LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

ANADROMOUS FISH ECONOMIC ANALYSIS

Abbreviated Version

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

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and
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prepared for

Foster Wheeler Environmental Corporation
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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. 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 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.

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Shannon W. Davis
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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.

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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	Discount Rates 0% Amount	Order	4 6/8% Amount	Order	6 7/8% Amount	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

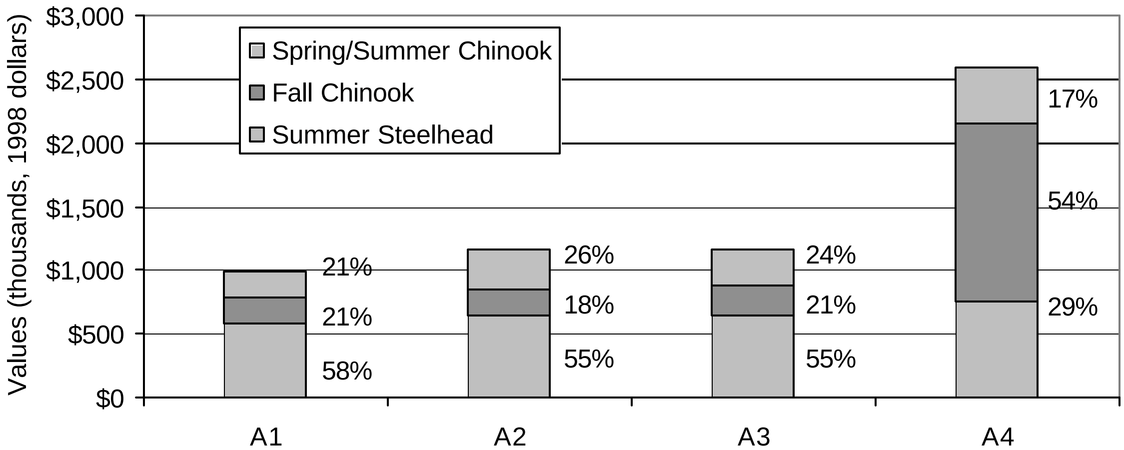
Table 2
Ranges of Annualized Economic Value (NED Benefits) by Fishery For Each Hydrosystem Action Using "Low", "Likely", and "High" Modeling Results

	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.

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.
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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.

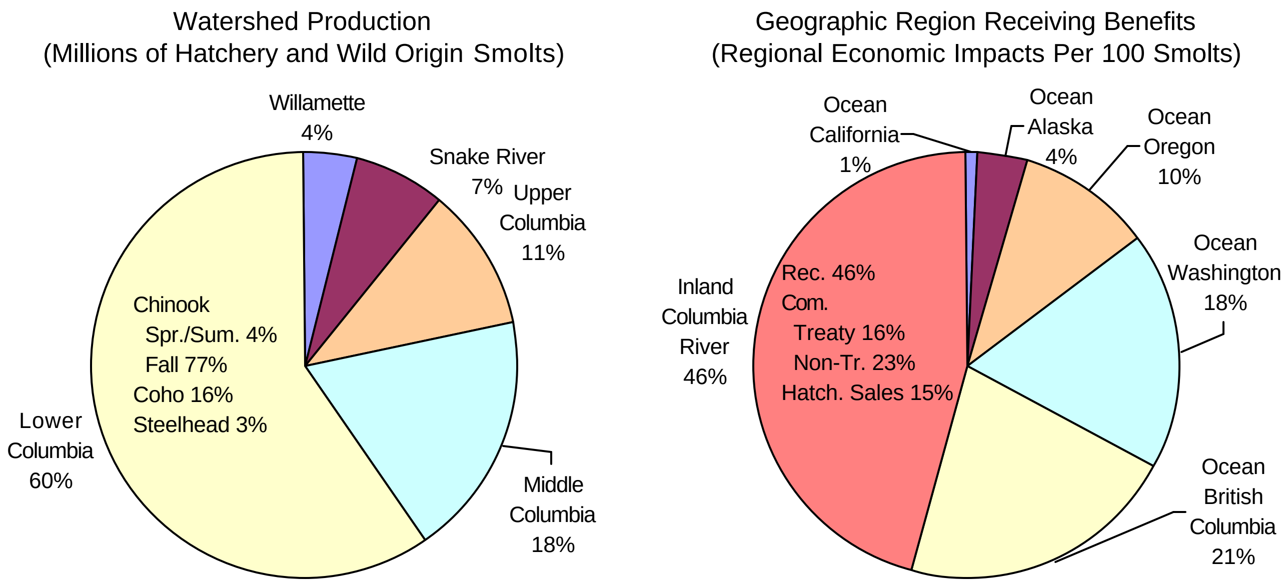
Table 3
Potential Economic Values (RED and NED Benefits) Per Year For Four Cases of Columbia River Basin Anadromous Fish Production and Harvest Management Policies

Policy Case	Assumptions	RED Benefits Commercial	RED Benefits Recreational	RED Benefits Total	NED 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 harvest opportunities.

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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

The study purpose, approach, and report outline is given in Chapter I. The changing patterns of the Columbia River Basin salmon and steelhead production and harvesting are discussed in Chapter II. 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. A discussion of fisheries economic evaluation methods used in this study is presented in Chapter IV. 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 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. Chapter VII 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.

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.

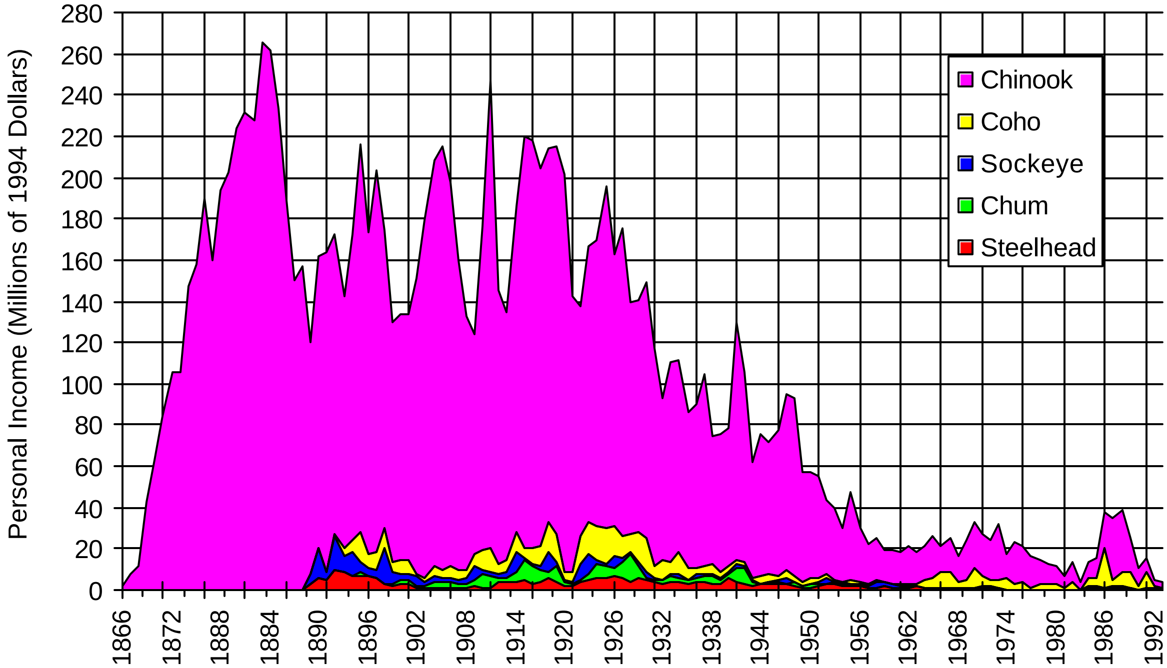
Salmon played a key role in developing the West by European settlers. As early as 1828, various trading companies were purchasing and exporting salmon caught by the Indians on the Columbia River. The first commercial use of fishery products in Oregon was the packing of salmon. Development of the canning 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.

<u>Sockeye</u>
Snake River (endangered);

<u>Steelhead</u>
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:

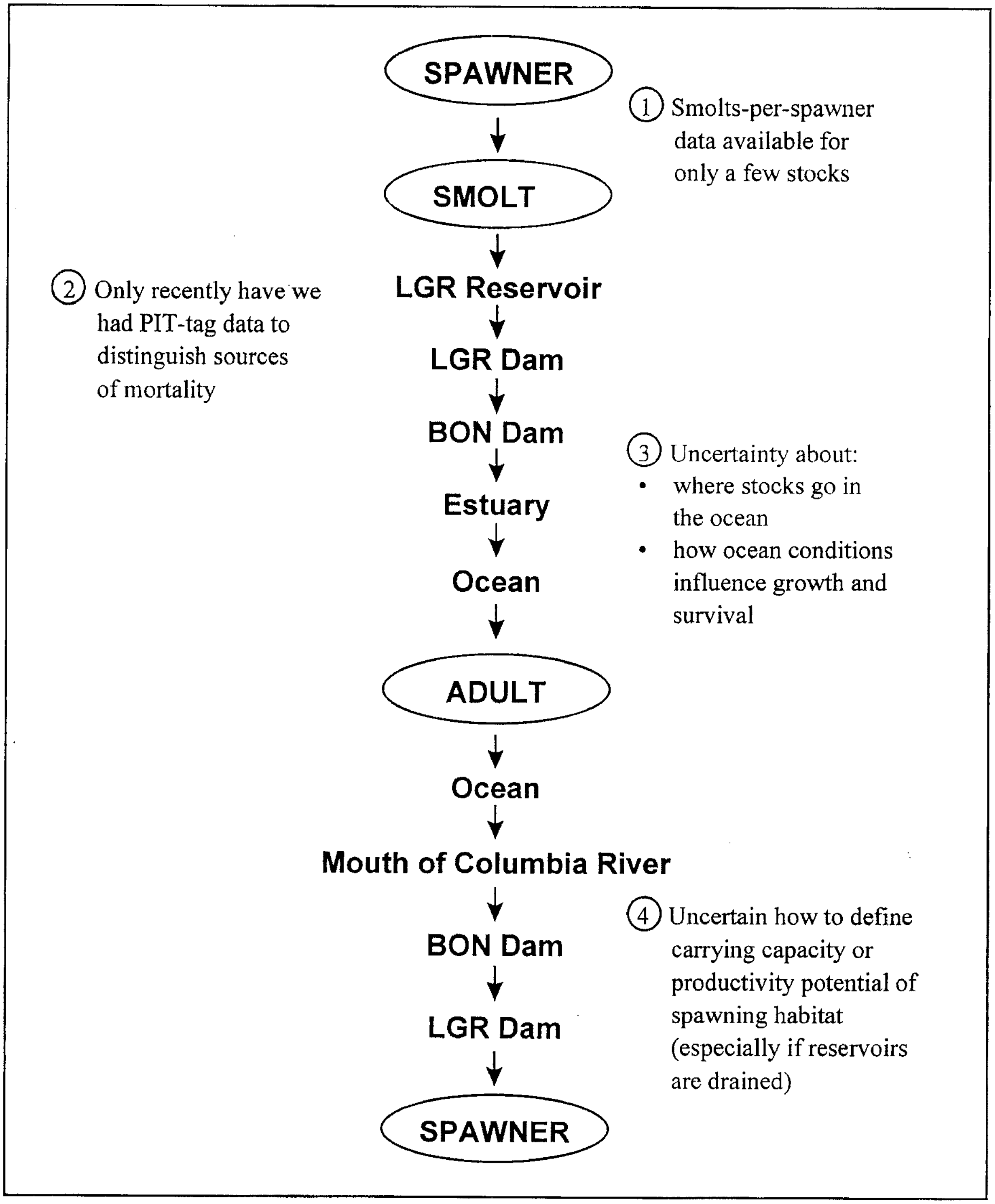
- PATH results did not include Year 0 information for any of the reported stocks. It is necessary to know the change in present conditions to Year 5 (first PATH forecast year) in order to estimate changes in stocks that are not accounted for in PATH results.
- PATH results for spring/summer chinook need 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.

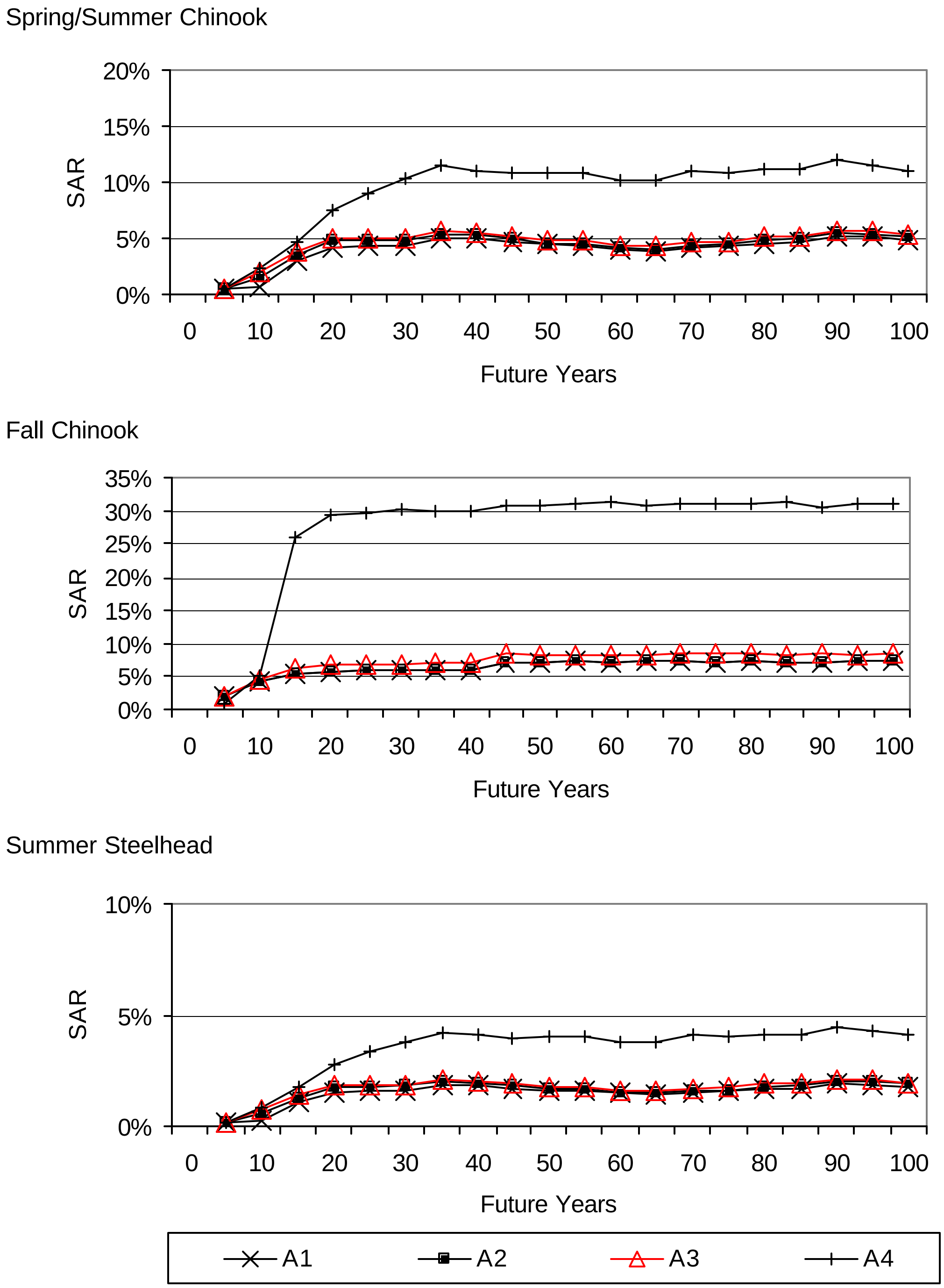
The beginning SAR's for wild stocks were determined using a spawner-recruit function between Year 5 and Year 10 using PATH information.[1] Because the PATH information resulted in an extremely high rate of change in SAR's during the early forecast years, study assumptions included the introduction of 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

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

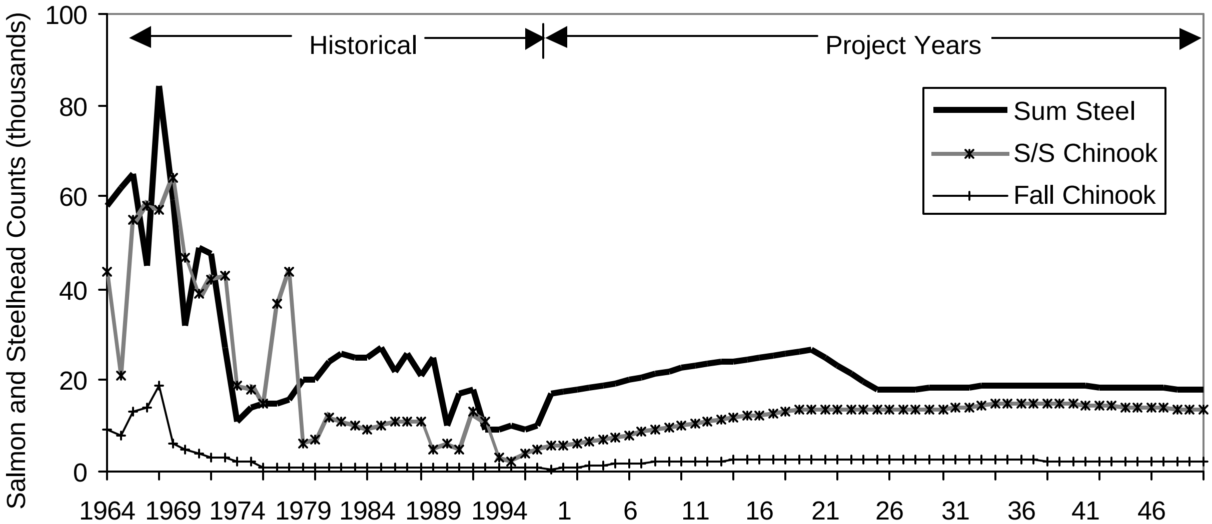
Geographic Area/User Group	Anadromous Species: Chinook Spring/Summer	Chinook Fall	Summer Steelhead
Ocean Harvest			
Alaska			
a) Commercial	0.000%	11.663%	0.000%
b) Sport	0.000%	0.002%	0.000%
British Columbia			
a) Commercial	0.000%	48.506%	0.000%
b) Sport	0.000%	3.880%	0.000%
Subtotal Alaska/B.C.	0.000%	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.

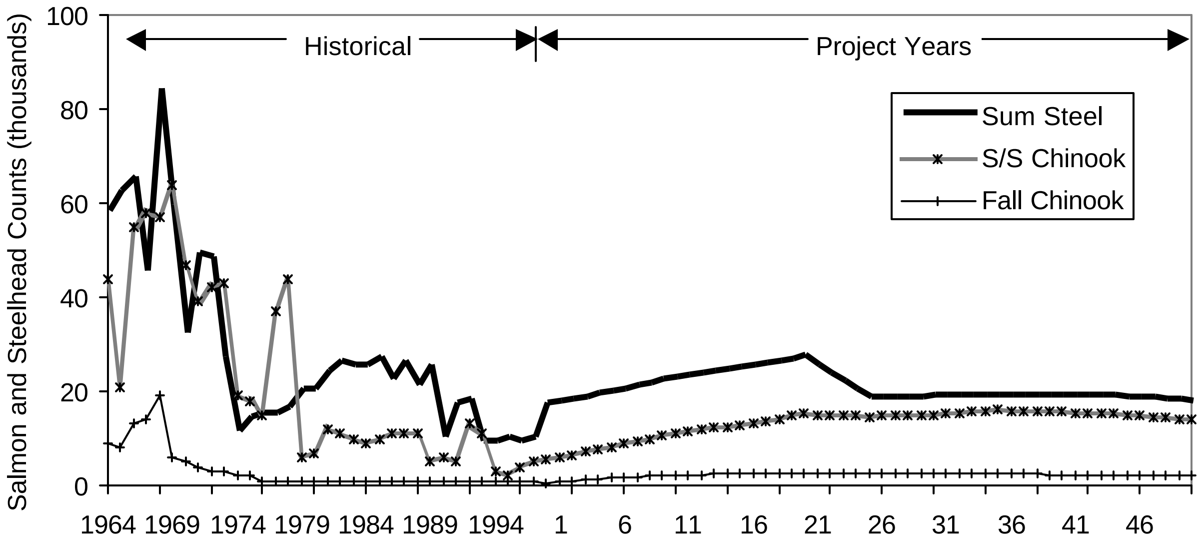
first 50 years of project life for each hydrosystem action are shown in Figures 1.V.2a through 1.V.2d. This means ocean and inriver harvests as well as other river passage mortalities have been accounted for in the wild run sizes. The forecasts show rapid recovery during early project period and minor 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).

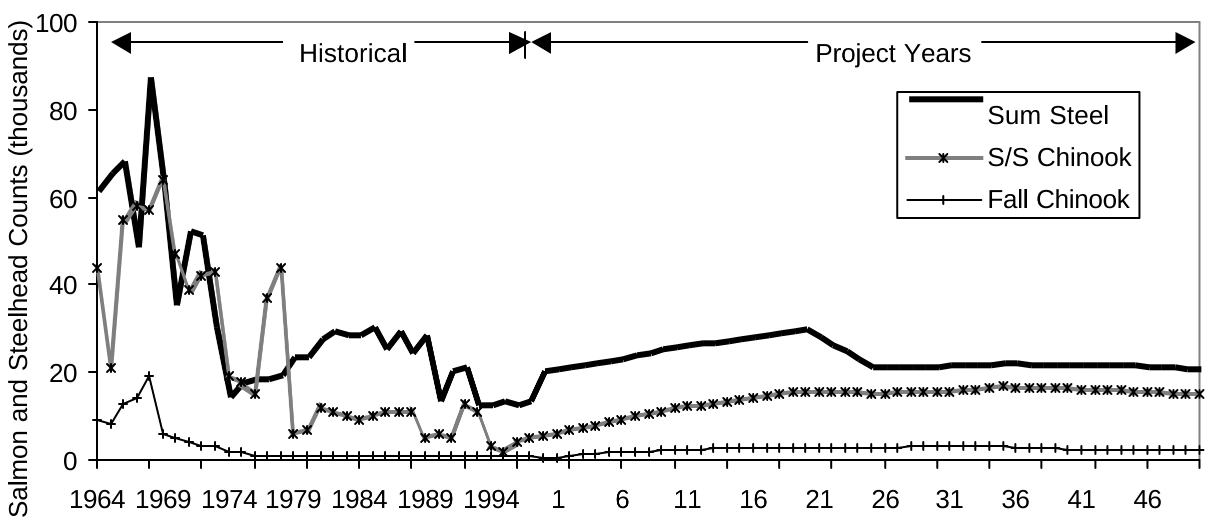
Figure 1.V.2b
Historical and Project Year Wild Origin Stock Run Counts at Snake River Uppermost Dam, Action A2



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).

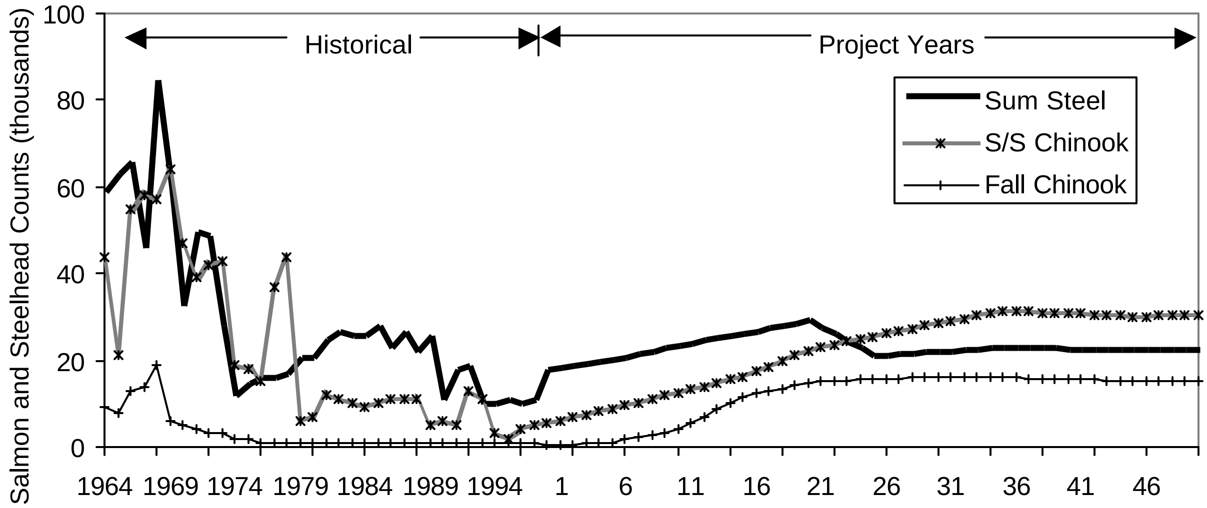
Figure 1.V.2c
Historical and Project Year Wild Origin Stock Run Counts
at Snake River Uppermost Dam, Action A3



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	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.

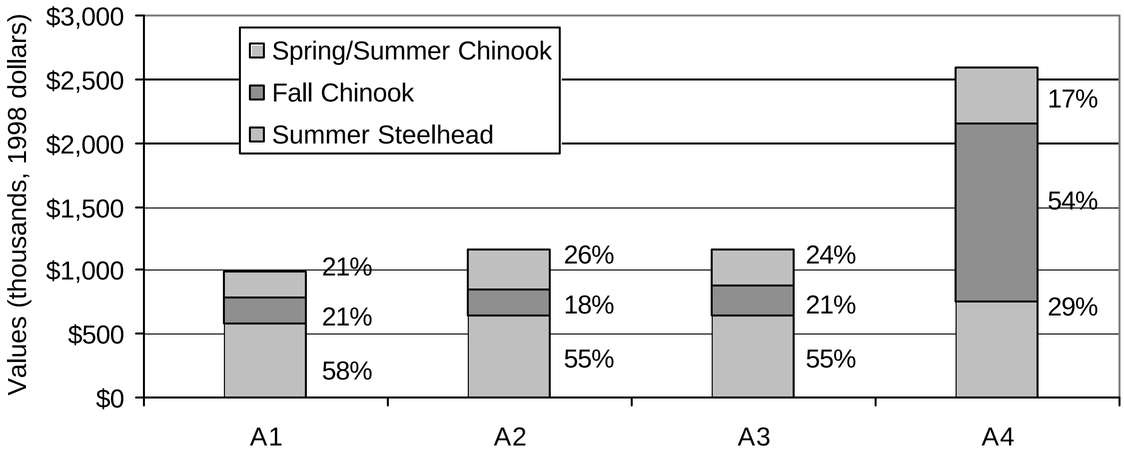
Table 1.VI.3c
Ranges of Annualized Economic Value (NED Benefits) by Fishery For Each Hydrosystem Action Using "Low", "Likely", and "High" Modeling Results

	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.

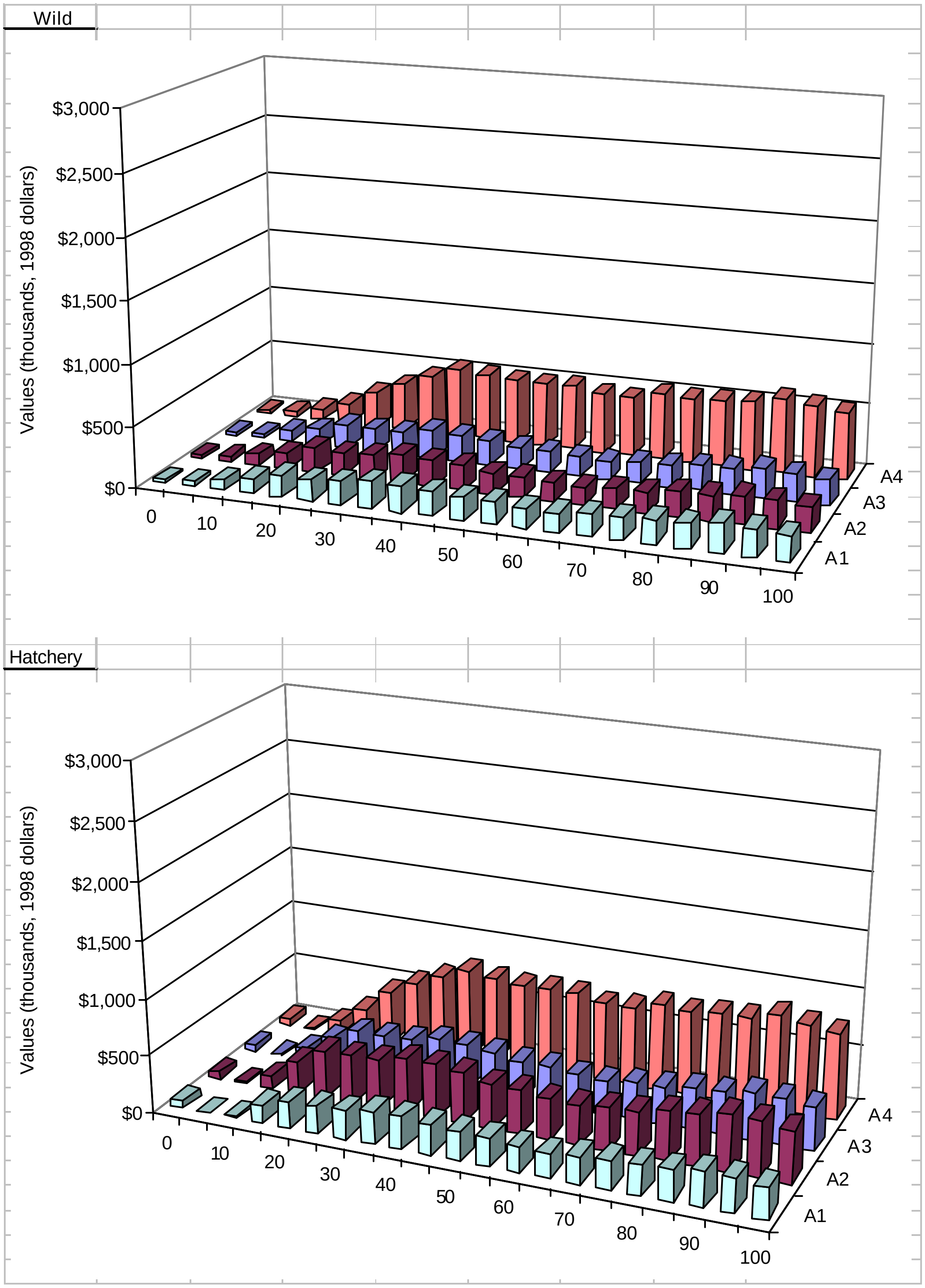
Figure 1.VI.1
Annualized Economic Values (NED Benefits) by Anadromous Fish Species for Each Project Action



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.

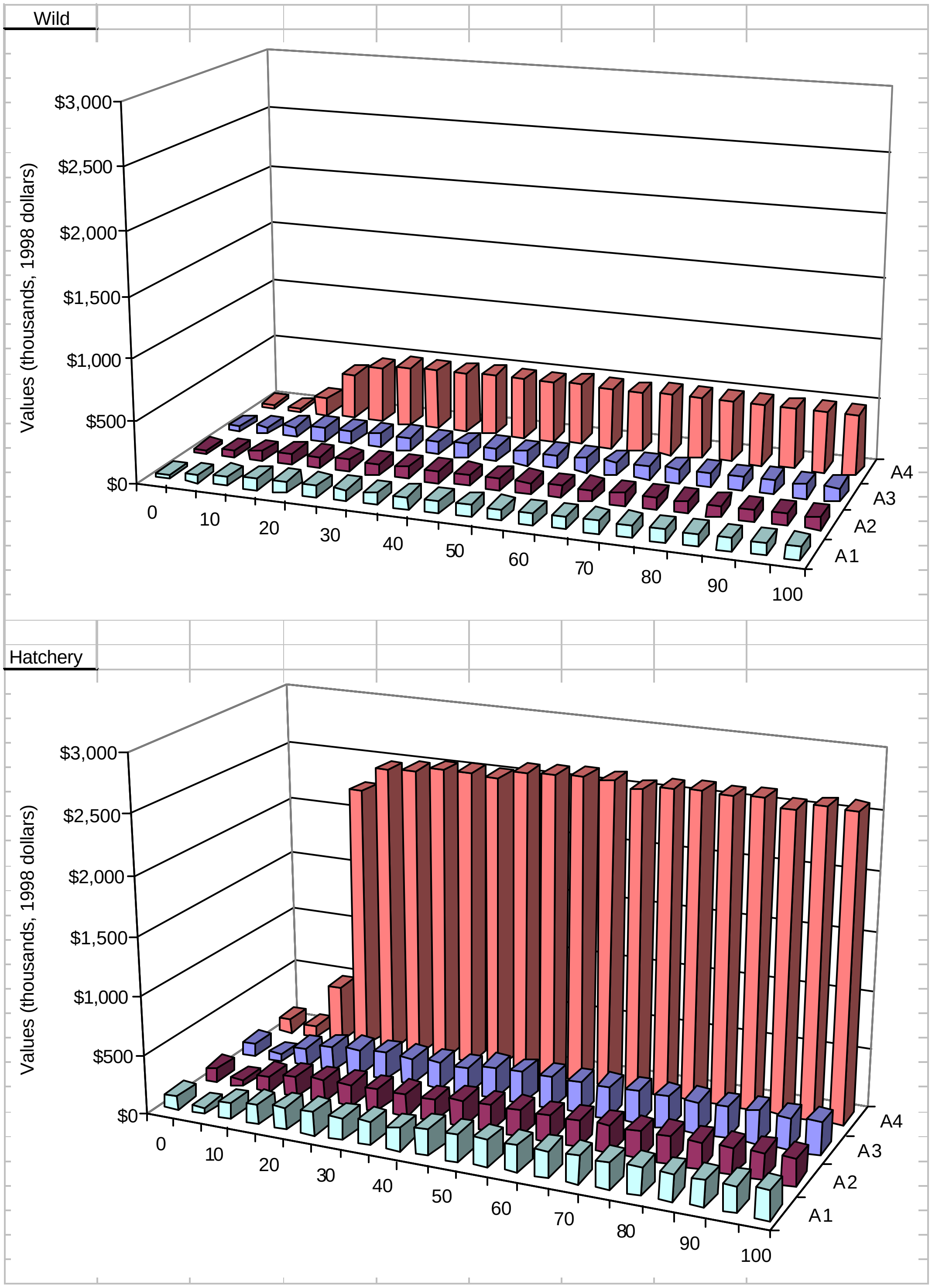
Figure 1.VI.2a
Economic Values (NED Benefits) for Spring/Summer Chinook
by Project Action Using "Likely" Modeling Results



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.

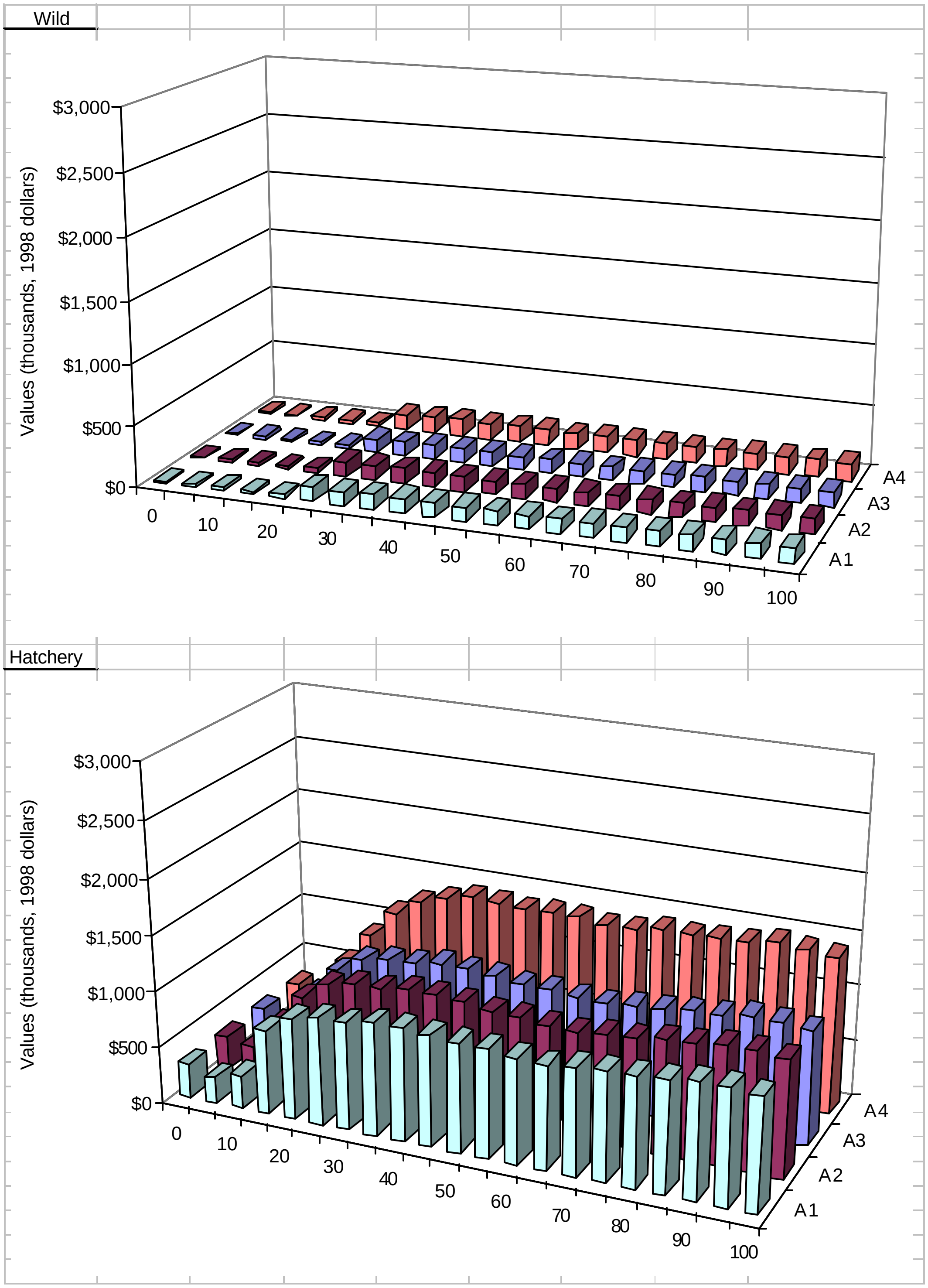
Figure 1.VI.2b
Economic Values (NED Benefits) for Fall Chinook
by Project Action Using "Likely" Modeling Results



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

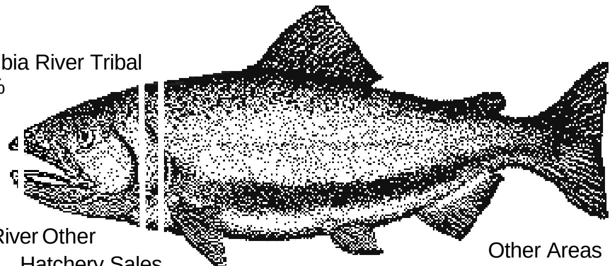
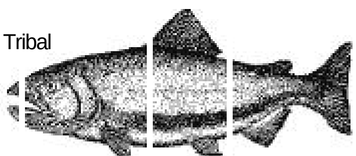
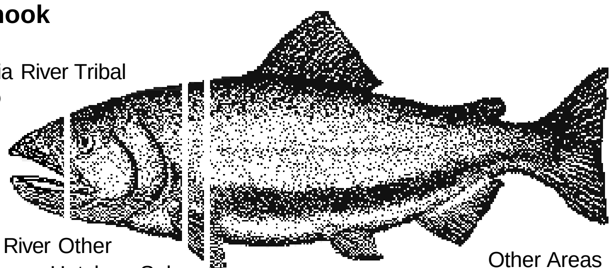
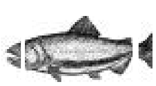
Notes:
1. RED and NED benefits measured per year in millions of 1998 dollars.
2. SAR is smolt-to-adult survival rate. Adults are harvests and returns to hatcheries for hatchery origin anadromous fish. Adults are harvests and spawners plus prespawning mortality for wild origin anadromous fish.
3. Commercial 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

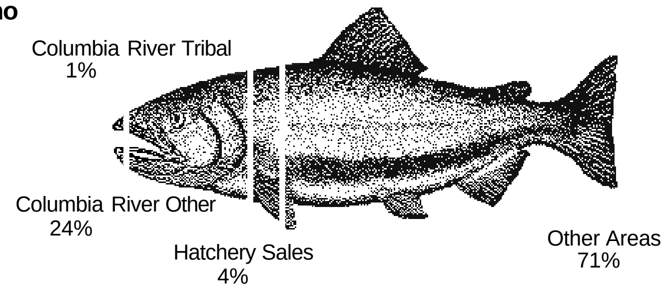
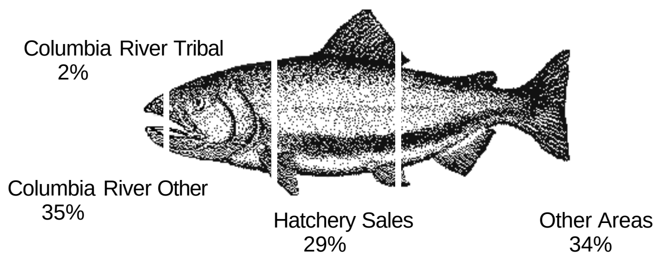
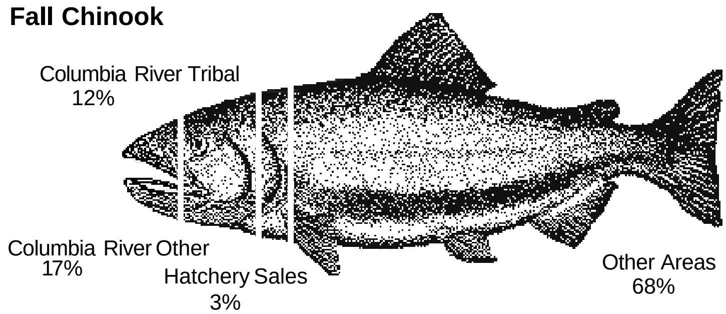
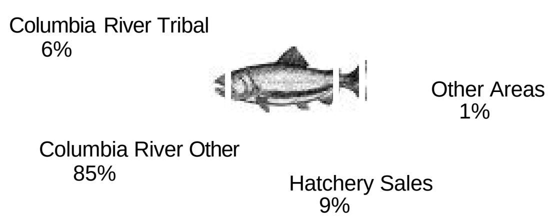
Figure 1.VI.1a
Net Economic Value (NED Benefits) in West Coast Geographic Areas Attributable to
Columbia River Produced Salmon (Hatchery and Wild) Under Four Cases

<table>
<tr><th></th><th>Total Smolts Released (millions)</th><th>Net Economic Value
I NMFS Cap
II 1980's Average
III "Doubling of Runs"
IV Early 1990's</th></tr>
<tr><td>Coho
</td><td>37.18
37.18
37.18
30.91</td><td>I. $18.69
II. $21.92
III. $44.82
IV. $5.55</td></tr>
<tr><td>Spring/Summer Chinook
</td><td>39.13
39.13
39.13
36.78</td><td>I. $6.60
II. $6.97
III. $21.52
IV. $1.85</td></tr>
<tr><td>Fall Chinook
</td><td>227.60
227.60
227.60
200.22</td><td>I. $23.56
II. $29.49
III. $64.72
IV. $13.81</td></tr>
<tr><td>Steelhead
</td><td>28.63
28.63
28.63
25.15</td><td>I. $6.48
II. $15.66
III. $28.88
IV. $3.39</td></tr>
<tr><td>Total</td><td></td><td>I. $55.33
II. $74.04
III. $159.92
IV. $24.59</td></tr>
</table>

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

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

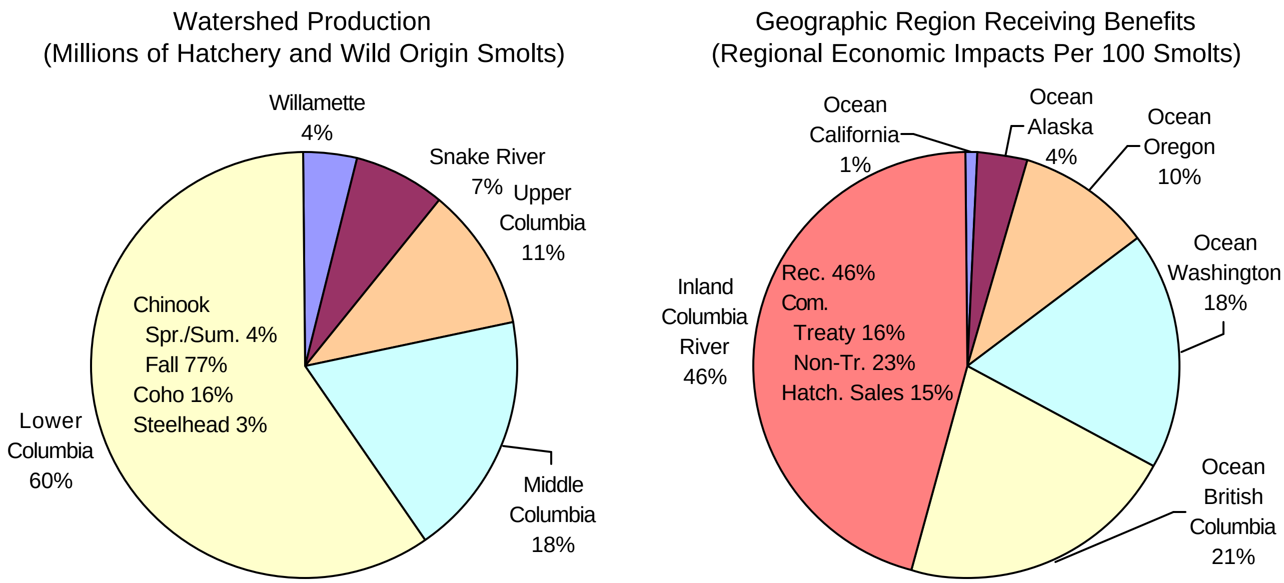
Figure 1.VI.1b
Regional Economic Impacts (RED Benefits) in West Coast Geographic Areas Attributable to Columbia River Produced Salmon (Hatchery and Wild) Under Four Cases

	Total 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

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).

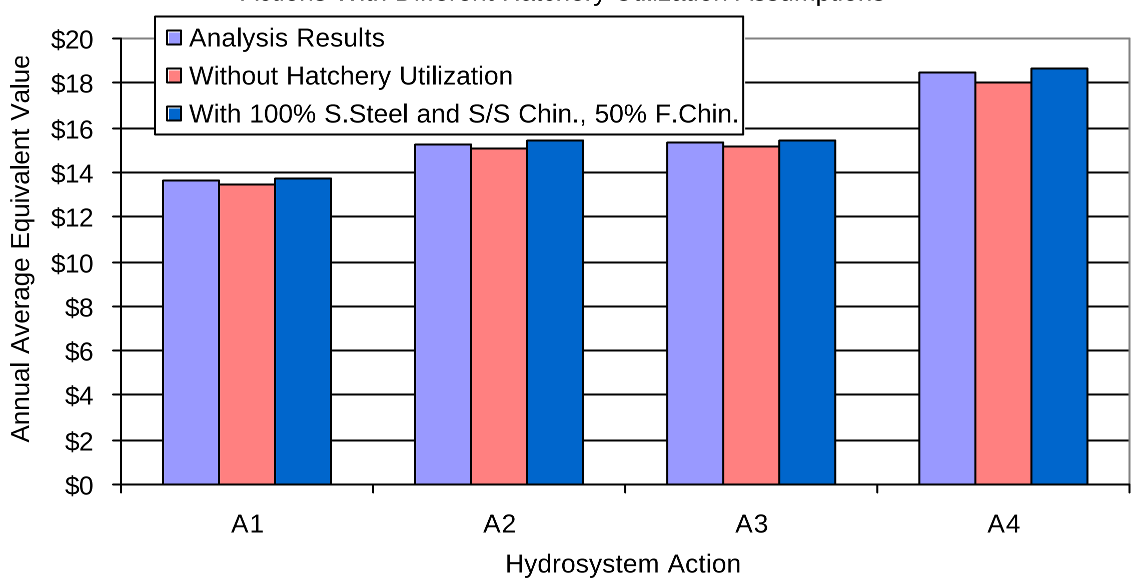
In general, the assumption of one fish per day is used in this evaluation of the benefits of recreational angling in ocean fishing. Past studies of ocean salmon fishing suggest the success of one fish per day is a reasonable representation of historical trends. Since salmon/steelhead fishing has been 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.

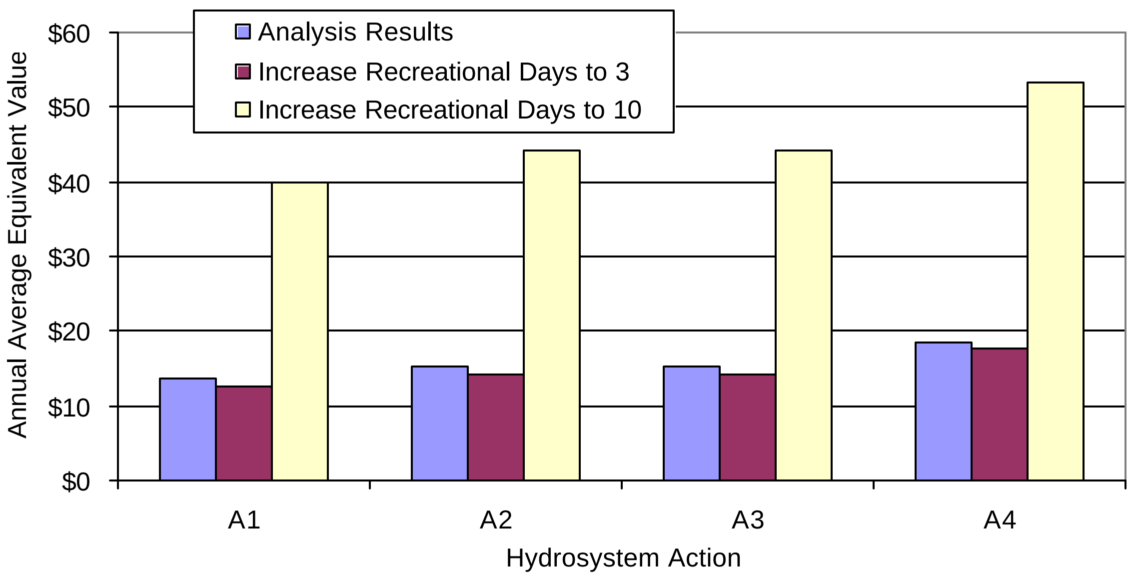
Lowering the success rates from the base case of one day per fish in the ocean and up to two days per fish in the river to three or 10 days increases the benefits substantially (Table 1.VIII.4) for the four policy cases analyzed for the Columbia River Basin. An increase to

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

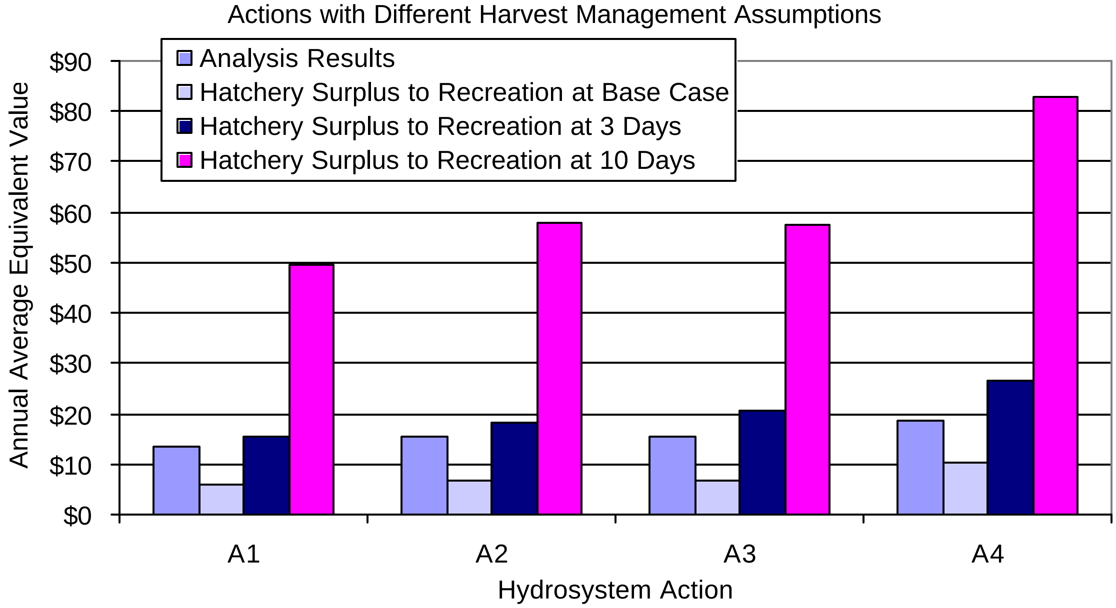
There are a host of salmon treaties and agreements that affect salmon of the Columbia River system. This report assumes that international and treaty agreements will not change. Under the four scenarios, the allocation to any of the historical harvesters changes only if spawning requirements and treaty 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).

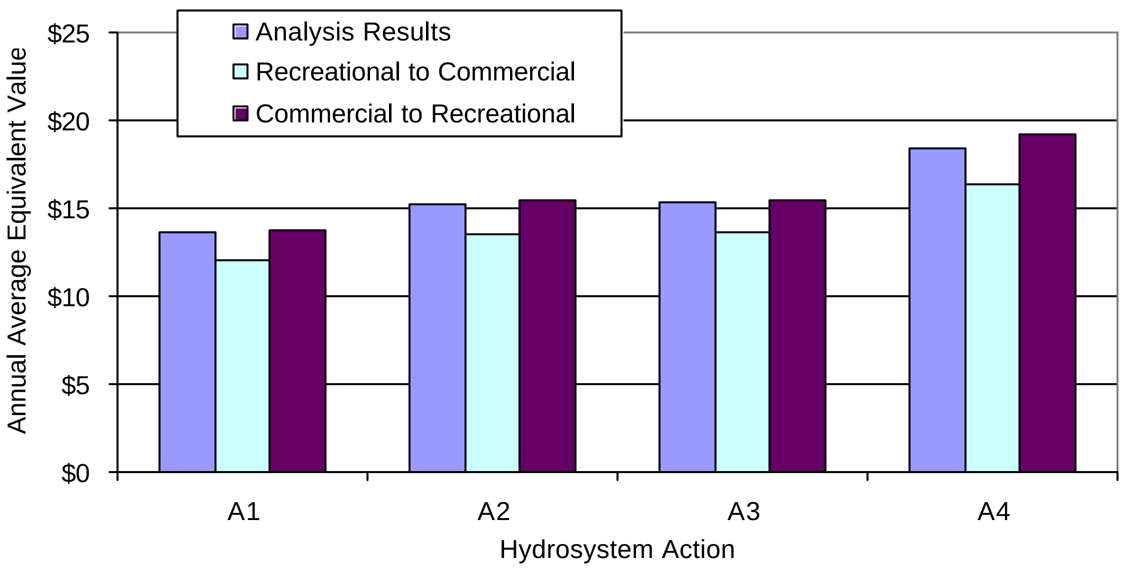
A total allocation from recreational harvest to commercial may decrease personal income generated in the region between $8.1 million and $64.7 million (net economic value from $9.2 to $71.6 million) for the entire Columbia River Basin production (Table 1.VIII.10). A shift from commercial to recreational 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

	Hydrosystem Action			
Category	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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