C&S) fisheries in Zone 6 are limited to seven percent of the run.

Based on Coded Wire Tag (CWT) recoveries (McCall Hatchery), the ocean distribution of Snake River summer chinook may be similar to that of spring chinook, and therefore not significantly harvested in the ocean.

The allowable non-Indian spring chinook harvest rates are described by a matrix (Table 2.IV.2a) that is based on the Willamette return and either the aggregate upriver or Snake River wild return.[1] Based on the projected 1997 returns, a harvest rate of two percent was allowed on upriver spring chinook for non-Indian fisheries under the Management Agreement. The Management Agreement provides that non-Indian commercial and recreational impacts on summer chinook and sockeye (runs) will be minimized to the degree possible, but shall not exceed one percent of the run.

The treaty Indian spring chinook harvest matrix is based on the aggregate upriver return and the Snake River wild return (Tables 2.IV.2b and 2.IV.2c). The Management Agreement states that treaty Indian summer chinook catch shall not exceed five percent of the run and the treaty Indian catch of sockeye is linked to the run size.

Table 2.IV.2a
Non-Indian Fisheries Spring Chinook Harvest Rate Matrix

Select the More Conservative of:		Willamette Spring Chinook Run Size (thousands)			
Aggregate Upriver Spring Chinook Return (thousands)	Snake River Wild Spring Chinook Return (thousands)	<50	50-75	75-100	>100
<50	<5	1%	1%	1%	--
50-115	5-7.5	2%	2%	<2.5%	--
50-115	7.5-10	2%	2%	3%	--
>115	>10	2%	2%	<3%	--
<115	>10	--	--	--	--

Note: "--" denotes further discussion by the Parties.

1. Much of the following material on spring chinook is taken from the ODFW/WDFW Joint Staff Report (January 1988).

Source: ODFW/WDFW (January 1998).

Table 2.IV.2b
Treaty Indian Fisheries Spring Chinook Harvest Rate Matrix

Select the More Conservative of:		Appropriate Harvest Rate
Aggregate Upriver Spring Chinook Return (thousands)	Snake River Wild Spring Chinook Return (thousands)	
<50	<5	5%
50-115	5-10	7%
<115	>10	CRFMP (5% or 7%)
>115	NA	--

Note: "--" denotes further discussion by the Parties.
Source: ODFW/WDFW (January 1998).

Table 2.IV.2c
Treaty Indian Fisheries Sockeye Harvest Rate Matrix

Aggregate Upriver Sockeye Run Size	Appropriate Harvest Rate
>50,000	5%
50,000-75,000	7%
>75,000	--

Note: "--" denotes further discussion by the Parties.
Source: ODFW/WDFW (January 1998).

b. Fall Chinook

The upriver fall chinook run is managed under the terms of the CRFMP to consist of two stocks: the Bonneville Pool Hatchery (BPH) and Upriver Bright Stock (URB) both hatchery and wild.

Ocean and in-river fisheries have experienced major changes as a result of U.S. v. Oregon litigation, enactment of the Magnuson Act, the U.S./Canada PST, and Endangered Species consideration. The general harvest management guideline, over and above minimum escapement needs, is that 50 percent of the adult chinook produced by mitigation funds should enter the Columbia River annually.

"Treaty Indian and non-Indian fisheries shall share equally (50 percent each) the upriver fall chinook available for harvest in the Pacific Ocean south of the southwesterly projection of the United States-Canada boundary between British Columbia and Washington, and in the mainstem Columbia River below Priest Rapids Dam. Treaty Indian and non-Indian fisheries in Columbia River tributaries, other than the mainstem Columbia River between McNary and Priest Rapids dams, shall be excluded from this allocation and shall be covered by the subbasin plans (ODFW 1998, p.29).

c. Steelhead

Upriver summer steelhead were once abundant in the Columbia River Basin and were harvested commercially along with other anadromous stocks. Between 1892 and 1896, combined runs of summer and winter steelhead were estimated to range as high as 554,000 adults. Average annual catch of summer steelhead during this period was estimated at 382,000 fish (TAC 1997). Habitat degradation and overfishing caused substantial declines of runs during the late 1800's and early 1900's and continued into the mid 1900's. Commercial landing of steelhead by non-Indians was prohibited beginning in 1975 (ODFW/WDFW 1998). Steelhead are presently managed under the Columbia River Fish Management Plan (CRFMP) (TAC 1997).

Summer steelhead make up the bulk of the present steelhead runs. Summer steelhead are divided into two groups, A and B, under the terms of the CRFMP. Group A steelhead originate in production areas throughout the Columbia Basin. Group B adult steelhead originate only in the Clearwater and Salmon River drainages in Idaho. The CRFMP limits treaty Indian fall fisheries to 15 percent of the wild A and 32 percent of the wild B run on wild runs less than 75,500 fish, as measured at Bonneville Dam.

The CRFMP contains no management or escapement goals for hatchery steelhead. According to the CRFMP, the relative abundance of Group A and Group B steelhead is to be considered in setting seasons, so tributary fishing opportunities of the parties to the CRFMP are not precluded and treaty Indian and non-Indian fisheries can harvest a fair share of salmon and steelhead runs. Neither the treaty Indian nor non-Indian catches are to exceed 50 percent of the aggregate of harvestable steelhead (hatchery plus natural/wild) in the mainstem and tributaries (TAC 1997, Tab 8, p.5).

5. Endangered Species Act and Allowable Harvest Considerations

The purpose of the ESA is to provide a means whereby the ecosystems upon which endangered species and threatened species depend, may be conserved to provide a program for the conservation of such species, and to take steps as may appropriate to achieve the purposes of various international treaties and conventions.[1] The ESA is a process for listing, protection and recovery of certain species, subspecies, and distinct populations.[2]

Alaska and West Coast salmon fisheries impact the following Columbia River anadromous fish species that are currently (September 1999) listed under the ESA:

<u>Chinook</u>
Snake River spring/summer (threatened);
Snake River fall (threatened);
Lower Columbia River (threatened);
Upper Willamette River (threatened);
Upper Columbia River (threatened);

<u>Coho</u>
Lower Columbia River/Southwest Washington (candidate);

<u>Chum</u>
Columbia River (threatened);

1. Most of this section is from WY-KAN-USH-MI WA-KISH-WIT, p. 4-10.
2. Much of the following is from Review of Ocean Salmon Fisheries for Various Years, PFMC, Portland, Oregon.

Sockeye
Snake River (endangered);

Steelhead
Upper Columbia River (endangered);
Lower Columbia River (threatened);
Snake River Basin (threatened);
Upper Willamette River (threatened); and
Middle Columbia River (threatened).

In addition, the recovery of several other Oregon and Washington coast and Puget Sound chinook and coho salmon and steelhead species are listed. Guidance for the management of these stocks will affect future Columbia River anadromous fish fisheries.

Alaska and West Coast managed ocean fisheries have identifiable impacts on only Sacramento River winter chinook, Snake River fall chinook, and the coho stocks. Based on the 1988-1993 average, the total mortality of Snake River fall Chinook due to all ocean salmon fisheries is proportioned as: 26 percent for the West Coast fisheries, 12 percent for southeast Alaska and 62 percent for Canada.

NMFS issues biological opinion for listed stocks that require fisheries management practices to meet objectives to avoid jeopardizing the recovery of the listed stocks. For example, the objectives for the stocks that have identifiable impacts from ocean fisheries are as follows.

- For Sacramento River winter chinook, achieve a 31 percent increase in the age three adult cohort replacement rate relative to the 1989-1993 mean rate.

- For Snake River fall chinook, barring an agreement among the parties to the PST to meet conservation needs of chinook salmon, harvest impacts of ocean fisheries in the West Coast and Alaska fisheries, or of all ocean fisheries, cannot exceed 50 percent or 70 percent, respectively, of the 1988-1993 average exploitation rate on age three and age four fish.

- For Central California, southern Oregon/northern California and OCN coho in 1998, limit impacts on OCN coho from West Coast area fisheries to no more than 13 percent and prohibit retention of coho in all catch areas that significantly impact listed coho. In addition, as a surrogate for southern Oregon/northern California coho, limit impacts on Rogue/Klamath hatchery coho to no more than 13 percent.

- For Columbia River fisheries, there are NMFS BO that specify like management objectives.

The PFMC and the North Pacific Fishery Management Council (NPFMC), through the State of Alaska, develop management plans to achieve the stock recovery plans. Similarly the Columbia River fisheries are under a court order to have CRFMP consistent with stock recovery plans.

The NMFS 1995 Federal Columbia River Power System (FCRPS) Biological Opinion (NMFS 1995) concluded that major changes were needed to significantly increase salmon survival. NMFS called for a detailed evaluation of alternative configurations and operations of the four federal hydroelectric projects on the lower Snake River. The purpose of the evaluation was to determine the likelihood that drawdown (breaching) of these four dams, or some other alternative such as expansion of the juvenile fish transportation program, would result in the survival and recovery of Snake River salmon and steelhead. The Corps initiated the evaluation with the Lower Snake River Juvenile Salmonid Migration Feasibility Study of which this study is one element. The Corps in-turn requested that the NMFS summarize available information on the potential effects of the management options on anadromous salmon and steelhead runs originating within the Snake River system. Because the effect of any hydrosystem action would be embedded in the broader relationship between fish and their environment, management actions were evaluated by NMFS (1999) in the context of factors that might occur outside the direct control of the hydrosystem (such as hatcheries output and changes in habitat, harvest, and ocean conditions). The NMFS (1999) conclusions pertaining to the adequacy of PATH results have been incorporated into this study.

C. Salmon Management Considerations

Because salmon range over a large geographic area both in inland waters and in the ocean, production and harvest management is very complex. As previously discussed, there are four general principles or agreements that give direction to production and harvest management. These four principles are international agreements on salmon interceptions, the PST, PFMC Salmon Management Plan, and the Columbia River harvest agreements. In addition, the ESA restricts the amount of wild salmon that may be harvested directly or indirectly once a species or sub-species has been placed on the threatened or endangered species list. Any forecast of future salmon harvests from Columbia River production has to include some or all of these considerations.

CHAPTER V. SURVIVAL RATES AND CONTRIBUTION TO FISHERIES

A. Historical Hatchery Survival Rates

The states in the Pacific Northwest and the federal government have funded hatchery salmon production for more than 100 years. This activity has been continually viewed as a relatively simple solution to persistent problems of habitat loss and overfishing. From the earliest efforts well into the 1960's, most production relied primarily on release of salmon fry with a gradual shift toward holding fish to fingerling size for stocking. By the 1960's, hatchery programs began holding fish for release as full term smolts.

Hatchery smolt production costs are only one component of the unit cost of a harvested adult. The unit cost of production allows an evaluation of a hatchery to control costs and reflect one part of the efficiency of an operation. However, smolts are not sold or caught, only harvestable adults. Therefore, the number of adults surviving gives a better evaluation of individual hatcheries and of the hatchery program in general. The number of returning wild spawners is also crucial to the survival of the species and to contribution to any harvests. Since only limited information is available on survival and harvest rates of wild fish, this section discusses the information available through the hatchery program. There is speculation that wild fish survive at higher rates. One study suggests that wild fall chinook in the lower Columbia River survive "at an average rate that may be as high as 12 times greater than the average of Columbia River hatchery stocks." (McIsaac 1990).

There is no consistent policy to include the differential survival rates of wild and hatchery fish in production or harvest management of Columbia River produced salmon. "Enhancement" studies in the 1970's generally focused on the engineering of hatchery ponds and assumed fairly high survival rates to justify these projects (Table 2.V.1) (Kramer, Chin & Mayo, Inc., December 1976). Experience has shown that survival rates have been a fraction of these assumed rates.

More recent scientific evidence about survival rates of hatchery reared salmon has given credibility to arguments cautioning the role of hatcheries. "The rapid decline of salmon runs throughout the Pacific Northwest has galvanized attention in the last 15 years. . . Recent scientific research suggests that hatcheries may have contributed to the decline of salmon runs." (Taylor 1996, abstract). "Yet artificial production has been implemented on a scale that will continue to commit a large percentage of the region's restoration resources, a large percentage of the available watersheds, and a large percentage of the remaining stocks to a single, unproven technology. There may be merit to reconsidering these practices." (Scientific Review Team 1999).

Table 2.V.1
Hatchery and Marine Survival Egg Take to Emerge

Species	Heath Trays	Wash. Pond Trays	Gravel Box	Spawn Channel	Stream Improv.	Survival Per Month Reared Prior to Release	Marine Survival From Release to Return to Fishery	Weight at Release Number/ Pound
Fall chinook	80%	80%				98%	1.0%	90
Resident chinook	80%	80%				98%	10.0%	8
Spring chinook	63%	63%				98%	3.0%	8
Coho	75%	80%				98%	5.0%	20
Chum		75%				95%	1.5%	300
			75%				1.0%	1,200
					33%		1.0%	1,350
Pink			80%				3.0%	1,830
					33%		3.0%	1,830
Sockeye				60%			0.5%	1,500

Source: Kramer, Chin & Mayo, Inc. (December 1976).

The optimism of dependence on hatcheries:

> "From a social point of view, salmon enhancement is a highly desirable activity. . . From a biological point of view, salmon enhancement is feasible. There is potential in the ocean for growing more salmon." (Larkin 1974, p.1434).

turned to caution:

> ". . . the continued needs for protection of environment and a broadly balanced enhancement program with the appropriate amount of research and evaluation, there are some necessary changes in attitude concerning regulation. Under *no* circumstances should the permissible harvest of any race of salmon be exceeded. Day-to-day regulation should be geared to salmon biology, not human convenience." (Larkin 1979, p.98).

B. Oregon and Columbia River Hatchery Survival Rates

1. Oregon Hatcheries (Lewis 1995 and Lewis 1996)

Salmon produced in Oregon's hatcheries migrate to their feeding grounds in the Pacific. Coho salmon return after two years and chinook after three to five years. Survival from smolt to adult during their migration depends on many factors, from the size of the smolt at release, to inland habitat quality, ocean conditions, and fishing mortality. Total survival from smolt to harvest is estimated by using data from coded-wire-tags (CWT). Survival reports for hatchery produced coho and chinook are shown in Table 2.V.2, Table 2.V.3, Table 2.V.4, and Appendix 2.E.

Table 2.V.2

Weighted Average Percent Survival of Coho Salmon Stocks Tagged for Stock Assessment /1

Stock Group		Brood Years	Overall Average Percent Survival	Percent Survival Range	1993 Brood Year Percent Survival	1984-1993 Brood Years Average Ocean	1984-1993 Brood Years Average Total
COLUMBIA RIVER COHO SALMON							
Sandy River	a	1977-1993	3.19	0.09 (1990) to 8.98 (1985)	0.32	1.53	3.24
Big Creek	a	1980-1993	2.82	0.21 (1990) to 8.12 (1986)	0.75	1.30	2.63
Bonneville Hatchery	a	1980-1993	2.48	0.42 (1992) to 6.92 (1986)	0.86	0.96	2.42
Klaskanine River	a	1981-1993	2.95	0.32 (1992) to 7.80 (1985)	0.51	1.18	2.41
Umatilla River		1985-1993	1.30	0.02 (1993) to 4.52 (1986)	0.02	0.65 /3	1.30 /3
Wahkeena Pond		1982-1992	1.45	0.00 (1985-87) to 7.17 (1983)	--	0.25 /3	0.88 /3
Yakima River		1986-1993	0.62	0.05 (1991) to 1.99 (1988)	0.08	0.38 /3	0.62 /3
Tualatin River		1991-1993	0.02	0.00 (1993) to 0.04 (1991)	0.00	0.01 /3	0.02 /3
COASTAL RIVERS COHO SALMON							
Rogue River	b	1977-1993	3.03	0.38 (1990) to 9.01 (1978)	4.04	0.55	2.59
Coos River	bd	1984-1993	2.35	0.22 (1993) to 7.88 (1985)	0.22	1.22	2.35
Nehalem River	bdf	1977-1993	1.62	0.37 (1992) to 6.22 (1985)	0.67	1.08	1.90
North Umpqua River	bdf	1980-1993	1.85	0.16 (1993) to 4.46 (1984)	0.16	1.22	1.56
Trask River	cdf	1977-1993	1.45	0.46 (1991) to 3.57 (1986)	0.52	0.89	1.51
Eel Lake		1980-1992	1.55	0.00 (1992) to 4.22 (1980)	--	0.73 /3	1.39 /3
Smith River		1976-86,1990-91	1.14	0.15 (1978) to 2.93 (1984)	--	1.23 /3	1.34 /3
Coquille River	cef	1980-1993	1.23	0.00 (1993) to 3.60 (1986)	0.00	0.60	1.20
South Umpqua R.	cef	1982-1993	1.15	0.08 (1992) to 4.10 (1985)	0.16	1.13	1.19
Alsea River	cef	1975-1993	1.94	0.24 (1993) to 5.90 (1978)	0.24	0.72	1.13
East Fork Trask R.		1983-1992	1.11	0.33 (1984) to 2.31 (1986)	--	0.72 /3	1.03 /3
Salmon River	ce	1976-1993	1.06	0.25 (1992) to 2.64 (1976)	0.40	0.22	0.49
Siletz River	e	1977-1993	0.98	0.09 (1992) to 2.72 (1980)	0.11	0.30	0.42
Siuslaw River		1986,1990-93	0.21	0.00 (1993) to 0.43 (1986)	0.00	0.16 /3	0.21 /3

Notes:
1. Percent survival includes both freshwater and ocean recoveries. Freshwater fisheries are only sampled in the Columbia River.
2. Survival (1984-1993 total survival) is not significantly different for stock groups followed by the same letter.
3. Does not include data from all ten years.

Source: Lewis (1997).

Table 2.V.3

Weighted Average Percent Survival of Chinook Salmon Stocks Tagged for Stock Assessment /1

Stock Group		Brood Years	Overall Average Percent Survival	Percent Survival Range	1991 Brood Year Percent Survival	1982-1991 Brood Years Average	
						Ocean	Total
FALL CHINOOK SALMON							
Rogue River		1977-86, 1988-89, 1991	1.73	0.02 (1979) to 8.07 (1983)	0.13	2.19 /3	2.42 /3
Rogue River Columbia R. release	a	1982-1991	2.11	0.50 (1991) to 4.83 (1982)	0.50	1.26	2.11
Salmon River	a	1976-80, 1982-91	1.62	0.27 (1991) to 3.18 (1990)	0.27	0.60	1.73
Elk River	a	1977-1991	1.21	0.19 (1982) to 4.81 (1983)	0.56	1.01	1.41
Chetco River	a	1977-1991	1.38	0.08 (1988) to 3.20 (1985)	0.49	1.22	1.39
Coquille River		1983-88, 1990-91	1.01	0.04 (1991) to 4.06 (1985)	0.04	0.86 /3	1.01 /3
Coos River		1983-85, 1987-91	0.68	0.22 (1983) to 2.55 (1985)	0.61	0.41 /3	0.68 /3
Pistol River		1988-89, 1991	0.59	0.24 (1988) to 0.78 (1989)	0.74	0.49 /3	0.59 /3
Alsea River		1978-81, 1984-86, 1991	0.45	0.05 (1981) to 0.75 (1978)	0.20	0.34 /3	0.50 /3
Trask River	b	1982-1991	0.46	0.21 (1989) to 0.84 (1984)	0.24	0.29	0.46
Winchuck River		1988-89, 1991	0.36	0.10 (1988) to 0.74 (1991)	0.74	0.32 /3	0.36 /3
Nestucca River		1977-81, 1991	0.60	0.08 (1991) to 1.19 (1980)	0.08	0.04 /3	0.08 /3
South Umpqua River		1985, 1987-91	0.06	0.00 (1990-91) to 0.19 (1987)	0.00	0.06 /3	0.06 /3
SPRING CHINOOK SALMON							
Rogue River	c	1980-1991	2.23	0.47 (1988) to 5.19 (1983)	3.54	1.14	2.42
North Umpqua River	d	1976-1991	1.28	0.03 (1991) to 4.75 (1983)	0.03	1.23	1.30
Coquille River		1983, 1985, 1988-91	0.74	0.02 (1991) to 1.79 (1983)	0.02	0.67 /3	1.74 /3
Trask River	d	1977-1991	0.43	0.05 (1991) to 0.92 (1977)	0.05	0.23	0.39
Wilson River		1990-1991	0.24	0.08 (1991) to 0.39 (1990)	0.08	0.15 /3	0.24 /3
Nestucca River		1977-83, 1991	0.32	0.01 (1982) to 1.06 (1977)	0.11	0.03 /3	0.05 /3
South Umpqua River		1989-1991	0.00	0.00 (1989 & 91) to 0.01 (1990)	0.00	0.00 /3	0.00 /3
WINTER CHINOOK SALMON							
Trask River		1986-88, 1990-91	0.24	0.03 (1987) to 0.45 (1986)	0.19	0.16 /3	0.24 /3

Notes:
1. Percent survival includes both freshwater and ocean recoveries. Freshwater fisheries are only sampled for the Columbia River and Salmon River stock groups.
2. Survival (1982-1991 total survival) is not significantly different for stock groups followed by the same letter.
3. Does not include data from all ten years.

Source: Lewis (1997).

Table 2.V.4
Weighted Average Percent Survival of Selected Columbia River Chinook Salmon Stocks /1

Stock Group	Brood Years	Overall Average Percent Survival	Percent Survival Range	1990 Brood Year Percent Survival	1984-1990 Brood Years Average: Ocean	1984-1990 Brood Years Average: Total	
FALL CHINOOK SALMON							
CEDC (Rogue Stock)	1984-87,1989	2.63	0.36 (1986) to 7.56 (1984)			2.63	/2
CEDC (Tule Stock)	1980-1987	0.29	0.04 (1987) to 1.68 (1984)			0.48	/2
Klaskanine (Tule)	1977-81, 1986-88	0.14	0.01 (1987) to 0.41 (1977)			0.08	/2
Big Cr. (Rogue)	1982-1990	2.28	0.71 (1990) to 4.84 (1982)	0.71		1.89	
Big Cr. (Tule)	1976-81, 1986-90	0.28	0.05 (1987) to 1.02 (1979)	0.07		0.12	/2
Bonneville (Tule)	1976-84, 1986-90	0.41	0.02 (1987) to 2.76 (1984)	0.10		0.57	/2
Bonneville (URB)	1977-1990	1.31	0.13 (1988) to 3.53 (1984)	0.15		1.17	
Stayton Pond (Tule)	1976-1990	0.57	0.09 (1986) to 3.41 (1984)	0.15		0.69	
SPRING CHINOOK SALMON							
Round Butte	1975-1990	0.84	0.04 (1976) to 1.93 (1986)	0.27		1.28	
West Fork Hood River	1986-1990	0.13	0.01 (1990) to 0.33 (1986)	0.01		0.13	/2
Willamette	1974-75, 77-80, 84-90	1.15	0.24 (1975) to 2.36 (1978)	0.31		0.98	
McKenzie	1978-81, 1984-90	0.81	0.05 (1990) to 1.61 (1981)	0.05		0.81	
South Santiam	1975-78, 84-85, 87-90	0.62	0.20 (1990) to 1.38 (1985)	0.20		0.77	/2
Marion Forks	1974-77, 79-80, 82-90	0.76	0.01 (1974) to 1.82 (1986)	0.08		1.06	
Clackamas	1984-1990	0.50	0.07 (1985) to 1.17 (1988)	0.25		0.50	
CEDC (SF Klaskanine)	1988-1990	0.01	0.00 (1990) to 0.04 (1989)	0.00		0.01	/2
CEDC (Youngs Bay)	1988-1990	0.20	0.05 (1990) to 0.44 (1988)	0.05		0.20	/2

Notes: 1. Percent survival includes both freshwater and ocean recoveries.
2. Does not include data from all seven years.

Source: Lewis (1995).

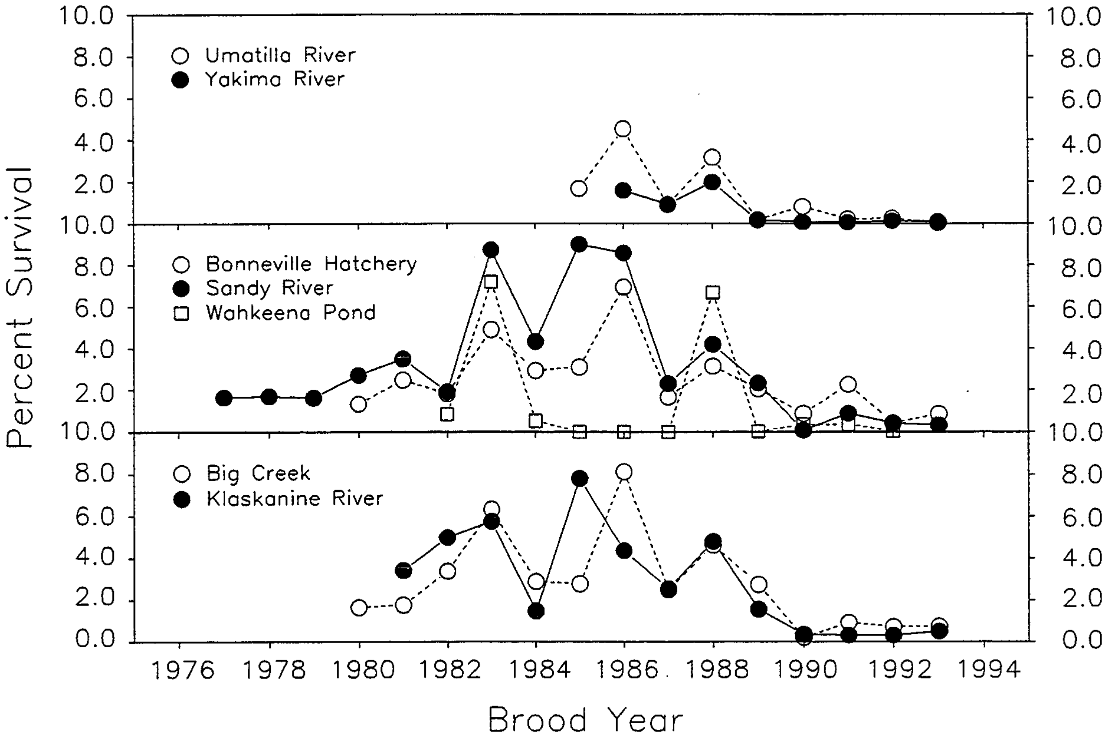
Survival rates vary a great deal. For example, Oregon coastal coho adult ocean survival rates of three to six percent were common in the late 1960's through the mid 1970's. Since then, survival has only been 1.5 percent or less. In the Columbia River, the coho survival was above four percent during the 1980's and seems to have dropped to less than one half percent since 1990.

2. Columbia River Hatcheries (Pastor 1996, 1997)

In addition to the Oregon reports on survival rates, the Bonneville Power Administration funds the collection of survival rate and catch rate information on Columbia River Basin produced salmon. These are generally called the "missing production groups" reports or the IHOT reports. The Columbia River Basin hatchery releases may be segregated into five general areas from the lower Columbia River to the Snake River (Appendix 2.E). The best estimates of survival rates that represent the last 20 to 30 years of production for these areas, utilizing the Pastor (1995, 1996), Garrison et al. (1995), and Fuss et al. (1994) data for these areas, are shown in Table 2.V.5, Figures 2.V.1 and 2.V.2, and Appendix 2.E.

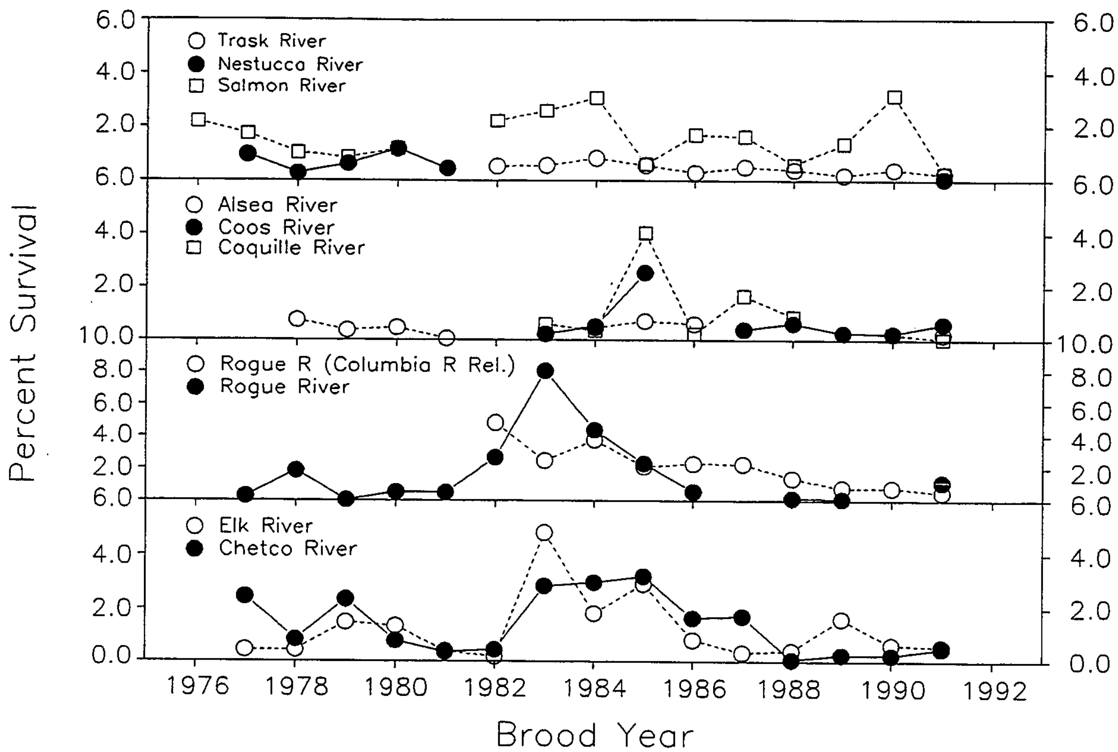
These should be considered representative survival rates for species released at various areas of the Columbia River Basin and what may be expected under fairly good freshwater and ocean survival. One year variation may misrepresent average expected survival rates over time. Care has to be taken when using averages, medians, or perhaps even representative rates. Survival rates should be used in the context of what may be expected during the years of interest (Figure 2.V.3).

Figure 2.V.1
Weighted Average Percent Survival of Columbia River Coho Salmon Stocks Tagged for Stock Assessment



Source: Lewis (1997).

Figure 2.V.2
Weighted Average Percent Survival of Fall Chinook Salmon Stocks Tagged for Stock Assessment



Source: Lewis (1997).

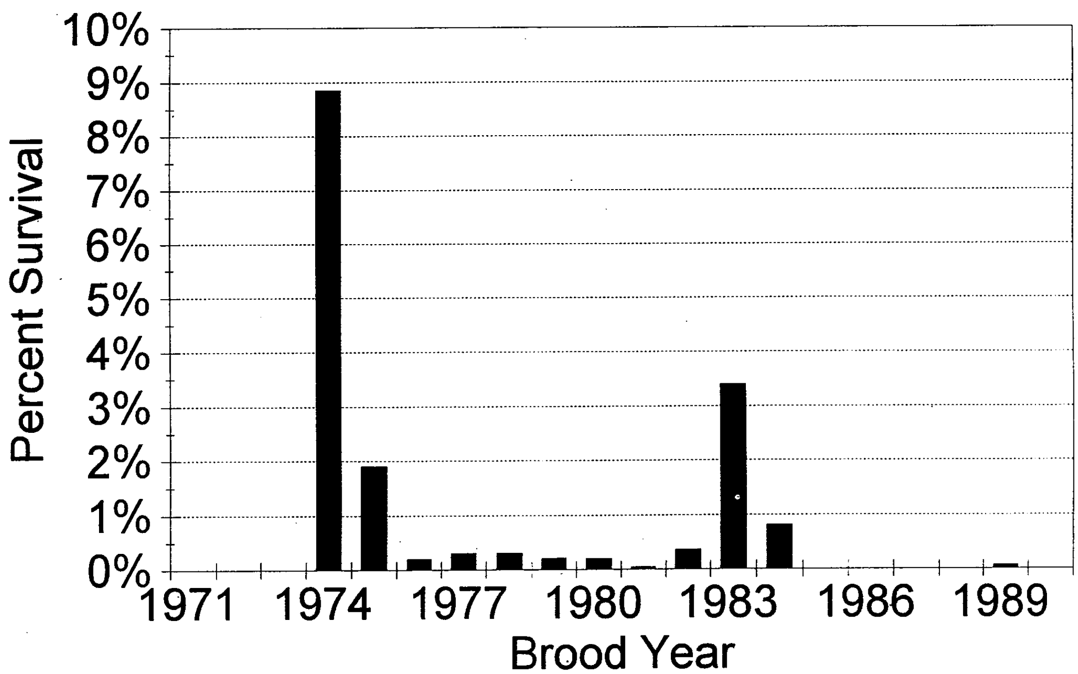
Table 2.V.5
Areas of Releases and Representative Recent (30 Year Average)
Survival Rates of Hatchery Fish in the Columbia River Basin

	Species and Average Survival Rates (Percent)			
Area of Release	Spring Chinook	Fall Chinook	Coho	Steelhead
Willamette	0.97	--	1.20	0.40
Lower Columbia	0.97	0.32	2.50	0.40
Middle Columbia River	0.37	0.60	1.20	0.70
Upper Columbia River	0.37	0.60	1.20	0.70
Snake River	0.37	0.60	--	0.70

Note: The size of the coho is about 12 smolts per pound, while spring chinook averaged about nine per pound. About 10 percent of the fall chinook are released as smolts that average about 15 per pound. These "large" smolts survive at rates from one percent to 1.75 percent rate. The smaller smolts, which are about 60 percent of smolt releases from the Columbia River system, survive at about a 0.30 percent rate.

Source: Pastor (1995, 1996), Smith (1998), Appendix 2.E, and Study.

Figure 2.V.3
Columbia River Fall Chinook, Grays River Hatchery



Source: Fuss (1994).

CHAPTER VI. PERSPECTIVE ON THE HISTORICAL ECONOMIC VALUE OF COLUMBIA RIVER ANADROMOUS FISH HARVESTS

A. Commercial and Recreational Fisheries for All Marine and Anadromous Fish Species Along the West Coast of North America

1. Share of Regional Economic Impacts (RED Benefits) From Anadromous Fish Runs Compared to All Commercial and Recreational Fishing

Improved harvesting and processing technology expanded harvests of salmon and other marine species along the west coast of North America. The lure of natural resources, including fish, provided investment capital and human resources. Personal income generated from harvesting marine resources may still be very important to individuals and coastal communities. However, as a percentage of total personal income generated, commercial fishing is a small part of total economies. As leisure time has increased, the personal income generated from recreational fishing is becoming a more important component of total personal income from fishing in many coastal communities.

Salmon produced in the Columbia River Basin are directly and indirectly harvested throughout the west coast of North America. Commercial and recreational fishing generated an annual total of about $7.5 billion in regional economic impacts (RED benefits) in 1994 (Table 2.VI.1 and Figure 2.VI.1). At an average full time equivalent job of $25,000 per year earnings, this is equal to about 300,000 jobs (Table 2.VI.2 and Figure 2.VI.2). The fisheries off Alaska waters generate the most personal income, about 73 percent of the total or about $5.4 billion.

Groundfish harvesting and processing contribute more than half of total regional economic impacts (RED benefits) from marine resources along the west coast of North America, or about $4 billion. Commercial salmon fishing, especially in Alaska, generates about 22 percent or about $1.7 billion.

Recreational fishing for salmon and steelhead generated about $0.8 billion in regional economic impacts (RED benefits). Of this amount, recreational fishing in Alaska and British Columbia contributed about 25 percent (four percent in Alaska and 21 percent in British Columbia), while recreational fishing in Washington, Oregon, and California generated about 15 percent each.

Commercial salmon fishing generates about $1.7 billion of personal income and supports about 67,000 jobs. Most personal income, about 72 percent or $1.2 billion, is generated by salmon harvested in waters off Alaska. The commercial salmon industry in Oregon and California generates less than one percent of the total personal income from salmon harvests on the west coast of North America (Table 2.VI.1). Recreational angling generates about $750 million in personal income. Most of this personal income and jobs is fairly evenly distributed among the regions from British Columbia to California.

Table 2.VI.1

Representative Annual Harvests of Major Marine Resources in Recent Years and Resulting Estimated Regional Economic Impacts (RED Benefits) Along the West Coast of North America

Region	Major Species	Pounds or Angler Days (in 1,000's)	Regional Economic Impacts (in 1,000's)	Percent By Region	Percent By Species
Alaska	Salmon	800,000	1,207,000		22%
	Shellfish	126,500	425,000		8%
	Herring	150,000	150,000		3%
	Groundfish	4,040,000	3,400,000		63%
	Recreational (salmon/steelhead only)	1,925	205,000		4%
	Total Economic Contribution	5,118,425	5,387,000	72%	
British Columbia	Salmon	150,000	353,100		38%
	Shellfish	25,000	55,500		6%
	Herring	65,000	70,500		8%
	Groundfish	325,000	258,000		28%
	Recreational (salmon/steelhead only)	5,970	191,000		21%
	Total Economic Contribution	570,970	928,100	12%	
Washington	Salmon	34,000	69,600		18%
	Shellfish	35,000	80,000		20%
	Tuna	5,000	8,000		2%
	Groundfish	165,150	100,750		26%
	Recreational (salmon/steelhead only)	4,180	134,000		34%
	Total Economic Contribution	243,330	392,350	5%	
Oregon	Salmon	5,000	17,100		4%
	Shellfish	35,000	66,900		17%
	Tuna	5,000	8,000		2%
	Groundfish	300,150	175,750		46%
	Recreational (salmon/steelhead only)	3,660	116,600		30%
	Total Economic Contribution	348,810	384,350	5%	
California	Salmon	5,000	18,300		5%
	Shellfish	45,000	75,500		19%
	Tuna	100,000	70,000		17%
	Herring etc.	110,000	66,000		16%
	Groundfish	60,000	72,000		18%
	Recreational (salmon/steelhead only)	1,930	103,000		25%
	Total Economic Contribution	321,930	404,800	5%	
Idaho	Recreational (steelhead only)	300	8,800		100%
	Total Economic Contribution	300	8,800	0%	
Total	Salmon	994,000	1,665,100		22%
	Shellfish	266,500	702,900		9%
	Herring, tuna, etc.	435,000	372,500		5%
	Groundfish	4,890,300	4,006,500		53%
	Recreational (salmon/steelhead only)	17,965	758,400		10%
	Total Economic Contribution	6,603,765	7,505,400	100%	

Table 2.VI.1 (continued)

Notes: 1. RED benefits expressed in thousands of 1994 U.S. dollars.

2. A recent study by Reading (1999) analyzed the regional economic impacts for trip and equipment expenditures from the 1992-1993 steelhead fishery in Idaho and a hypothetical salmon fishery. The results are not comparable due to differences in methods and data. For example, the table shows only personal income generated by trip expenditure effects, while Reading (1999) expresses impacts as business sales and includes equipment expenditures.

3. <u>Data and Regional Economic Impact Models</u>

Data of harvests and recreational angling trips are taken from three basic sources. These are:

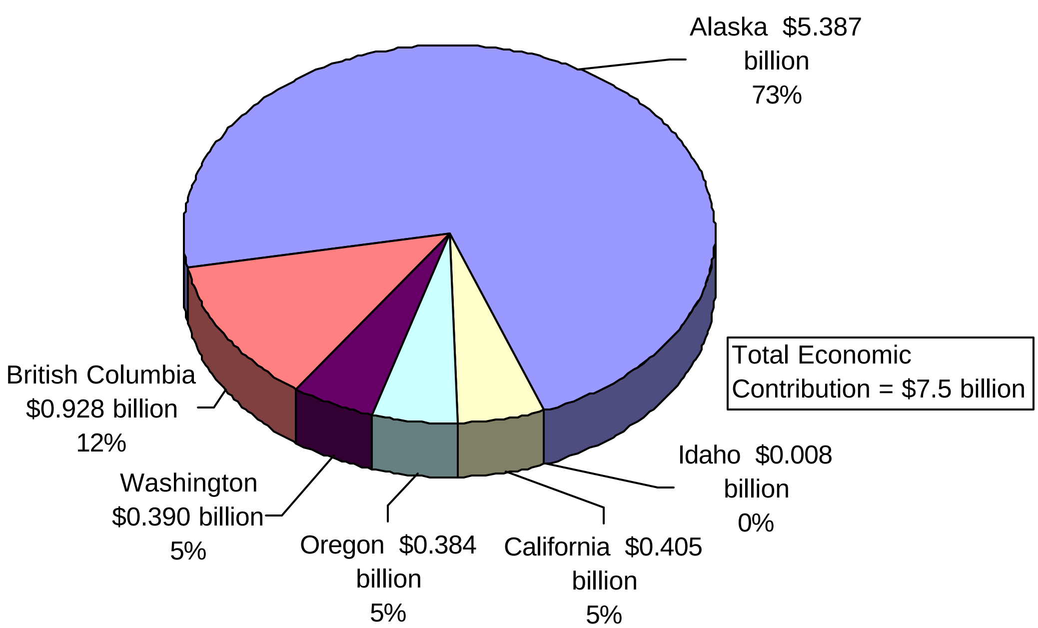
- Pacific Fishing Magazine, "Annual Stats Pack," Seattle, Washington
- Pacific States Marine Fisheries Commission, "Annual Reports," Gladstone, Oregon
- National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (Alaska, Washington, Oregon, California, and Idaho), U.S. Department of the Interior, U.S. Fish and Wildlife Services, 1991

The basic model for estimating the economic contribution is the Fisheries Economic Assessment Model (FEAM), originally developed by Hans Radtke and William Jensen for the West Coast Fisheries Development Foundation and now used by agencies such as the PFMC and ODFW. For an explanation, please refer to:

- The Research Group, Oregon Angler Survey and Economic Impact Analysis, prepared for ODFW, June 1991
- Hans Radtke and Shannon Davis, The Economics of Ocean Fishery Management in Oregon, prepared by prepared for Oregon Coastal Zone Management Association, Inc., 1994
- Review of Ocean Salmon Fisheries (annual reports), PFMC, Portland, Oregon

Source: Radtke (May 1997).

Figure 2.VI.1
Regional Economic Impacts (RED Benefits) of Marine Harvests
Along the West Coast of North America by Region



Note: Shares are representative of recent years' harvests.
Source: Radtke (May 1997).

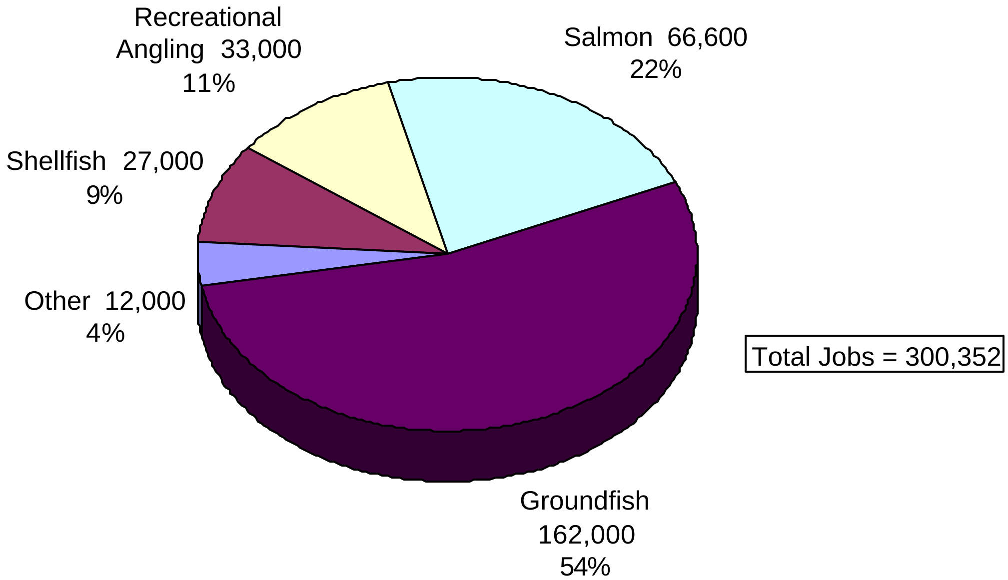
Table 2.VI.2
Regional Economic Impacts (RED Benefits) and Jobs
From Fishing Along the West Coast of North America

Area	Percent of Total	Regional Economic Impacts	Jobs
Alaska	73%	5.4	216,000
British Columbia	12%	0.9	36,000
Washington	5%	0.4	16,000
Oregon	5%	0.4	16,000
California	5%	0.4	16,000
Idaho	0%	0.008	352
Total	100%	7.5	300,352

Notes: 1. RED benefits expressed as personal income per year in billions of 1994 U.S. dollars.
2. Job estimates assume $25,000 average earnings per job.

Source: Radtke (May 1997).

Figure 2.VI.2
Fishing Industry Jobs Supported by Commercial Fishing and Recreational Angling



Note: Job shares are representative of harvests in 1994.
Source: Radtke (May 1997).

Although fishing is very important for some coastal communities on the west coast of North America, commercial marine fishing including recreational angling for salmon and steelhead generates about less than one percent of total personal income (Table 2.VI.3). In 1997, total personal income generated in the West Coast states of the United States and British Columbia, Canada totaled $1.182 trillion. In the Pacific Northwest states of Oregon and Washington, commercial fishing and recreational fishing for salmon and steelhead make up 0.3 to 0.5 percent of all personal income generated in these states.

2. Commercial and Recreational Anadromous Fish Harvest Trends

Salmon harvests on the west coast of North America have remained steady or have increased overall since 1988. Most of this increase has occurred in Alaska (Figure 2.VI.3). Sockeye and pinks consistently are harvested at about 300,000 mt per year (Figure 2.VI.4). Total chinook harvests have declined substantially from 1988 to 1996, while overall coho harvests have remained stable over this period. Declining salmon runs on the West Coast are site specific and have occurred in areas of increased economic development and species that rely heavily on hatcheries. Ocean productivity cycles have also had a derogatory effect on salmon runs in the waters of the west coast of North America.

B. Regional Economic Impacts (RED Benefits) From Anadromous Fish Runs

1. Historical Columbia River Anadromous Fish Runs

Historically, all salmon were wild fish produced in the natural stream environment. The NPPC concluded that up to 16 million fish run size is the most reasonable estimate of Columbia River historic runs (NPPC, March 1986). A 50 percent harvest rate of these runs (mostly summer and spring chinook) could have supported a one half billion dollar industry (Table 2.VI.4) (Radtke and Davis, January 1996).

The internal combustion engine has contributed to changes in the harvesting of salmon that originate in the Columbia River. As early as 1910 trollers ventured out in the open ocean off Washington and Oregon in order to harvest salmon over a longer period of the year. Much of the fisheries that harvest Columbia River produced salmon now take place in ocean fisheries (troll as well as net) from southeast Alaska to Northern California.

The salmon that swim in the river today differ fundamentally from those of the aboriginal Columbia. The pre-European development salmon runs were predominantly spring and summer chinook on their way to spawn in the upper reaches of the Columbia River system. As compensation for the loss of wild salmonid production, many artificial propagation hatcheries were built throughout the Columbia River Basin. Artificial production now accounts for about two thirds to three quarters of all fish returning to the Columbia River system (WDFW and ODFW, August 1996). Past production and management policies that were designed to be based on hatchery operation may not be meeting expectations of producing fish for harvest and may be incompatible with protecting existing wild stocks.

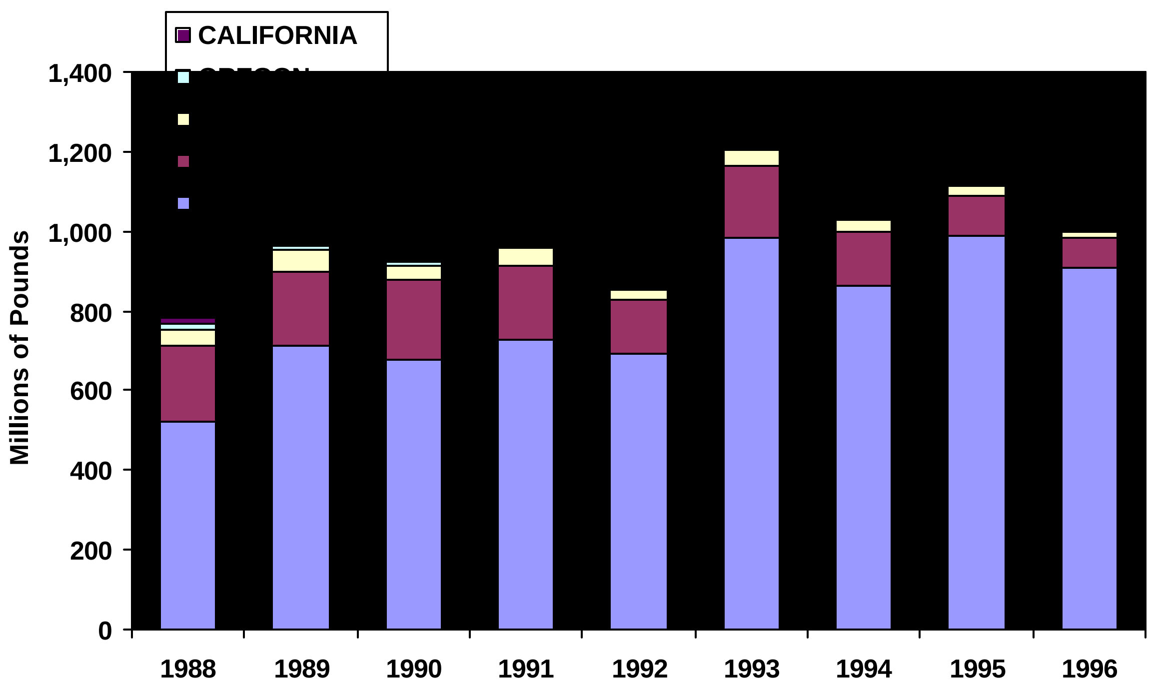
Table 2.VI.3
Share of Regional Economic Impacts (RED Benefits) From Commercial and Recreational Salmon Fishing on the West Coast of North America

State or Province	Total Personal Income	Personal Income From Commercial and Recreational Fishing		Personal Income From Recreational Fishing	
		Amount	Share	Amount	Share
California	866	0.4	0.05%	0.12	0.01%
Oregon	80	0.4	0.50%	0.13	0.20%
Washington	152	0.4	0.30%	0.20	0.10%
British Columbia	68	0.9	1.30%	0.54	0.80%
Alaska	16	5.4 /2	33.80%	1.4	8.80%
Total	1,182	7.5	0.60%	2.4	0.20%

Notes: 1. Personal income in billions of 1994 U.S. dollars.
2. Much of the personal income is generated in waters off Alaska but flows to the State of Washington, especially the Seattle area.

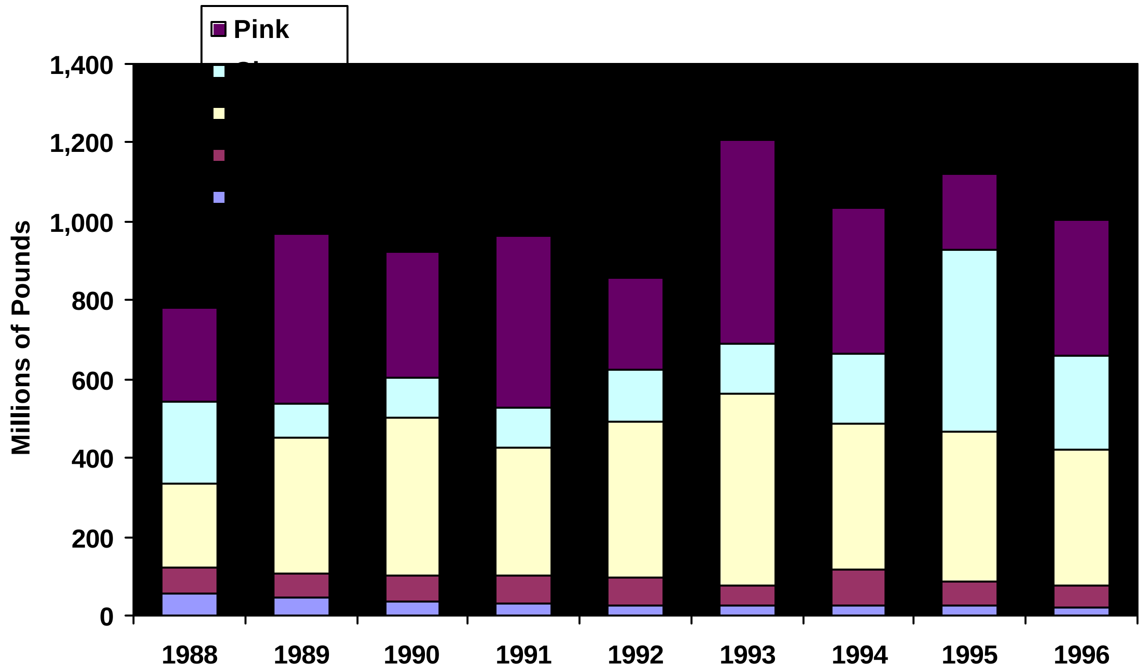
Source: Study and Werner (1998).

Figure 2.VI.3
Average Commercial Salmon Harvest by Region on the West Coast of North America
1988-1996



Source: Radtke (May 1997).

Figure 2.VI.4
Average Commercial Salmon Harvest by Species on the West Coast of North America
1988-1996



Source: Radtke (May 1997).

Table 2.VI.4
Estimated Historic, Pre-Development Salmon and Steelhead Run Size of the Columbia River System and Resulting Annual Potential Ex-Vessel Revenues, Regional Economic Impacts, and Jobs

Species	Total Number of Fish (thousands)	Average Weight Per Fish in Pounds	Total Pounds (thousands)	Price	Ex-Vessel Revenues at 50% Harvest Rate (thousands)	Regional Economic Impacts Per Pound in $	Regional Economic Impact at 50% Harvest Rate (thousands)	Estimated Total Full Time Equivalent Annual Jobs at $20,000 per Year - Range
Spring chinook	2,300	20	46,000	3.25	74,750	5.75	132,250	6,613
Summer chinook	4,600	20	92,000	3.25	149,500	5.75	264,500	13,225
Fall chinook	2,300	20	46,000	1.00	23,000	2.20	50,600	2,530
Coho	1,780	9.0	16,020	1.00	8,010	2.20	17,622	881
Sockeye	2,600	3.5	9,100	2.00	9,100	3.75	17,063	853
Chum	1,392	12	16,704	0.60	5,011	1.75	14,616	731
Steelhead	1,348	8.5	11,458	0.60	3,437	1.75	10,026	501
Total	16,320		237,282		272,808		506,677	25,334

Notes:
1. Total number of fish from NPPC (1986), pp.18-19.
2. Price is representative 1994 dollars. These represent recent years prices for salmon harvested in the Columbia River. In the world salmon market, regional salmon production should be considered a commodity. Spring and summer chinook having timing and quality characteristics that command attractive prices.
3. Ex-vessel revenues at 50 percent harvest rate in most years with healthy stocks is considered a sustainable harvest rate.

4. Regional economic impacts (RED benefits) expressed as personal income.

Source: Radtke (May 1997).

Most of the fish returning to the mouth of the river today are coho or “tule” chinook released at lower Columbia hatcheries. The origin of salmon stocks in pre-development runs was about 77 percent Upper River to 23 percent Lower River, whereas the origin of the 1977-1981 salmon runs was 58 percent Lower River and 42 percent Upper River (Figures 2.III.4a and 2.III.4b) (Lee 1993, p.25).

NMFS has imposed a “cap” on hatchery production of 197 million fingerling and smolt annual releases (Table 2.III.2) (U.S. Department of Commerce, March 1995). Hatchery production has been about 130 million fingerlings and smolts in recent years (Smith 1998).

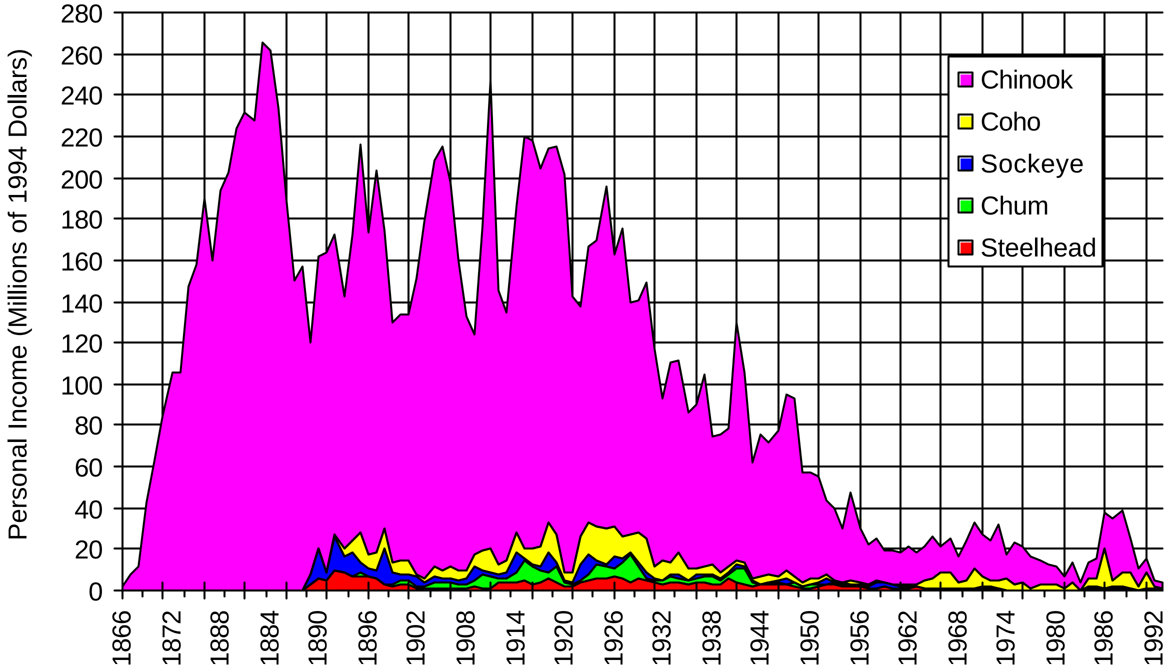
Unless there are fundamental changes to Columbia River production, it has to be assumed that any dramatic increases in adult salmon returns will result from improved hatchery practices and downriver and ocean survival. Improvements to hatchery practices may allow natural production to be "supplemented" with artificial propagation practices that are integrated into the functioning of the entire ecosystem. Increases in returns from wild origin anadromous fish, such as through freshwater habitat improvements, will assist but not lead to restoration of historical fisheries or to the NPPC "doubling of runs" level.

2. Example Regional Economic Impacts (RED Benefits) From Salmon Fishing on Coastal Communities

The changing nature of salmon harvests and their regional economic impact may best be illustrated by showing the effects on a coastal community, such as Astoria, Oregon. During the late 1880's and early 1920's, the salmon gillnet fishery in the Columbia River pumped a substantial amount of income into the Astoria area. At today's prices (reflecting 1998 price levels), these runs contributed as much as $260 million in regional economic impacts (RED benefits) into this area (Figure 2.VI.5 and Appendix 2.C). This would support about 10,000 to 13,000 jobs. During these early years of development, salmon was the most important sector in the area's economy. Personal income received by residents along the lower Columbia River in the years between 1987 and 1992 averaged about $29 million (PFMC, February 1997) from commercial gillnet and recreational salmon fishing. However, since 1993, because of very poor survival rates of hatchery fish, the personal income generated from salmon fisheries in the lower Columbia River has declined to about $2 million (Table 2.VI.5). Total personal income in the Astoria area (Clatsop County) was $684 million in 1996 (Oregon Employment Department 1998). All commercial fishing generated an estimated $70 million.[1] Commercial fishing is about 10 percent of the local area, while salmon fishing in the Columbia River at the present time generates about 0.2 percent of the personal income in this area. This is a small share of what may have been generated with historic salmon runs.

1. Estimates made by Hans Radtke, Economist, with Fisheries Economic Assessment Model (FEAM), February 1998.

Figure 2.VI.5
Historical Columbia River Estimated Regional Economic Impacts (RED Benefits)



Sources: Landing data are from NPPC (1986), fish size and ex-vessel price are from ODFW (1995), and regional economic impacts (RED benefits) per pound in 1994 U.S. dollars are from Radtke (May 1997).

Table 2.VI.5
Regional Economic Impacts (RED Benefits) From Commercial Salmon Gillnet and Recreational Lower Columbia Fisheries from 1987 to 1996

	Years				
	1987-1992 Average	1993	1994	1995	1996
Commercial gillnet	23,101	2,092	2,019	956	1,389
Lower Columbia recreational	6,332	4,879	3,036	379	999
Total	29,433	6,971	5,055	1,335	2,388

Note: RED benefits expressed as personal income in thousands of 1996 U.S. dollars.
Source: Radtke (May 1997).

3. Change to Anadromous Fish Hatchery Based Production

The hatchery salmon smolt production cap as proposed in March 1995 by the NMFS, at representative mid-1980's smolt to adult survival rates, may generate about $74 million in regional economic impacts (RED benefits) from hatchery smolt releases. Another $9 million could be expected from wild salmon harvests for a total of $83 million. In order to have eight million adult fish harvested (the historic harvests) out of the hatchery and wild fish smolt production (246 million smolt total), the smolt to adult survival rates would have to be about three percent overall. The 1980's survival rates of hatchery fall chinook releases (majority of releases) were 0.3 percent in good ocean conditions and are about 0.03 percent at the present. Therefore, by changing to hatchery based production, the Columbia River system will not be able to again generate the $200 million to $500 million of personal income it once generated. This, of course, may change if the wild fish resource were to be returned to its historic levels by remedying habitat alterations and hydrosystem problems.

4. Change to Ocean Mixed Stock Fisheries

Historically, harvesters waited until adults returned to the Columbia River to harvest salmon. Today, salmon produced in the Columbia River system are harvested from California to Alaska by trolling gear and by nets set to harvest other species of salmon, and are caught incidentally in other ocean fisheries.

In recent years, the Columbia River economy only received a portion of the personal income generated by each salmon hatched and reared in the Columbia River system. For example, out of 100 released fall chinook smolts, the Columbia River area economies may receive $7.30 of personal income out of a total of $22.05 generated (Table 2.VI.6). From both hatchery and wild origin smolt production during the 1980's, the Columbia River communities may only receive about 46 percent of the of the regional economic impacts (Figure 2.VI.6).

About half of the Columbia hatchery smolt releases are presently fall chinook. Most of these salmon will be harvested in other geographic areas, not in the Columbia River. This is a direct result of the growth of the ocean troll mixed stock specie fishery and a hatchery production program that produced fall chinook salmon that moved close to the Washington shore on their return to the Columbia River. Therefore, hatchery practices have resulted in a shift of personal income generated from the Columbia system to other geographic areas.

Table 2.VI.6
Estimated Regional Economic Impacts (RED Benefits) From the Columbia River Hatchery System Produced Salmon by Species and Geographic Regions

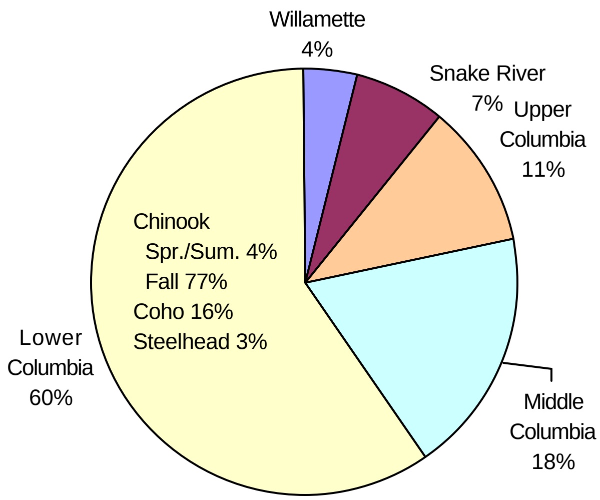
Species	Survival Rate	Hatchery Smolt Releases	Columbia River Region Hatchery Impacts	Other Region Hatchery Impacts	Total Hatchery Impacts
Coho	2.72%	35,325,745	22.56	54.39	76.95
Spring/summer chinook	0.69%	27,392,626	19.77	10.17	29.95
Fall chinook	0.49%	113,802,184	7.30	14.75	22.05
Steelhead	1.38%	20,042,061	59.05	0.36	59.41
Total		196,562,616	17.06	19.77	36.83

Notes: 1. Regional economic impacts (RED benefits) expressed as personal income in 1998 dollars per 100 released smolts.
2. Analysis assumes representative 1980's survival rates and hatchery production.
3. The table includes all spring chinook releases. These survival rates and area of catch may represent the Willamette stocks more than the upper Columbia and Snake. Upper Columbia and Snake in recent years have not survived at these rates nor have they been harvested in the open ocean.

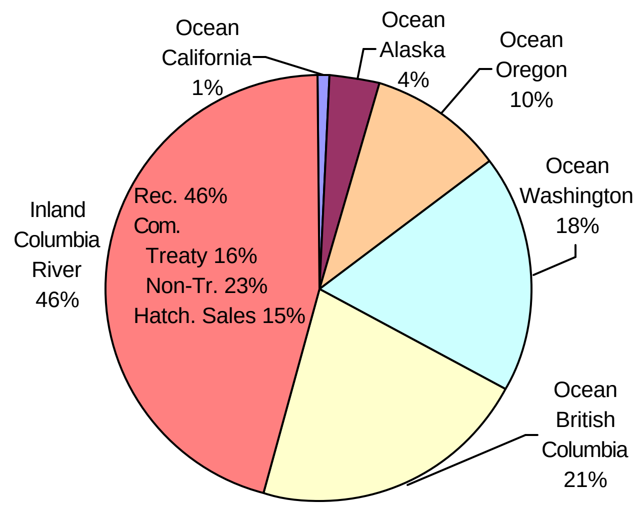
Source: Study.

Figure 2.VI.6
Shares of Columbia River Basin Anadromous Fish Production and Geographic Regions Receiving Regional Economic Impacts (RED Benefits) From the Production

Watershed Production
(Millions of Hatchery and Wild Origin Smolts)



Geographic Region Receiving Benefits
(Regional Economic Impacts Per 100 Smolts)



Notes: 1. Wild and hatchery origin smolt production is representative of the 1980's.
2. The regional economic impacts for the inland Columbia River region include inriver treaty and non-treaty commercial fisheries, inriver recreational fisheries, and hatchery return sales.

Source: NMFS (1995) and Study.

PART 3

ECONOMIC EVALUATION OF CHANGED ANADROMOUS FISH HARVESTS DUE TO LOWER SNAKE RIVER DAMS HYDROSYSTEM ACTIONS

CHAPTER I. INTRODUCTION

The U.S. Army Corps of Engineers (Corps) has initiated a study to examine the engineering, economic, social, and biological effects of alternative hydrosystem actions for operating the four Corps dams on the lower Snake River for improved salmon migration. The four dams are Lower Granite, Little Goose, Lower Monumental, and Ice Harbor located in southeast corner of the State of Washington. This report only provides information about one aspect of the effects of the alternative hydrosystem actions. The report describes the economic evaluation expressed as regional economic impacts, or the Regional Economic Development (RED) accounting stance used by the Corps, and net economic values, or the National Economic Development (NED) accounting stance used by the Corps, from changes to harvests of anadromous fish originating in the Snake River Basin due to alternative hydrosystem actions. Discussion is also offered in this report for the economic values from harvesting anadromous fish produced in the entire Columbia River Basin. The other Corps reports for economic, social, and biological effects are referenced as needed.

The alternatives being considered are:

- Maintain the existing system of juvenile fish bypass systems, juvenile fish transportation, spill for fish at the dams, and release of water from storage dams to augment river flows and aid juvenile fish migration. This includes improvements such as extended length guidance screens in the juvenile fish bypass systems to guide a greater percentage of fish away from turbine intakes and into the bypass system. This hydrosystem action is referred to as base case or Action A1.

- Construct major improvements to the dams and maximize the juvenile fish transportation system. One improvement possibility is surface-oriented juvenile fish bypass systems to provide a potentially more efficient and less stressful means for diverting juvenile fish before they dive down toward the turbine intake area. Other possible major system improvements are turbine modifications to reduce injury to fish that go through the turbines; gas abatement measures to allow more spill with less gas supersaturation; and fish guidance improvements. The hydrosystem action for maximizing juvenile fish transportation without the surface-oriented bypass system is referred to as Action A2. Including surface-oriented improvements is Action A3.

- Draw down, or breach, the four lower Snake River dams to return to natural river level. This would entail removing the earthen portion at each of the dams to create a channel around the dams and provide a 140 mile free flowing stretch of river. Power production at the dams would cease, and there would be no commercial navigation on the lower Snake River. It is assumed the breaching alternative would take eight years to implement. The breaching alternative is referred to as Action A4.

This report is organized in four parts for the convenience of the reader. Part 1 contains an abstract, the executive summary, the risks and uncertainties in results for changing analysis assumptions, and references cited in all parts.

Part 2 contains background information about historical anadromous fish runs and harvests in the Columbia River Basin. The information should prove especially helpful in understanding the complexity of Columbia River anadromous fish harvest management. A discussion of fisheries economic evaluation methods used in this study is also presented in Part 2.

Commercial and recreational fishing for Columbia River Basin anadromous fish stocks generates a significant amount of personal income and has national benefits. These economic value estimates for changed harvests due to alternative lower Snake River dams hydrosystem actions are presented in Part 3. The Part 3 discussion of economic values includes all modeled stocks for all fisheries. Since the economic analysis for general recreation and tourism includes recreational inriver anadromous fish fisheries, there will be overlapping economic values attributed to the recreational user group in the Columbia River mainstem and Snake River tributary geographic areas. The economic values from the general recreational and tourism analysis will be used to represent the economic value for this fishery. However, to make the discussion about the economic consequences of anadromous fish complete, the recreational inriver fishery has been included.[1]

This report also describes the potential economic value to the Pacific Northwest region and to the nation that may result from four cases of anadromous fish production and harvest management policies. The broader overview of what net economic value and contributions to regional personal income and jobs may result from the four cases is presented in Part 4. Part 4 descriptions may be viewed as what is at risk if the Columbia River Basin anadromous fish survival rates, and therefore harvestable fish runs, are not improved.

The economic analysis for the alternative hydrosystem actions evaluates all major anadromous fish stocks originating in the Snake River Basin. The major anadromous fish stocks are defined to be

1. The economic evaluation for this fishery has used methods that are different from the assessment of general recreation and tourism, so the reader is cautioned that comparison between the two analyses should not be made. The economic value of this fishery compared to other user groups and geographic areas should be relatively proportional.

spring/summer and fall chinook salmon *(Oncorhynchus tshawytscha)* and summer steelhead *(O. mykiss)*. Other anadromous fish, such as shad *(Alosa sapidissima)*, sturgeon *(Acipenser transmontanus and A. medirostris)*, coho salmon *(O. kisutch)*, sockeye salmon *(O. nerka)*, etc., would not have fisheries significantly changed by the hydrosystem actions. All utilization of both wild and hatchery originating stocks was considered. This includes commercial and recreational harvests, as well as sales of hatchery egg, carcass, and surplus fish. The economic analysis for the entire Columbia River Basin adds coho salmon and winter steelhead to the Snake River list of major anadromous fish stocks.

CHAPTER II. METHODS USED TO FORECAST HARVESTS

A. PATH Results

The possible effects from alternative hydrosystem actions on the Snake River anadromous fish stocks examined in this report only includes the causation factors considered in an external modeling process. Readers are directed to the many publications from the committee based process called PATH for understanding forecasts of harvests and returning spawners related to the hydrosystem actions. The National Marine Fisheries Service (NMFS) (1999) provides a biological evaluation of PATH results to estimate the recovery probabilities of ESA listed stocks.

The PATH process intended to identify, address, and (to the maximum extent possible) resolve uncertainties in the fundamental biological issues surrounding recovery of endangered spring/summer chinook, fall chinook, and summer steelhead stocks in the Columbia River Basin. The PATH modeled the survival of some of the Snake River wild spring and summer chinook stocks and fall chinook stocks to determine the effects of the hydrosystem actions.

The objectives of PATH were to:

- determine the overall level of support for key alternative hypotheses from existing information and propose other hypotheses and/or model improvements that are more consistent with these data (retrospective analyses);
- assess the ability to distinguish among competing hypotheses from future information, and advise institutions on research, monitoring, and adaptive management experiments that would maximize learning; and
- advise regulatory agencies on management actions to restore endangered salmon stocks to self-sustaining levels of abundance (prospective and decision analyses).

PATH developed a quantitative decision analysis framework for spring/summer chinook and a preliminary framework for fall chinook. The process also developed a qualitative analysis for summer steelhead using comparisons of the likely effects of actions on spring/summer chinook as a guide to the probable response of summer steelhead. The PATH decision analysis focused on the probability to which alternative hydrosystem actions contributed to preventing extinction and aiding recovery of stocks either listed or proposed for listing.

It was necessary to expand the PATH results to represent all Snake River stocks as well as perform the economic evaluation. Information contained in PATH results is limited to seven index stocks for Snake River spring/summer chinook, a comprehensive review of Snake River fall chinook, and a narrative description about how smolt-to-adult survival rates between Snake River spring/summer chinook and steelhead are correlated. For spring/summer chinook and fall chinook, the information includes numbers of fish harvested in the ocean, river mainstem, and tributaries; harvest rates for ocean and mainstem based on ocean escapement; harvest rates for tributaries based on Lower Granite (LWG) Dam escapement; and, numbers of spawners. Results are reported in five year increments starting with Year 5, i.e. five years after an improvement is implemented.

Uncertainty information is also contained in released PATH results.[1] Numbers of fish and harvest rates are reported at 10th, 25th, 50th, 75th, and 90th percentile model runs. Each set of percentiles has several scenarios. Spring/summer chinook has a set for "unweighted upper bound," "unweighted lower bound," "equal weights," and "four expert weighing schemes." Fall chinook has a "base case," "conservative case," and "liberal case." Table 3.II.1 describes the PATH results selected for the point estimates used in the economic analysis.

To generate the hydrosystems management actions' effects on all Snake River originating anadromous fish, study assumptions were used for certain life-cycle modeling factors that were
in addition to those included in the PATH process. A generalized life-cycle representation for Snake River salmonids is shown on Figure 3.II.1. The reasons that further analytical work was required include:

- PATH results did not include Year 0 information for any of the reported stocks. It is necessary to know the change in present conditions to the first forecast year in order to estimate changes in stocks that are not accounted for in PATH results.
- PATH results for spring/summer chinook need to be expanded from the reported seven index wild stocks to all wild stocks.
- Hatchery production needs to be added to PATH results for spring/summer chinook and fall chinook wild stocks.
- Summer steelhead hatchery and wild production are not included in PATH results.

1. The PATH analyses directly incorporated potential effects of key uncertainties. Each action was analyzed across a range of assumptions reflecting alternative biological considerations, survival responses, and variations in future climate effects. As a result, the projected effects of any given action on Snake River salmon runs generated by the PATH analyses were not simple point estimates. Summary statistics were used to compile across the large number of model runs necessary to capture possible combinations of key assumptions in a balanced way. In addition to expressing projections in terms of numbers of fish, PATH also summarized results in the context of the relative probability of exceeding survival and recovery criteria. Projected numbers of fish and harvest were summarized in terms of a standard set of fractions or percentiles of the total number of combinations run for each action (10th, 25th, 50th, 75th and 90th percentiles). For example, if the harvest reported at the 25th percentile was 100 fish, that means that of 25% of the model runs for that particular action resulted in a harvest of 100 fish or less. If, for that same action, the harvest reported at the 75th percentile was 500, that means that 75% of the runs for that action resulted in a projected harvest of 500 or less. Other summary statistics were also used to characterize the results. For example, runs averaged across assumption sets that gave relatively optimistic projections ('best case' or 'unweighted upper bounds') or relatively pessimistic projections ('worst case' or 'unweighted lower bounds'). For any given action the difference between these two perspectives gives a good indication of the effects of uncertainty. For spring/summer chinook results were also summarized after weighting key assumptions based on the opinions solicited from a scientific review panel (Personal communication Tom Cooney, July 1999).

Table 3.II.1
Release Dates and Scenarios Selected From PATH Results Used in the Economic Analysis

Actions		PATH Results' Release Dates and Scenarios Assumptions	
Identifier	Improvements	Spring/Summer Chinook /1	Fall Chinook /2
A1	Current operations under 1995 Biological opinion	Results released October 1998	Same as fall chinook A2
A2	A1 plus maximize transportation w/o surface bypass collectors	Results released October 1998	Results released November 1998
A3	A2, but also use surface bypass collectors	Results released November 1998	Results released November 1998
A4	Natural river drawdown of four Snake River dams	Results released October 1998	Results released November 1998

Notes: 1. "Likely" point estimates for spring/summer chinook harvest and spawner estimates are based on the PATH results "equal weight" scenario, median percentile outputs. Fall chinook harvest and spawner estimates are based on the PATH "base case" scenario, 50th percentile outputs. A range from "low" to "high" estimates were based on the 25th and 75th percentiles, respectively.
2. Summer steelhead harvests and spawner estimates are based on ratio changes to spring and summer chinook stocks.

Source: Study.

The assumptions used to expand PATH results should not be considered an attempt to develop a separate life-cycle model. Wherever possible, PATH modeling factors were reused as proportions in the expansion methods. The assumptions for the life-cycle modeling factors by species are shown in Table 3.II.2.

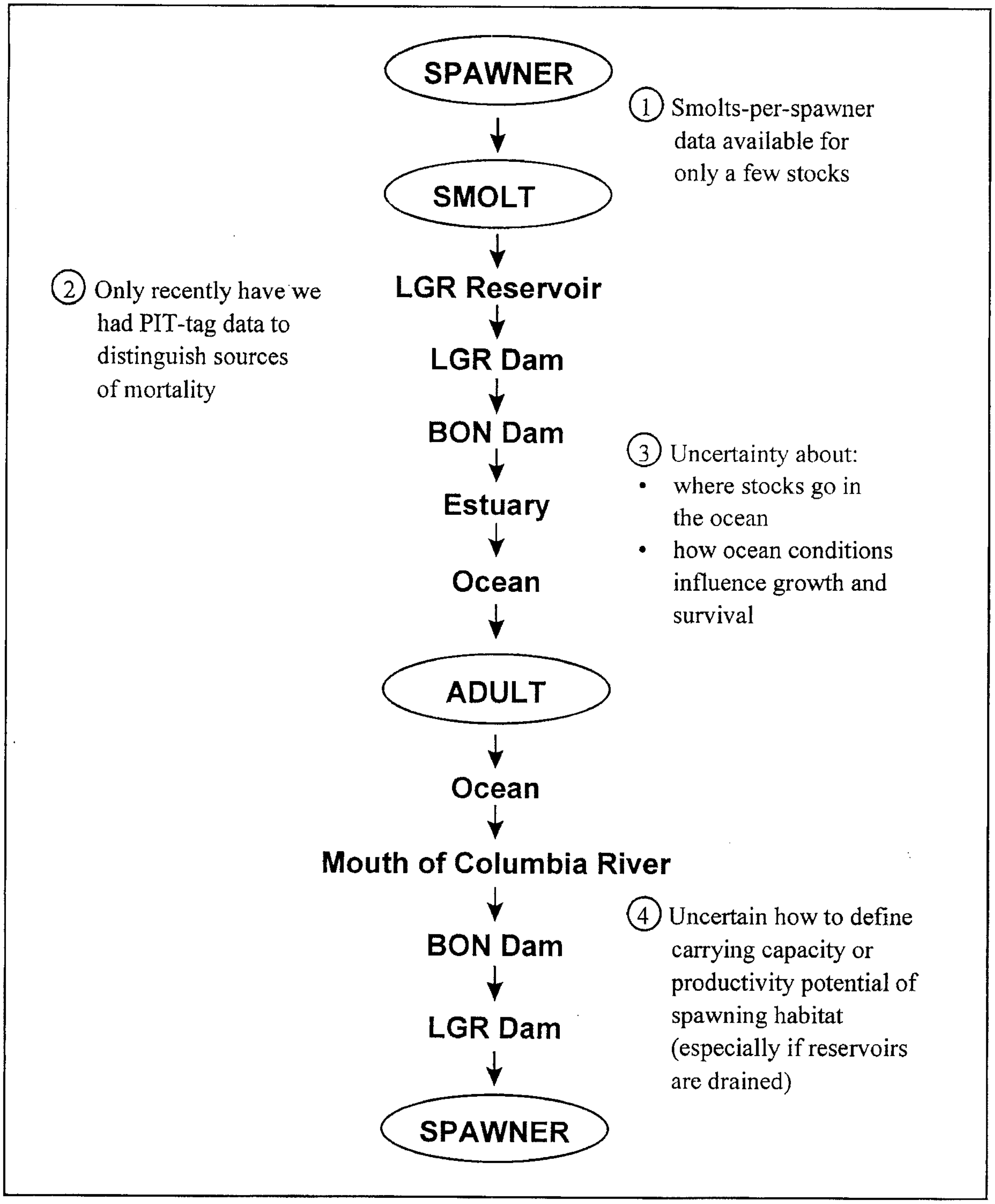
B. Life-Cycle Modeling Factors

1. Smolt-to-Adult Return Rates

Historical information is available on the survival of hatchery reared salmon and steelhead releases and some test wild reared anadromous fish. For this study, a survival rate is defined to be hatchery releases divided by adults that subsequently show up in fisheries or hatchery returns.[1] Analogous survival rate for wild origin fish is the ratio of downstream migrating smolts and harvests plus spawner escapement. The smolt-to-adult return rates (SAR) used for the economic analysis differ somewhat from rates used in the simulation modeling conducted by PATH. The definition change was needed to align expressions of wild adult returns with

1. Because recent hatchery practices mostly have released fish at smolt age, the survival rates are referenced in this study as smolt-to-adult survival rates or SAR.

Figure 3.II.1
Straight-Line Representation of a Generalized Life-Cycle for Snake River Salmonids



Note: Annotations show examples of points in the life cycle where empirical data are missing or incomplete.
Source: NMFS (1999).

Table 3.II.2
Additional Biological Assumptions Needed to Expand PATH
Results for Use in the Anadromous Fish Economic Analysis

Life-Cycle/ Modeling Factors	Spring/Summer Chinook
Smolt downstream passage mortality	Nan
Ocean incidental mortality	Nan
Ocean harvest	Nan
Run size total - wild	For Year 0, 1986-95 average from Table 2, Tab 1 and 2, TAC (1997). Future years calculated at the same percentage change as PATH results for index stock's ocean escapement. PATH results ocean escapement calculated using mainstem harvest divided by mainstem harvest rates.
Run size total - hatchery	Nan
Total adults - wild	Mainstem harvest + tributary harvest + pre-spawning mortality after LWG + spawners
Total adults - hatchery	For Year 0, hatchery smolt production goals in 1998 from Smith (1998) times SAR recent year averages in various CWT Missing Production Group Annual Reports (Fuss et al. 1994 and Garrison et al. 1995). For future years, hatchery production held constant and hatchery SAR same changes as wild SAR.
Mainstem harvest - wild	For Year 0, same proportion as PATH results index stocks. For future years, PATH results expanded to represent total production.
Mainstem harvest - hatchery	Proportion of PATH results for mainstem harvest to total wild adults.
Tributary harvest - wild	PATH results expanded to represent total production.
Tributary harvest - hatchery	Proportion of PATH results for index stock's tributary harvest to total wild adults
Upstream passage mortality	Nan
LWG Dam escapement - wild	(tributary harvest + spawners) ÷ 0.9. The 10% LWG prespawning mortality factor is from Marmorek (personal communication 1999).
LWG Dam escapement - hatchery	Nan
Pre-spawning mortality - wild	10% of LWG escapement
Female fraction fecundity - wild and hatchery	Female fraction 50% and fecundity 3,500
Smolt capacity and egg survival rates - wild	Smolt carrying capacity and density dependent egg-smolt survival rate
Smolt capacity and egg survival rates - hatchery	67% fecundity

Note: 1. Nan - No assumption needed; SAR - smolt-to-adult survival rate; CWT - coded wire tag; LWG Dam - Lower Granite Dam.

2. Fecundity is the number of fertilized eggs that can be attributed to a spawning pair.

Source: Study.

Table 3.II.2 (cont.)

Life-Cycle/ Modeling Factors	Fall Chinook	Summer Steelhead
Smolt downstream passage mortality	Nan	Nan
Ocean incidental mortality	Nan	Nan
Ocean harvest	PATH results	Nan
Run size total - wild	For Year 0, 1986-95 average from Table 9, Tab 3, TAC (1997).	For Year 0, 1986-95 average (length method) for A and B runs Tables 12 and 13, Tab 8, TAC (1997). Future years, 37% s/s chinook SAR changes.
Run size total - hatchery	Nan	Nan
Total adults - wild	Total harvest + spawners + hatchery supplements. Pre-spawning mortality assumed to be zero.	Mainstem harvest + tributary harvest + pre-spawning mortality after LWG + spawners
Total adults - hatchery	For Year 0, hatchery smolt production goals in 1998 from Smith (1998) times SAR recent year averages in various CWT Missing Production Group Annual Reports (Fuss et al. 1994 and Garrison et al. 1995). For future years, hatchery production held constant and SAR same changes as wild SAR.	For Year 0, hatchery smolt production goals in 1998 from Smith (1998) times SAR recent year averages in various CWT Missing Production Group Annual Reports (Fuss et al. 1994 and Garrison et al. 1995). For future years, hatchery production held constant and SAR same changes as 37% wild spring/summer chinook SAR.
Mainstem harvest - wild	For Year 0, Table 9, Tab 3, TAC (1997). For future years, PATH results.	Table 12 and 13, Tab 8, TAC (1997).
Mainstem harvest - hatchery	Proportion of PATH results for mainstem harvest to total wild adults.	Table 12 and 13, Tab 8, TAC (1997).
Tributary harvest - wild	PATH results	Table A1d, Tab 8, TAC (1997).
Tributary harvest - hatchery	Nan	Table A1d, Tab 8, TAC (1997).
Upstream passage mortality	Nan	Nan
LWG Dam escapement - wild	Tributary harvest + spawners + supplements, i.e., zero assumed pre-spawning mortality.	For Year 0, 1986-95 average (length method) for A and B runs, Table 12, Tab 8, TAC (1997). Future years calculated as same percentage change as PATH results calculated LWG escapement
LWG Dam escapement - hatchery	Nan	Nan
Pre-spawning mortality - wild	Zero assumed pre-spawning mortality.	10% of LWG escapement
Female fraction fecundity - wild and hatchery	Female fraction 50% and fecundity 3,500	Female fraction 50% and fecundity 2,500
Smolt capacity and egg survival rates - wild	Smolt carrying capacity and density dependent egg-smolt survival rate varying from 15% in Year 5 to 2% in Year 25+	Varying from 15% in Year 5 to 2% in Year 25+
Smolt capacity and egg survival rates - hatchery	67% fecundity	67% fecundity

Note: 1. Nan - No assumption needed; SAR - smolt-to-adult survival rate; CWT - coded wire tag; LWG Dam - Lower Granite Dam.

2. Fecundity is the number of fertilized eggs that can be attributed to a spawning pair.

Source: Study.

that reported in other publications for hatchery adult returns. This report's economic analysis SAR definition for wild components is similar to the SAR2 used by Petrosky and Schaller (1998).

Hatchery SAR are from CWT Missing Production Group Annual Reports by Fuss et al. (1994) and Garrison et al. (1995). These reports describe adult returns as harvest plus returns-to-hatchery. Analogous reporting for wild origin stocks would be harvest plus escapement past LWG Dam divided by wild smolt production. In terms of PATH results (using the example of spring/summer chinook), the SAR number is ocean harvest + mainstem harvest + ((spawners + tributary harvest) ÷ 0.9). The factor 0.9 means there is a 10 percent pre-spawning mortality after LWG Dam escapement (Marmorek 1999). The SAR denominator is spawners times a female fraction times fecundity times egg-to-smolt survival. The egg-to-smolt survival rate relationship was density dependent. A typical spawner-recruitment analysis is dependent upon age-composition of returning adults. Because PATH results were only reported at five year intervals, an indicator SAR was calculated based on wild returns from a previous five year smolt production.

2. Assumptions for Year 0 Harvests, Spawners, and Smolt-to-Adult Survival Rates

a. Year 0 Harvests and Spawners

As previously mentioned, the PATH results did not provide starting year information for the forecasts of fish harvests or spawners. PATH forecasts were in five year increments, starting with Year 5 and ending with Year 100. The PATH results also did not include SAR's, or fishery user group harvest allocations. Using Beamesderfer (1997) and TAC (1997) for the period 1986 to 1995, the study estimate for the spawner share of PATH index spring/summer stocks is 52 percent of all wild stocks. It is assumed this spawner share also represents the harvest share. For fall chinook, the Year 5, Action A1 is used for Year 0 starting points for all actions (Krasnow 1999).

b. Year 0 Smolt-to-Adult Survival Rates

A starting point was needed to determine changes to witnessed SAR's, and to determine relationships of the wild stocks analyzed by PATH to all stocks. The 1986 to 1995 ten year average was adopted to provide the Year 0 SAR information. This average has the following SAR's for hatchery stocks: 0.25 percent for spring/summer chinook, 0.6 percent for fall chinook, and 0.8 percent for summer steelhead. The beginning SAR's for wild stocks were determined using a spawner-recruit function and Year 5 and Year 10 PATH information.[1] Because the PATH information resulted in an extremely high rate of change in SAR's during the early forecast years, supplemental fish were introduced into the model to modify the spawner-recruit relationships. This is a plausible explanation, because there are presently test programs for out-planting first generation hatchery rearings at early ages rather than releasing smolts

1. Insufficient information existed to develop an age structure, life cycle model to calculate a SAR. Instead, PATH index wild origin stocks adult to previous five year smolt production indicator was calculated. The movement of the Year 0 hatchery rate was then tied to the PATH index stock rate. Readers are directed to Williams et al. (1998), Petrosky and Shaller (1998), and Shaller (1999) for a more rigorous treatment of Snake River stock survival rate discussions.

at migrating ages. The previous chapter explained the species-by-species life cycle modeling assumptions used to pattern the wild non-index stocks and all hatchery stocks after PATH stocks. Figure 3.II.2 shows the results from the modeling assumptions on SAR's over the project life.

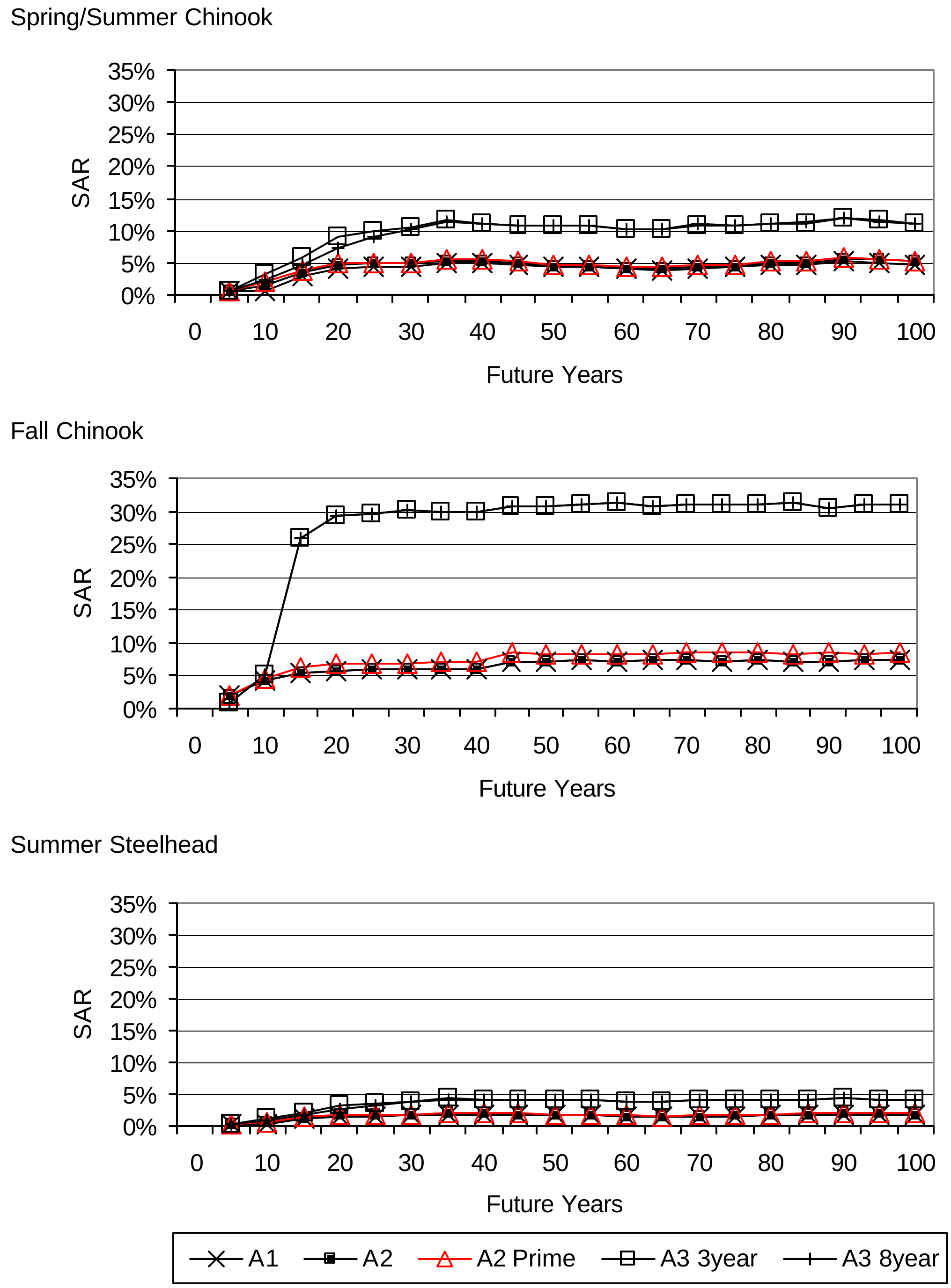
3. Summer Steelhead Assumptions

The PATH process did not develop harvest and spawner impact information, but did provide a comparative analysis between summer steelhead and spring/summer chinook. The analysis concluded actions that benefit spring/summer chinook are likely to benefit steelhead as well. The discussion of steelhead SAR's in the FY98 PATH report (pp. 173-179) states that "... the incremental smolt-to-adult survival change to bring recent survival levels up to the mean historical level is less for Snake River steelhead than for Snake River spring/summer chinook salmon. This suggests that a set of management actions that results in an adequate likelihood of survival and recovery for Snake River spring/summer chinook is likely to do the same for Snake River steelhead if the action has a similar incremental effect on survival of each species." The relative decline for summer steelhead has been proportionately less than the decline for spring/summer chinook. It would be reasonable to presume that the response to actions that address the factors for decline would be proportionately less (to the same degree as during the decline) for summer steelhead than for spring/summer chinook. It was therefore assumed that the SAR response for steelhead would be reduced relative to that for spring chinook by a proportionality constant reflecting the relative historical decline. The current best estimates of the ratios of recent SAR's to historical SAR's are 11.2x for spring/summer chinook and 4.1x for steelhead (Cooney 1999). Using those ratios, the proportional change in steelhead SAR's is about 0.37 times the change in spring/summer SAR's.

4. Egg-to-Smolt Survival Rate

The PATH process assumes a spawner-recruit relationship under which the egg-to-smolt component of survival is projected to be higher when spawner numbers are low (Petrosky and Shaller in PATH 1996). This is consistent with many studies about salmon population dynamics and fish species in general. Several relationships have typically been used where fish recruitment is a function of spawning biomass (Bjørndal 1986). While Shaller et al. (1999) has identified function parameters for some individual Snake River salmon stocks, there was insufficient information to specify a relationship across all stocks. None of the studies itemized the components of survival necessary to determine the egg-to-smolt component of the life-cycle. For this report's analysis, a theoretical quadratic curve was fit to spawner abundance whereby a higher rate in Year 0 dropped to two percent in Year 25. The curve fitting relationship results in an approximately constant rate at two percent for Year 25 through 100. The rate accounts for smolt survival to the start of migration and does not include downstream mortality due to interdam losses. The rate is only applicable to the freshwater

Figure 3.II.2
Snake River Wild Origin Fish Smolt-to-Adult Survival Rate
Indicators by Hydrosystem Actions During Project Period



Notes: 1. The Y-axis maximums are different for each species.

2. Smolt-to-adult rates are referenced as indicators because they are not based on age structures. The indicator rates are spawners, prespawning mortality, and harvest divided by smolts produced five years previous expressed as a percent. Smolts are calculated using a density dependent egg-to-smolt relationship and the number of spawners five years previous.

3. Summer steelhead rates are based on changes to spring/summer chinook changes.

Source: Study.

phases of the life-cycle. The maximum and minimum values for the calibration are from Reeves (1993), Petrosky and Shaller (in PATH 1996), and others.

C. Harvest Rates and Fisheries Distributional Assumptions

The economic evaluation depends on the user group and geographic area accomplishing the harvests. Table 3.II.3 shows the 1986 to 1995 average inriver harvest shares, based on run size measured at ocean escapement. The inriver and ocean user group distributions used in the modeling are shown in Table 3.II.4. These tables need to be carefully interpreted if compared, because of the basis of the shares. Treaty rights are for 50 percent of the harvestable fish, regardless of the geographic area. Treaty harvests have consistently fallen below this share for composite (wild and hatchery) Snake River summer steelhead. To provide for a realistic transition to this distribution, a 25 year trend was used. This means that summer steelhead recreational mainstem (about 10,000 fish) and tributary harvest (about 40,000 fish) are held relatively constant during the 25 year transition period. After the transition period, both treaty and recreational harvests grow proportionally.

Tributary harvest of spring and summer chinook salmon was introduced as a fishery by PATH results. This recreational fishery has been absent since the 1970's in Idaho. The PATH harvest rates for this fishery, for example, are about 6.5 percent run size at ocean escapement after 20 years, for Action A4. The inriver recreational mainstem fishery is 29.5 percent.

D. Runs Size and Harvest Forecast Results

Run sizes can be measured at ocean escapement or at other geographic locations. The major anadromous fish stock's wild origin run size measured at escapement past the upper most dam on the lower Snake River over a recent historical period (1964-1996) and forecasts over the first 50 years of project life for each hydrosystem action are shown in Figures 3.II.3a through 3.II.3d. The forecast for wild and hatchery run sizes, as well as harvests, are shown in Appendix 3.A. The historical and forecast run sizes mean ocean and inriver harvests as well as other river passage mortalities have been accounted for in the run size. The forecasts show rapid recovery during early project period and minor fluctuations in later years. The fluctuations, as explained by PATH documentation, are due to ocean regime shifts. The forecasted wild origin run sizes are less than about one third pre-dam historical levels.

The forecast of harvests over the project period by actions is shown in Figure 3.II.4. The forecast is enveloped around point estimates based on PATH results variability.

The fishery called commercial treaty includes both the treaty gillnet and ceremonial and subsistence (C&S) harvest, because PATH results did not distinguish these fisheries. The Columbia River Fish Management Plan (CRFMP) has specific harvest rates for C&S. For example, the C&S entitlement is 10,000 spring and summer chinook or fish of equivalent quality. During years of very low abundance, states have provided tribes hatchery surplus fish from both within the Columbia River Basin and outside the Basin to attain this minimum. The C&S harvest from Indian platform and gillnet fisheries was about 5,000 spring and summer

Table 3.II.3
Snake River Anadromous Fish Inriver Harvests and Harvest Rates for 10-year Average, 1986-1995

		Existing Inriver Harvest and Harvest Rates									
		Mainstem								Tributary	
	Ocean	Commercial Non-Treaty		Recreational		Treaty Indian		LWG Escapement		Recreational	
Species/Stock	Escapement	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Snake River											
Fall Chinook											
Wild	1,813	--	--	--	--	419	23.1%	381	21.0%	--	--
Hatchery	4,458	--	--	--	--	1,108	24.9%	1,679	37.7%	--	--
Total	6,271	803	12.8%	159	2.5%	1,527	24.3%	2,060	32.8%	--	--
Spring Chinook											
Wild	8,657	--	--	--	--	561	6.5%	5,126	59.2%	--	--
Hatchery	19,865	--	--	--	--	1,363	6.9%	12,234	61.6%	--	--
Total	28,522	506	1.8%	364	1.3%	1,924	6.7%	17,360	60.9%	--	--
Summer Chinook											
Wild	3,073	0	0.0%	--	--	78	2.5%	2,294	74.6%	--	--
Hatchery	2,856	0	0.0%	--	--	89	3.1%	1,972	69.0%	--	--
Total	5,929	0	0.0%	3	0.0%	167	2.8%	4,265	71.9%	--	--
Summer Steelhead											
Wild	21,187	0	0.0%	0	0.0%	4,115	19.4%	16,225	76.6%	0	0.0%
Hatchery	105,598	0	0.0%	10,733	10.2%	25,972	24.6%	72,795	68.9%	40,248	38.1%
Total	126,785	0	0.0%	9,846	7.8%	29,636	23.4%	89,020	70.2%	40,248	31.7%

Notes:
1. Averages are based on 1986 through 1995 period.
2. Harvest rates based on ocean escapement.
3. Upriver refers to mainstem escapement from the lower Columbia River into either the Upper Columbia River or the Snake River.
4. All references to specific tables and tabs are found in TAC 1997.
5. Recreational mainstem and tributary harvest are assumed to be illegal and zero for wild fall chinook, spring chinook, and summer chinook after 1990 and for summer steelhead after 1984.
6. Fall chinook
   a. Total fall chinook harvest from commercial, recreational, and treaty user groups is from Table 8 Tab 3. The assumption is made that catch in zone 6 is treaty.
   b. Ocean and LWG escapement is from Tables 8 and 9 Tab 3.
   c. Treaty harvest of wild fall chinook is from Table 9 Tab 3. Hatchery is the residual of total and wild.
7. Spring chinook
   a. Total ocean escapement is the total upriver run size times the proportion of Snake River spring chinook from Tables 1 and 2 Tab 1.
   b. Wild ocean escapement and LWG escapement are from Tables 2 and 3 Tab 1.
   c. Hatchery ocean escapement is the residual between total and wild.
   d. Hatchery LWG escapement is from Table 3 Tab 1.
   e. Total commercial and total recreational Snake River harvests are estimated using upriver spring chinook mainstem harvest by user group and applying the proportion of mainstem escapement to Snake River.
   f. Treaty harvest of wild mainstem Snake River spring chinook is from Table 2 Tab 1. It is assumed that harvest in zone 6 are treaty harvest only. Total harvest is estimated using harvest of upriver spring chinook and proportion to Snake River spring chinook. Treaty harvest of hatchery spring chinook is the residual of total and wild.
8. Summer chinook
   a. Wild ocean escapement and LWG escapement is from Table 2 Tab 2.
   b. Hatchery ocean escapement and LWG escapement is from Table 3 Tab 2.
   c. Total recreational mainstem harvest of summer chinook is estimated from harvest of upriver summer chinook and proportion Snake River summer chinook.
   d. Non-treaty commercial harvest in zones 1-5 for wild and hatchery summer chinook is zero. Table 1 Tab 2. Incidental non-retention excluded.
   e. Treaty harvest of wild summer chinook is from Table 2 Tab 2. This assumes zone 6 harvest is treaty only.
   f. Treaty harvest of hatchery summer chinook is from Table 3 Tab 2. This assumes zone 6 harvest is treaty only.
9. Summer steelhead
   a. Non-treaty commercial harvest is assumed to be zero.
   b. LWG escapement is from Tables 12 through 15 Tab 8. Lower Granite counts of group A and B were summed (based on the length method).
   c. Total tributary harvest is from Tables A1c and A1d.
   d. Wild and hatchery ocean escapement is from Tables 12 through 15 Tab 8. Lower Granite with no mainstem fishery counts of group A and B were summed (based on the length method). This provides a minimum run size.
   e. Mainstem harvest rates are assumed to equal mainstem harvest rates for total upriver summer steelhead stocks. Tab 8 Table 4.

Source: TAC 1997.

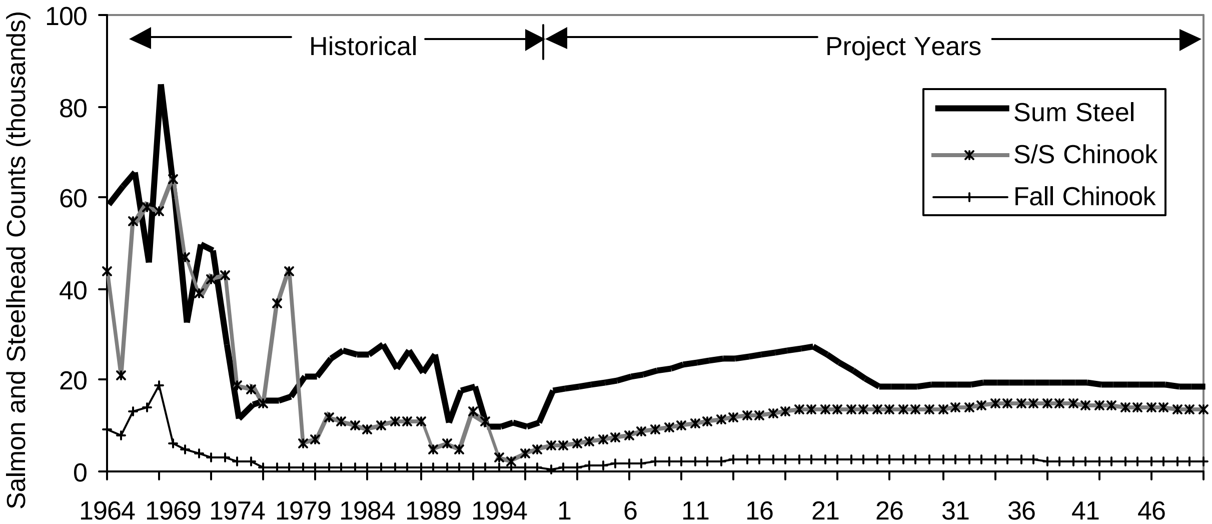
Table 3.II.4
Assumptions for Anadromous Fish User Group Distributions by Species and Geographic Area

Geographic Area/User Group	Anadromous Species: Chinook Spring/Summer	Chinook Fall	Summer Steelhead
Ocean Harvest			
Alaska			
a) Commercial	0.000%	11.663%	0.000%
b) Sport	0.000%	0.002%	0.000%
British Columbia			
a) Commercial	0.000%	48.506%	0.000%
b) Sport	0.000%	3.880%	0.000%
Subtotal Alaska/B.C.	0.000%	64.051%	0.000%
Washington ocean			
a) Commercial	0.000%	19.027%	0.000%
b) Sport	0.000%	8.456%	0.000%
Washington Puget Sound			
a) Commercial	0.000%	0.002%	0.000%
b) Sport	0.000%	0.002%	0.000%
Oregon			
a) Commercial	0.000%	6.343%	0.000%
b) Sport	0.000%	2.115%	0.000%
California			
a) Commercial	0.000%	0.002%	0.000%
b) Sport	0.000%	0.002%	0.000%
Subtotal WOC Ocean	0.000%	35.949%	0.000%
Subtotal Ocean	0.000%	100.000%	0.000%
In-river Harvest			
Treaty Year 0	50.000%	62.219%	37.200%
Year 5	50.000%	62.219%	39.760%
Year 10	50.000%	62.219%	42.320%
Year 15	50.000%	62.219%	44.880%
Year 20	50.000%	62.219%	47.440%
Year 25-100	50.000%	62.219%	50.000%
Non-treaty			
Mainstem	(less treaty)		(less treaty)
a) Freshwater sport	77.000%	2.874%	100.000%
b) Commercial non-Treaty	17.000%	34.491%	0.000%
c) Other in-river	6.000%	0.416%	0.000%
Tributary			
a) Freshwater sport	100.000%	0.000%	100.000%
Returns to Hatcheries			
Requirement to Carcass	100.000%	100.000%	100.000%
Surplus			
a) Carcass and egg sales	50.000%	50.000%	50.000%
b) Food fish	50.000%	50.000%	50.000%

Notes: 1. Expressed as percent of fish harvested by the geographical fisheries.
2. See text narrative on survival rates and contribution to fisheries for explanation of distributional assumptions.
3. Results assume 50% for treaty harvest and zero ocean harvests for spring/summer chinook and summer steelhead.
4. Treaty harvest percent of fish is based on all inriver harvestable fish (mainstem and tributary). It is assumed that all treaty harvest are in the mainstem.
5. Non-treaty mainstem harvest for spring/summer chinook and summer steelhead, represent the distribution of the remaining mainstem harvestable fish by user group.
6. Non-treaty harvest for fall chinook represent shares of total inriver harvest.

Source: Study.

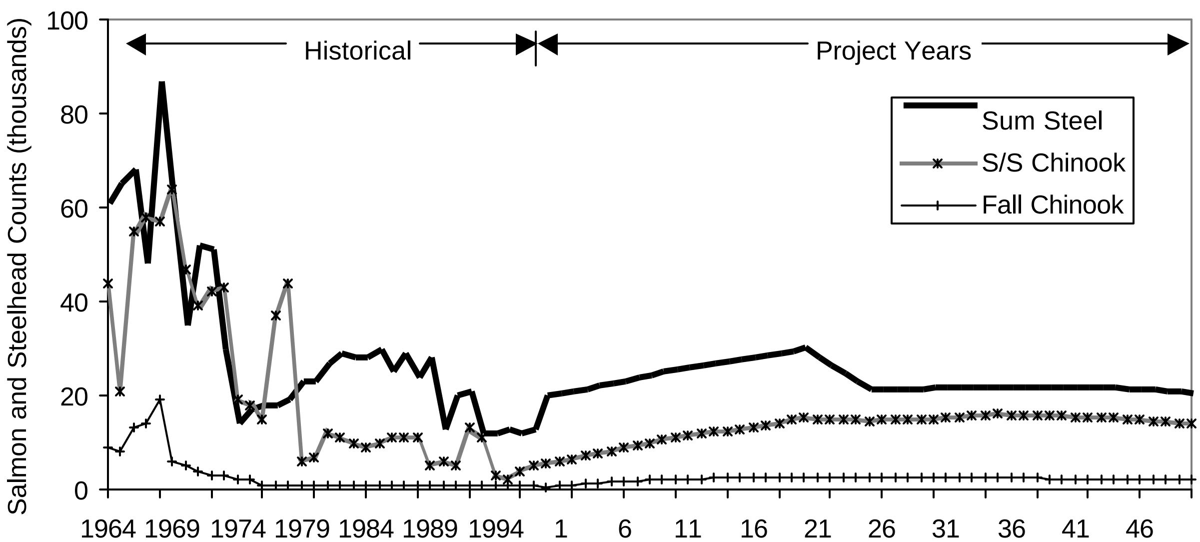
Figure 3.II.3a
Historical and Project Year Wild Origin Stock Run Counts at Snake River Uppermost Dam, Action A1



Note: Adult wild salmon and steelhead counts at the uppermost dam on the Snake River below Lewiston (Ice Harbor Dam 1964-68, Lower Monument Dam 1969, Little Goose Dam 1970-74, Lower Granite Dam 1970-74).

Source: Study and Idaho Department of Fish and Game (IDFG) (1998).

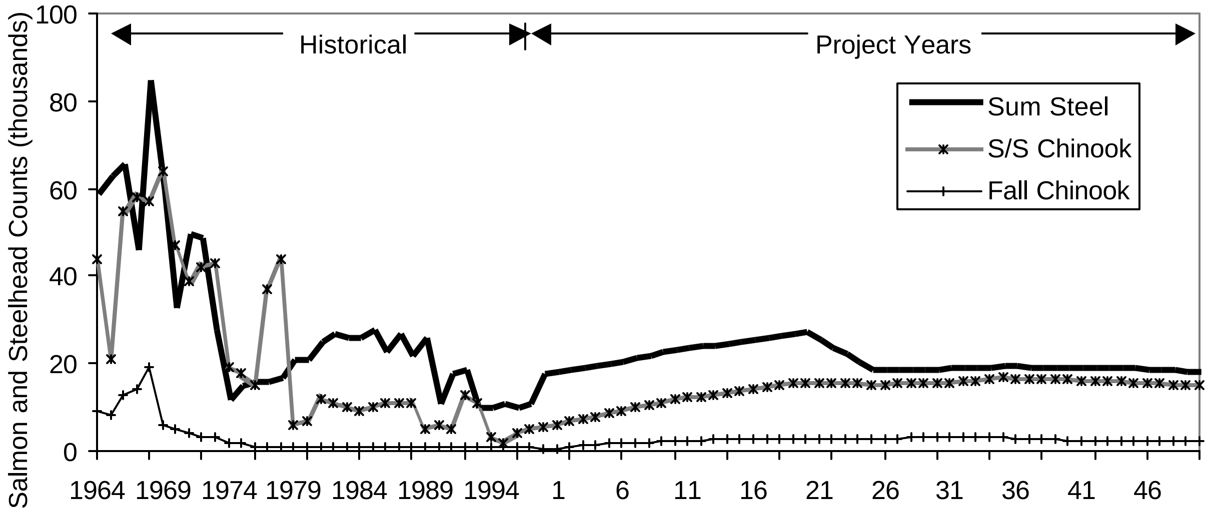
Figure 3.II.3b
Historical and Project Year Wild Origin Stock Run Counts at Snake River Uppermost Dam, Action A2



Note: Adult wild salmon and steelhead counts at the uppermost dam on the Snake River below Lewiston (Ice Harbor Dam 1964-68, Lower Monument Dam 1969, Little Goose Dam 1970-74, Lower Granite Dam 1970-74).

Source: Study and IDFG (1998).

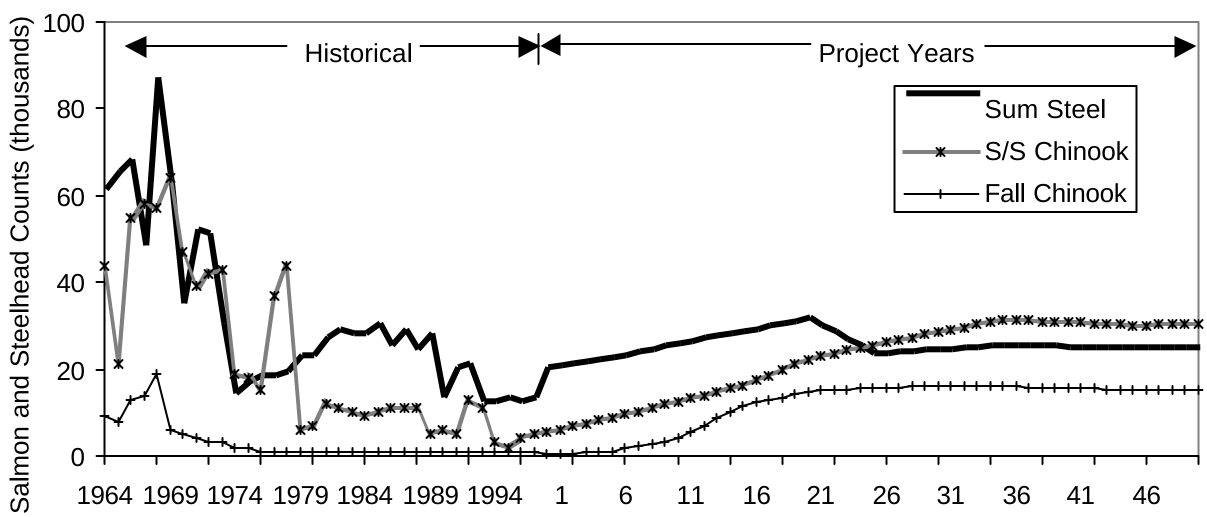
Figure 3.II.3c
Historical and Project Year Wild Origin Stock Run Counts
at Snake River Uppermost Dam, Action A3



Note: Adult wild salmon and steelhead counts at the uppermost dam on the Snake River below Lewiston (Ice Harbor Dam 1964-68, Lower Monument Dam 1969, Little Goose Dam 1970-74, Lower Granite Dam 1970-74).

Source: Study and IDFG (1998).

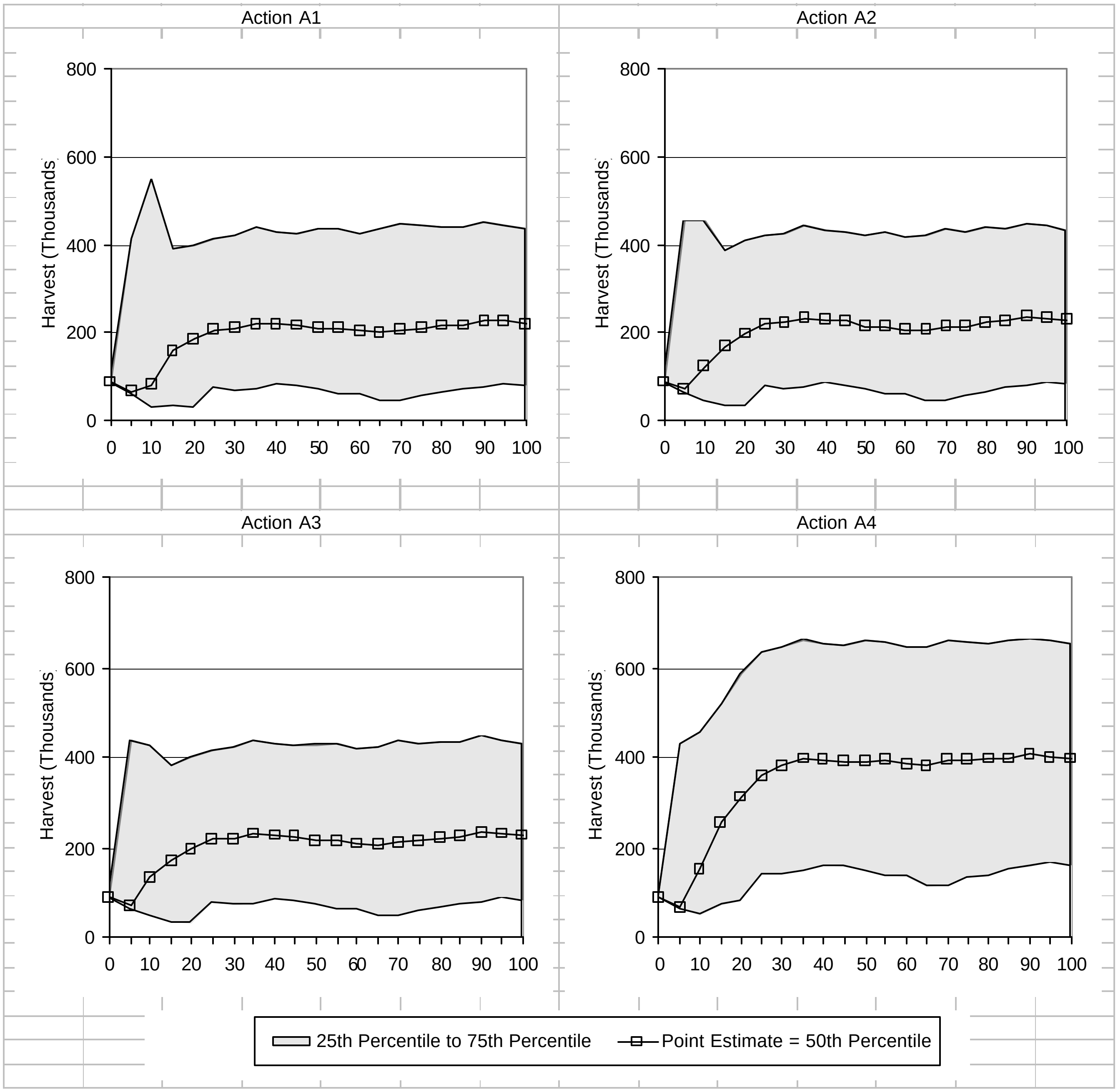
Figure 3.II.3d
Historical and Project Year Wild Origin Stock Run Counts
at Snake River Uppermost Dam, Action A4



Note: Adult wild salmon and steelhead counts at the uppermost dam on the Snake River below Lewiston (Ice Harbor Dam 1964-68, Lower Monument Dam 1969, Little Goose Dam 1970-74, Lower Granite Dam 1970-74).

Source: Study and IDFG (1998).

Figure 3.II.4
Harvest Forecast for Snake River Stocks Over Project Period
by Action for "Low," "Likely," and "High" Modeling Results



Notes: 1. Harvests include all ocean, mainstem, and tributary fisheries for all species.
2. The envelop (shaded area) around the point estimates (boxes) corresponds to PATH results for "high" (75th percentile) and "low" (25th percentile) modeling outputs. The point estimates are "likely" (50th percentile) modeling results.
3. The analysis is based on PATH results for fall chinook based on base case scenarios and spring and summer chinook based on equal weights scenario.

Source: Study.

chinook during the 1988 to 1995 time period (TAC 1997). During this same period, C&S harvest of summer steelhead was about 6,000 fish. The proportion of Snake River stocks contributing to the C&S harvests was accounted for in the commercial treaty fishery distributional assumptions.

CHAPTER III. ECONOMIC VALUES OF THE HARVESTS

A. Economic Value Assumptions

The economic evaluation of changed anadromous fish stocks due to hydrosystem actions relies on available methods and data. The PATH provided information for some wild index stocks which were expanded to represent all stocks using abbreviated life cycle modeling procedures. Historical harvest distribution patterns were used as a base and then modified for future expected management regimes. For example, inriver tribal harvests are now less than treaty rights for 50 percent of harvestable summer steelhead stocks. Future distributional allocations were modified to attain a 50 percent share within 25 years.

The forecast of fish available for harvest in the ocean and in-river is distributed to user groups within constraints of international understandings and Columbia River tribal treaty agreements. The benefits to regional economies and the nation were then calculated using the forecasted harvests. Table 3.III.1 shows the economic modeling assumptions used to calculate economic values using forecasted commercially harvested fish and recreational angler days.

Catch per unit effort (CPUE) to determine angler days used recent period catch rates. Ocean recreational composite rates are one day per fish, Columbia River mainstem is two days per fish, and Snake River tributary is 5.88 days per fish. CPUE is influenced by fishing motivational factors and fishery management techniques. For example, all recreational steelhead fishing is selective for hatchery origin fish. If future wild origin abundance levels allow retention, then the CPUE (expressed as days per fish) will decrease. Modeling assumptions for CPUE incorporated increasing tributary success rates (expressed as fish per day) with increasing harvests.

The anadromous fish forecasting analysis resulted in a large share of summer steelhead destined to the Snake River watershed escaping fisheries and returning to hatcheries as surplus. The default use of this surplus is for food fish, egg, and carcass sales. There may be fishery management opportunities to convert these sales to harvest opportunities. Changing fish forecasting assumptions to realize this opportunity is described in the risk and uncertainty chapter.

B. Net Economic Values (NED Benefits)

The changed economic value (NED benefits) measured by annual average equivalent values (AAEV) over a project life of 100 years between base case and other hydrosystem actions using the most current Corps discount rate (6 7/8 percent) ranges between $1.67 million and $4.87 million in 1998 dollars (Table 3.III.2). If a zero percent discount rate is used for valuing future generation benefits, then the changed values (NED AAEV benefits) may be as high as $8.65 million for one of the actions. Action A4 has the highest changed values.

Table 3.III.1
Regional Economic Impact (RED Benefits) and Net Economic
Value (NED Benefits) Assumptions by Species and Fishery

	Regional Economic Impacts		Net Economic Value	
	Commercial	Recreational	Commercial	Recreational
Spring/Summer Chinook				
Ocean				
Alaska	69.15		33.83	
British Columbia	69.99		34.30	
Washington ocean	48.31		23.68	
Washington Puget Sound	41.22		21.19	
Oregon	42.05		21.65	
California	53.80		22.33	
Columbia Basin inland				
Mainstem	98.59	60.00	49.95	51.43
Tributary		60.00		63.23
Other	0.00		0.00	
Food fish	49.12		26.87	
Carcass and egg sales	2.00		0.00	
Fall Chinook				
Ocean				
Alaska	69.15	60.00	33.83	51.43
British Columbia	69.99	60.00	34.30	51.43
Washington ocean	48.31	60.00	23.68	51.43
Washington Puget Sound	41.22	60.00	21.19	51.43
Oregon	42.05	60.00	21.65	51.43
California	53.80	60.00	22.53	51.43
Columbia Basin inland				
Mainstem	41.22	60.00	23.53	51.43
Tributary				
Other	0.00		0.00	
Food fish	29.75		18.25	
Carcass and egg sales	2.00		1.23	
Summer Steelhead				
Ocean				
Alaska				
British Columbia	22.28		11.44	
Washington ocean				
Washington Puget Sound				
Oregon				
California				
Columbia Basin inland				
Mainstem	16.89	60.00	9.99	52.85
Tributary		60.00		63.23
Other				
Food fish	14.21		8.73	
Carcass and egg sales	2.00		1.23	

Notes: 1. Average 1998 dollars per fish (commercial fisheries) and angler day (recreational fisheries).
2. Carcass sales assume $0.10 per pound for whole body dressed weight.

Source: Study.

Table 3.III.2
Changed Annualized Economic Value (NED Benefits) Between Base Case and Other Hydrosystem Actions for Various Discount Rates

Hydrosystem Actions	0% Amount	0% Order	4 6/8% Amount	4 6/8% Order	6 7/8% Amount	6 7/8% Order
Annual Average Equivalent Value (Year 0 to Year 100)						
A2 less A1	$0.97	2	$1.56	3	$1.67	3
A3 less A1	$0.86	3	$1.59	2	$1.73	2
A4 less A1	$8.65	1	$5.81	1	$4.87	1

Notes:
1. NED benefits measured by annual average equivalent values over a 100 year project life in millions of 1998 dollars.
2. Evaluation is for all modeled anadromous fish species and includes harvests and hatchery surplus utilization. The evaluation excludes the economic values for inriver recreational fishing.
3. The analysis is based on PATH results' "base case" scenario for fall chinook and "equal weights" scenario for spring/summer chinook using median percentile output.
4. See text for explanation of hydrosystem action descriptions.

Source: Study.

Table 3.III.3 shows the annualized economic value (NED AAEV benefits) range by fisheries for three discount rates. The "high" modeling results are interesting in that Action A1 for some fisheries is greater than other proposed project actions.

Annualized economic values (NED AAEV benefits) generated per year by species for wild and hatchery origin fish over the life of the project for each hydrosystem action are shown in Figures 3.III.2a through 3.III.2c. The user groups' share of economic values (NED benefits) are shown in Figures 3.III.3a through 3.III.3d. For Action A3_3 year, the Columbia River treaty commercial fishery creates the highest benefit share for fall chinook (24 percent), while the inriver recreational fishery creates the highest share for spring/summer chinook (61 percent). The inriver recreational fishery generates the highest benefits for summer steelhead (95 percent).

C. Regional Economic Impacts (RED Benefits)

The regional economic impacts (RED benefits) are between $11 and $22 million (personal income, 1998 dollars) per year or 285 to 600 jobs per year after the first ten years (Table 3.III.4). The order of which actions generate the highest regional economic impacts (Action A4) does not change after 10 years.

Table 3.III.3a
Ranges of Annualized Economic Value (NED Benefits) by Fishery For Each Hydrosystem Action Using “Low”, “Likely”, and “High” Modeling Results

	A1			A2			A3			A4		
Anadromous Fish	Low	Likely	High	Low	Likely	High	Low	Likely	High	Low	Likely	High
Commercial												
Ocean												
Alaska	$6.15	$12.72	$26.35	$6.15	$12.72	$26.35	$6.85	$14.56	$30.54	$31.99	$69.48	$136.12
British Columbia	$25.93	$53.66	$111.09	$25.93	$53.66	$111.09	$28.90	$61.41	$128.77	$134.89	$292.97	$573.99
WA Ocean	$7.02	$14.53	$30.08	$7.02	$14.53	$30.08	$7.83	$16.63	$34.87	$36.53	$79.34	$155.44
WA Puget Sound	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.01
Oregon	$2.14	$4.43	$9.17	$2.14	$4.43	$9.17	$2.39	$5.07	$10.63	$11.13	$24.18	$47.38
California	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.02
Subtotal Ocean	$41.24	$85.34	$176.70	$41.24	$85.34	$176.70	$45.97	$97.68	$204.82	$214.55	$465.99	$912.95
Inriver												
Non-treaty	$21.50	$45.76	$96.49	$23.09	$51.36	$110.14	$24.26	$52.75	$113.84	$120.47	$223.36	$409.35
Treaty Indian	$293.52	$702.77	$2,003.61	$323.81	$795.22	$2,062.65	$323.18	$789.90	$1,992.09	$564.64	$1,287.11	$2,771.28
Hatchery Returns	$8.77	$137.06	$522.24	$28.98	$198.78	$613.34	$25.47	$188.48	$567.35	$206.31	$480.92	$990.32
Subtotal Inriver	$323.79	$885.59	$2,622.34	$375.88	$1,045.36	$2,786.14	$372.92	$1,031.12	$2,673.27	$891.43	$1,991.39	$4,170.95
Subtotal Commercial	$365.02	$970.93	$2,799.04	$417.12	$1,130.70	$2,962.84	$418.89	$1,128.80	$2,878.09	$1,105.97	$2,457.38	$5,083.90
Recreational												
Ocean												
Alaska	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
British Columbia	$3.11	$6.44	$13.32	$3.11	$6.44	$13.32	$3.47	$7.37	$15.44	$16.18	$35.14	$68.84
WA Ocean	$6.78	$14.03	$29.04	$6.78	$14.03	$29.04	$7.55	$16.05	$33.66	$35.26	$76.58	$150.04
WA Puget Sound	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
Oregon	$1.70	$3.51	$7.26	$1.70	$3.51	$7.26	$1.89	$4.02	$8.42	$8.82	$19.15	$37.53
California	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
Subtotal Ocean	$11.59	$23.98	$49.65	$11.59	$23.98	$49.65	$12.92	$27.44	$57.55	$60.28	$130.93	$256.51
Inriver												
Mainstem	$845.77	$1,799.03	$4,953.40	$909.49	$1,989.36	$4,951.16	$900.82	$1,973.13	$4,769.80	$1,071.64	$2,423.65	$5,224.66
Tributary	$6,196.61	$10,798.75	$38,901.81	$6,728.14	$12,121.18	$38,169.53	$6,703.46	$12,196.96	$36,744.24	$6,988.05	$13,447.44	$37,630.20
Subtotal Inriver	$7,042.37	$12,597.78	$43,855.20	$7,637.64	$14,110.54	$43,120.69	$7,604.28	$14,170.09	$41,514.04	$8,059.68	$15,871.09	$42,854.86
Subtotal Recreational	$7,053.96	$12,621.76	$43,904.85	$7,649.22	$14,134.52	$43,170.34	$7,617.19	$14,197.53	$41,571.59	$8,119.97	$16,002.02	$43,111.37
Total Commercial and Recreational	$7,418.98	$13,592.69	$46,703.89	$8,066.34	$15,265.22	$46,133.18	$8,036.08	$15,326.34	$44,449.68	$9,225.94	$18,459.40	$48,195.27

Notes:
1. NED benefits measured by annual average equivalent values over a 100 year project life using 6 7/8% discount rate in thousands of 1998 dollars.
2. Evaluation is for all modeled anadromous fish species and includes harvests and hatchery surplus utilization. The evaluation excludes the economic values for inriver recreational fishing.
3. PATH results fall chinook Action A1 is the same as Action A2. Fall chinook is the only significantly harvested species in ocean fisheries.
4. “Low”, “likely,” and “high” modeling results correspond to PATH results for 25th, 50th, 75th percentile outputs, respectively.
5. The analysis is based on PATH results' "base case" scenario for fall chinook and "equal weights" scenario for spring/summer chinook.
6. Total and subtotals may not equal sum of values due to rounding.

Source: Study.

Table 3.III.3b
Ranges of Annualized Economic Value (NED Benefits) by Fishery For Each Hydrosystem Action Using "Low", "Likely", and "High" Modeling Results

	A1			A2			A3			A4		
Anadromous Fish	Low	Likely	High	Low	Likely	High	Low	Likely	High	Low	Likely	High
Commercial												
Ocean												
Alaska	$6.42	$13.71	$28.66	$6.42	$13.71	$28.66	$7.33	$15.94	$33.65	$39.67	$84.82	$163.84
British Columbia	$27.07	$57.80	$120.87	$27.07	$57.80	$120.87	$30.91	$67.22	$141.87	$167.30	$357.68	$690.88
WA Ocean	$7.33	$15.65	$32.73	$7.33	$15.65	$32.73	$8.37	$18.20	$38.42	$45.30	$96.86	$187.10
WA Puget Sound	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.02
Oregon	$2.23	$4.77	$9.98	$2.23	$4.77	$9.98	$2.55	$5.55	$11.71	$13.81	$29.52	$57.03
California	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.02
Subtotal Ocean	$43.05	$91.93	$192.24	$43.05	$91.93	$192.24	$49.16	$106.91	$225.66	$266.09	$568.91	$1,098.88
Inriver												
Non-treaty	$23.38	$52.57	$110.98	$25.38	$59.30	$127.02	$27.08	$61.25	$132.53	$155.22	$287.02	$514.37
Treaty Indian	$309.67	$821.38	$2,175.04	$341.58	$920.20	$2,246.11	$341.37	$911.40	$2,177.94	$677.23	$1,601.70	$3,238.98
Hatchery Returns	$7.26	$167.65	$556.91	$30.41	$237.63	$658.06	$27.33	$223.90	$609.53	$269.56	$605.58	$1,154.79
Subtotal Inriver	$340.31	$1,041.60	$2,842.92	$397.36	$1,217.13	$3,031.18	$395.77	$1,196.55	$2,920.00	$1,102.01	$2,494.30	$4,908.14
Subtotal Commercial	$383.36	$1,133.53	$3,035.17	$440.42	$1,309.06	$3,223.43	$444.92	$1,303.46	$3,145.66	$1,368.10	$3,063.21	$6,007.02
Recreational												
Ocean												
Alaska	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
British Columbia	$3.25	$6.93	$14.50	$3.25	$6.93	$14.50	$3.71	$8.06	$17.02	$20.07	$42.90	$82.86
WA Ocean	$7.08	$15.11	$31.59	$7.08	$15.11	$31.59	$8.08	$17.57	$37.08	$43.73	$93.49	$180.59
WA Puget Sound	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
Oregon	$1.77	$3.78	$7.90	$1.77	$3.78	$7.90	$2.02	$4.39	$9.28	$10.94	$23.38	$45.17
California	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
Subtotal Ocean	$12.10	$25.83	$54.01	$12.10	$25.83	$54.01	$13.81	$30.04	$63.40	$74.76	$159.84	$308.75
Inriver												
Mainstem	$858.60	$2,067.46	$5,308.03	$922.64	$2,264.33	$5,320.22	$912.65	$2,239.11	$5,143.21	$1,165.63	$2,891.09	$5,791.10
Tributary	$5,297.50	$10,474.48	$35,545.99	$5,756.90	$11,667.06	$34,745.96	$5,736.57	$11,720.12	$33,502.27	$6,146.17	$13,399.67	$34,905.09
Subtotal Inriver	$6,156.10	$12,541.95	$40,854.01	$6,679.54	$13,931.39	$40,066.18	$6,649.22	$13,959.23	$38,645.48	$7,311.79	$16,290.77	$40,696.19
Subtotal Recreational	$6,168.20	$12,567.78	$40,908.03	$6,691.64	$13,957.22	$40,120.19	$6,663.03	$13,989.27	$38,708.88	$7,386.56	$16,450.61	$41,004.95
Total Commercial and Recreational	$6,551.55	$13,701.30	$43,943.20	$7,132.05	$15,266.28	$43,343.62	$7,107.96	$15,292.73	$41,854.54	$8,754.66	$19,513.82	$47,011.97

Notes:
1. NED benefits measured by annual average equivalent values over a 100 year project life using 4 6/8% discount rate in thousands of 1998 dollars.
2. Evaluation is for all modeled anadromous fish species and includes harvests and hatchery surplus utilization. The evaluation excludes the economic values for inriver recreational fishing.
3. PATH results fall chinook Action A1 is the same as Action A2. Fall chinook is the only significantly harvested species in ocean fisheries.
4. "Low", "likely," and "high" modeling results correspond to PATH results for 25th, 50th, 75th percentile outputs, respectively.
5. The analysis is based on PATH results' "base case" scenario for fall chinook and "equal weights" scenario for spring/summer chinook.
6. Total and subtotals may not equal sum of values due to rounding.

Source: Study.

Table 3.III.3c

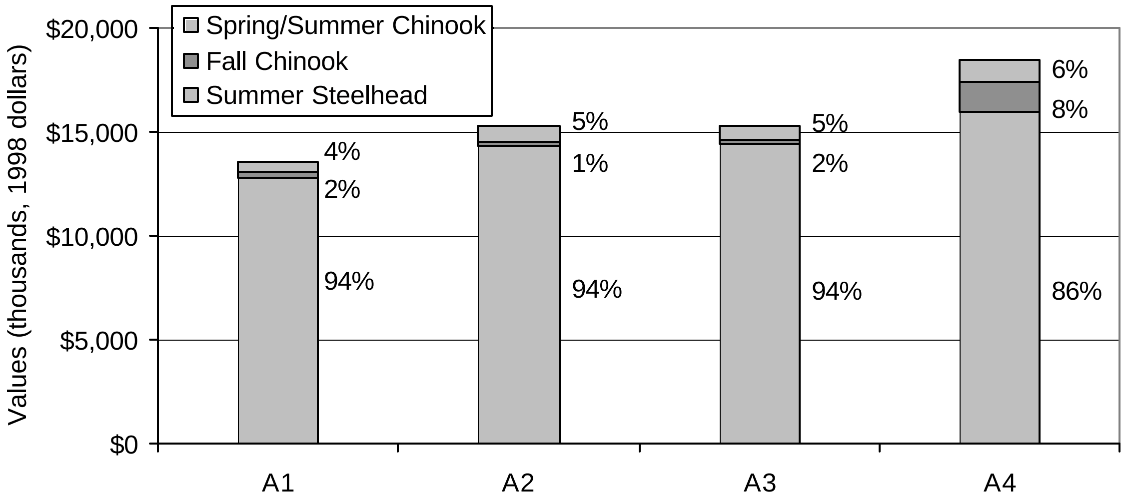
Ranges of Annualized Economic Value (NED Benefits) by Fishery For Each Hydrosystem Action Using "Low", "Likely", and "High" Modeling Results

	A1			A2			A3			A4		
Anadromous Fish	Low	Likely	High	Low	Likely	High	Low	Likely	High	Low	Likely	High
Commercial												
Ocean												
Alaska	$7.83	$16.97	$35.34	$7.83	$16.97	$35.34	$9.35	$20.41	$42.62	$61.71	$126.69	$235.99
British Columbia	$33.00	$71.55	$149.01	$33.00	$71.55	$149.01	$39.43	$86.08	$179.70	$260.20	$534.22	$995.10
WA Ocean	$8.94	$19.38	$40.35	$8.94	$19.38	$40.35	$10.68	$23.31	$48.66	$70.47	$144.67	$269.48
WA Puget Sound	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.01	$0.03
Oregon	$2.72	$5.91	$12.30	$2.72	$5.91	$12.30	$3.25	$7.10	$14.83	$21.48	$44.09	$82.14
California	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.01	$0.03
Subtotal Ocean	$52.48	$113.81	$237.00	$52.48	$113.81	$237.00	$62.72	$136.91	$285.82	$413.87	$849.71	$1,582.76
Inriver												
Non-treaty	$30.77	$74.27	$152.91	$33.77	$83.38	$174.65	$37.31	$87.20	$186.39	$263.24	$479.50	$817.23
Treaty Indian	$381.49	$1,190.57	$2,663.95	$414.35	$1,291.15	$2,756.41	$416.17	$1,272.42	$2,708.91	$1,071.46	$2,616.35	$4,671.95
Hatchery Returns	$7.40	$255.19	$635.86	$37.97	$343.14	$761.36	$37.13	$319.21	$709.59	$468.72	$967.27	$1,602.86
Subtotal Inriver	$419.65	$1,520.04	$3,452.72	$486.10	$1,717.67	$3,692.42	$490.61	$1,678.83	$3,604.88	$1,803.42	$4,063.12	$7,092.04
Subtotal Commercial	$472.13	$1,633.85	$3,689.72	$538.58	$1,831.48	$3,929.42	$553.33	$1,815.74	$3,890.71	$2,217.29	$4,912.82	$8,674.80
Recreational												
Ocean												
Alaska	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.01	$0.01	$0.02	$0.03	$0.06
British Columbia	$3.96	$8.58	$17.87	$3.96	$8.58	$17.87	$4.73	$10.32	$21.55	$31.21	$64.07	$119.35
WA Ocean	$8.63	$18.70	$38.95	$8.63	$18.70	$38.95	$10.31	$22.50	$46.97	$68.02	$139.64	$260.11
WA Puget Sound	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.01	$0.01	$0.02	$0.03	$0.06
Oregon	$2.16	$4.68	$9.74	$2.16	$4.68	$9.74	$2.58	$5.63	$11.75	$17.01	$34.93	$65.06
California	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.01	$0.01	$0.02	$0.03	$0.06
Subtotal Ocean	$14.75	$31.98	$66.59	$14.75	$31.98	$66.59	$17.62	$38.47	$80.31	$116.28	$238.74	$444.71
Inriver												
Mainstem	$945.85	$2,914.82	$6,328.99	$1,002.23	$3,096.92	$6,384.08	$988.97	$3,044.45	$6,247.28	$1,539.33	$4,411.10	$7,484.29
Tributary	$3,347.93	$9,492.06	$24,026.08	$3,546.98	$10,082.92	$23,395.71	$3,523.85	$10,032.77	$22,840.03	$4,367.79	$13,164.31	$25,840.52
Subtotal Inriver	$4,293.78	$12,406.88	$30,355.07	$4,549.21	$13,179.84	$29,779.79	$4,512.81	$13,077.22	$29,087.31	$5,907.12	$17,575.42	$33,324.81
Subtotal Recreational	$4,308.52	$12,438.86	$30,421.66	$4,563.96	$13,211.82	$29,846.38	$4,530.44	$13,115.69	$29,167.62	$6,023.41	$17,814.16	$33,769.51
Total Commercial and Recreational	$4,780.66	$14,072.71	$34,111.38	$5,102.54	$15,043.31	$33,775.80	$5,083.76	$14,931.43	$33,058.33	$8,240.70	$22,726.98	$42,444.31

Notes:
1. NED benefits measured by annual average equivalent values over a 100 year project life using 0% discount rate in thousands of 1998 dollars.
2. Evaluation is for all modeled anadromous fish species and includes harvests and hatchery surplus utilization. The evaluation excludes the economic values for inriver recreational fishing.
3. PATH results fall chinook Action A1 is the same as Action A2. Fall chinook is the only significantly harvested species in ocean fisheries.
4. "Low", "likely," and "high" modeling results correspond to PATH results for 25th, 50th, 75th percentile outputs, respectively.
5. The analysis is based on PATH results' "base case" scenario for fall chinook and "equal weights" scenario for spring/summer chinook.
6. Total and subtotals may not equal sum of values due to rounding.

Source: Study.

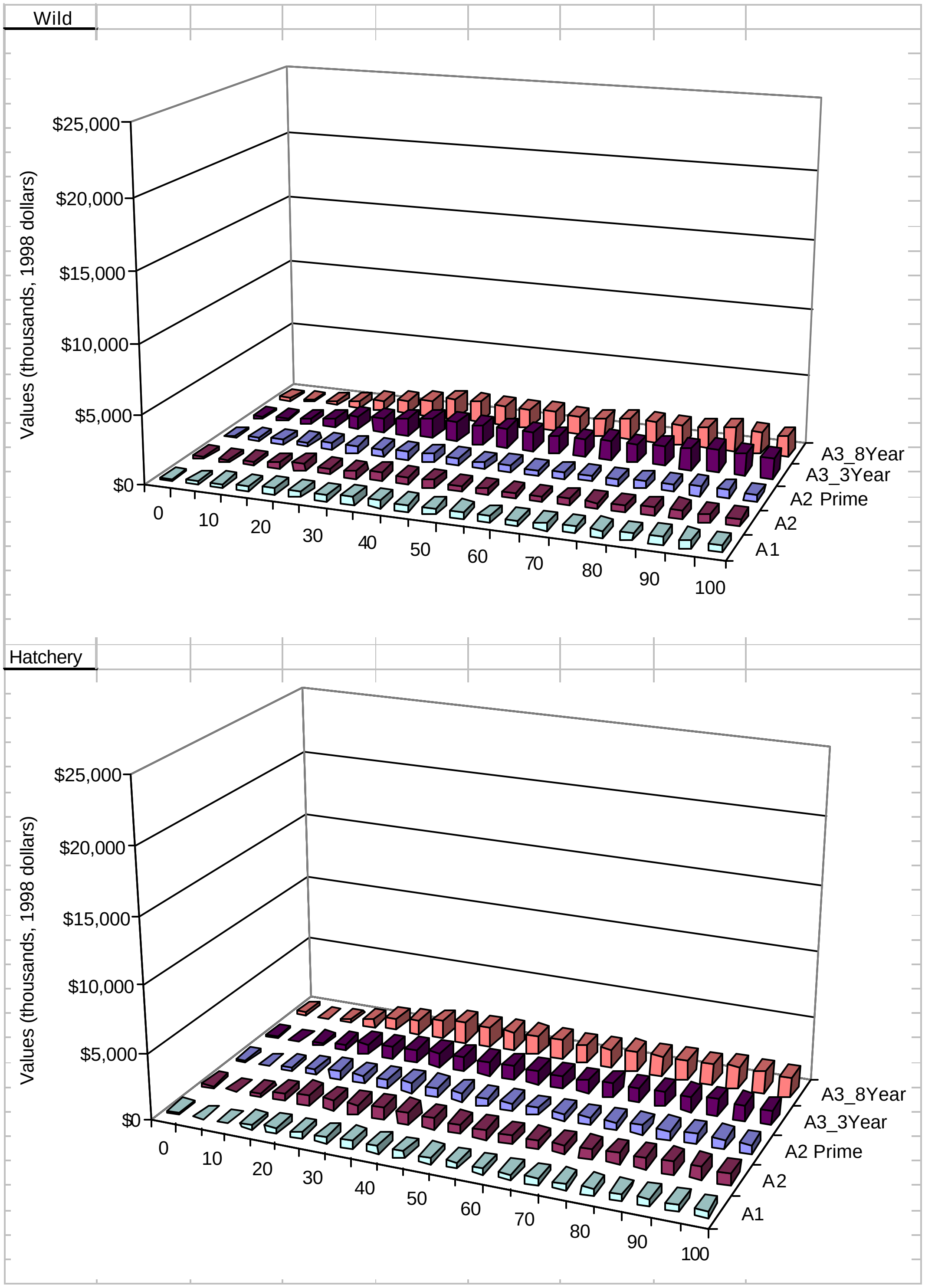
Figure 3.III.1
Annualized Economic Values (NED Benefits) by Anadromous Fish Species for Each Project Action



Notes:
1. NED benefits measured by annual average equivalent values over a 100 year project life using 6 7/8% discount rate in thousands of 1998 dollars.
2. Evaluation is for all modeled anadromous fish species and includes harvests and hatchery surplus utilization.
3. PATH results fall chinook Action A1 is the same as Action A2. Fall chinook is the only significantly harvested species in ocean fisheries.
4. The analysis is based on PATH results' "base case" scenario for fall chinook and "equal weights" scenario for spring/summer chinook using "likely" (50th percentile) modeling output.

Source: Study.

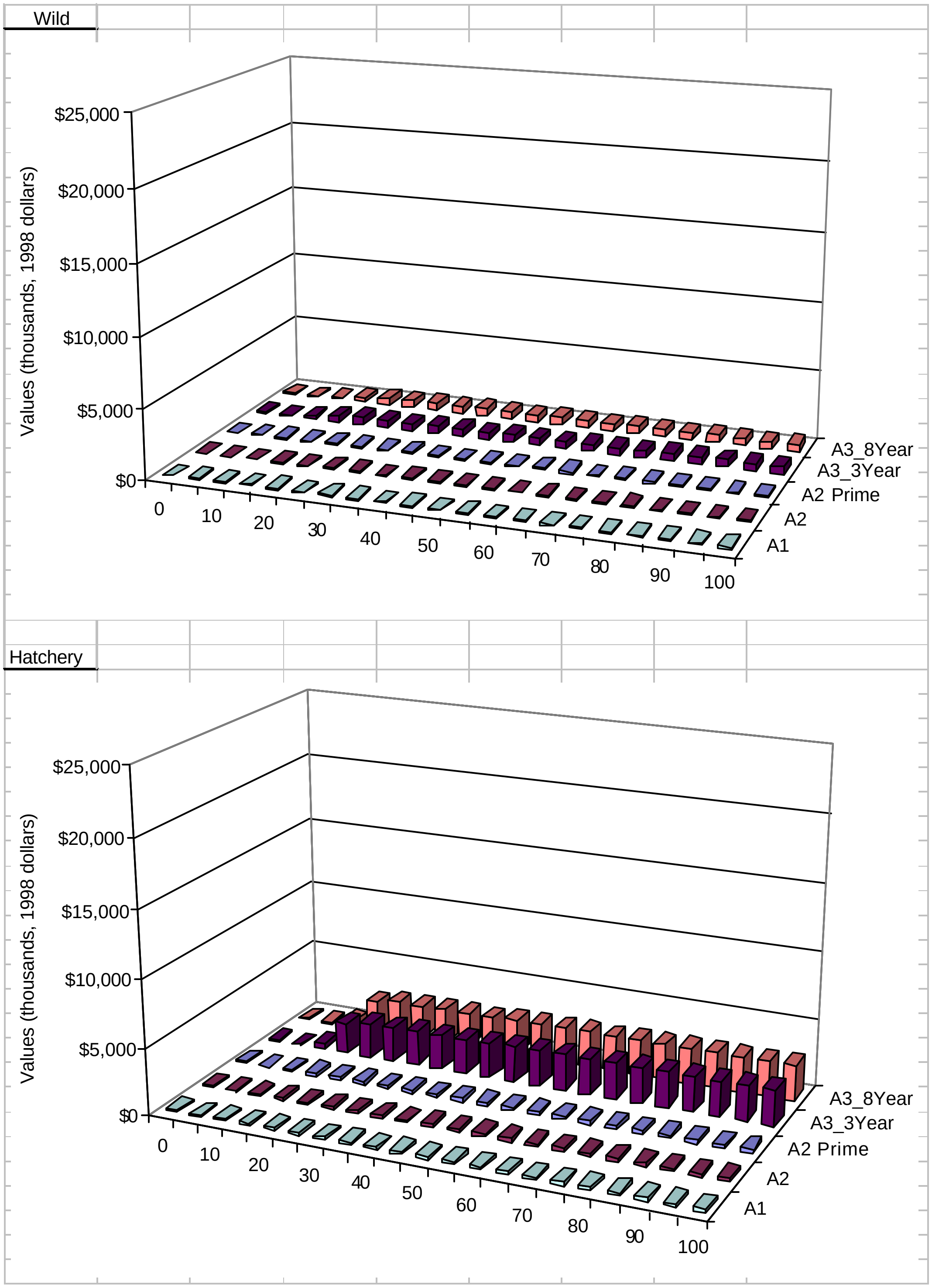
Figure 3.III.2a
Economic Values (NED Benefits) for Spring/Summer Chinook
by Project Action Using "Likely" Modeling Results



Note: 1. Recreational inriver fisheries are excluded from the analysis.
2. NED benefits are based on PATH results fall chinook "base case" and spring/summer chinook "equal weights".

Source: Study.

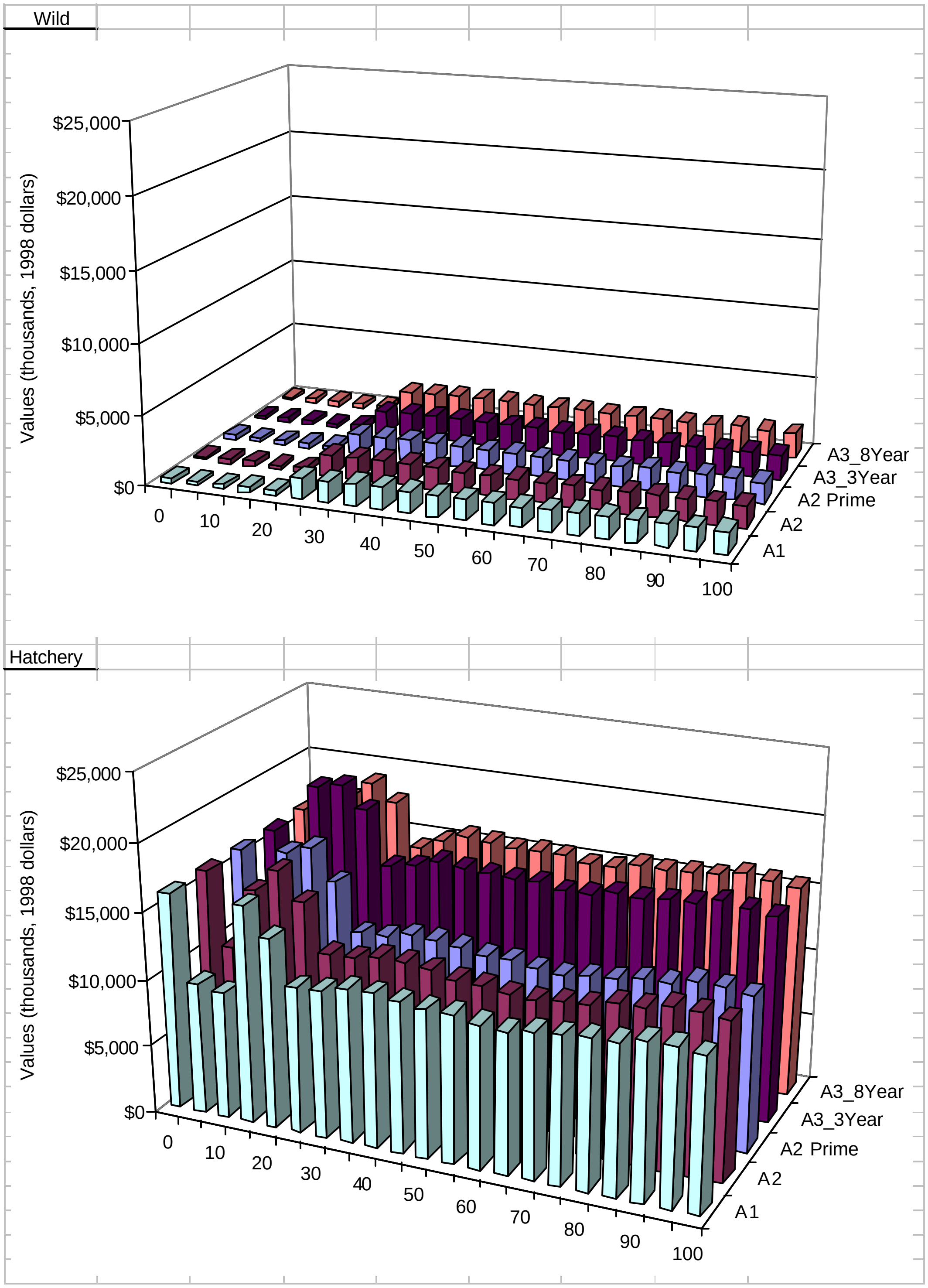
Figure 3.III.2b
Economic Values (NED Benefits) for Fall Chinook
by Project Action Using “Likely” Modeling Results



Note: 1. Recreational inriver fisheries are excluded from the analysis.
2. NED benefits are based on PATH results fall chinook "base case" and spring/summer chinook "equal weights".

Source: Study.

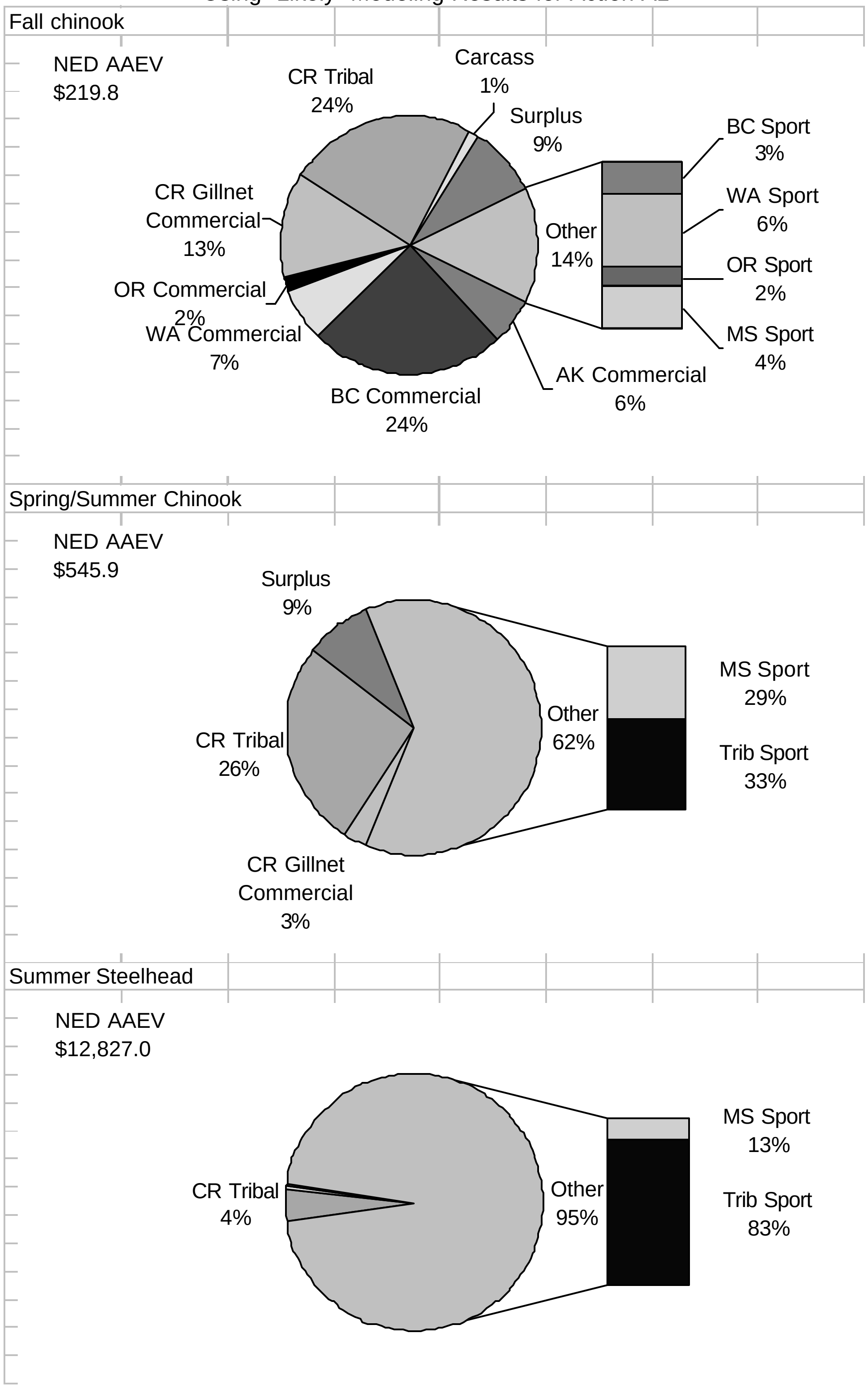
Figure 3.III.2c
Economic Values (NED Benefits) for Summer Steelhead
by Project Action Using "Likely" Modeling Results



Note: 1. Recreational inriver fisheries are excluded from the analysis.
2. NED benefits are based on PATH results fall chinook "base case" and spring/summer chinook "equal weights".

Source: Study.

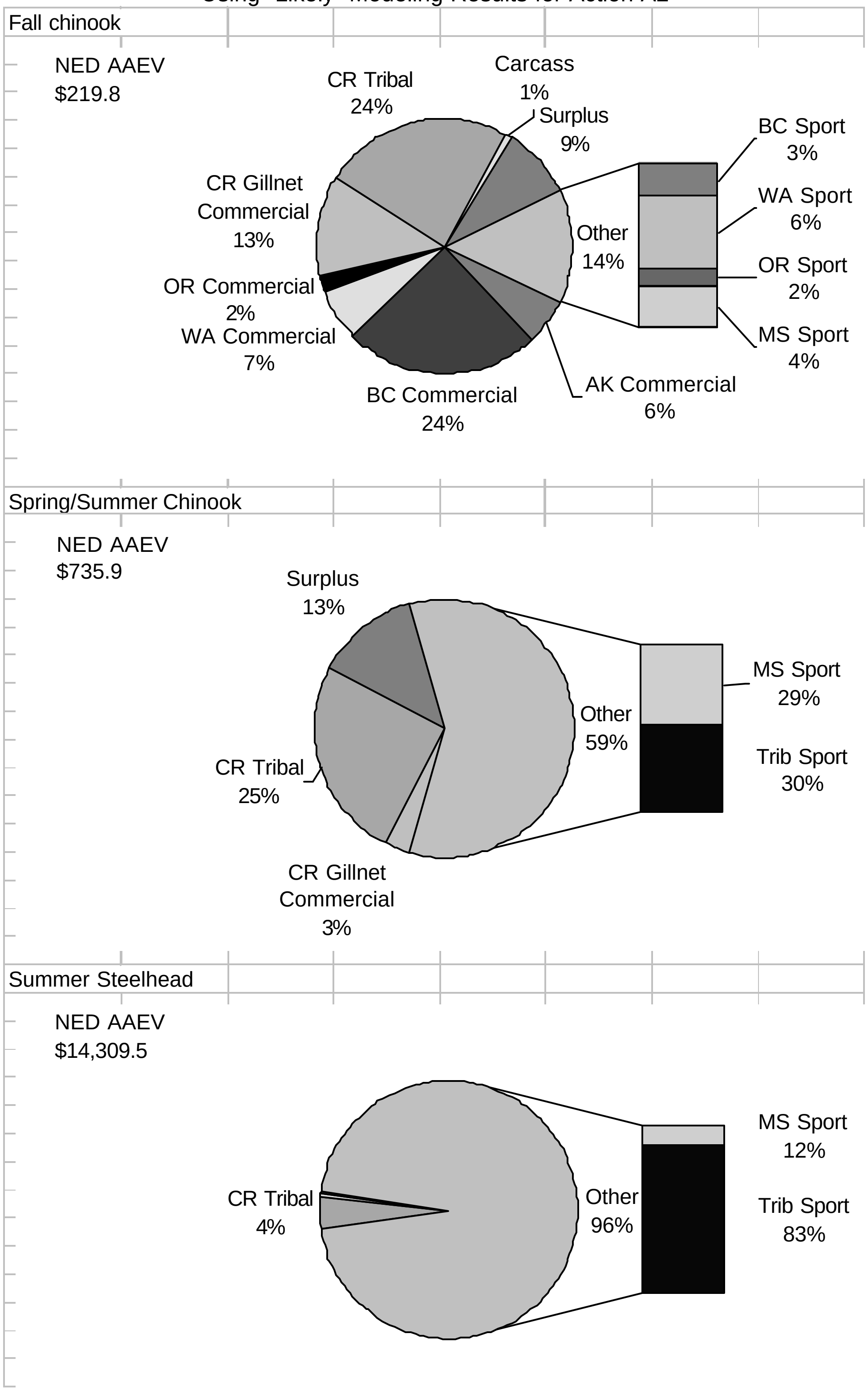
Figure 3.III.3a
Annualized Economic Values (NED AAEV Benefits) by Species and Fishery User Group
Using “Likely” Modeling Results for Action A1



Notes: 1. NED AAEV benefits are over a 100 year project life using 6 7/8% discount rate in thousands of 1998 dollars.

2. Percentages may not sum to 100% due to omissions of very small fishery values.

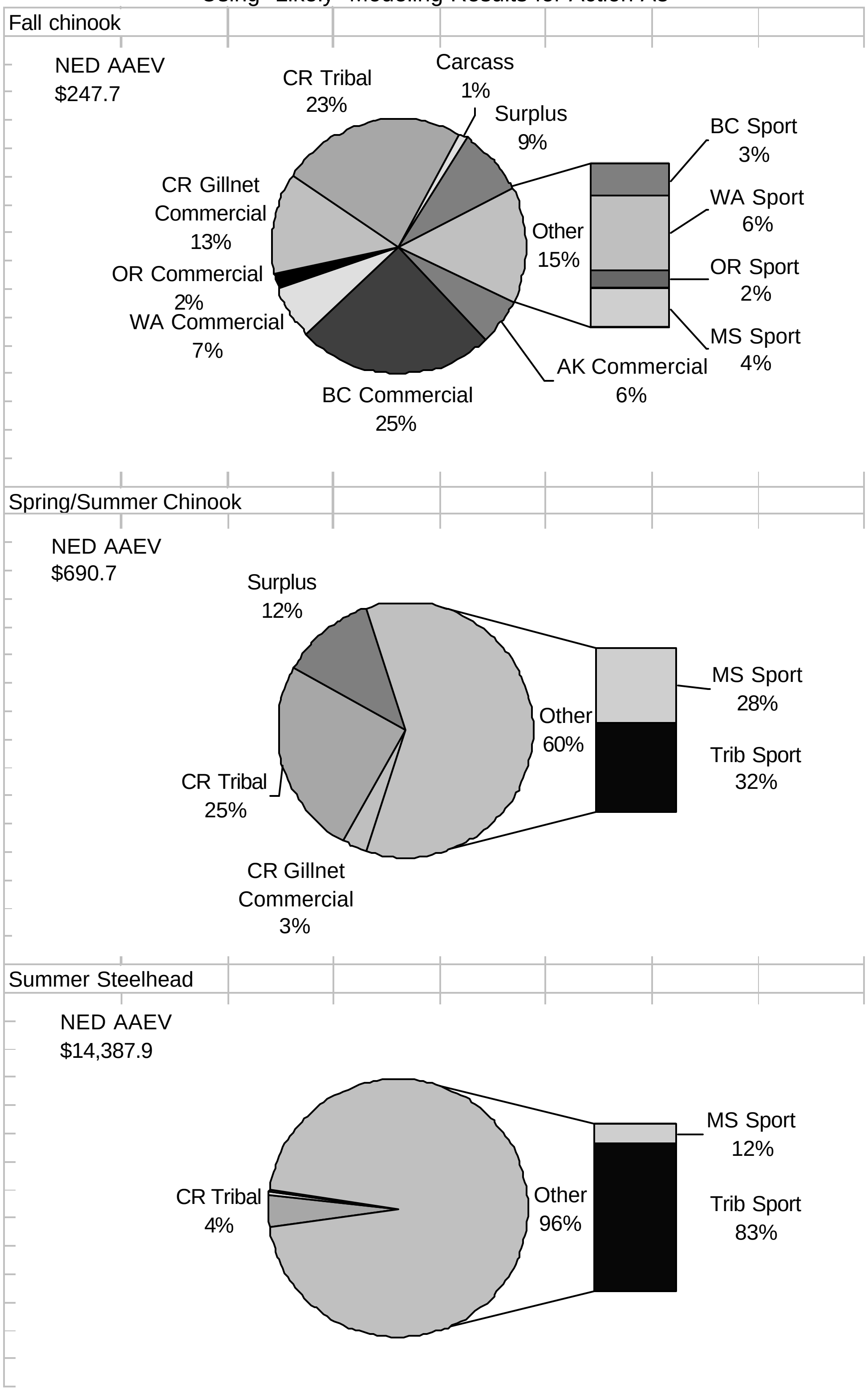
Figure 3.III.3b
Annualized Economic Values (NED AAEV Benefits) by Species and Fishery User Group
Using "Likely" Modeling Results for Action A2



Notes: 1. NED AAEV benefits are over a 100 year project life using 6 7/8% discount rate in thousands of 1998 dollars.

2. Percentages may not sum to 100% due to omissions of very small fishery values.

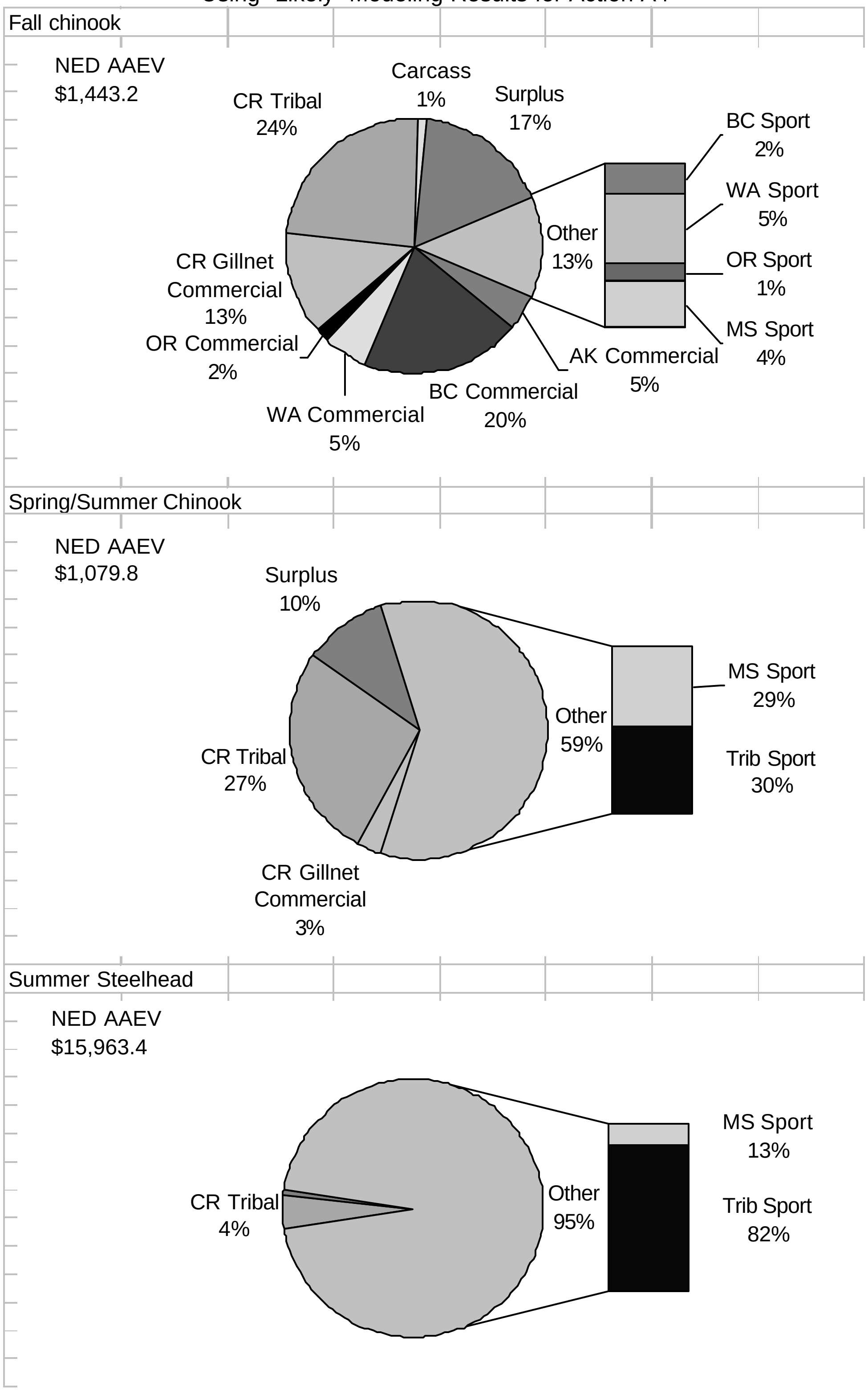
Figure 3.III.3c
Annualized Economic Values (NED AAEV Benefits) by Species and Fishery User Group
Using "Likely" Modeling Results for Action A3



Notes: 1. NED AAEV benefits are over a 100 year project life using 6 7/8% discount rate in thousands of 1998 dollars.

2. Percentages may not sum to 100% due to omissions of very small fishery values.

Figure 3.III.3d
Annualized Economic Values (NED Benefits) by Species and Fishery User Group
Using "Likely" Modeling Results for Action A4



Notes: 1. NED AAEV benefits are over a 100 year project life using 6 7/8% discount rate in thousands of 1998 dollars.

2. Percentages may not sum to 100% due to omissions of very small fishery values.

Table 3.III.4
Economic Value (RED Benefits) Measured by Personal Income, Sales, and Jobs for Each Hydrosystem Action During Selected Years Using "Likely" Modeling Results

	Total Harvest and Hatchery Utilization			
Hydrosystem Actions	Personal Income	Sales	Jobs	Order
Year 5				
A1	$10.37	$32.21	281	4
A2	$11.38	$35.35	308	1
A3	$11.01	$34.21	298	2
A4	$10.84	$33.66	293	3
Year 10				
A1	$10.52	$32.69	285	4
A2	$16.64	$51.68	450	3
A3	$17.89	$55.56	484	2
A4	$19.84	$61.62	537	1
Year 25				
A1	$14.88	$46.23	403	4
A2	$16.13	$50.11	436	2
A3	$15.80	$49.09	428	3
A4	$25.79	$80.12	698	1
Year 50				
A1	$15.18	$47.15	411	4
A2	$15.64	$48.60	423	2
A3	$15.55	$48.32	421	3
A4	$28.36	$88.08	767	1
Year 100				
A1	$15.81	$49.10	428	4
A2	$16.75	$52.04	453	2
A3	$16.42	$51.01	444	3
A4	$28.68	$89.11	776	1

Notes: 1. RED benefits expressed as personal income and sales are in millions of 1998 dollars and jobs are full and part-time employment.
2. Based on PATH results' scenarios "base case" for fall chinook and "equal weights" for spring/summer chinook using "likely" (50th percentile) modeling results.

Source: Study.

PART 4

POTENTIAL ECONOMIC VALUES FOR FOUR CASES OF COLUMBIA RIVER BASIN ANADROMOUS FISH PRODUCTION AND HARVEST MANAGEMENT POLICIES

CHAPTER I. INTRODUCTION

The U.S. Army Corps of Engineers (Corps) has initiated a study to examine the engineering, economic, social, and biological effects of alternative hydrosystem actions for operating the four Corps dams on the lower Snake River for improved salmon migration. The four dams are Lower Granite, Little Goose, Lower Monumental, and Ice Harbor located in southeast corner of the State of Washington. This report only provides information about one aspect of the effects of the alternative hydrosystem actions. The report describes the economic evaluation expressed as regional economic impacts, or the Regional Economic Development (RED) accounting stance used by the Corps, and net economic values, or the National Economic Development (NED) accounting stance used by the Corps, from changes to harvests of anadromous fish originating in the Snake River Basin due to alternative hydrosystem actions. Discussion is also offered in this report for the economic values from harvesting anadromous fish produced in the entire Columbia River Basin. The other Corps reports for economic, social, and biological effects are referenced as needed.

This report is organized in four parts for the convenience of the reader. Part 1 contains an abstract, the executive summary, the risks and uncertainties in results for changing analysis assumptions, and references cited in all parts.

Part 2 contains background information about historical anadromous fish runs and harvests in the Columbia River Basin. The information should prove especially helpful in understanding the complexity of Columbia River anadromous fish harvest management. A discussion of fisheries economic evaluation methods used in this study is also presented in Part 2.

Commercial and recreational fishing for Columbia River Basin anadromous fish stocks generates a significant amount of personal income and has national benefits. These economic value estimates for changed harvests due to alternative lower Snake River dams hydrosystem actions are presented in Part 3.

This report also describes the potential economic value to the Pacific Northwest region and to the nation that may result from four cases of anadromous fish production and harvest management policies. The broader overview of what net economic value (NED benefits) and contributions to regional personal income and jobs may result from the four cases is presented in Part 4. Part 4 descriptions may be viewed as what is at risk if the Columbia River Basin anadromous fish survival rates, and therefore harvestable fish runs, are not improved.

The economic analysis for the alternative hydrosystem actions evaluates all major anadromous fish stocks originating in the Snake River Basin. The major anadromous fish stocks are defined to be spring/summer and fall chinook salmon *(Oncorhynchus tshawytscha)* and summer steelhead *(O. mykiss)*. Other anadromous fish, such as shad *(Alosa sapidissima)*, sturgeon *(Acipenser transmontanus and A. medirostris)*, coho salmon *(O. kisutch)*, sockeye salmon *(O. nerka)*, etc., would not have fisheries significantly changed by the hydrosystem actions. All utilization of both wild and hatchery originating stocks was considered. This includes commercial and recreational harvests, as well as sales of hatchery egg, carcass, and surplus fish. The economic analysis for the entire Columbia River Basin adds coho salmon and winter steelhead to the Snake River list of major anadromous fish stocks.

CHAPTER II. METHODS USED TO DETERMINE COLUMBIA RIVER BASIN ANADROMOUS FISH HARVESTS

A. Representative Survival Rate Estimates Used to Forecast Columbia River Basin Harvest

For almost all species and stocks, Columbia River anadromous fish survival rates have steadily decreased since the mid 1980's. There are many theories about the decrease, from hatchery practices to ocean conditions. For this study, the expected survival of wild runs in the Snake River system is taken from PATH results. For evaluation of the production from the Columbia River Basin, as described under four cases of Columbia River anadromous fish production and harvest management policies, representative survival rates for three periods are used: the past 30 years, the 1980's, and the early 1990's. Table 4.II.1 shows the survival rates by area and species. For example, based on the National Marine Fisheries Service (NMFS) cap releases of 197 million smolt releases, a total of 1.59 million smolts may survive to adults from hatchery releases (Table 4.II.2).

B. Hatchery and Wild Smolt Production

For hatchery origin fish, at least two spawners (one male and one female) are required for future egg and smolt production. Each coho salmon and steelhead female spawner produces about 2,500 eggs, while chinook produce 3,500 or more eggs. Hatchery egg-to-smolt survival tends to be about 80 percent. In order to provide some flexibility in hatchery spawner requirements, three future returning spawners per spawning pair are used in calculations of this report. Other fish returning to the hatchery are assumed available for sale as fresh, frozen, or processed product. Total survival from smolt-to-adult will determine the amount available for harvest and those returning to the hatchery.

For wild origin fish, the assumption is wild spring/summer chinook and steelhead contribute an additional 30 percent to the total salmon runs of the Columbia River Basin, while wild fall chinook contribute about 50 percent of the run.[1] For coho, the wild to hatchery rate is about five percent.

For coho and steelhead, at survival rates of 0.01, about 25 adults will have survived from a pair of spawners (three spawners are used in this analysis to allow for egg to smolt mortality and other unforeseen factors). Therefore, 12 percent of adults are required for hatchery purposes. At 0.005, this increases to 24 percent, etc. For chinook, the requirement at 0.01 survival is 8.6 percent and 17 percent at 0.005 percent. The hatchery origin and wild origin smolt production is shown in Appendix 4.A.

1. The ceiling may be viewed as a limit to present hatchery releases, using present hatchery management practices. Supplementation practices based on species specific, habitat based practices may increase wild stock production. These same practices, that alter the water resources of the Columbia River Basin, may also increase the survival rates of hatchery based production.

Table 4.II.1
Smolt-to-Adult Survival Rate Assumptions by Area and Species Used For Four Cases of Production and Harvest Management Policy in the Columbia River Basin

	Snake River	Upper Columbia	Middle Columbia	Lower Columbia	Willamette	Weighted Average
Coho						
I. NMFS Cap (1970's-1990's Actual)	NA	1.20%	1.20%	2.50%	1.20%	2.33%
II. 80's Actual Runs	NA	1.49%	1.49%	2.90%	1.49%	2.72%
III. Run Doubling Objective	NA	2.98%	2.98%	5.80%	2.98%	5.43%
IV. Early 90's Runs	NA	0.15%	0.15%	1.00%	0.40%	0.90%
Spring/Summer Chinook						
I. NMFS Cap (1970's-1990's Actual)	0.37%	0.37%	0.37%	0.97%	0.97%	0.65%
II. 80's Actual Runs	0.39%	0.39%	0.39%	1.01%	1.02%	0.69%
III. Run Doubling Objective	0.79%	0.79%	0.79%	2.03%	2.04%	1.37%
IV. Early 90's Runs	0.10%	0.10%	0.10%	0.35%	0.35%	0.22%
Fall Chinook						
I. NMFS Cap (1970's-1990's Actual)	0.60%	0.60%	0.60%	0.32%	NA	0.41%
II. 80's Actual Runs	0.73%	0.73%	0.73%	0.38%	NA	0.49%
III. Run Doubling Objective	1.45%	1.45%	1.45%	0.77%	NA	0.99%
IV. Early 90's Runs	0.40%	0.40%	0.40%	0.25%	NA	0.30%
Steelhead						
I. NMFS Cap (1970's-1990's Actual)	0.70%	0.70%	0.70%	0.40%	0.40%	0.62%
II. 80's Actual Runs	1.56%	1.56%	1.56%	0.89%	0.89%	1.38%
III. Run Doubling Objective	3.11%	3.11%	3.11%	1.78%	1.78%	2.76%
IV. Early 90's Runs	0.50%	0.50%	0.50%	0.20%	0.20%	0.42%

Notes: 1. Rates expressed as representative percents of hatchery reared smolts released divided by adults contributing to fisheries plus adults returning to hatcheries. Survival rates are best estimates based on information provided by the "Annual Coded Wire Program - Missing Production Groups" annual reports (Fuss et al. 1994 and Garrison et al. 1995).

2. Survival rate assumptions for the "Run Doubling Objective" case are the survival rates that would be required to meet the objectives.

Source: Study.

Table 4.II.2
Estimated Total Released Hatchery Smolts Based on NMFS
Cap of 197 Million and Representative 1990's Survival Rates

	Fall Chinook		
Area of Release	Number of Smolts	Estimated Survival Rate	Adult Survival
Snake	612,797	0.60	3,677
Upper Columbia	12,329,885	0.60	73,979
Lower Columbia	76,857,203	0.32	245,943
Middle Columbia	24,002,299	0.60	144,014
Willamette	--	--	--
Total	113,802,184		467,613

	Spring/Summer Chinook		
Area of Release	Number of Smolts	Estimated Survival Rate	Adult Survival
Snake	2,342,791	0.37	8,668
Upper Columbia	5,990,957	0.37	22,167
Lower Columbia	5,253,481	0.97	50,959
Middle Columbia	6,264,260	0.37	23,178
Willamette	7,541,137	0.97	73,149
Total	27,392,626		178,120

	Coho		
Area of Release	Number of Smolts	Estimated Survival Rate	Adult Survival
Snake	--	1.20	--
Upper Columbia	843,373	1.20	10,120
Lower Columbia	30,742,613	2.50	768,565
Middle Columbia	2,462,651	1.20	29,552
Willamette	1,277,108	1.20	15,325
Total	35,325,745		823,563

	Steelhead		
Area of Release	Number of Smolts	Estimated Survival Rate	Adult Survival
Snake	12,900,795	0.70	90,306
Upper Columbia	1,363,636	0.70	9,545
Lower Columbia	3,775,119	0.40	15,100
Middle Columbia	536,886	0.70	3,758
Willamette	1,465,625	0.40	5,863
Total	20,042,061		124,572
Total	196,562,616		1,593,868

Source: Smith (1998) and Study.

C. Distribution to Fisheries

There are three basic distribution patterns of Columbia River Basin produced salmon: north turning fish (fall chinook), south turning fish (coho), and some that tend to migrate in either direction (some of the above). Steelhead tend to scatter and migrate as far as Russian waters. Harvest rates by geographic area depend on migration patterns, as well as historic fishing patterns, and on international and historic treaties and management policies. The same reports used in calculating survival rates are used to calculate geographic and user group harvests. The distributional assumptions by species are included in Appendix 4.B. The distributional assumptions are that future harvests will reflect recent historical catches. These assumptions, however, depend on present U.S. - Canada and treaty tribal allocations. Columbia River treaty allocation represents the amount that may be harvested by treaty fisheries after harvests north of the U.S./Canada border and hatchery requirements are met. In the case of spring/summer chinook, only the "doubling of the runs" case will return sufficient returning fish to allow a 50 percent take by treaty fisheries. Within these components, historical and expected allocations are calculated.

D. Economic Values

The economic values per fish assumptions used in the analysis are shown in Appendix 4.C. The economic values are itemized by commercial and recreational fisheries and the area where fish are harvested. The appendix information also shows recreational effort per fish assumptions used to calculate angler days. Two important economic assumptions are that hatchery surplus is utilized in the commercial sector and that wild and hatchery fish survive and are harvested at similar rates. A discussion of the importance of these assumptions is included in the risk and uncertainty section.

CHAPTER III. POTENTIAL ECONOMIC VALUES

A. Background

The four lower Snake River dams were planned in the 1950's for economic development reasons. The planning evaluation in 1951 pointed to "technical difficulties involved in maintaining that large portion of the Columbia salmon resources produced in the Snake River if Ice Harbor and the other three lower Snake River dams are constructed at the present time." (McKernon 1951). The evaluation estimated that about 135,000 fall and spring chinook salmon spawn in the Snake River and its tributaries each year, 2,000 silver [coho] salmon, and 65,000 steelhead trout. From these, some 200,000 adults, approximately 12 million pounds, are landed annually. "Between one half and one billion salmon and steelhead eggs are deposited in the Snake River drainage each year. Our problem would be a hatchery or hatcheries capable of spawning, hatching, and rearing this colossal number of fingerlings. . . Further, the races involved are among the most difficult to rear in a hatchery." (McKernon 1951).

The four dams were built and problems have developed in maintaining wild origin anadromous fish production. In the most recent five year average (1991 to 1995), the escapement past the upper most of the four dams (Lower Granite Dam) was about 16,000 fall and spring chinook (40 percent wild origin), 83,000 summer steelhead (15 percent wild origin), and coho salmon are now extinct. This escapement contributed to about 62,000 adult harvests.

In the 1980's, the concern for decreasing Columbia River Basin salmon runs was the basis for the NPPC's interim goal of doubling salmon populations. The overall effect of hatchery fish on the survival of certain anadromous species has led to the NMFS placing a cap on the total hatchery releases in the Columbia River System. Because hatchery and wild fish cannot always be separated during harvesting, hatchery production and harvest management directly affect the existing wild salmon runs. In recent years, for every two wild spawners from the Snake River system, about 1.2 spawners return in subsequent cycles (Smith 1998). The low rate of returning wild spawners has raised concerns about maintaining and recovering any wild salmon species in the Snake River system. Strategies for recovery may be habitat based, hatchery based, or a combination of both. However, a strategy based on artificial propagation with no increase in natural production would, over time, result in higher annual hatchery costs (Smith 1999).

In order to estimate the total potential economic value of salmon produced in the entire Columbia River Basin, four policy cases are assumed. These are the production of the 1980's, a doubling of these levels, and a NMFS cap on the amount and species released from hatcheries in the Columbia River Basin. A case is also included that includes the low survival rates of the 1990's. Two of these cases may be viewed as goals or policies that have been presented. The other two, the 1980's and 1990's cases, reflect recent actual conditions.

The ability to harvest salmon has an important economic value to people of the Pacific Northwest and to the nation. Historically, salmon have been a part of the economy and culture of the people of the Pacific Northwest. To the Indians living along the Columbia River, salmon were their lifeblood, essential to their subsistence, their culture, and their religion. Salmon today also play an important part in the lives of most citizens of the Pacific Northwest. These values can be defined as option or existence values. These may be considerable, but are not included in these evaluations. The fishing values in this section only estimate commercial and recreational economic value of what may show up in economies. The economic value of non-use (option or existence value) placed on these fish runs may be much higher than the values that can be shown as contributing to economies.

B. Potential Regional Economic Impacts (RED Benefits)

The regional economic impact (RED benefits) results may be viewed as the value of what may be lost to the region if survival rates are not increased. The potential regional economic impacts (RED benefits) of harvestable fish under the first three cases ranges from $83 million under the NMFS cap case to $233 million per year (Table 4.III.1 and Appendix 4.E). The latter assumes that "doubling of the runs" may be achieved. The fourth case includes the survival rates that are being experienced in the 1990's. At these low survival rates, with present hatchery smolt releases, the regional economic impacts (RED benefits) throughout the region would total $38 million per year. The hatchery surplus utilization is an important assumption for spring/summer chinook and steelhead, where up to 30 percent of the regional economic impacts (RED benefits) may be derived from commercial utilization of surplus hatchery fish.

Potential economic contribution by geographic area for the four cases is displayed graphically in Figure 4.III.1. The size of the portrayed fish is proportionally correct to the economic contribution. Fall chinook, even though they survive at lower rates, are released at greater volumes (about 60 percent of the total); the average adult harvested is also larger than the other species.

Most coho are produced in the lower Columbia and have historically been harvested off the coasts of Washington and Oregon. Lower Columbia gillnetters and recreational anglers have also harvested a portion of these runs. Spring/summer chinook from the upper Columbia and Snake River are caught only incidentally in ocean fisheries, while lower Columbia and Willamette River produced fish have historically contributed substantially to the Alaska/B.C. commercial fisheries, as well as the inland commercial and recreational fisheries. Fall chinook is the economic producer for the Pacific Northwest regional economy. Alaska and Canada harvesters receive about 30 percent of the total income from harvesting these fish produced in the Columbia Basin. Fall chinook is also the major producer of income for the tribal fisheries in the Columbia. Fall chinook production in-river makes up almost 50 percent of all personal income generated by these production cases. Steelhead are not harvested commercially in the Pacific Northwest, except by tribal treaty fisheries.

Recent policy goals, such as "doubling of the runs," may result in restored salmon runs contributing significant income to the region and the nation. The burden of these reductions would be felt from Alaska to California along the Pacific coast and as far as Idaho in the

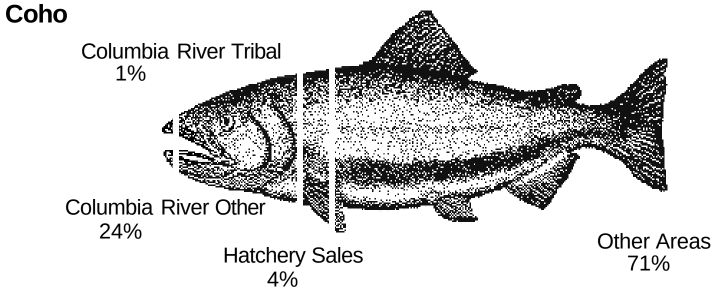
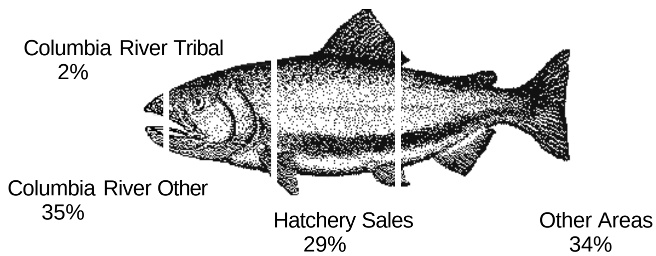
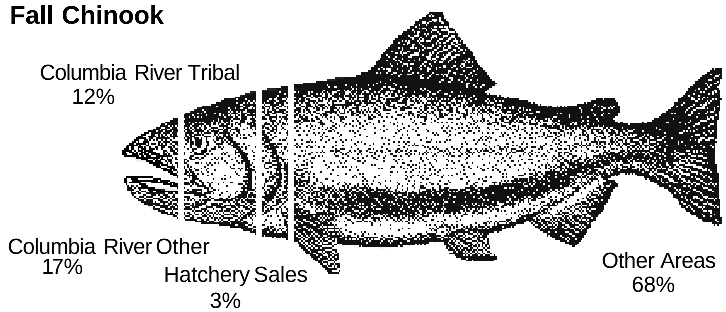
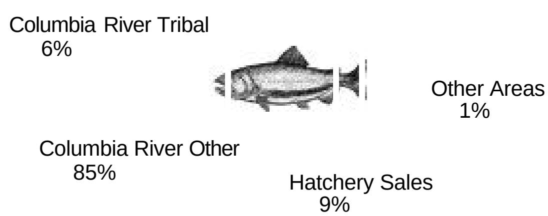
Table 4.III.1
Regional Economic Impacts (RED Benefits) of Columbia River Basin Produced Salmon/Steelhead by Geographic Areas For Four Cases of Production and Harvest Management Policies

	I. NMFS Cap	%	II. 1980's Average	%	III. "Doubling of Runs"	%	IV. Early 1990's	%
Species: Coho								
Alaska	172	0.0%	200	0.0%	399	0.0%	57	0.0%
British Columbia	931,431	3.8%	1,082,468	3.8%	2,164,937	3.7%	304,729	4.2%
Washington ocean	7,932,510	32.5%	9,312,546	32.5%	19,074,457	32.6%	2,337,418	32.2%
Washington Puget Sound	31,107	0.1%	36,337	0.1%	74,329	0.1%	9,520	0.1%
Oregon	7,870,260	32.3%	9,229,961	32.3%	18,900,175	32.3%	2,337,581	32.2%
California	477,110	2.0%	564,282	2.0%	1,158,039	2.0%	132,474	1.8%
Columbia Basin inland								
Freshwater sport								
Mainstem	2,449,256	10.0%	2,863,341	10.0%	5,858,368	10.0%	745,099	10.3%
Tributary	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Gillnet	3,413,032	14.0%	3,992,654	14.0%	8,170,337	14.0%	1,033,242	14.3%
Tribal	277,742	1.1%	353,124	1.2%	737,882	1.3%	5,842	0.1%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	794,035	3.3%	933,697	3.3%	1,913,269	3.3%	231,010	3.2%
Hatchery carcass	222,248	0.9%	245,642	0.9%	409,725	0.7%	112,881	1.6%
Total with hatchery surplus utilization	24,398,902	100.0%	28,614,251	100.0%	58,461,917	100.0%	7,249,852	100.0%
Total without hatchery surplus utilization	23,382,619		27,434,912		56,138,923		6,905,961	
Species: Spring/Summer Chinook								
Alaska	1,247,437	11.2%	1,311,767	11.2%	2,623,533	7.8%	411,745	13.6%
British Columbia	1,764,542	15.9%	1,856,639	15.8%	3,713,277	11.0%	573,534	18.9%
Washington ocean	532,560	4.8%	560,304	4.8%	1,120,608	3.3%	173,517	5.7%
Washington Puget Sound	19,825	0.2%	20,993	0.2%	41,985	0.1%	5,370	0.2%
Oregon	220,303	2.0%	231,830	2.0%	463,660	1.4%	71,370	2.4%
California	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Columbia Basin inland								
Freshwater sport								
Mainstem	2,127,562	19.2%	2,234,885	19.1%	8,990,462	26.6%	721,616	23.8%
Tributary	0	0.0%	0	0.0%	1,506,898	4.5%	0	0.0%
Gillnet	1,747,970	15.8%	1,836,144	15.7%	4,497,649	13.3%	592,868	19.5%
Tribal	248,507	2.2%	269,032	2.3%	6,261,798	18.5%	538	0.0%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	2,992,786	27.0%	3,200,379	27.3%	4,359,440	12.9%	404,233	13.3%
Hatchery carcass	188,940	1.7%	197,393	1.7%	244,586	0.7%	79,518	2.6%
Total with hatchery surplus utilization	11,090,431	100.0%	11,719,364	100.0%	33,823,897	100.0%	3,034,310	100.0%
Total without hatchery surplus utilization	7,908,705		8,321,593		29,219,871		2,550,559	
Species: Fall Chinook								
Alaska	2,352,286	5.8%	2,838,088	5.7%	5,676,176	5.2%	1,420,898	6.0%
British Columbia	16,060,162	39.9%	19,328,072	38.5%	38,656,145	35.4%	10,176,525	43.0%
Washington ocean	7,298,685	18.1%	9,473,119	18.9%	22,542,414	20.7%	4,141,848	17.5%
Washington Puget Sound	224	0.0%	284	0.0%	629	0.0%	112	0.0%
Oregon	1,328,284	3.3%	1,718,309	3.4%	4,051,936	3.7%	742,102	3.1%
California	162,083	0.4%	211,709	0.4%	512,469	0.5%	94,719	0.4%
Columbia Basin inland								
Freshwater sport								
Mainstem	2,612,493	6.5%	3,396,348	6.8%	8,117,941	7.4%	1,493,872	6.3%
Tributary	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Gillnet	4,423,246	11.0%	5,688,803	11.3%	13,198,355	12.1%	2,403,171	10.2%
Tribal	4,815,713	12.0%	6,094,991	12.1%	13,495,301	12.4%	2,414,571	10.2%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	757,659	1.9%	977,090	1.9%	2,284,273	2.1%	417,071	1.8%
Hatchery carcass	441,114	1.1%	455,866	0.9%	543,743	0.5%	371,269	1.6%
Total with hatchery surplus utilization	40,251,950	100.0%	50,182,678	100.0%	109,079,381	100.0%	23,676,157	100.0%
Total without hatchery surplus utilization	39,053,176		48,749,723		106,251,365		22,887,817	

Table 4.III.1 (continued)

	I. NMFS Cap	%	II. 1980's Average	%	III. "Doubling of Runs"	%	IV. Early 1990's	%
Species: Summer/Winter Steelhead								
Alaska	3,203	0.0%	7,116	0.0%	14,233	0.0%	1,910	0.1%
British Columbia	39,650	0.6%	88,084	0.5%	176,168	0.6%	23,645	0.6%
Washington ocean	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Washington Puget Sound	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Oregon	3,203	0.0%	7,116	0.0%	14,233	0.0%	1,910	0.1%
California	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Columbia Basin inland								
Freshwater sport								
Mainstem	2,706,779	38.4%	6,292,245	37.0%	11,874,912	37.2%	1,177,319	32.1%
Tributary	3,268,905	46.4%	8,098,924	47.6%	14,069,114	44.1%	1,882,489	51.3%
Gillnet	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Tribal	408,976	5.8%	1,013,265	6.0%	2,640,304	8.3%	235,520	6.4%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	481,041	6.8%	1,256,747	7.4%	2,667,466	8.4%	251,351	6.8%
Hatchery carcass	136,420	1.9%	245,598	1.4%	444,151	1.4%	95,744	2.6%
Total with hatchery surplus utilization	7,048,177	100.0%	17,009,095	100.0%	31,900,579	100.0%	3,669,889	100.0%
Total without hatchery surplus utilization	6,430,716		15,506,750		28,788,962		3,322,794	
Species: Total								
Alaska	3,603,098	4.4%	4,157,171	3.9%	8,314,341	3.6%	1,834,611	4.9%
British Columbia	18,795,784	22.7%	22,355,263	20.8%	44,710,527	19.2%	11,078,433	29.4%
Washington ocean	15,763,754	19.0%	19,345,968	18.0%	42,737,479	18.3%	6,652,783	17.7%
Washington Puget Sound	51,156	0.1%	57,613	0.1%	116,942	0.1%	15,003	0.0%
Oregon	9,422,051	11.4%	11,187,216	10.4%	23,430,004	10.0%	3,152,962	8.4%
California	639,193	0.8%	775,990	0.7%	1,670,508	0.7%	227,192	0.6%
Columbia Basin inland								
Freshwater sport								
Mainstem	9,896,090	12.0%	14,786,818	13.8%	34,841,683	14.9%	4,137,906	11.0%
Tributary	3,268,905	3.9%	8,098,924	7.5%	15,576,012	6.7%	1,882,489	5.0%
Gillnet	9,584,247	11.6%	11,517,601	10.7%	25,866,341	11.1%	4,029,281	10.7%
Tribal	5,750,938	6.9%	7,730,413	7.2%	23,135,284	9.9%	2,656,472	7.1%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	5,025,522	6.1%	6,367,912	5.9%	11,224,449	4.8%	1,303,665	3.5%
Hatchery carcass	988,722	1.2%	1,144,498	1.1%	1,642,204	0.7%	659,412	1.8%
Total with hatchery surplus utilization	82,789,460	100.0%	107,525,388	100.0%	233,265,774	100.0%	37,630,209	100.0%
Total without hatchery surplus utilization	76,775,216		100,012,977		220,399,121		35,667,132	

Figure 4.III.1
Regional Economic Impacts (RED Benefits) in West Coast Geographic Areas Attributable to Columbia River Produced Salmon (Hatchery and Wild) Under Four Cases of Production and Harvest Management Policies

	Total Smolts Released (millions)	Total Personal Income I NMFS Cap II 1980's Average III "Doubling of Runs" IV Early 1990's
Coho 	37.18 37.18 37.18 30.91	I. $24.40 II. $28.61 III. $58.46 IV. $7.25
Spring/Summer Chinook 	39.13 39.13 39.13 36.78	I. $11.09 II. $11.72 III. $33.82 IV. $3.03
Fall Chinook 	227.60 227.60 227.60 200.22	I. $40.25 II. $50.18 III. $109.08 IV. $23.68
Steelhead 	28.63 28.63 28.63 25.15	I. $7.05 II. $17.01 III. $31.90 IV. $3.67
Total		I. $82.79 II. $107.53 III. $233.27 IV. $37.63

Coho chart labels:

Spring/Summer Chinook chart labels:

Fall Chinook chart labels:

Steelhead chart labels:

Note: 1. RED benefits are expressed as personal income in millions of 1998 dollars.
2. Columbia River other includes inriver commercial and recreational fisheries.

Source: Study.

Columbia River Basin. The consequence of not recovering natural runs in the Columbia River Basin raises the possibility of eliminating much of the harvesting of salmon produced in the Columbia River Basin within its migration route.

C. Potential Net Economic Value (NED Benefits)

The potential net economic value (NED benefits) results may be viewed as the value of what may be lost to the nation if survival rates are not increased. The potential net economic value (NED benefits) of harvestable fish under the first three cases ranges from $55 million per year under the NMFS cap case to $160 million per year (Table 4.III.2 and Appendix 4.C). The latter assumes that "doubling of the runs" may be achieved. The fourth case includes the survival rates that are being experienced in the 1990's. At these low survival rates, with present hatchery smolt releases, the net economic value (NED benefits) throughout the region would total $25 million per year.

Table 4.III.2
Net Economic Values (NED Benefits) of Columbia River Basin Produced Salmon/Steelhead by Geographic Areas For Four Cases of Production and Harvest Management Policies

	I. NMFS Cap	%	II. 1980's Average	%	III. "Doubling of Runs"	%	IV. Early 1990's	%
Species: Coho								
Alaska	83	0.0%	96	0.0%	191	0.0%	27	0.0%
British Columbia	540,796	2.9%	628,473	2.9%	1,256,945	2.8%	176,966	3.2%
Washington ocean	6,721,240	36.0%	7,890,826	36.0%	16,162,563	36.1%	1,979,963	35.7%
Washington Puget Sound	24,311	0.1%	28,398	0.1%	58,090	0.1%	7,440	0.1%
Oregon	6,164,564	33.0%	7,230,071	33.0%	14,805,269	33.0%	1,830,011	33.0%
California	332,134	1.8%	392,980	1.8%	806,574	1.8%	91,904	1.7%
Columbia Basin inland								
Freshwater sport								
Mainstem	2,099,420	11.2%	2,454,360	11.2%	5,021,598	11.2%	638,674	11.5%
Tributary	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Gillnet	2,025,291	10.8%	2,369,238	10.8%	4,848,273	10.8%	613,125	11.0%
Tribal	164,812	0.9%	209,544	1.0%	437,859	1.0%	3,467	0.1%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	484,135	2.6%	569,289	2.6%	1,166,549	2.6%	140,850	2.5%
Hatchery carcass	136,683	0.7%	151,070	0.7%	251,981	0.6%	69,422	1.3%
Total with hatchery surplus utilization	18,693,469	100.0%	21,924,345	100.0%	44,815,892	100.0%	5,551,848	100.0%
Total without hatchery surplus utilization	18,072,651		21,203,986		43,397,362		5,341,576	
Species: Spring/Summer Chinook								
Alaska	614,193	9.3%	645,862	9.3%	1,291,725	6.0%	202,764	11.0%
British Columbia	912,298	13.8%	959,920	13.8%	1,919,839	8.9%	296,476	16.1%
Washington ocean	317,075	4.8%	333,680	4.8%	667,359	3.1%	102,611	5.6%
Washington Puget Sound	11,286	0.2%	11,942	0.2%	23,884	0.1%	3,132	0.2%
Oregon	157,763	2.4%	166,018	2.4%	332,036	1.5%	51,109	2.8%
California	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Columbia Basin inland								
Freshwater sport								
Mainstem	1,823,675	27.6%	1,915,669	27.5%	7,706,325	35.8%	618,546	33.5%
Tributary	0	0.0%	0	0.0%	1,588,019	7.4%	0	0.0%
Gillnet	885,598	13.4%	930,271	13.3%	2,278,706	10.6%	300,373	16.3%
Tribal	125,905	1.9%	136,303	2.0%	3,172,500	14.7%	273	0.0%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	1,637,137	24.8%	1,750,696	25.1%	2,384,735	11.1%	221,127	12.0%
Hatchery carcass	116,198	1.8%	121,396	1.7%	150,420	0.7%	48,904	2.7%
Total with hatchery surplus utilization	6,601,128	100.0%	6,971,756	100.0%	21,515,547	100.0%	1,845,313	100.0%
Total without hatchery surplus utilization	4,847,793		5,099,664		18,980,393		1,575,283	
Species: Fall Chinook								
Alaska	1,151,779	4.9%	1,389,651	4.7%	2,779,301	4.3%	695,708	5.0%
British Columbia	8,390,928	35.6%	10,097,472	34.2%	20,194,944	31.2%	5,325,036	38.6%
Washington ocean	4,855,956	20.6%	6,305,358	21.4%	15,021,931	23.2%	2,761,199	20.0%
Washington Puget Sound	161	0.0%	204	0.0%	451	0.0%	81	0.0%
Oregon	830,436	3.5%	1,074,277	3.6%	2,533,249	3.9%	463,958	3.4%
California	80,873	0.3%	105,632	0.4%	255,687	0.4%	47,257	0.3%
Columbia Basin inland								
Freshwater sport								
Mainstem	2,239,342	9.5%	2,911,236	9.9%	6,958,429	10.8%	1,280,497	9.3%
Tributary	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Gillnet	2,524,963	10.7%	3,247,393	11.0%	7,534,141	11.6%	1,371,825	9.9%
Tribal	2,748,999	11.7%	3,479,261	11.8%	7,703,649	11.9%	1,378,332	10.0%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	464,783	2.0%	599,391	2.0%	1,401,277	2.2%	255,850	1.9%
Hatchery carcass	271,285	1.2%	280,357	1.0%	334,402	0.5%	228,331	1.7%
Total with hatchery surplus utilization	23,559,504	100.0%	29,490,233	100.0%	64,717,461	100.0%	13,808,075	100.0%
Total without hatchery surplus utilization	22,823,436		28,610,485		62,981,782		13,323,894	

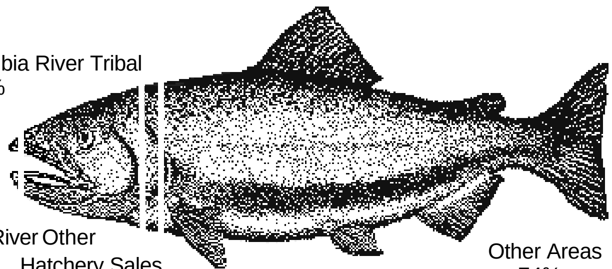
Table 4.III.2 (continued)

	I. NMFS Cap	%	II. 1980's Average	%	III. "Doubling of Runs"	%	IV. Early 1990's	%
Species: Summer/Winter Steelhead								
Alaska	2,822	0.0%	6,268	0.0%	12,537	0.0%	1,683	0.0%
British Columbia	20,359	0.3%	45,228	0.3%	90,456	0.3%	12,141	0.4%
Washington ocean	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Washington Puget Sound	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Oregon	2,822	0.0%	6,268	0.0%	12,537	0.0%	1,683	0.0%
California	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Columbia Basin inland								
Freshwater sport								
Mainstem	2,384,221	36.8%	5,542,419	35.4%	10,459,818	36.2%	1,037,022	30.6%
Tributary	3,444,881	53.2%	8,534,916	54.5%	14,826,501	51.3%	1,983,830	58.5%
Gillnet	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Tribal	241,899	3.7%	599,320	3.8%	1,561,672	5.4%	139,304	4.1%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	295,531	4.6%	772,090	4.9%	1,638,774	5.7%	154,419	4.6%
Hatchery carcass	83,898	1.3%	151,043	1.0%	273,153	0.9%	58,882	1.7%
Total with hatchery surplus utilization	6,476,431	100.0%	15,657,552	100.0%	28,875,447	100.0%	3,388,964	100.0%
Total without hatchery surplus utilization	6,097,002		14,734,419		26,963,520		3,175,662	
Species: Total								
Alaska	1,768,876	3.2%	2,041,877	2.8%	4,083,754	2.6%	900,183	3.7%
British Columbia	9,864,380	17.8%	11,731,092	15.8%	23,462,185	14.7%	5,810,619	23.6%
Washington ocean	11,894,271	21.5%	14,529,864	19.6%	31,851,853	19.9%	4,843,772	19.7%
Washington Puget Sound	35,758	0.1%	40,544	0.1%	82,425	0.1%	10,653	0.0%
Oregon	7,155,585	12.9%	8,476,635	11.4%	17,683,090	11.1%	2,346,761	9.5%
California	413,007	0.7%	498,612	0.7%	1,062,261	0.7%	139,161	0.6%
Columbia Basin inland								
Freshwater sport								
Mainstem	8,546,659	15.4%	12,823,684	17.3%	30,146,169	18.9%	3,574,738	14.5%
Tributary	3,444,881	6.2%	8,534,916	11.5%	16,414,520	10.3%	1,983,830	8.1%
Gillnet	5,435,852	9.8%	6,546,902	8.8%	14,661,119	9.2%	2,285,322	9.3%
Tribal	3,281,614	5.9%	4,424,429	6.0%	12,875,680	8.1%	1,521,376	6.2%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hatchery								
Hatchery surplus market	2,881,585	5.2%	3,691,466	5.0%	6,591,335	4.1%	772,246	3.1%
Hatchery carcass	608,064	1.1%	703,866	1.0%	1,009,956	0.6%	405,538	1.6%
Total with hatchery surplus utilization	55,330,532	100.0%	74,043,887	100.0%	159,924,347	100.0%	24,594,200	100.0%
Total without hatchery surplus utilization	51,840,882		69,648,554		152,323,057		23,416,415	

Figure 4.III.2
Net Economic Value (NED Benefits) in West Coast Geographic Areas Attributable to Columbia River Produced Salmon (Hatchery and Wild) Under Four Cases of Production and Harvest Management Policies

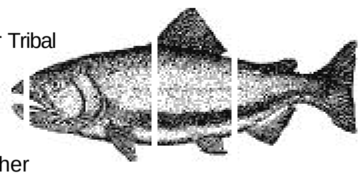
Net Economic Value: I NMFS Cap; II 1980's Average; III "Doubling of Runs"; IV Early 1990's

Coho



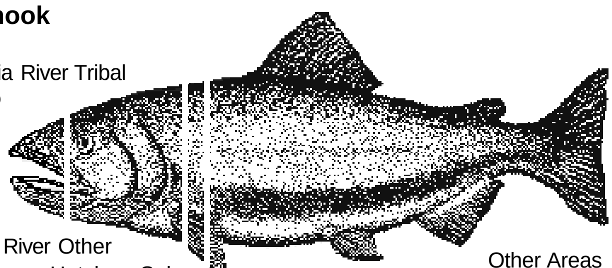
Case	Total Smolts Released (millions)	Net Economic Value
I.	37.18	$18.69
II.	37.18	$21.92
III.	37.18	$44.82
IV.	30.91	$5.55

Spring/Summer Chinook



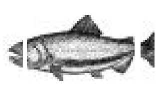
Case	Total Smolts Released (millions)	Net Economic Value
I.	39.13	$6.60
II.	39.13	$6.97
III.	39.13	$21.52
IV.	36.78	$1.85

Fall Chinook



Case	Total Smolts Released (millions)	Net Economic Value
I.	227.60	$23.56
II.	227.60	$29.49
III.	227.60	$64.72
IV.	200.22	$13.81

Steelhead



Case	Total Smolts Released (millions)	Net Economic Value
I.	28.63	$6.48
II.	28.63	$15.66
III.	28.63	$28.88
IV.	25.15	$3.39

Total

Case	Net Economic Value
I.	$55.33
II.	$74.04
III.	$159.92
IV.	$24.59

Note: 1. NED benefits expressed in millions of 1998 dollars.
2. Columbia River other includes inriver commercial and recreational fisheries.

Source: Study.