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ECONOMICS OF SNAKE RIVER SALMON RECOVERY

A REPORT TO THE NATIONAL MARINE FISHERIES SERVICE

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Economics of Snake River Salmon Recovery

A Report to the National Marine Fisheries Service

by

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The seven-member Recovery Team deserves credit for its careful deliberations and comprehensive approach to planning for recovery of the endangered salmon. We would like also to thank Gary Smith, Rob Jones, Merritt Tuttle and Randy Cross and their colleagues at the National Marine Fisheries Service for their support. We thank Louie Echols and his colleagues at the Washington Sea Grant College who provided fiscal support and Ora Chapman and the staff at the School of Marine Affairs assisted in innumerable ways.

1.0 INTRODUCTION

1.1 Purpose

This report examines the economic costs of the Snake River Salmon Recovery Team's Final Recommendations to the National Marine Fisheries Service. These recommendations concern three Snake River salmon stocks listed by the National Marine Fisheries Service (NMFS) under the Endangered Species Act (ESA):

(1) sockeye salmon (Oncorhynchus nerka)

(2) spring and summer chinook salmon (Oncorhynchus tshawytscha)

(3) fall chinook salmon (Oncorhynchus tshawytscha)

Snake River sockeye salmon were listed as endangered on November 20, 1991, and Snake River spring & summer chinook and fall chinook salmon were listed as threatened on April 22, 1992. Following the listing of Snake River sockeye, NMFS appointed a Snake River Salmon Recovery Team (RT) to independently develop recovery plan recommendations. After over two years of study, meetings, and deliberation the Recovery Team produced its Final Recommendations in May 1994. The Recovery Team did not estimate the economic costs of its recommendations, but instead referred to this report as the eventual source of that information. To ease cross-referencing between the RT report and this report on economic costs, each sub-section of Chapter 3 below corresponds to a chapter in the RT Report. Because this report does not repeat the Recovery Team's full explanation of each recovery action, an understanding of the Recovery Team recommendations requires study of the RT report itself. A draft of this report on economics was distributed during September, 1994. This final version incorporates many comments received in response to the draft. In addition, the author's acknowledge the analytical contributions and guidance from numerous regional experts and representations appointed by NMFS to the Economic Technical Committee for Snake River endangered salmon.

1.2 Economics and Species Recovery Planning under the ESA

The Endangered Species Act amendments of 1988 added section 4(f)(1)(B) to the ESA. That addition specifies that species recovery plans include:

a. "Site specific management actions" needed to achieve recovery;

b. "objective, measurable criteria" for delisting; and

c. "estimates of the time required and **the cost** to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal."

Further, the NMFS's Recovery Planning Guidelines (NMFS 1992) call for recovery plans to identify and assign priorities to recovery actions. According to the RT recommendations, development of recovery plans will be based solely on biological considerations, leaving economic costs as a factor in selecting recovery actions only when equally effective alternative measures have different costs. If two means of achieving a given recovery goal are being considered, the lower cost alternative may be chosen. The economic costs are conditionally relevant to recovery planning only when alternative means are being weighed for achieving a given amount of progress towards recovery. Decision processes of this sort are called "cost-effective". Because the complex life cycle of Snake River salmon presents biological planners with numerous alternative means of achieving a given amount of recovery, this weighing of alternatives using economic and other criteria could be an important element of the public decision process.

1.3 The Recovery Team's Recommendations

The RT recommendations are comprehensive in addressing every stage in the salmon's life history -- freshwater spawning and rearing habitats, downstream migration corridor, ocean feeding and maturation, survival through ocean and river fisheries, and upstream migration back to spawning grounds. The recommended measures deal with present conditions and historic causes of salmon population decline, including hydropower dam operations, water appropriations for irrigation, over-fishing, habitat destruction, hatchery practices, land use, and other factors. To achieve recovery to the point of de-listing, the Recovery Team seeks improvement in survival in every life stage of the listed species. This necessarily requires changes in private and public uses of headwaters and riparian habitats of the Snake River, mainstem Snake and Columbia Rivers, and ocean areas through which the subject salmon species migrate.

Implementation of a broad-based recovery effort for Snake River salmon will inevitably cause some social and economic disturbances in the Pacific Northwest region (Washington, Oregon, Idaho, and western Montana). Some recovery actions are relatively limited in geographic scope and economic impact, while other actions can trigger complex, wide-ranging changes in the structure of the regional economy. As described in more detail below and in Chapter 2, methods for estimating economic costs of resource conservation are well-established in theory and practice. We attempt to follow these tried-and-true approaches to establishing the magnitudes of economic ramifications of proposed measures. Because the proposed measures are diverse and could trigger widespread and complex economic and social changes, however, it is not possible to anticipate the full extent of economic effects in detail.

A summary of recovery recommendations and economic sectors likely to incur is contained in Table 1-1 below. The RT recommended organizational changes in the agencies responsible for salmon recovery and river operations. These will involve some incremental increase in resources devoted to managing the endangered species and in coordinating the activities of numerous public agencies involved. The high-cost recovery measures can be grouped into the "four H's": Habitat, Harvest, Hatcheries, and Hydropower. The habitat measures are focused on freshwater spawning and rearing habitat in the mid- and upper Snake river and tributaries. Protection of anadromous fish habitat will involve restrictions on riparian timber harvest, grazing, mining, irrigation practices, and recreational activities in lakes, streams, and rivers supporting sockeye salmon. This could affect a broad spectrum of the natural resource-based economy in eastern Washington and Oregon, and Idaho. While short-run disruptions of production are likely, not all of the effects of habitat preservation will be negative, especially in the longer run.

Table 1. Categories of Recovery Actions for Snake River Sockeye, Spring/Summer Chinook, and Fall Chinook and Economic Entities Affected

Salmon Conservation Actions	Economic Sector Incurring Cost
(1) Organizational Measures: - Putting NMFS in charge - Salmon Oversight Committee - Subcommittees and work groups - Monitoring and evaluation	Gov't Agencies. Expenditures on staff, experts, contract studies, coordination between agencies, office space, equipment.
(2) HABITAT - freshwater habitat for spawning and rearing: - Modify Idaho lakes for sockeye salmon - Reduce grazing and timber harvest in riparian zones - Regulate mining to improve water quality - Install and operate fish screens at all irrigation diversions and pumping stations	- US Forest Service, Bureau of Land Management, State Fish and Game; - Recreational users of lakes; - Timber and livestock industries; - State water quality agencies - Mining industry (mainly in Idaho) - Irrigation Districts, private irrigators.
(3) HARVEST - Re-shape ocean fisheries to avoid Snake river fall chinook salmon - Reduce ocean fishing capacity by 50% - Buy-out commercial gill nets permits in lower river - Convert river commercial fishery to live-capture gear. - Move treaty fishery between Bonneville and McNary dams to above Snake confluence.	- Commercial troll fleet in Washington, Oregon, and maybe Southeast Alaska and British Columbia, - Columbia River gill net fleet, and sport fishing in Estuary (Buoy 10) and river - Treaty Tribes (Yakima, Umatilla, Warm Springs, Nez Perce) fishing in the Columbia River
(4) HATCHERIES **Improve Freshwater Production of Salmon:** - Modify hatchery plantings to avoid negative effects on wild salmon - Captive broodstock for sockeye salmon - Supplementation of natural stocks with hatchery stocks - Improve health and quality of hatchery fish - Stop planting hatchery fish (including trout and steelhead) in wild chinook rearing areas.	- State and Federal hatchery program budgets - Recreational fisheries in salmonid habitats if stocking of trout is reduced - Commercial fisheries relying on hatchery fish

Table 1. continued

Salmon Conservation Actions	Economic Sector Incurring Cost
(5) HYDROPOWER	
Downstream Migration - Improve **smolt passage** routes through dams, including improved traveling screens, diversion channels, predator control, etc.	- US Army Corps of Engineers - Hydropower system - Electrical utility ratepayers in the Pacific Northwest
Flow Augmentation in lower Snake and Columbia rivers - Increase water budget in Snake and Col. R. - Shape the water releases for best effect - Negotiate for more upper Snake water - Make in-stream flow a "beneficial use" - Issue no new water permits - Create water market in Idaho	- Hydropower system - Electrical utility ratepayers in the Pacific Northwest - Irrigated agriculture - Reservoir recreation (e.g. Dworshak dam)
Spill - Increase proportion water "spilled" over spillways during smolt migration when appropriate	- Hydropower system - Electrical utility ratepayers in the Pacific Northwest
Draw downs - Many Alternatives to Study Lower reservoir behind Snake R. dams: - to spillway crest or to natural river level - for 2 months or 4-1/2 months - at all 4 dams or just Lower Granite dam	- Farms pumping from Ice Harbor and John Day reservoirs - River navigation, barge traffic - Reservoir recreation in Snake R. - Hydropower system - Electrical utility ratepayers in the Pacific Northwest
(6) Smolt Transportation	
Improve barge transportation of smolts from Snake river dams to below Bonneville dam: - Operate more barges - Improve barges and release strategies - Study upstream collection for transportation from head of Lower Granite reservoir	- US Army Corps of Engineers - Bonneville Power Administration - Electrical utility ratepayers in the Pacific Northwest

Changes in the salmon harvesting regimes will affect ocean troll fishing off Oregon and Washington (and possibly Canada and Alaska), the non-Treaty gill net fishery in the lower Columbia river (below Bonneville dam), and the Treaty fisheries above Bonneville dam. The recreational fishery for salmon off southern Washington, off northern Oregon, and in the Columbia River estuary (e.g., the so-called "Buoy 10" fishery) could also be curtailed under some circumstances. Some segments of the fishery will be restricted to improve survival of the threatened and endangered species; other parts of the fishery could be expanded as the fisheries are better tailored to the mix of weak and strong salmon stocks.

The extensive salmon, trout, and steelhead hatchery system in the Columbia river basin has proven to be both a contributor to expanded production of salmon and a cause of concern for some wild stocks of salmon. Production of Snake river hatchery fish increased from 2.4 million salmon and steelhead in the mid-1970s to over 28 million in recent years. Most of this production is from hatcheries built under the Lower Snake River Fish and Wildlife Compensation Program. The planned full production from the hatchery system may be as much as 47 million fish above Lower Granite dam.[1] Hatchery populations can negatively affect the naturally-spawning salmon runs due to competition for food in freshwater rearing areas, to spread of diseases, to genetic weakening of wild stocks through inter-breeding, and to wild fish being taken by hatchery managers to maintain hatchery stocks. Actions outlined in the Recovery Team recommendations are designed to make the hatchery system less intrusive on the natural spawning stocks of salmon and to assist the recovery efforts through captive broodstock and supplementation programs. Economic effects of these changes will be threefold: lower overall budgetary costs for some State and Federal hatchery operations (which are funded in part by BPA and Pacific Northwest electric utility customers), investments in improved hatchery operations to avoid disease and genetic problems, and some reductions in recreational catches due to reduced stocking of trout and salmon.

Several changes are recommended for the system of hydropower dams in the Columbia river basin. The dams, reservoirs, and the shifts in seasonal river flow caused by hydropower and flood control operations apparently reduce the survival of both downstream migrating smolts and upstream migrating adults. The recommended changes include (a) structural improvements in dams to improve both downstream and upstream migration survival during passage through the dams, (b) operational changes which release water from storage reservoirs to enhance river flow volume during spring and summer migration periods, (c) "spill" of water over dam spillways (rather than through turbines) to increase survival of smolts passing through dams, and (d) "draw down" of reservoir elevations behind Snake river dams which decreases the cross-sectional area of the reservoirs to increase flow velocity of the river without added flow volume.

We expect substantial shifts in river flow regimes to alter firm power generation potential, to reduce regional value of hydroelectric power (by shifting generation from the peak demand winter season to low-demand spring and summer seasons), and to increase the need for flexible hydro-thermal systems and inter-regional power sales and exchanges. Decreases in hydropower generation in the face of stable or increasing demand for electricity will stimulate development of alternative, higher-cost energy sources that generally depend upon combustion of

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[1] US Army Corps of Engineers. April 1994. Columbia River Salmon Mitigation Analysis System Configuration Study, Appendix E Improvements in the Existing System Technical Report. Walla Walla District. p 2-6.

fossil fuels. Increases in regional electrical generation costs and portions of the structural improvements will be paid for by electrical power rate payers of the Pacific Northwest region.

A fifth "H" (for "Haul") represents the transportation of out-migrating salmon smolts from Snake river dams to the lower Columbia river below Bonneville. The US Army Corps of Engineers (COE) operates a number of barges and trucks which haul salmon smolts from collecting points at Lower Granite, Little Goose, Lower Monumental, and McNary dams to the Columbia river below Bonneville dam. The numbers of fish collected peaked in 1990, with 22.4 million collected and 21.5 million transported. Studies quoted by the COE indicate that the transportation system has no significant effect on homing or survival, and that transportation results in returns of more adult fish to the river than in-river passage. Improvements in the barges and collection/holding facilities, increased numbers of barges to handle peak capacity of smolt arrivals, and experimentation with smolt release strategies below Bonneville dam are proposed by the Recovery Team. Costs associated with these recommendations are incorporated in the reports on the System Configuration Study and the COE's Project Improvements of Endangered Species (PIES) program.

In recognition that these recovery options vary significantly in cost, development time, effectiveness, and technical readiness, the Recovery Team lays out a strategy of sequencing recovery actions. Actions that are well understood and that require no design and construction phase are to be implemented immediately in order to recover the three Snake river salmon species. These immediate actions include an increased "water budget" (i.e., an amount of stored water that is put at the disposal of fish agencies) to improve river flow during appropriate stages of the migration period. Importantly, the RT also calls for substantial increase in research on survival of smolts and adults through dams and reservoirs, in order to find effective strategies for further action. Continuation and improvement of the Corps of Engineers smolt transportation program is also an immediate need. In combination with the transportation program, the RT calls for increased spill and in-stream migration of smolts under appropriate flow conditions. Further, a captive broodstock program for the endangered sockeye salmon is endorsed.

The near-term actions (3 to 6 years) include measures that require moderate engineering design and construction or research and development. This includes improvements to the Corps of Engineers smolt collection and transportation system, and ongoing improvements in the fish passage facilities at the eight mainstem dams. In the long term (> 6 years), the RT includes a huge number of specific improvements to the fish passage facilities, research efforts to evaluate the various long-term options, major construction options, and decisions on more extensive modifications to the river operations. Most of the major shifts in river operations that have been discussed in connection with the salmon recovery problem are left for long term consideration after thorough scientific study and design. These include drawdown of the Snake river reservoirs, an additional smolt collector at the head of Lower Granite reservoir, construction of surface smolt collectors at Lower Granite, and re-establishing salmon populations above Brownlee and Dworshak dams. Many of the RT recommendations are presented in a contingency planning framework; the adoption of a major strategy (e.g., drawdown of reservoirs) depends upon research and experimentation with alternatives.

The time sequencing of recommended actions, and the contingency planning framework has important implications for the construction of an economic cost estimate. The first consequence is that there can be no simple comprehensive cost figure for the recovery recommendations. Costs clearly depend upon which options are eventually chosen, and the eventual choices depend upon findings not yet available. Second, there is a substantial reliance on science, research, experimentation, monitoring and learning in the Recovery Team's approach. This means that costs of studying and learning more about how salmon survive through the river system is an important cost component. Unfortunately, we have only the most rudimentary methods of forecasting the cost of learning more about how to design the system. Hence, accurate cost estimates for important parts of the recovery plan are not feasible. Third, the delay of ten years or more until significant options in the recovery effort could be implemented (e.g., drawdown of Snake river reservoirs to natural river level) means that discounting of future costs will have a significant effect on comparable present values of costs of the recommendations. This places the spotlight on discount rates used, and means of comparing costs incurred at different times in the future. Finally, the range of possible costs and the uncertainty pertaining to the cost estimates is going to be relatively large for the salmon recovery effort. We discuss these problems in more detail below and in Section 2.

1.4 Measuring Economic Effects of Recovery

Use of divergent quantitative measures of economic effects of salmon recovery can cause misunderstandings among analysts, decision makers, and the general public. Three differing concepts are in common use: (1) economic *opportunity costs* -- the value of goods and services sacrificed or value of inputs used up in pursuing a recovery option; (2) agency expenditures or budgets for a particular program (e.g., how much is spent directly for salmon hatchery operation); and (3) changes in employment and income in local communities or the broader region due to resource management changes (e.g., impacts of reduced irrigation water on agricultural communities). These related concepts are all legitimate concerns of policy makers. Any of these concepts must be measured versus a *status quo* or *without project* condition. Hence, each of these economic effects represents a change in the mix of economic values, expenditures, or activities from some pre-existing or alternative pattern.

Opportunity cost is the concept most often employed by economists. It is the value of commodities and services that would have been provided to the economy but for the recovery program. This incorporates the notion that resources are scarce, that any particular choice of resource use implies the abandonment of some other potential uses, and that the cost of making one choice is the value of the opportunities foregone. The second concept, which is often estimated in government budgetary processes, measures governmental revenues needed to fund salmon recovery efforts. *Budgetary cost* is frequently used by, for example, agencies operating the hydropower facilities -- US Army Corps of Engineers, Bureau of Reclamation, and Bonneville Power Administration -- to prepare for appropriations requests or to determine needed increases in electricity rates. Budgetary costs are estimated from detailed plans for a project, including the requirements for employees with various trades and skills, for office space, for materials, etc. Because they reflect the costs of resources used directly in a project, the budgetary cost represents a portion of the overall opportunity costs. However, government programs influence the use of private resources or the production of goods and services used in other economic sectors. Consequently, the economic costs of an agency program can far exceed the agency budget. The third concept is often called ***economic impact***. It represents a forecast of changes in local economic activity triggered by a specific shift in production or resource use. Impacts are often measured in terms of "jobs" or regional income gained or lost.

In the report the term "economic cost" refers to the economic opportunity costs associated with a conservation measure. "Budgetary costs" refers to estimated government agency expenditures needed to implement a recovery action. Finally, "economic impact" refers to the extended repercussions of policy changes on local economies, measured in terms of employment or regional income changes.

1.5 Information for Economic Cost Assessment

Comprehensive information concerning the extensive requirements for and economic effects of salmon recovery measures is scarce. However, many components of the RT recommendations are included in the Federal Columbia River Systems Operation Review (SOR) being carried out by the Bonneville Power Administration, US Army Corps of Engineers, and Bureau of Reclamation[2] and in the Corps of Engineers' System Configuration Study (SCS)[3]. Additional analyses have been completed by the Northwest Power Planning Council, Natural Resources Defense Council, Environmental Defense Fund, Idaho Department of Water Resources, and others. Parts of some Recovery Team recommendations were analyzed by the U.S. Forest Service and by state and tribal fisheries agencies while evaluating policies within their normal scope of action. Yet other aspects of the recovery recommendations have been assessed by economists working on water policy or agricultural policy. While the analytical approaches, depth of investigations, and policy questions differ among these sources of information, we have no choice but to assemble and use the diverse information available. Consequently, this report is eclectic. We use cost estimates that are not all directly comparable and cannot logically be added together to arrive at a single quantitative estimate of "What Salmon Recovery Will Cost". Our economic cost estimates should be viewed as illustrative of the economic consequences likely to follow adoption of salmon recovery measures. Our purpose is to inform the public and decision makers about the type and size of economic consequences of the salmon recovery effort, but not to formulate precise estimates that could be used for program planning.

1.6 Economic Benefits

While the Endangered Species Act does not require analysis of economic benefits from species recovery planning, consideration of benefits could play an important role in developing policy options for the Columbia River system. Further, some would claim that the benefits derived from conserving species like the Snake River salmon are quite large and that this perception encouraged Congress to pass the ESA in the first place. Some benefits are derived from the prospect of increasing the volume of harvestable fish - including commercial harvests, subsistence and ceremonial harvests by Treaty tribes, and recreational harvests. Besides these tangible benefits, broad public support for protection and restoration of natural environments and key species in those environments is evident even among those not directly using or harvesting the species of concern. Salmon have a symbolic and spiritual importance to both native peoples and recent migrants to the Pacific Northwest. While quantitative estimates of these non-use

[2] Draft Environmental Impact Statement, Columbia River System Operation Review, July 1994, especially Appendix O "Economic and Social Impact".

[3] US Army Corps of Engineers. April 1994. Draft Columbia River Salmon Mitigation Analysis System Configuration Study. Walla Walla District.

values are rather sketchy, a general review and summary of pertinent economic values is included at the end of Chapter 2 as a useful adjunct to the economic cost information.

2.0 METHODOLOGY OF THE ECONOMIC ASSESSMENT

This section lays out the framework adopted by the authors for assessing economic costs of recommendations by the Recovery Team. The techniques of economic cost estimation are thoroughly reviewed by works on water resources management, such as Howe (1992), and Young and Howe (1988). Specific assumptions pertinent to Columbia River operations assessment are clearly laid out in Bonneville Power Administration, Army Corps of Engineers, and US Bureau of Reclamation. 1994. *Preliminary Draft Environmental Impact Statement for the Columbia River System Operation Review*, and in the Army Corps of Engineers, 1994. Draft *Columbia River Salmon Mitigation Analysis System Configuration Study, Phase I. Main Report, Appendices E and F*. Readers wanting more extensive explanations of economic cost methodology are directed to those references. We conclude the section with a brief overview of issues concerning economic benefits of salmon recovery.

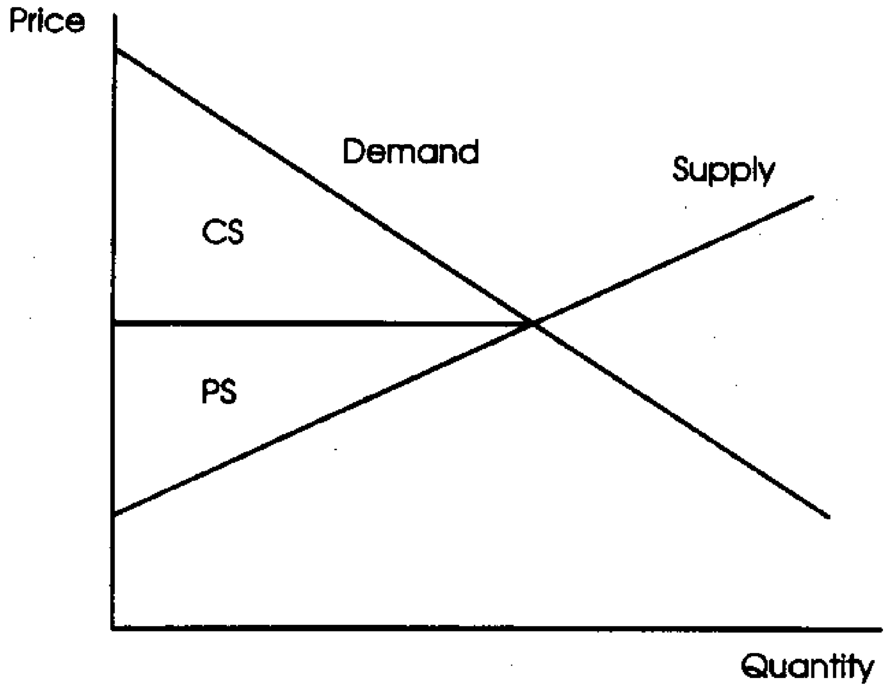
2.1 Concept of Economic Cost

Following standard practice in economic evaluation, we assign dollar values to the changes in quantity of goods and services caused by proposed recovery actions. Each dollar value is based upon the amount consumers are willing to pay minus the cost of production. The first step in costing a given salmon conservation measure is to determine how goods and services are affected. The second is to assign a value based upon the consumer's "willingness to pay" (WTP) for an increase or decrease in goods. For marketed goods, the WTP for the quantity supplied equals the area under the demand curve. Figure 2-1 depicts simple market demand and supply curves, where the intersection of the two is termed the market equilibrium. Because consumers pay the market price for each unit purchased, their total payment equals price times quantity (PxQ). We define the net WTP or "consumer's surplus" as the total WTP minus actual payments. This dollar amount will equal the area of the triangle labeled CS in Figure 2-1. A reduction in quantity available (leftward move along the horizontal axis) causes an increase in price and reduces the CS. The reduced CS is one component of the net economic cost.

Producers also earn a surplus equal to the amount they are paid for quantity sold minus the minimum cost of producing that quantity. In practice, the "producer's surplus" is reflected in profits to business enterprises and rents earned by owners of land or other scarce natural resources (e.g., water rights, grazing allotments, minerals, etc.). In a typical competitive market for private goods, the supply curve represents the marginal cost of supply (including opportunity cost of scarce resources). Consequently, producer's surplus can be roughly measured as the revenue received from sales minus production costs. Since revenue received is just equal to the amount consumers pay (PxQ), producer surplus is the area over the supply curve and below the price, the area labeled PS in Figure 2-1. When the good is not sold at a price approximating marginal cost (e.g., subsidized water, electrical power), the same concept of economic value applies, but the estimation technique must account for deviation between actual marginal cost and apparent measures of price or rates paid.

For "public goods" which are not sold in markets (recreation, scenic quality), a survey of the public may be used to obtain price-like information from users of the resource. In outdoor recreation economics, for example, a variety of techniques (travel cost demand estimation, contingent value survey) are used to estimate demand for recreational sites or conditions. These

Figure 2-1. Net economic Value as Consumer Surplus (CS) and Producer Surplus (PS).



methods have been used extensively to determine fishing and other reservoir-based recreation values in the Pacific Northwest. When a specific estimate of WTP for recreation days or visits is available for a site, this value is used to evaluate a decline or increase in recreation caused by a salmon conservation measure. Where studies have not been completed for the specific lake, reservoir, or national forest that is potentially affected, estimated values for similar recreational sites are often used as proxies. This necessarily involves some subjective choice and results in some error, but it is the best approach available under the circumstances. A comprehensive survey for recreation values of federal reservoirs is to be released in conjunction with the Columbia River System Operation Review Final Environmental Impact Statement.

Finally, people derive value from some resources (particularly environmental goods) without "using" them in the usual sense. For example, people appreciate the wondrous features of the natural world (Grand Canyon, ancient forests), and are willing to pay to preserve them. These values are variously named "existence" value, "non-use" value, or "passive use" value. Measurement of existence value is a growing field of application for environmental economists, but there are still major controversies over technique and meaning of the measurements. Because little existence value information is available concerning the Snake River salmon, the incremental existence values associated with recovery actions are not well accounted for in this report. We provide a brief and suggestive summary of miscellaneous economic benefits information in Chapter 4.

2.2 Compensation versus Costs

Some expenditures occurring under the salmon recovery could be categorized as compensatory payments, meaning that they compensate individuals for loss of potential income. The loss of income may or may not be linked to a real economic cost. An example would be "buy-out" payments to salmon gill net permit holders in the Columbia River fishery. If salmon stocks in tributaries to the Columbia continue to be harvested in those rivers, and if the ocean troll and upriver treaty fisheries increase their harvests as the gill net fishery is curtailed, the overall catch of salmon may be unaffected by the buy-out. Further, since the salmon fishery (like most other fisheries) has a vast over-supply of fishing capacity, the fishery may be operated at lower cost without the Columbia River gill net component. In aggregate, therefore, the reduction in gill net fishing does not reduce the amounts of goods and services available in the economy. If resources previously devoted to gill net fishing are re-deployed to supply other goods, the fleet reduction may even generate an overall economic benefit. Despite the absence of overall economic cost to the buy-out of fishing permits, each permit represents a potential source of future harvests and income to the permit holder. Hence, individuals must be paid to willingly give up their permits. The payment is not an economic cost in the usual sense, but it is a compensatory payment. If a government agency funds the guy-out of permits, the budgetary cost will not represent an economic opportunity cost at all. And, the budget for purchasing the permits will equal the needed compensatory payment only if the sellers are paid an amount they would willingly accept.

As noted by Berry and Rettig (1994), reasons for providing compensation to individuals may stem from legal requirements, ethical commitments, and political or economic thinking. Whatever the underlying motive, providing compensation to potential losers in the salmon recovery process may facilitate the process of implementing changes in the social structure to improve the long-term prospects for the salmon. A question is whether such payments should be added to real economic costs attributed to salmon recovery. Should they be treated as costs of the program, or should they be labeled as "re-distributions" of wealth which have no direct cost implications? From the perspective of agency or political decision makers, however, this labeling may seem opaque. To agencies, a budgetary requirement has the same operational meaning whether or not economists label it a cost or a compensatory payment. We think the correct procedure would be to establish a separate category for compensation that distinguishes it from economic cost. This report will identify estimated expenditures for compensatory payments where appropriate. We will not include such payments in a total cost estimate; but budget planners will want to include those payments in expenditure/funding plans.

2.3. Methodological Issues in Costing Recovery Team Recommendations

Accounting Stance

Two broad issues concerning "accounting stance" are (a) the geographic scope of economic effects considered, and (b) the baseline from which positive and negative economic effects are measured. The geographic scope can be narrow or broad, depending upon the focus of the study. For Snake River salmon assessment, we focus at the national level and at the level of the Pacific Northwest region. Except where significant portions of the direct costs or funding for species conservation or other affected economic activities are drawn from U.S. general tax revenues, most of the costs are expected to fall within the Pacific Northwest. The difference between national and regional will be unimportant for most categories of cost. Where we identify a specific case of divergence between national and regional costs, we will call attention to it.

An economic impact analysis could focus on narrower economic regions. For example, income and employment impacts of forest management options may impact rural logging communities, and options affecting availability of irrigation water may impact agricultural communities. Lack of harvestable salmon clearly affects Treaty tribes and gill net fishermen. Information regarding regional and local economic impacts is not yet available for the main salmon recovery recommendations, although this type of analysis is being developing in conjunction with the System Operations Review.

In gauging changes in economic activity, economists normally take the *status quo* as the baseline. For the Snake River salmon case, the relevant *status quo* is taken to be the level of economic production in each sector under river conditions prevailing before salmon recovery measures. Some people, however, would argue that *status quo* is not always the correct baseline. Past practice, legal mandates, property rights, and similar evidences of commitments to particular resource users or sectors could be considered also in selecting a baseline. For example, an individual having established a legal right to catch salmon in the Columbia River might consider changes needed to achieve fish runs supporting her catch to be a part of the baseline even though it is not part of the status quo. From this perspective, reduced electricity production due to salmon enhancement efforts should not be added into a "cost" estimate; instead the deficit in valued salmon should be considered a cost of continuing not to meet obligations. The Northwest Power Planning Act incorporates a commitment to provide "equitable treatment" for fish and wildlife in the Columbia River basin. To some salmon advocates, this means that the salmon have a property right of sorts to conditions necessary for their continued prosperity. So long as those conditions are not met, the system needs to be modified to achieve the mandate. Further, some would argue that economic costs should not be assigned to actions designed to meet pre-existing these mandates.

Despite these logical assaults on the procedure, we do take the *status quo* as baseline in our accounting stance. The reason is primarily practical. There are many overlapping and inconsistent statements of mandates and commitments to various affected parties in the Columbia basin. Past legislation has created mandates for flood control, reliable and economic power production, irrigation systems, and other system outputs besides salmon recovery. Furthermore, the federal courts and legislative bodies are actively considering decisions which could change the suite of mandates. Consequently, it is not practical for the study team to establish an agreed upon set of adjustments from the status quo that represent legal mandates. That such claims exist is undeniable, but there is much contention over the details.

Alternative Practical Measures of Economic Cost

In practice, where estimated market supply and demand curves for commodities affected by salmon conservation measures are poorly known or completely unavailable, approximations are used as substitutes for conceptually correct economic values. For example, some economic outputs affected by salmon conservation measures are sold commercially, but they are not sold at a competitive market price that covers costs of production. This is true of many commodities from Federal lands, hydroelectric power sold through BPA, and some agricultural irrigation water. In some cases the price paid does not equal marginal cost (as in electric power), or the price is set below market clearing price (as with grazing allotments on Federal land), or is based upon an incomplete measure of cost due to incomplete property rights (e.g., fees for recreational fishing). For example, the price paid for timber on public lands may not cover the costs of road building, sale administration, and other costs incurred by the US Forest Service. Ideally, we would carefully evaluate each case to devise a second-best valuation method approximating the economic value or cost. Because of the vast scope of measures and economic effects considered in the recovery effort, we can deal with only a few of these issues.

One approximation technique commonly used in hydroelectric power planning is the "replacement cost" method. In this case, a hydropower resource (or an amount of electricity generation) is assigned a value equal to the amount it would cost to replace the quantity with the least cost production technique. When a salmon conservation measure causes a loss of, say, 200 megawatts of annual hydropower generation (i.e., 200 MWa), the replacement cost is the cost of a replacement generation facility or of a firm contract to supply 200 MWa from a competitive supplier. The cost of new generation represents a system-wide marginal cost of replacing the lost supply of electricity. If the initial loss of 200 MWa is not accompanied by a decrease in generation costs (i.e., all costs are fixed, as is generally true of hydropower) then the replacement cost reflects the increment to total system costs. This replacement cost does not necessarily reflect the economic value of replacement power, however, unless consumer's place a value on that increment to power of at least the replacement cost.

To gauge the relationship between cost of replacement and value of replacement power we need to refer back to the demand and supply diagram. Electrical rates are generally established to cover average costs, which, in the Pacific Northwest, blends substantial amounts of low-cost hydropower with higher cost thermal generation. Given this price convention, the supply curve of power represents the average cost of power. Since new generating resource involve higher costs that the established hydropower plants, the marginal cost of new power is generally greater than the current price of electricity. In this case, the consumer's WTP to replace the lost power could be less than the replacement cost. The divergence between replacement cost and consumer surplus loss depends upon the elasticity of demand for electricity. With high price elasticity of demand (roughly meaning an almost horizontal demand curve), the consumer surplus loss would be much smaller than the replacement cost. With low price elasticity of demand (roughly a vertical demand curve) the consumer surplus loss could be very large relative to replacement cost.

When we average in the cost of the replacing power lost to salmon conservation, the average cost used in setting electricity rates would have to rise. Whatever the price elasticity of demand for electricity happens to be, as prices rise the quantity demanded would fall. To recognize this connection between demand (load level on the hydropower system) and incremental costs of replacing power, we construct a "net replacement cost" estimate. This is the cost of replacing only that portion of the lost power that could be sold at the higher rate caused by the hydropower system change. The System Operation Review study which we reference extensively in the section on hydropower system costs (Section 3.5) has produced estimates of replacement cost, net replacement cost, and consumer surplus loss.

The replacement cost method could also be used to measure the cost to irrigators of reservoir drawdown in the Snake River. Here the replacement cost would be the cost of obtaining the status quo quantity of irrigation water with lower reservoir levels (which increases pumping costs) or reduced total quantity of water from public irrigation projects. The correct measure of economic cost would be the reduction in producer surplus, i.e., the reduced net economic return to farmers due to curtailed water supply, which presumably equals the maximum amount that these operators would be willing to pay to avoid the drawdown. The producer surplus measure assumes that farmers optimally adjust their cropping patterns, irrigation practices, and irrigation systems to minimize the costs imposed. Instead, the replacement cost method assumes the same amount of water would be needed before and after. The replacement cost overstates the economic cost if the economic return to irrigated acreage is too low to justify the investment in pump modifications. Hence, while the replacement cost is a practical measure of potential economic loss, it is generally biased upwards.

Similarly, a replacement cost approach to assessing losses from interruption of river barging under a Snake river reservoir drawdown strategy would calculate the extra cost of transporting a constant amount of cargo on a given schedule with the reservoir drawdown. The problem with this approach is that it ignores substantial opportunities for rational re-adjustment of storage/shipping strategies which can reduce the overall costs substantially. In general, we try to avoid use of the replacement cost approach; applying instead economic reasoning to think through the system changes which are likely to follow a salmon recovery measure that interferes with previous resource use or business practice.

Real Versus Nominal Costs

Following standard practice in economics and project planning, we express all costs associated with potential salmon conservation measures in terms of real, inflation-adjusted dollars. Inflation distorts the apparent measure of costs over time, because it changes the purchasing power of the currency unit over time. Consequently, actual dollars expended on costs at different times will represent different real costs in the sense of purchasing power. Costs expressed in terms of current year dollar amounts are termed nominal costs. For example, the nominal price of gill-net salmon caught in the Columbia river was $0.93 per pound in 1985. Expressed in inflated 1993 dollars, the 1985 price would be $1.22. To adjust for the distorting effect of inflation on historic costs, we divide the nominal dollar amounts by a price index. The price index (or price deflator) accounts for the increase or decrease in purchasing power of the dollar over time relative to a base year. We adopt the convention that all costs and impacts reported in this document should be real costs based upon the value of dollars in 1993 (abbreviated "1993 $"). Estimated future expenditures or costs for salmon recovery will undoubtedly be consummated with currency that is further reduced in value due to inflation. Since we have no reliable way to estimate what future inflation rates will be, however, we simply express all anticipated future costs in terms of the base year 1993 dollars.

The Corps of Engineers routinely reports projected costs of future projects in terms of future nominal dollars as well as in base year dollars. For example, the SCS study reports "fully funded project costs" as the amount of nominal dollar funding needed to initiate the project in a future year. To calculate these future nominal dollar costs, the Corps must apply some hypothetical future inflation rates. The Federal Office of Management and Budget establishes standard inflation rates to be used in such calculations. While the resulting numbers are not comparable to cost estimates in base year dollars, they are probably better estimates of the amount that Congress would have to appropriate in the future to fully fund the project. For purposes of this report, we do not need to estimate inflation rates in order to plan future appropriations needs. Hence, we will report costs only in terms of 1993 dollars.

Present Value, Discount Rates, and "Annualized" Costs

If costs associated with salmon conservation measures occur at a constant rate per year, the costs of two alternative recovery measures can be compared simply by comparing annual real costs. However, while some measures may generate costs fairly evenly every year, other cost impacts may involves a very uneven pattern over time. Development of a hydropower facility, for example, involves first planning and design costs, then construction costs, and finally operating costs. Similarly, over a forty-year planning horizon for a thermal energy plant, the annual expenditures are much higher during the construction phase than during the normal operation phase. Further, different types of energy plants entail different levels of construction versus operating costs. It is standard practice in economics and project planning to place resources with differing capital and operating cost structures on a equal footing for cost comparison by using present values. The present value is the sum of future annual costs discounted back to the base period.

A discount rate, representing the diminishing current value of future costs or benefits, is used to convert costs in each future year back to an equivalent present value in the base year. With a discount rate of 3%, for example, the present value of a $100 cost occurring years hence would be \$100/(1+.03) = \$97.1. The present value of a \$100 cost occurring two years from now would be \$100/[(1+.03)(1+.03)] = \$94.25. If costs occur over fifty years, the present value will be the sum of fifty terms such as these:

$$\text{(2-1)}\quad \text{Present Value} = \sum_{t=1}^{50} C_t \left(\frac{1}{1+d}\right)^t$$

Costs occurring further in the future are discounted more heavily, as the compound term in the denominator becomes larger. The present value of costs over a similar planning period can be used to gauge the relative cost of two options. However, where the planning period (or "time horizon") differs between projects or options, a direct comparison of cost present values requires conversion to a consistent planning period. For example, if a hydropower project lasts 50 years, while a gas turbine generator must be replaced after 25 years, the correct procedure would be to compare the present value of the hydropower plant with the present value of 2 sequential gas turbine generator projects.

Power planners often adopt a different way to bring costs of different length projects into comparable terms. The procedure is called annualizing. The annualized cost of a project is the annual cost which would have the same present value as the actual project costs over time. The concept is similar to converting a large lump sum cost (such as constructing a house) into a periodic payment (a monthly mortgage). One can compare the cost of two houses by looking at their prices or by looking at the monthly payment required to pay off a 30-year loan. Similarly, one could compare costs of power projects or salmon conservation measures based upon their present values or upon their annualized costs. Taking the present value of costs as the principal on a loan, the annualized cost is like the annual payment required to pay off that loan (using an interest rate equal to the discount rate). The formula for computing the annual payment needed to pay off a loan principal of P over N years at r % interest is:

$$\text{(2-2)}\quad A = P\left(r \Big/ \left(1 - \frac{1}{(1+r)^N}\right)\right)$$

It is clear from Equation (2-2) that the annualized cost is proportional to the present value or loan principal. Since familiar financial quantities like personal income and agency budgets are expressed as annual amounts, it is natural to compare options and recovery activities in terms of annualized costs.

At other times, the use of simple annualized costs or present values can conceal important differences between programs, and this could be significant in evaluation of a salmon recovery plan. For example, a draw down of Snake River reservoirs to natural river level might not be possible until after 10 years of engineering and construction, while augmentation of flow from upstream storage reservoirs could occur relatively soon. The annualized cost of a flow augmentation program starting today and continuing into the indefinite future may exceed the annualized cost of a drawdown simply because the drawdown begins 10 years in the future and its present value is discounted for that period of time. A correct procedure would be to compare a composite program, including both near-term measures for 10 years and the time-delayed drawdown cost, to annualized cost of the flow augmentation alternative. Presenting annualized costs or present values of costs for programs covering different periods of time can confuse or misrepresent the relative costs of alternative measures, so we need to construct options that cover comparable periods of time.

The ranking of present values (or annualized costs) across options is affected by the size of the discount rate used. For example, with a low discount rate, a project involving large initial capital investment and small future annual costs (Project A) may have a lower present value cost than a project involving low initial capital costs but relatively large annual costs (Project B). But, with a high discount rate, Project B may have lower present value of cost than Project A. That is because the high discount rate will make delayed costs seem cheaper in present value terms. Hence, it is important to select an appropriate discount rate.

A substantial literature has addressed the issue of discount rate selection. Of special note is the volume by Robert C. Lind, Ed. (1982) on discounting for time and risk in energy policy. Further, NPPC's Northwest Power Plan (1991), which references Lind and other sources, notes that real, inflation-adjusted discount rates in use vary from 1 percent (for riskless investments) to 10 percent (recommended by U.S. Office of Management and Budget). The literature concludes that, while theory and practice do not yield precise guidance on discount rate choice, the appropriate "social discount rate" is based upon individual rates of time preference as reflected in after-tax, risk-adjusted savings and investment decisions. Long term evidence of investment in low risk assets suggests discount rates as low as 1 percent real. For a more typical level of risk, the long term, after-tax real rate of return on a "market portfolio" of investments is about 4.6%. The NPPC uses a social discount rate of 3%; while the US Army Corps of Engineers uses a discount rate based upon the cost of government borrowing. For fiscal year 1993, the federal discount rate was 8.25%. While choice of specific discount rates for evaluating project remains controversial, we suspect that the best estimate of the real social discount rate is 3%. The higher discount rate of 8.25% reflects a nominal rate of interest incorporating expectations of future inflation. Throughout this report we have adhered to the 3% rate. In Appendix C we report various agency estimates of system costs based upon both 3%.[1]

Baseline (Without ESA Action) Condition

As already noted, we must establish a baseline from which changes or costs are measured. This is termed the "without project" condition in a benefit-cost analysis. Any economic cost associated with salmon recovery represents a shift from a baseline economic value of production or an increase from the baseline value of inputs used to achieve a given level of output. The baseline assumed for each economic sector affected by salmon recovery actions demands careful attention. For federal agencies on the Columbia River, the conditions during 1986-90 water years represent operations that incorporate many measures to help salmon under the Northwest Power Planning Council's Columbia River Fish and Wildlife Program. This baseline would not include specific actions taken in 1992 and 1993 in response to the ESA listing of Snake River sockeye and chinook salmon. However, some of the RT recommendations add to actions already taken for Snake River salmon and are continuing. For example, we could view RT recommendations as incremental to increased flow, dam operational changes, and fishing restrictions incorporated in 1993 ESA Section 7 consultations. This baseline would result in lower cost estimates for

[1] In the draft version of this report (dated August 31, 1994) we presented annualized and capitalized costs of recovery actions for both the 3% and 8.25% rates. We are now convinced that the 8.25% government borrowing rate is not appropriate for assessing future agency costs in real 1993 dollars.

Recovery planning, but would result in an understatement of the overall costs of Snake River salmon recovery measures. Ultimately, the baseline chosen is somewhat arbitrary. For some of the cost estimates (e.g., those analyzed in the aforementioned SOR and SCS studies) it is necessary to quantify the costs using alternative baselines.

Baseline conditions in upstream salmon habitat areas are assumed to include the Federal land management (U.S. Forest Service and Bureau of Land Management) plans and practices. As with the river operations baseline, the variety of measures in various stages of implementation on the Federal lands makes the appropriate choice of baseline somewhat ambiguous. The Federal Ecosystem Management Assessment Team (FEMAT) 1993 guidelines, for example, include numerous measures designed to protect riparian habitats. If these are taken as separate from and preceding any measures specifically for ESA salmon, then associated costs of Forest Service actions need not be attributed to Snake River salmon recovery. Extension of FEMAT-type protections throughout the Snake River drainage, however, would likely involve extra costs. We use cost estimates provided by the federal agencies, which represent additional costs needed to assure protection of salmonid habitats for ESA listed species and others.

Another issue is implementation of federal Clean Water Act water quality guidelines which apply to salmon freshwater habitat. These actions are carried out by State water quality agencies, which do not always aggressively investigate water quality deterioration affecting salmon. Contamination from mine tailings and placer mining in salmon rivers, for example, are already regulated by the Clean Water Act. Where the regulations are not fully enforced, however, an increase in monitoring and compliance efforts to assist salmon recovery could entail additional economic costs for agencies and impose costly cleanup or preventive measures on operators. The question may arise as to whether additional enforcement of existing laws and regulations should be accounted as a cost of salmon recovery. We will not include these costs in our estimate.

Baselines for river navigation, recreational activity, and agricultural irrigation are all taken as recent past averages as reflected in official statistics of the relevant agencies. This seems a straightforward approach, but the reader should be aware that the recent past may be an unrealistic projection of without-ESA levels of service due to the dependence of these on weather, rainfall, and other economic conditions.

2.4 Economic Impacts or Multiplier Effects

Economic impacts are quite different from economic costs. While economic cost or benefit reflects a change in value of goods and services, economic impact is a measure of change in regional economic output (or sales), regional income, or employment due to an exogenous change (e.g., shift in resource availability, market demand, location of an employer, or government policy). Suppose a reservoir drawdown disables a boat launching ramp, diverting recreational boaters and fishermen from a favored recreational site. Reduced tourism and recreational activity could cause reduced sales of goods and services (motels, restaurants, gas stations, bait shops) in a neighboring community. The economic cost of the reservoir drawdown would be measured as the loss in value of recreation to the recreationists. The economic <u>impact</u> on the nearby community could be measured as the loss in total sales, or personal income, or employment in the community. Clearly, economic benefits/costs are an entirely different concept from regional economic impacts, and they are measured using distinctly different data and models.

The economic value of the reservoir for fishing (recreational value) would be measured as the area under a recreational fishing demand curve for that site. Even though other substitute sites may be available, recreational fishermen would be willing to pay some amount to have the original reservoir available to them. This value is lost when the reservoir is removed from the site of available fishing sites. Hence, the consumer surplus loss is the economic loss which would be accounted for in a benefit/cost analysis. From the perspective of the recreation-based community, however, the lost economic value of recreation may be of no interest; the regional economic impact would be more important for local economic planning purposes. The prosperity and stability of the community may be adversely affected by loss of recreational business. However, the recreational participants are unlikely to simply burn the money not spent in the impacted community; their expenditures will be shifted to other locations. Thus, while local or regional economic impacts are of great concern to the community most affected by the salmon conservation measure, changes in location of recreational and other activities will often cause off-setting impacts in other communities. From a national or inter-regional perspective, therefore, economic impacts are not equivalent to real economic costs or benefits. The shifting sales volumes, incomes, and employment among regions do not measure net economic costs.

Two kinds of economic impact can be estimated using regional economic models. These are direct (or primary) impacts and indirect (or secondary) costs. Direct output (or sales) impact equals the increase or decrease in value of final goods and services produced in economic sectors directly affected. By the usual conventions of income and product accounting, the final value of goods and services will equal the associated factor payments plus purchases of inputs from outside the region. Regional income equals the wages, rents, and profits earned by inputs used in regional production. Hence, the regional income impact will be a fraction of the regional output impact.

Secondary impacts, sometimes called "spillover" effects or (confusingly) secondary benefits, are reductions in value of goods and services occurring in economic sectors related to the direct economic sectors. Related sectors include "forward linkages", those sectors which purchase from the directly affected sector, and "backward linkages", those sectors which sell inputs to the directly affected sector.[2] Using the example of the reservoir drawdown, reduced sales of goods to recreational visitors results in a direct loss of output and income in directly affected sectors (motels, restaurants, bait shops). Secondary impacts will occur as these local businesses purchase fewer goods from local suppliers and local workers spend less on locally supplied items.

There is no necessary linkage between secondary impacts and net national benefits. For example, negative economic impacts in a town distressed by reduced US Forest Service timber sales will be balanced to a large extent by expansion in other logging communities or in communities producing substitute building materials. One community's secondary negative impact is linked to another community's positive secondary impact. The "other community" is likely to be a geographically dispersed and diffuse group of people, while the losers are often

[2] A more thorough discussion of these issues is available in Joel R. Hamilton, Norman K. Whittlesey, M. Henry Robison, and John Ellis (1991).

concentrated in the specific community. Hence, the negative economic impacts of many salmon conservation measures may be acutely felt in specific communities. Inclusion of secondary costs for only those communities most directed impacted, however, would cause an overstatement of net economic losses. As already noted, income and employment lost in one sub-region would likely be gained in another sub-region or outside the region, thus making the "regional economic impacts" a duplicative and inaccurate measure of economic costs. Further, other economists contend that we should be measuring the economic costs of causing people and businesses to adjust to changed economic conditions. The transition from the before to the after condition will take a discrete amount of time, and the costs of that transition are not necessarily reflected in the I-O based employment and income effects. This last viewpoint seems theoretically strong, but the models and data necessary to accomplish the analysis are not readily available.

The Systems Operation Review being carried out by the Corps of Engineers, Bureau of Reclamation, Bonneville Power Administration includes an updated regional input-output model based upon the Forest Service's IMPLAN system. These models permit estimation of direct and indirect impacts of changes in the four-state region and in sub-regions of the Pacific Northwest. The analysis provides first-cut estimates of initial shifts in regional income and employment caused by changes in the operation of the river facilities. In responding to the perceived need to measure the economic impacts of Snake River salmon recovery actions, we will summarize available input-output type impact assessments. But, we recommend caution in forecasting actual future economic cost from these simplified models.

2.5 Cost Effectiveness

A full economic analysis of salmon conservation measures would assess both costs incurred and benefits enjoyed due to salmon recovery. A less comprehensive economic analysis stops short of measuring benefits, instead evaluating costs and effectiveness for various options. This approach seems appropriate to evaluating actions under ESA, where the objective of recovery is not being questioned. One version of cost-effectiveness analysis would focus on the ratio of cost to effectiveness of each recovery measure. Selection of recovery measures could proceed by first adopting the measures with higher ratio of effectiveness to cost. Another approach to cost-effectiveness analysis examines the choice of a mix of options designed to achieve the maximum total effectiveness for a given expenditure or cost. The question is: if we decide to spend $150 million per year on salmon restoration, what set of programs gives us the most restoration (e.g., largest increase in run sizes or most ESUs)?

Several different measures of biological effectiveness have been examined. A measure relevant to the ESA mandate to avoid species extinction is the likelihood that the salmon stock would survive over the long run. Because population survival probability is extremely difficult to quantify, more narrowly construed measures are adopted by analysts in practice. Among these are: (1) predicted salmon population trajectory over an arbitrary number of years (see NPPC report "Summary of Council Staff Analysis of Biological Benefits, River Operations, and Costs of Mainstem Passage Amendment" dated December 9, 1994); (2) predicted one life-cycle change in number of spawning adult salmon, which may be indicated by a smolt-to-adult survival rate (see Olsen 1992,or Appendix A of Huppert, Fluharty, and Kenny. 1992); (3) survival during a single stage of the salmon life cycle such as downstream or upstream migration; (4) the decrease in travel time for migrating smolts (see Willey and Diamant, 1994).

Ultimately, the array of effectiveness measures appropriate to the threatened and endangered species of Snake River salmon needs be established on a system-wide basis by knowledgeable biologists and ecologists. Unfortunately, there are a multiplicity of methodologies for predicting effectiveness of salmon conservation measures, each yielding a different perspective. Several intensive research efforts have developed computer models to predict effects of hydropower system operations on salmon survival in the river. These models include: the Columbia River Salmon Passage model (CRiSP 1) developed at the Fisheries Research Institute at the University of Washington; the Passage analysis Model (PAM), developed by the Northwest Power Planning Council; and the Fish Leaving Under Several Hypotheses model (FLUSH) developed by the Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, Washington Department of Fisheries and Wildlife, and the Columbia River Intertribal Fish Commission (which are often referred to as State and Tribal Fishery Agencies, STFA). Life cycle models have been developed to track salmon from the gravel bed or hatchery back to the river as mature adults. These models include: the Stochastic Life Cycle Model (SLCM), developed by Resources for the Future for the Bonneville Power Administration; the System Planning Model (SPM), developed by NPPC; and the Empirical Life Cycle Model (ELCM) developed by STFA. The models provide somewhat different results, and each inspires support by its developers. Apparently, the various models do not differ radically in their predictions when initialized with the same conditions and assumptions.

These models have been used to provide measures of effectiveness for the System Operation Review, the System Configuration Study, and for the Salmon Recovery Team deliberations. The SOR analysis examined the in-river survival and ultimate returns as adults for various operating strategies. The Recovery Team focused on the relative in-river survival rates achieved under different configurations of the hydropower system, including drawdowns, in-river migration, and smolt transportation. More recently, the University of Washington's CRiSP model has been updated and applied to various salmon recovery options in Olsen and Anderson (1994). The Willey and Diamant (1994) have ranked a number of Snake River salmon recovery alternatives by the ratio of cost to downstream migration travel time reduction. Generally speaking, the results of these modeling exercises can be used to help structure the priorities for various recovery options, but the Recovery Team warns against using them to calculate a cost-effective policy. The Recovery Team chair notes a lack of adequate information to properly specify the models; in particular the reliance of model builders on disparate assumptions concerning the relationship between flow rates and smolt survival and concerning the relative survival rates of smolts that are transported versus those migrating in-river. Because of the great uncertainties apparently involved in modeling salmon conservation effectiveness under alternative river system changes, we do not endorse any particular results. However, we have provided a brief summary of some of the cost-effectiveness results in an appendix to this report.

After explicit measures of biological or ecological effectiveness are carefully identified, the economic costs can be used rationally to select from among a myriad of management measures. Without a solid analysis of biological effects, development of management measures for recovery plans based upon unclear goals and incomplete criteria would be a recipe for squandering substantial resources. Little purpose could be served by development of an expensive "fix" to habitat problems based upon faulty knowledge of the linkage between habitat and salmon population size. Hence, the most important role for the economic information presented in this report is to guide selection of alternative management measures based upon economic costs and biological results. To accomplish this will require additional research and experimentation concerning the biological effectiveness of proposed conservation measures as recommended by the Recovery Team. The need for more biological research is not a reason to avoid immediate actions, but it does suggest that immediate and near-term salmon recovery actions need to incorporate scientific research objectives.

2.6 Economic Benefits of Snake River Salmon Recovery

It is plain that economic benefits will be enhanced when and if the Snake River runs are recovered. The magnitude of those economic values for Snake River salmon is not so easy to determine. The difficulties are three-fold:

(1) The term "recovery" has many meanings. The economic benefit of returning the Snake River endangered salmon stocks to a minimal level for survival would be much smaller than the benefit of returning them to 1.5 million fish per year, the level reported to be the highest historical returns. Some observers are anticipating a return to high levels of harvest; the ESA requires only recovery to a level not threatened with extinction.

(2) The economic benefit associated with any level of recovery includes both use and non-use values, neither of which can be measured accurately with available information. Use value estimates (e.g., value of commercial and recreational fishing) are available for Columbia River and ocean fishing for salmon in general. Non-use (sometimes called passive use) value has been estimated for some specific salmon stock improvements. It is unclear whether these estimates can be transferred to the specific stock recoveries anticipated under the Recovery Plan.

(3) Some people hold spiritual or cultural values which, they say, transcend the mundane economic values. Economic values are based upon payment for or compensation for changes in availability of environmental characteristics. The spiritual/cultural "values" do not conform to the usual notion of economic value, and the people expressing these values are often hostile to the notion that salmon can be economically valued or traded off against costs. This difficulty for economic evaluation is largely one of perceived relevance and cannot be overcome through perfecting technique or data.

If the first issue is resolved by limiting discussion to recovery under the ESA, then only small use values would be attached to recovered Snake River salmon. However, harvest restrictions which prevent taking of endangered Snake River fish may curtail fisheries targeting other stocks of salmon. Recovery of the endangered stocks may enable greater utilization of the other non-endangered stocks. Further, the kinds of systematic changes recommended for the Columbia River are expected to cause significant increases in both the endangered and other fish stocks. The main fisheries affected would be the lower Columbia River gill net fishery and ocean troll fisheries off Washington and northern Oregon. As shown in Chapter 3, the ten-year average gross sales of commercial salmon are about $11 million for the troll fishery and $7.3 million for the non-treaty gill net fishery. The treaty gill net fishery in the river is of great cultural importance (and legal obligation), and has generated an average of $2.1 million in ex-vessel value over 1982-91. Further, the Columbia River contributes some fish to commercial fisheries in Canada and Southeast Alaska. Recent commercial ex-vessel values per chinook for ocean troll and river gill net combined have been about $30 per fish. The ten-year period covered was one of relatively low salmon runs, suggesting that a recovered salmon economy would be of much greater value. These observations suggest that commercial fishing value enhancement due to a substantial Snake River salmon recovery (i.e., recovered to, say, a hundred thousand harvestable fish, not just recovered to non-endangered status) is likely to be several million dollars. For example, a one hundred thousand increase in harvestable fish in the Columbia River would generate about $3 million in exvessel value. To properly value the increased fishery, we would need to subtract incremental capital and operating costs of fishing fleet, hatcheries, and harvest management programs from the gross value of fishing. Since the fishing fleet, hatcheries, and management programs would likely not need significant expansion to accommodate the size of fish run enhancements envisioned, the net increase in economic value would be nearly equal to the gross increase.

The recreational fisheries for salmon and steelhead in the ocean, the Columbia River estuary, and the river system itself have great economic value. Relatively recent estimates of recreational and existence (non-use) values for salmon in the Pacific Northwest are provided by Olsen, Richards, and Scott (1991). Using survey methods similar to those applied in other recreational and existence value studies, these authors examine the value of doubling the size of Columbia River salmon and steelhead runs. They report a range of average and marginal net recreational values for salmon as follows:

Table 2.6-1 Economic Values for Recreational Salmon Fishing

	Average Net Value per Trip	Marginal net value per trip of Doubling salmon runs	Average Net value per fish caught	Marginal Net Value of Doubling Runs per fish
Salmon Location:				
Puget Sound	$75.88	$26.89	$51.27	$18.17
Washington-Oregon coast	89.47	54.31	41.61	25.26
Coastal rivers	58.39	25.55	36.72	17.81
Columbia River Basin	111.46	45.07	45.68	18.47
Steelhead location:				
Coastal rivers	59.58	23.21	64.06	24.96
Columbia River Basin	$90.08	$37.29	$132.47	$54.84

Source: Table 4 (p.53) D. Olsen et al. (1991).

Two important characteristics of economic recreational values are illustrated by this table. First, the value of fishing (i.e., value per trip) and value of fish (i.e., value per fish caught) vary widely among locations. Even the locations designated for this particular study are highly aggregated over fishing sites, modes (e.g., shoreline, private boat, chartered boat) and seasons. Hence, we know that when and where the salmon are available has a good deal of influence on the economic values generated. Second, there is a significant difference between average value per salmon caught and marginal value generated by an increase in number of salmon available to be caught. For recreational salmon in the Columbia River basin, for example, the value of doubling the runs from current size (as of 1991) is about 1/3 the average value per salmon with existing catch rates. This empirical result is very consistent with what economic theory would normally predict. It means that further enhancements must be assessed on their incremental or marginal contribution to economic value, not on their average values at current levels of abundance.

The Olsen, Richards, and Scott study also investigated values held by non-users, defined as willingness to pay for doubling of Columbia base salmon runs.[3] Extrapolating from the sample to all Pacific Northwest households permits division of people into three categories: (a) no probability of future use (1,599,360 households), (b) non-users with some probability of future use (304,640 households), and (c) users of salmon (1,496,000 households). The average non-use values per household were $2.21 per month ($26.52 per year), $4.88 per month ($58.56/year), and $6.18 per month (74.16/year) for the three classes of households respectively. Extrapolating from the sample to all households in the region, the total non-use value for doubling the Columbia River basin anadromous fish runs was estimated to be about $170 million. These non-use values pertain to the Columbia basin as a whole, and are not attributable soley to the Snake River, because rather pertain to the all the Columbia Basin salmon runs.

Another piece of information concerning the public's willingness to pay for recovery of Pacific Northwest salmon runs was provided by the Elway Poll of May, 1994. Elway is a local Seattle survey firm which periodically surveys Washington State registered voters across congressional districts. One of the many questions posed in the poll asked whether respondents were willing to pay at least $1 per month more in electric bills "if you thought it would help restore salmon". A follow-up question asked whether they would pay $5 per month. Responses were tabulated as follows:

Table 2.6-2 Response to Elway Poll

Category of Response	Willing to Pay $1/month?	Willing to Pay $5/month?
No Answer	9%	16%
Yes	73%	39%
No	18%	52%

As with the Olsen et al. estimates, these responses do not pertain specifically to the Snake River salmon recovery. Further, the Elway survey question does not distinguish between use and non-use values. They do reaffirm that the magnitude of values attached to recovery of salmon, are likely somewhere in the neighborhood of $1 - $5 dollars per month per household. Whether people would be willing to pay this much for recovery of the three endangered species in the Snake River is unlikely. The total recovery values discovered by the referenced studies entail much broader salmon runs.

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[3] Also reported in the study were estimates of willingness to accept compensation. We do not report those numbers here due to the high refusal rate for those questions.

The impressionistic result of this review is that a significant increase in Snake River runs will directly generate several million dollars worth of commercial and recreational fishing, and it may also account for a significant portion of the estimated $170 million non-market value the Region's citizens attach to expanded Columbia River salmon populations. This review of recent information on salmon fishing values and existence values may be useful in putting the recovery values in perspective, but it does not provide specific, quantitative information needed to support a thorough benefits assessment of the Snake River recovery effort. Perhaps the responsible government agencies will devote some effort in this direction in the future.

3. 0 Estimated Costs by Category of Recovery Action

Using the economic cost assessment methodologies discussed in Section 2 of this report, the specific recommendations of the Recovery Team are examined in the following eight sub-sections; institutional changes and monitoring, protect and restore spawning and rearing habitat, improve freshwater production of chinook salmon, improve freshwater production of sockeye salmon, improve survival of downstream migrants, limit harvest, reduction of predation-competition, and improvement of adult passage and survival through dams and reservoirs. While these are dis-aggregated for purposes of analysis, the fundamental purpose of the RT recommendations is a comprehensive strategy of linked study and action to promote recovery of ESA listed species of salmon.

3.1 Institutional Changes and Monitoring

The RT recommends that: (1) the NMFS be placed in charge of ensuring that management of the Columbia River basin salmon fisheries is carried out in a coordinated manner; (2) a Salmon Oversight Committee be established; (3) working subcommittees be established; and (4) a comprehensive monitoring and evaluation program be instituted.

Each of these recommendations results in additional costs. The federal government will likely bear most of the costs but tribes, state agencies and, potentially, private commercial, sport fishing and environmental groups involved in the processes of salmon management may also incur costs associated with participation in new institutional measures. We focus chief attention on costs to the federal government as these appear to be the major incremental costs in terms of institutional initiatives to increase coordination. To the extent the NMFS and its working groups can build on existing processes or shift existing efforts into a more effectively coordinated system for salmon management cost savings may result to offset other additional costs.

Place NMFS in Charge.

The RT recommendation to place NMFS in charge of salmon management in the Columbia River basin requires additional staff to provide administrative and financial support for the Salmon Oversight Committee (see below), develop a comprehensive data and information system, and produce authoritative decisions. While some of this work could come from reassignment of personnel, it appears to involve incremental change from current levels of staffing. In other cases of ESA listings, e.g., the spotted owl and the Klamath salmon, the NMFS staff working on the listing, Section 7 consultations and other recovery planning work is available to shift to staff implementation of the Recovery Plan. In the Snake River salmon case, new proposals for listing of additional species of salmon make it unlikely that staff currently engaged in ESA work could shift to this implementation function.

It is assumed that the SOC would have a minimum life time of 8-10 years (2 salmon life cycles) and likely longer. It is difficult to assess impact of having the NMFS in charge of salmon management in comparison to current management by tribes, states and federal entities. However, the RT recommendations are made with the intent to improve conditions for listed stocks of salmon.

Annual operating costs of placing the NMFS in charge including staff salaries, operations, travel, and office rental are estimated at $448,200. One-time equipment costs are estimated at $52,100 (1993$)[1] which amortized over a period of 20 years results in annual cost of approximately $3,500 using a discount rate of 3%. These estimates are not adjusted for inflation. (See Appendix B for detailed estimates). Given the likely life of the added NMFS responsibilities, equipment costs are probably underestimated, because no replacement costs are included.

Salmon Oversight Committee.

The RT envisions the establishment of an independent five-member Salmon Oversight Committee which will set priorities for funding recovery measures, ensure use of best possible scientific information, broker disputes, gather information, and coordinate with all affected parties. The SOC would consist of highly competent proven fishery professionals appointed by Congress to serve for a limited period of time. The SOC would have its own staff, to assure its independence, but it would receive some administrative and financial (e.g., accounting) assistance from the NMFS salmon management group described above. The SOC would have the capability to contract for necessary research and peer review. The RT recommends that the SOC provide an annual report to Congress on salmon recovery. The minimum life time of the SOC is likely to by 8-10 years (2 salmon life cycles) and probably considerably longer.

Annual costs of the SOC staff salaries, operations, travel, and office rental are estimated to be $1,436,100 and one-time equipment costs are estimated to be $89,800. If equipment costs are amortized over 20 years this results in an annual cost of about $6,000 using a discount rate of 3%. (See Appendix B for detailed cost estimates).

Subcommittees and Working Groups.

The RT recommends that at least six subcommittees or working groups be established for such topics as salmon population dynamics, habitat, hatcheries, natural production, genetics, and fish culture and health. In addition, other such groups can be established as needed.

In making cost estimates for the NMFS management function and the SOC, we included estimates of the incremental coordinating and staffing roles each would play for these committees and working groups. NMFS and other federal agencies, tribes, States and entities like BPA and NPPC already are engaged in work in many of these areas, albeit not necessarily specifically devoted to issue of salmon recovery. Groups are already constituted for sockeye salmon and for hatchery operations (BPA 1994). Because the RT intends to build on existing efforts, where possible, and because the subcommittee work is seen to be a reallocation and re-focusing of ongoing efforts, incremental costs are not expected to be large -- perhaps on the order of $100,000 - $200,000 per annum exclusive of those mentioned above. This estimate might be doubled under the assumption that the SOC and NMFS would convene new subcommittees or working groups on topics heretofore not receiving attention. Thus, a plausible estimate of economic costs in this area could be $300,000 per year.

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[1] Estimates for institutional recommendations were made with the assistance of Randy Cross and his staff in the NMFS Northwest regional Office in consultation with the project Team. They are based on federal salary and job rating categories as well as real costs of operational and office space currently occupied by NMFS.

Monitoring and Evaluation for Adaptive Management.

A key element of the RT recommendations is monitoring and evaluation of recovery actions in order to gain information for use in making further decisions by the SOC and NMFS. Recommended monitoring actions are replete throughout the RT report. Monitoring and evaluation programs do exist at present but only for limited parameters associated with water quality regulations, stock estimation, etc. These programs provide useful information under specific research programs and for limited areas. However, relatively few are oriented to recovery of ESA listed species. Most significantly, the RT charges NMFS with development of a database to include data resulting from monitoring. This implies a development of a comprehensive monitoring protocol, although the protocol is not specifically noted in the RT Plan. Further, there is a lack of specificity for the scale and detail of this activity. There is only a partial identification of what is expected to result from development of incremental monitoring and evaluating actions.

A comprehensive, coordinated monitoring and analysis program could reduce any duplication, if any, in present programs and might result in a more efficient monitoring system design than the present ad hoc and sometimes competing efforts. These improvements could result in cost savings. It is beyond the scope of this report to develop a monitoring program and to determine if existing efforts by multiple agencies are adequate. Clearly, the RT considers the present efforts to be lacking with respect to listed species of salmon under the ESA. Therefore, it is apparent that significant efforts are required to achieve RT objectives. Equipment, personnel, laboratory, and analysis costs are likely to be major, if all requirements of a comprehensive program are to be met, and especially, if the adaptive management approach recommended by the RT is implemented. Adaptive management requires substantial expenditures for monitoring; and it fails when funding is not provided to perform monitoring and evaluation in the iterative fashion of that method.

Thus, incremental monitoring costs of $10 million per year for ESA listed salmon would not be an unreasonable estimate when one considers cost of current monitoring efforts by tribal, state and federal entities such as fish counts at dams, redd counts, tagging program follow-up, harvest landings, etc.

In summary, annual costs of implementing the RT's institutional and monitoring recommendations for ESA listed salmon in the Columbia River basin are estimated to be in the vicinity of $12.2 million. See Table 3.1-1.

Table 3.1-1 Estimated Costs of RT Recommendations for Institutional Change

No	Description of Item	Scope of Action	Annual Costs 1,000s 1993 $
1	NMFS in Charge+	Annual, Ongoing, Indef.	$448.2
	Equipment Purchase	Capital costs amortized over 20 years @ 3%	$3.5
2	Salmon Oversight Committee+	Annual, Ongoing, Indef.	$1,436.1
	Equipment Purchase	Capital costs amortized over 20 years @ 3%	$6.4
3	Committees/Working Groups+	Annual, Ongoing, Indef.	$300.0
4	Monitoring of ESA Listed Species Recovery+	Annual, Ongoing, Indef.	$10,000.0
	Total	**Mix of Scopes**	**12,194.2**

+ Cost includes costs listed in other sections.
Source: See text infra.

3.2 Protect and Restore Spawning and Rearing Habitat

In the Columbia Basin, some 60% of the remaining anadromous habitat for all salmon species is within federal ownership. Private and state lands contain approximately 40 % of the anadromous habitat(NPPC 1992). More than 80% of the Snake River salmon of all species are produced on spawning and rearing habitat on lands managed by the US Forest Service (USFS) and the Bureau of Land Management (BLM). In part, this is a function of the existence of high quality habitat in some headwater streams on federal lands as well as the extensive nature of federal land holdings in the area. Anadromous watersheds occupy about 52% of the total acreage managed by the USFS and BLM in the Snake River area (USDA/FS - USDI/BLM 1994). This amounts to 13.3 million acres. (See Table 3.2-1). No breakdown of habitat occupied by the ESA listed species is available.

This section primarily refers to the salmon habitat in the Snake River and its tributaries where ESA listed species of sockeye and chinook salmon exist. Mainstem Columbia River habitat recommendations of the RT for water intakes and diversions are the only habitat issues treated from outside the area. The RT recommends that measures developed under the FEMAT (1993) Aquatic Ecosystem Assessment chapter , PACFISH (1993), and the report of the Eastside Forest Scientific Society Panel (1993) be applied to management of salmon habitat in the Snake River basin. The habitat management measures called for in these reports, already being implemented to some extent, may significantly expand on the policies and standards of the NPPC (1992) Strategy for Salmon according to the RT. In addition, the RT calls attention to the potential of the results of the Eastside Ecosystem Management Project (commenced in 1994) to influence future land management decisions. It is possible that the analyses below overstate the costs of measures attributable to ESA salmon species in the Snake River.

All of the general habitat management policies and standards, to which the RT refers, would apply to all salmon habitat in Critical Habitat for the listed species. The RT does not call for additional habitat protection or recovery measures to protect listed species although its recommendations to plan and prioritize actions might result in habitats occupied by listed species receiving earlier and higher levels of attention than other areas. The lack of specificity about the type of measure to be applied for salmon habitat management makes it difficult to assess the economic cost of the measures. This problem, coupled with that of differentiating costs associated with recovery measures, if any, from general measures to be applied to all species, makes for added difficulties. The final analytical issue is how to evaluate the cost of "voluntary" measures to be taken on private and state lands as recommended by the RT apart from the federal planning mentioned above. This issue is not addressed here as the study was restricted to measures taken on federal lands.

The approach to assessing the economic costs of the RT recommendations adopted for this section is to display the economic costs as developed under PACFISH. PACFISH analyses show a range of impacts from full loss of recreation, timber and range outputs to various levels of mitigation deemed feasible by USFS personnel for each anadromous watershed. As such, considerable latitude was available to USFS managers in determining how they might respond to various management scenarios, i.e., to mitigate or not to mitigate for adverse effects. In the

PACFISH analysis a four percent discount rate is used which differs slightly from the three percent used elsewhere in this document. The difficulty of properly redoing the PACFISH analysis and the potential confusion from two sets of numbers mitigates against altering the USFS analysis, however, we have modified decadal values to obtain an annual value that is more or less consistent with other values presented here. (Technically, the USFS allocated higher costs to the early years of the decade but we assumed a constant cost for the decade. The differences probably fall well within the bounds of error for the estimate).

A further caveat is necessary as data for range, timber and recreation are for fair market values not consumer surplus. Depending on the shape of the demand curve, these values can be about the same (i.e., assuming a horizontal demand curve) which may be the case for range and recreation.

Table 3.2-1 Amount of Anadromous Watershed on USFS and BLM Lands in Snake River

State/Administrative Unit	Size of Administrative Unit	Anadromous Watersheds	Anadromous Watersheds as % of Administrative Unit
	Million Acres	*Million Acres*	
Idaho			
Boise NF	2.3	0.7	30%
Challis NF	2.5	1.6	64%
Clearwater NF	1.8	0.8	44%
Nez Perce NF	2.2	2.0	91%
Payette NF	2.3	1.7	74%
Salmon BLM	1.2	1.0	83%
Salmon NF	1.8	1.7	94%
Sawtooth NRA (NF)	0.8	0.3	37%
Oregon (WA)			
Umatilla NF	1.4	0.5	36%
Wallowa-Whit.NF	2.4	1.7	71%
Prineville BLM	1.6	1.2	75%
Vale BLM	5.2	0.1	2%
TOTAL	25.5	13.3	52%

Source: USDA/FS, USDI/BLM 1994. Environmental Assessment for the Implementation of Interim Strategies for Managing Anadromous Fish-Producing Wastersheds in Eastern Oregon and Washington, Idaho, and Portions of California. Washington, D.C. Appendix B. p. B-1.

Subsequent to the release of the RT report in May 1994, several court decisions speak to the restrictiveness of habitat measures that may be required to restore habitat -- especially the 9th Circuit Court of Appeals injunction against livestock grazing, logging and road building on the Wallowa-Whitman and Umatilla National Forests. This decision, at least in the short run, requires the USFS to cease certain land uses in order to protect salmon habitat. Management measures to mitigate for grazing and timber harvest are not allowed by this ruling, although such actions go beyond that expected by the RT. Thus, there is an immediate change in grazing and timber harvest revenues and levels of commodity benefits independent of the RT recommendation for Snake River salmon.

The principal recommendations of the RT with regard to habitat measures are discussed under following the headings:

1. Moratorium on Degradation
2. Formation of a Habitat Subcommittee
3. Assessments of Habitats and Prioritization for Protection and Restoration
4. Implementation of Habitat Protection and Restoration
5. Long-Term Sub Basin Habitat Management Planning.
6. Habitat Protection and Restoration for Sockeye Salmon

Moratorium on Degradation

This action recommended by the RT would allow no measurable degradation of spawning and rearing habitat for salmon. Careful reading of the recommendation reveals the intent to not preclude habitat disturbing activities in the watershed as long as they do not affect salmon. This management objective is to be achieved through local application of FEMAT, PACFISH and Eastside Ecosystem Scientific Panel measures to protect and restore habitat. The effect of this action for federal lands reinforces but is indistinguishable from actions called for in the habitat recommendation for implementation of protection and restoration. Therefore, costs associated with the measure are discussed in sections 3.3 and 3.4 below.

Formation of a Habitat Subcommittee

The RT recommends the appointment of a Habitat Subcommittee to advise the NMFS and other agencies on priority measures to protect and restore habitat. The RT recognizes that there are existing committees composed of federal, tribal, state and other officials already engaged with habitat analysis and planning under various authorities. Members of these existing committees could form the core of the Habitat Subcommittee. The RT would build upon, rather than compete with, existing habitat efforts. Recovery Team recommendations place highest priority on recovery of listed salmon species. This may represent a change in present action priorities but would not necessarily impose a major increase in scope or activity of the existing committees.

It is very difficult to estimate the required response to the RT recommendations without more detailed descriptions of expected actions. In addition, this planning and prioritization work is to be completed relatively quickly after appointment (6-9 months). Thus, we deem that costs associated with the staffing and convening of a Habitat Subcommittee, from the NMFS standpoint, are included in the Institutional measures discussed above, i.e., cost of one working group at approximately $50,000 yr. Additional emphasis on ESA listed species may distort or delay the normal work of existing committees established under other authorities if no increase in staffing is anticipated and this could constitute a cost. In contrast, it may be possible to argue that measures taken to assist in recovery for Snake River sockeye and chinook salmon may benefit other species as well.

Assessments of Habitat and Prioritization for Protection and Restoration.

These assessments are to be performed as the first order of business for the Habitat Subcommittee. Presumably the Habitat Subcommittee, when constituted, will draw on research done for the RT as well as all of the other on-going programs for assessments. The chief difference in the process is the ranking of protection and recovery projects in light of the listed stocks. The RT clearly is asking that these efforts be ranked to improve the river habitat that benefits stocks of listed salmon. This probably represents marginal adjustment in the existing sub basin evaluations - not wholesale recasting of the programs. Because this ranking task is assigned to the Habitat Subcommittee, the economic costs of this action are considered to be covered by the discussion above.

The RT recommends that the Habitat Committee assume that the financial and human resources are available to implement and monitor actions based on the habitat prioritization. Because the actions are not specified at this time, it is not possible to assign an economic cost. To the extent that reprioritization for ESA listed species of salmon results in reprogramming of existing funds, this would not constitute an incremental cost due to Recovery since the overall commitment of funds was to improve salmon habitat. Depending on the Habitat Subcommittee determinations, significant implementation funding may be required and, most certainly, monitoring costs would be commensurate. These are discussed in further detail in the long-term sub basin planning (see below).

Implementation of Habitat Protection and Restoration Actions

The chief RT recommendation to end degradation of salmon habitat is the only habitat measure that has been partially assessed for the Snake River Basin. In this section we examine the assignment of economic costs for habitat protection. Restoration measures, except those occurring naturally though time, are not indicated in sufficient detail to assess at this time. The possible costs of investing in closure of roads, stabilization of eroding slopes, and other similar measures that would result from further analysis for site-specific restoration actions, are not addressed here.

Habitat protection may require the cessation of some on-going or planned activities on private and public lands. On private lands, the RT calls for voluntary efforts to mitigate or avoid the impacts. On public lands the RT would allow habitat disturbing activities to continue subject to a non-degradation criterion. Indications from recent court cases suggest that more stringent measures, i.e., complete halt to habitat disturbing actions may be required. Therefore, this section examines the incremental nature of costs of habitat protection with respect to salmon recovery for the categories of 1.) irrigation diversions, 2.) grazing and stock holding, 3.) water quality and forest practices, 4.) mining and other developments, 5.) recreation, 6.) migration corridor activities, 7.) law enforcement, and 8.) habitat research and monitoring.

1. Irrigation Diversions

The RT indicates that screening and stream flow are both important considerations relative to irrigation (and other water intakes) diversions and recovery of ESA listed salmon. The RT calls for effective screening of water withdrawals and periodic inspection and maintenance of screen systems. According to state laws in Idaho, Oregon and Washington and federal regulations (e.g., US. Corps of Army Engineers requirements for pumping stations) , all water withdrawals in salmonid habitat are supposed to be screened to at least the standard specified by the RT. Screen construction and operation and maintenance programs are in operation in these states funded by states, federal and regional sources.[2] The fact remains that many withdrawals are neither screened nor are screens maintained in working order. There is a significant backlog in terms of design, construction, operation and maintenance as well as enforcement in the water diversion programs. Therefore, in order to meet the minimum objectives of the RT recommendation with respect to fish screens on diversions, significant costs would be incurred.

Estimates of the costs of remedial measures to bring the diversions into compliance were made in an earlier report (Huppert et al. 1992). Because proper screening to protect fish was a requirement of state and federal law prior to the RT recommendations, we take the position that it does not constitute an incremental cost of recovery actions. We acknowledge that the costs may be significant and that the recovery program for ESA listed species provides additional impetus for compliance. Still, the benefits of a program are shared by all salmon and other species resident in the rivers from which water is withdrawn. Therefore it constitutes part of the base case from which protection and restoration measures should be measured and not an incremental cost due to ESA.

2. Grazing and Stock-Holding

Grazing is a major use of anadromous watersheds in the Snake River basin on private and public lands. Riparian areas have been degraded in large portions of this area with respect to utility to salmon spawning and rearing habitat (Johnson 1992, Elmore 1992, Chapman and Witty 1993, Salmon Recovery Team 1994). Impacts are direct from sheep and cattle utilizing the riparian corridor and indirect from increased erosion on lands that are overgrazed. In some areas,

[2] The Mitchell Act (PL-75-502, May 11, 1938 as amended PL-79-679, August 8, 1946) was passed to mitigate salmon and steelhead losses from hydropower project development. Regional funding is available from Bonneville Power Administration under programs of the Northwest Power Planning Council.

livestock are concentrated in holding lots for transshipment or slaughter. These areas may be situated to allow run-off from the holding areas to contaminate salmon spawning and rearing habitat.

The focus in this treatment is on dealing with the direct and indirect costs of wide-spread grazing on public lands. The USFS and BLM performed a survey of the anadromous habitat of National Forests and BLM Districts in the Western U.S. outside of Alaska, including the Columbia/Snake river area containing listed species of salmon (Bolon et al. 1994). Results of this survey for the Snake River ESA salmon areas are shown in Table 3.2-2. Total output of range resources in anadromous habitats under the approved management plans were projected to be about 430,000 AUMs for the decade 1994-2003 (Animal Unit Months = forage needed to support by one bull, a cow and calf or five sheep for one month). Existing reductions in management plan outputs due to lack of funding for a full program, special management measures for fish and wildlife and measures to protect ESA listed species (e.g., Section 7 consultations) resulted in a drop of approximately 16% (70.500 AUMs) in projected outputs between the time the management plans were completed and the present (1993). If PACFISH strategy standards (large streamside buffers) were applied to the same area and if managers minimize loss of outputs through various forms of mitigation, the difference between current output levels and PACFISH levels would be a decrease of about 19,000 AUMs (ca. 5%). This represents an annual fair market value loss of about $104,000. If the 19.100 AUM reduction is applied over a decade, the present value (@ 4%) foregone at market clearing prices (RPA 1990) adjusted to 1993 dollars would be $850,000. Mitigation costs associated with the PACFISH strategy option amount to about $2 million per year. One might question the management sense of mitigation measures that exceed the value of the outputs retained. However, if the public policy objective is to maintain range activities on public lands such would be the costs.

If a worst case scenario is defined as a prohibition of grazing on public lands in anadromous habitats in the Snake River basin, the loss of current outputs would be about 360,000 AUMs annually with a decadal present value in fair market terms of $15.6 million. The worst case scenario may be realistic if the 9th Circuit Court of Appeals decision to issue an injunction covering grazing, road construction and timber harvest for the Wallowa-Whitman and Umatilla National Forests in 1994 is applied more broadly on public lands in the Snake River basin and persists in future years.

Debate continues on how to include the full cost, including administration, range improvements, and natural resource damage, of grazing programs on public lands. This national level concern has resulted in significant efforts to reform grazing fees to reflect the true value of the range and to cover costs of range and allocation management. Even a modest rationalization of fee structures can make a significant difference in the program (USDA/USDI 1992). Traditionalists within and outside the range management bureaucracy argue that regardless of cost-effectiveness of range programs, grazing is a recognized use of public lands and, therefore, the public has an obligation to provide for management.

Table 3.2-2 Estimated Cost of Implementing PACFISH on Range in Anadromous Habitat on Federal Lands

	Range	Current Output[1] w/constraints due to other F/W/listings	Mitigated Output Under PACFISH[2]	Cost[3] to Apply PACFISH Strategy with mitigation	Net Annual Decrease in Output due to PACFISH	Annual Market Value[4] Foregone	mitigation Cost+ Reduced Market Value
	Units	*AUMs/Yr.*	*AUMs/Yr.*	*1993 $*	*AUMs/Yr.*	*1993 $*	*1993 $*
BLM							
Oregon	Prineville	29,899	29,899	$360,000	0	$0.	$360,000
	Vale	6,900	6,900	$117,000	0	$0	$117,000
Idaho	Salmon	33,792	32,777	$169,725	1,015	$56,995	$176,752
BLM	**Sub-Total**	**70,591**	**69,576**	**$646,725**	**1,015**	**$56,995**	**$653,752**
USFS							
Oregon	Umatilla	29,550	28,664	$611,900	886	$28,433	$615,406
	Wallowa-Whitman	108,597	103,171	$152,900	5,426	$235,371	$181,919
Idaho	Boise	10,177	10,177	$50,000	0	$0	$50,000
	Challis	25,664	21,607	$214,000	4,057	$166,294	$234,503
	Payette	17,300	12,100	$66,700	5,200	$213,145	$92,979
	Salmon	48,000	48,000	$31,000	0	$0	$31,000
	Sawtooth	16,200	16,200	$90,000	0	$0	$90,000
	Nez Perce	25,500	22,950	$40,000	2,550	$143,190	$57,654
	Clearwater	7,125	7,125	$61,312	0	$0	$61,312
USFS	**Sub-total**	**288,113**	**269,994**	**$1,317,812**	**18,119**	**$786,433**	**$1,414,772**
USFS/BLM	**Total**	**358,704**	**339,570**	**$1,964,537**	**19,134**	**$843,428**	**$2,068,524**

Source: Modified from Bolon, et al. 1994.

[1] Total Forest/District outputs given mitigation measures implemented to accommodate ESA listing and Section 7 consultations as well a special management measures for other fish and wildlife species.

[2] Output per Forest/District given PACFISH strategy is applied and mitigation measures are used to minimize reductions in output.

[3] Cost to the government of implementing mitigation measures in each Forest/District.

[4] Using 1990 RPA values adjusted to 1993 using PPI.

The survey results report the costs to the federal government of implementing a riparian habitat protection policy in anadromous areas. Some argue that this tends to ignore and understate the local and individual costs. If it is assumed that mitigation measures to be taken under a PACFISH strategy in the Wallowa-Whitman NF are fully funded, the local economy would receive a considerable boost in public sector employment and income if output levels were maintained through mitigation.

The Recovery Team asks that riparian landowners voluntarily restrict grazing to avoid degrading salmon spawning and rearing habitat. There is no assessment of the scale of grazing activity on private lands in the anadromous habitat of the Snake River basin and there is no estimate of response of property owners to the RT's request. The USDI Natural Resource Service (NRS- formerly Sail Conservation Service) provides a system of technical expertise to private land owners. Operating under the authorities contained in the Watershed Protection and Flood Prevention Act (PL 83-566), NRS can facilitate watershed planning processes and is specifically encouraged to use this law to protect salmon habitats. Its Columbia River basin programs include 8.4 million acres with conservation compliance plans, 2.3 million acres seeded to grass and trees under the Conservation Reserve Program, studies and watershed projects. Presently there are 34 watershed projects being implemented or planned and all have direct and indirect beneficial effects on fish habitat. Among these are four model watershed projects funded by BPA. The FY 1993 Conference Report for the Agricultural Appropriations Act included $500,00 for fish habitat measures in the upper Columbia River basin (George 1993).

3. Water Quality and Forest Practices

While the use of rivers for transporting logs to market no longer is practiced, direct and indirect impacts of forest harvest activities affect water quantity and quality for salmon. In some areas, extensive timber harvest and road construction have altered the hydrology, shelter, temperature and nutrient regimes and other key factors for anadromous habitats in the Snake River basin. These activities, to some extent, are responsible for declines in salmon stocks. Existing state and federal forest practice regulations are intended to provide a modicum of protection for fish bearing streams and rivers among their other purposes. In actual practice they are frequently inadequate or are simply not enforced to the degree to make them fully effective. The RT recommendation to allow no degradation of habitat due to logging and road building implies that implementation of the PACFISH standards would be adequate protection. The PACFISH protection applied to public lands in the National Forests and BLM Districts in the Snake River basin would be more stringent regulations than those in current use. Thus, incremental costs of protecting habitat for ESA listed species would be incurred albeit all anadromous species would benefit, not just listed ones.

Based on a survey of National Forests and BLM Districts that covers the Snake River basin area (Bolon et al. 1994), application of the PACFISH strategy to timber harvests could result in a reduction of annual harvests of about 36 million board feet of timber. That is about 10% of current harvest levels if mitigation is permitted. (See Table 3.2-3.) Mitigation measures anticipated would mostly be in the form of moving timber sales outside of anadromous habitat.

Over the course of one decade the present value (@ 4%) foregone at RPA 1990 market clearing prices would be about $60 million total, or about $7.3 million per year. Mitigation to achieve these levels would cost about $1.4 million a year. Current harvest levels are already reduced by more than 40% over the original plan levels. Under a worst case scenario where all outputs of timber from current output levels in anadromous habitats were lost, (approximately 245 mmbf annually) the present value (@4%) of timber output losses over a decade would be approximately $442.4 million. These values represent timber outputs only and do not include most of the cost of road building (except temporary short slid roads) and maintenance or costs associated with timber sale management. Because these costs are not estimated readers should be cautioned not to treat the timber values as net values for harvest outputs.

The Recovery Team suggests that little-used and out-of-service timber roads in anadromous habitats be considered for decommissioning and that poorly constructed roads and culverts be rehabilitated. The RT also expresses concern about use of herbicides and pesticides as part of forest management activities and mentions possible spills of helicopter fuel spills in anadromous watersheds. No study of the extent of needed restoration or decommissioning of roads is available at this time nor is the extent known of threat to salmon from forest biocides and fuel spills. Therefore, cost estimates are not made. Again, we acknowledge that such costs could be substantial.

4. Water Quality Impacts of Mining and Other Developments

Besides the water quality implications discussed for timber harvests above, point sources of pollution from domestic, municipal and industrial sources may have negative impacts on salmonid habitat and non-point source pollution can also be detrimental. The urban and agricultural water quality impacts are covered by state and federal laws and management programs. Existing standards are thought to be adequate to protect salmon habitats. However, it is clear that enforcement and monitoring of such standards may not be adequate at present. The RT expects that water quality be maintained to protect ESA listed species. Because this is a requirement that pre-dates listings, we adopt the position that the economic costs of achieving adequate water quality are part of the base case and cannot be ascribed as incremental costs of recovery measures.

The legacy of extensive mineral development activities affects salmon habitats, particularly in Idaho but in other states as well. The historic practices have degraded water quality in some parts of the salmon range, and major rehabilitation projects are needed if degraded habitat is to be restored (Chapman and Witty 1993). Much of the mining activity takes place in headwater areas administered by public agencies. Therefore, mining is singled out as an activity of concern by the Recovery Team. Current mining is not known by the RT to have a direct effect on Snake River sockeye. Mineral developments are proposed in areas that could affect chinook habitat. The RT encourages state and federal agencies to control any impacts on salmon habitats, but does not require cessation of activities or blocking new developments. Because operating permits are subject to restrictions intended to protect fish and wildlife habitat, it would appear that it is inappropriate to assign rehabilitation costs or costs of meeting existing

Table 3.2-3 Estimated Cost of Implementation of PACFISH on Timber in Anadromous Habitat on Federal Lands

	Forest	Current Output[1] w/constraints due to other F/W/listings	Mitigated Output[2] Under PACFISH	Cost[3] to Apply PACFISH Strategy with mitigation	Net Annual Decrease in Output due to PACFISH	Annual Market Value[4] Foregone	Mitigation Cost+ Reduced Market Value
		mmbf	*mmbf*	*1993 $*	*mmbf*	*1993 $*	*1993 $*
BLM							
Oregon	Prineville	3.21	2.73	$10,000	0.48	$131,933	$141,933
	Vale	2.4	1.65	$20,000	0.75	$206,145	$226,145
Idaho	Salmon	1.54	1.47	$19,000	0.07	$13,970	$32,970
BLM	**Sub-Total**	**7.15**	**5.85**	**$49,000**	**1.3**	**$352,049**	**$401,049**
USFS							
Oregon	Umatilla	55	55	$483,000	0	$0	4483,000
	Wallowa-Whitman	49.5	47.3	$0	2.2	$604,692	$604,692
Idaho	Boise	83.9	83.4	$292,800	0.5	$99,789	$392,589
	Challis		0	$25,000	0	$0	$25,000
	Payette	86	82.3	$228,000	3.7	$738,437	$966,437
	Salmon	17.7	17.7	$19,600	0	$0	$19,600
	Sawtooth	1.5	0.75	$27,560	0.75	$149,683	$177,243
	Nez Perce	45	38	$173,000	7	$1,397,043	$1,570,043
	Clearwater	60	40	$108,000	20	$3,991,551	$4,099,551
USFS	**Sub-total**	**398.6**	**364.45**	**$1,356,960**	**34.15**	**$6,981,194**	**$8,338,154**
USFS/BLM	**Total**	**405.75**	**370.3**	**$1,405,960**	**35.45**	**$7,333,243**	**$8,739,203**

Source: Natalie A. Bolon, Christopher S. Hansen-Murray and Richard W. Haynes 1994. Draft Estimated Economic Impacts on the Timber, Range and Recreation Programs on National Forest and BLM Public Lands from Adopting the Proposed Interim PACFISH Strategy. Pacific Northwest Research Station. Portland, OR. unpublished report.

[1] Total Forest/District outputs given mitigation measures implemented to accommodate ESA listing and Section 7 consultations as well a special management measures for other fish and wildlife species.

[2] Output per Forest/District given PACFISH strategy is applied and mitigation measures are used to minimize reductions in output.

[3] Cost to the government of implementing mitigation measures in each Forest/District.

[4] Using 1990 RPA values adjusted to 1993 using PPI.

regulations as incremental costs due to ESA listings. Such measures are intended to benefit all fish and wildlife. Costs of rehabilitation of water quality problem areas that pre-date the Clean Water Act may be an exception, however, the RT does not appear to recommend special measures in such areas.

5. Recreation

Outdoor recreation in anadromous habitats can produce direct and indirect negative impacts, like disturbance of redds or frightening of smolts, that could potentially affect recovery of ESA listed salmon stocks. Recreationists wading in streams, river rafters as well as jet boat operations are potential threats to salmon spawning and rearing at different locations and times. The RT encourages relevant public agencies to cooperate with various recreation groups to educate them about how to avoid impacts and to work with them to reduce impacts at critical times in the salmonid life cycle. The RT suggests that informative signs and education campaigns be developed. The scope of this activity seems consistent with current staffing and activity levels. Therefore, we do not anticipate major additional expense with this change in priority for fish protection. No specific restrictive measures are outlined by the RT at this time to cause major expenses to agencies or loss of outputs, although, as shown for federal lands below, implementation of other general measures (i.e., PACFISH) may carry considerable costs depending on the approach to interpretation and implementation.

Implementation of PACFISH by the USFS and BLM may have impacts on outdoor recreation. Survey results (Table 3.2-4) indicate a wide range in expectations of the impact on recreation of measures to protect salmon habitat. The chief difference among management areas seems to relate to manager's perceptions of how mitigation can be used to maintain current recreational outputs. Several BLM Districts or National Forests account for nearly all the expected decrease in recreational activities despite significant expenditures on mitigation. Most of the other Districts or Forest managers expected to be able to mitigate changes in recreational patterns so that there would be no net change in recreation outputs. If we accept that some losses may be overstated and some may be understated by the above approach, it may be appropriate to assume that they cancel out.

According to survey results (Bolon et al. 1994), current recreational outputs (measured in Recreational Visitor Days - RVDs)[3] are running about 30% below the outputs anticipated in forest and district plans for the decade. This is ascribed to constraints on recreation management due to fish and wildlife protection measures. Because recreation patterns appear to be similar to the recent past, the discrepancy may be due to overestimation of RVDs in the plans rather than any real loss in recreation activity. Net annual decrease in RVDs due to measures to implement PACFISH, e.g., restrictions on camping in riparian zones, limits on swimming and wading in streams and other measures, could be around 372,000 RVDs or approximately 6% compared with current use if mitigation measures costing approximately $2.9 million per year are employed. Annual loss of recreation value with mitigation is estimated to be $12.6 million. Over the decade 1994-2003 this loss of outputs would have a present value (@ 4%) of about $102.4

[3] RVD is defined as twelve visitor hours, which may be aggregated continuously, intermittently, or simultaneously by one or more persons.

million using market clearing prices (RPA 1990) adjusted to 1993 dollars. The present value of mitigation cost to maintain the rest of the recreation output over the same period would be about $23.5 million. The worst case situation, loss of all recreation outputs in anadromous habitats on federal lands, would result in cost of $184.2 million per year. Obviously, this must be seen as an outer bound of the possible costs and should not be misconstrued as likely.

Another aspect of recreational impacts of concern to the RT is the potential impact of stocking and management programs for fish species that compete for food and habitat with ESA listed species or are predators on these species. No estimate of the extent of this set of issues is available but the RT calls upon relevant fish management agencies to protect ESA listed species at the expense of programs for resident fish, trout and steelhead. Halting stocking could result in a loss in value of those recreational activities dependent on stocking, if not offset by expansion of comparable opportunities elsewhere in the region. If measures to limit stocking are confined to relatively discrete areas, the loss may be easily offset. Furthermore, the RT gives management agencies the option of planting or releasing trout and steelhead stocking actions in ESA listed habitats in a manner to minimize competition as opposed to a complete cessation. This latter approach could result in modestly higher costs in terms of feeding and design of release strategies but not result in lost recreational opportunities. It is simply not possible to make an estimate of this component without further study and direction.

Table 3.2-4 Estimated Cost of Implementing PACFISH on Recreation in Anadromous Habitat on Federal Lands

	Recreation	Current Output[1] w/constraints due to other F/W/listings	Mitigated Output[2] Under PACFISH	Cost[3] to Apply PACFISH Strategy with mitigation	Net Annual Decrease in Output due to PACFISH	Annual Market Value[4] Foregone	Mitigation Cost+ Reduced Market Value
		RVD/Yr.	*RVD/Yr.*	*1993 $*	*RVD/Yr.*	*1993 $*	*1993 $*
BLM							
Oregon	Prineville	551,000	526,000	$155,000	25,000	$1,304,092	$1,459,092
	Vale	24,000	24,000	$5,000	0	$0	$5,000
Idaho	Salmon	205,845	205,845	$60,000	0	$0	$60,000
BLM	**Sub-Total**	**780,845**	**755,845**	**$220,000**	**25,000**	**$1,304,092**	**$1,524,092**
USFS							
Oregon	Umatilla	1,034,163	1,034,163	$1,235,650	0	$0	$1,235,650
	Wallowa-Whitman	775,000	525,000	$561,000	250,000	$8,725,113	$9,286,113
Idaho	Boise	413,861	340,286	$150,088	73,575	$2,097,226	$2,247,314
	Challis	448,800	448,800	$50,000	0	$0	$50,000
	Payette	360,000	360,000	$50,000	0	$0	$50,000
	Salmon	670,000	670,000	$63,000	0	$0	$63,000
	Sawtooth	940,000	940,000	$100,000	0	$0	$100,000
	Nez Perce	264,707	264,707	421,500	0	$0	$421,500
	Clearwater	230,000	206,800	$39,500	23,200	$498,649	$538,149
USFS	**Sub-total**	**5,136,531**	**4,789,756**	**$2,670,738**	**346,775**	**$11,320,988**	**$13,991,726**
USFS/BLM	**Total**	**5,917,376**	**5,545,601**	**$2,890,738**	**371,775**	**$12,625,079**	**$15,515,817**

Source: Modified from Natalie A. Bolon, Christopher S. Hansen-Murray, and Richard W. Haynes 1994. Draft Estimated Economic Impacts on the Timber, Range, and Recreation Programs on national Forest and BLM Public Lands from Adopting the Proposed Interim PACFISH Strategy. Pacific Northwest Research Station. Portland. OR. unpublished report.

[1] Total Forest/District outputs given mitigation measures implemented to accommodate ESA listing and Section 7 consultations as well a special management measures for other fish and wildlife species.

[2] Output per Forest/District given PACFISH strategy is applied and mitigation measures are used to minimize reductions in output.

[3] Cost to the government of implementing mitigation measures in each Forest/District.

[4] Using 1990 RPA values adjusted to 1993 $ using CPI-U.

6. Migration Corridor Activities Affecting Water Quality

Municipal and industrial point sources of effluent discharge into the Columbia/Snake River migration corridor for ESA listed salmon is a potential problem highlighted by the RT. Non-point source pollution from agriculture and transportation along the river banks may also be of concern. Studies are underway to determine what effect, if any, toxic discharges have on migrating smolts and adults in the river system. Results of the study may provide information useful in designating release points from salmon smolts being transported around dams. No cost estimate for incremental costs due to ESA listed species seems appropriate given that the study benefits all species passing through the migration corridor.

7. Law Enforcement

The RT exhorts the relevant water quality management agencies to fully enforce water quality regulations to ensure protection of ESA listed species. This general measure calls for increased attention from management agencies that are probably strapped for resources. Greater efforts on behalf of listed salmon species may result in additional costs or may be accomplished by a reprioritization of effort. In either case, the RT calls for enforcement of regulations that pre-date the listing decisions and enforcement is not solely required to protect salmon. Thus, ensuring present standards are being enforced cannot be counted as an incremental cost due to recovery plan actions.

Law enforcement for protection of salmon from poaching and illegal fishing has been stepped up as part of the NPPC program for Columbia River fish and wildlife. The NPPC program more than doubled the enforcement capabilities in 1992 and 1993 compared with 1991. The comprehensive program involves funding of an interagency task force, funding for salmon enforcement activities by the Columbia River Intertribal Fisheries Commission, Oregon State Police, Washington Department of Fish and Wildlife and Idaho Department of Fish and Game, and funding for evaluation of the program. In 1992 costs borne by BPA for law enforcement amounted to $5.8 million and in 1993 they amounted to approximately $3.0 million. Support for increased law enforcement continued by BPA into 1994 (BPA PMISDATA computer printout 8/15/94). Enforcement costs covered by the enforcement authorities themselves are not known to be estimated. We estimate annual costs for enforcement to be $3.5 million based on the RT report (Snake River Salmon Recovery Team 1994).

The RT's law enforcement recommendation for listed species encourages continuation of the NPPC law enforcement program. Therefore, a component of that effort is, of course, applicable to ESA listed species. Still there is no agreement on how much to ascribe to such actions. Further, other recommended salmon conservation actions may decrease costs of enforcement and monitoring, for example, effects of the west coast salmon harvest moratorium in 1994, on the costs of the enforcement program.

8. Habitat Research and Monitoring.

The measures recommended here reiterate the need for recovery actions specified earlier in this section. Costs associated with habitat research and monitoring are assumed to be included in the above assessment of costs from the institution section, i.e., a portion of the $10 million additional cost associated with ESA listed species. These costs are really the incremental costs of monitoring the monitoring programs of all agencies and tribes as well as additional monitoring required for ESA listed species. Existing state, tribal and federal agency programs are not estimated and the total cost of these activities is not known.

No systematic reporting of monitoring costs appears to be available at this time, although considerable monitoring costs are being borne already encompassing all salmon species. Federal agencies, for example, received at least $6.1 million from BPA for monitoring smolt mortality in reservoirs of federal dams over the period 1984-1992. Non-federal entities received at least $8.3 million from BPA for smolt monitoring over the period 1987-1992. In addition, a five-year monitoring program for health of anadromous species of salmon cost approximately $1.6 million. (All figures from BPA PMISDATA computer printout 8/15/94).

Long-Term Sub-Basin Habitat Management Planning

The RT recommends that watershed management plans be developed for all watersheds where ESA listed species exist. It cites several examples of model programs like those for the Grande Ronde, Lemhi and Wallowa Rivers. The basic concept the RT seeks to encourage is that of local governments, citizens groups and user groups working with technical support of state and federal agencies to develop watershed management plans that protect water quality and quantity at the same time they prioritize restoration of habitat for listed species of salmon and other stocks of special concern. This approach is preferred to that of counties, cities or other entities using professional planning staff or hiring consultants to develop plans (See Deschutes County/City of Bend 1986) because participation in the development of the plans by affected parties is perceived to lead to better understanding of and compliance with the measures that need to be taken. The RT approach echoes the similar recommendations flowing from the FEMAT, PACFISH and Eastside Ecosystem Management Project. While none of the plans mentioned by the RT are developed for ESA listed species, they do provide a range of possible approaches to watershed planning that could be used in that context.

Cost of such planning processes vary tremendously. The Wallowa County effort so far is estimated to have cost less than $10,000-25,000 (Perry, personal communication) while the Grande Ronde model watershed project is estimated to have cost about $370,000 -- most of which came from NPPC/BPA sources. The Eastern Washington Model Watershed Development costs are about $157,700 and the Model Watershed Studies for the Lemhi River Basin are about $294,600 (PMISDATA file computer print 8/15/94). Depending on the size and complexity of the watershed ecosystems and the social and economic systems they contain, additional habitat management planning efforts could be expected to fall within the range cited above. These costs represent coordination, research and production (maps, drafts, photographs, field work) parts of the planning process. They do not include estimates of volunteered time and expenses of participants. Obviously, those in-kind donations can exceed the formal costs of the process if even low rates are assigned to the hours of participation in the process.

Assuming that there are at least 10 sub-basin plans needed to encompass the ESA listed species prime habitat watersheds, a minimum estimate of formal costs could be $100,000 and could reach as high as $2.5 million dollars. If plans are to be implemented, much more funding is necessary. The Grande Ronde Action Plan has received $5 million in support for implementation in the 1994-1995 biennium. Therefore, we suggest that it is necessary to expect similar estimates of implementation costs for each of the watershed plans of comparable size and complexity. If similar costs were assigned to each of 10 sub basin plans, biennial restoration costs could approximate $50 million. A precise estimate of costs is not possible given the early stages of discussion of watershed plans but clearly this is where salmon habitat recovery action becomes expensive. In addition, the question arises about apportioning the costs of these watershed plans as incremental costs of ESA listed salmon recovery. Watershed plans serve multiple purposes besides salmon protection. Water basin planning for fish and wildlife by the NPPC and other cooperating entities began out of a concern for all declining salmon stocks. The ESA listing and RT recommendations, however, lend impetus to the process.

Habitat Protection and Restoration for Sockeye Salmon

Measures to protect and restore sockeye salmon habitat in the remote Stanley Basin of Idaho are seen by the RT to include special education and recreation management tasks, reduction of barriers to sockeye migration, and experimental programs to increase the nutrients available to fuel fish production in lakes where sockeye brood stock would be planted. Huppert et al. (1992) estimated that the recreation management to protect the sockeye in the Sawtooth National Recreation Area might require 2.5 FTE of staff time at a GS-9 rating. In addition, $7,000 per year would be needed to provide brochures, signs and other educational materials. These costs would likely be loaded most heavily on the first part of the program to protect the sockeye and might diminish as recreationists became educated. Total costs for additional recreation management to protect ESA listed fish could amount to about $150,000 per year for the Sawtooth NRA. Given that the most potentially damaging recreation occurs during the summer and fall months, it may be appropriate to treat the incremental protection measures as seasonal measures. In such case, the costs might be reduced to less than $100,000 per year.

The RT specifies that the program is to be expanded to other lakes and this would likely increase in staffing and expense for existing programs. The RT discourages continuation of stocking of trout and kokanee in Redfish Lake and other lakes in the Stanley Basis because this may foster competition for the protected sockeye. This measure would reduce the value of Redfish Lake for fishing but by an undetermined amount because little is known about the population dynamics of the existing trout and kokanee populations in relation to fishing pressure and wild spawning. Further, it is reasonable to assume that a decline in fishing success at Redfish Lake could result in a shift of fishing recreation to other lakes in Idaho and therefore result in minor changes to the regional economy, despite its potentially large negative impacts on local ones.

Economic cost of reducing barriers to fish passage to the Stanley Basin Lakes is difficult to assess without engineering design and site plans. A preliminary estimate for barrier removal affecting the Stanley Basin Lakes is a one-time cost of about $100,000 (Fluharty et al.1992). This estimate is consistent with the cost of fish passage enhancement projects funded by BPA for the Snake River basin habitat ($104,600 in 1993). The RT recommends that fish counting equipment be installed and operated in conjunction with removal of the barriers. No estimate for the fish counting equipment and operation is available at this time.

Efforts to increase nutrients in Stanley Basin Lakes are seen as experimental programs to first obtain information on feasibility and consequences of fertilization in oligotrophic lakes and then to apply the information in real programs. Cost of the experimental programs to study Stanley Lake limnology and effects of fertilization are estimated at about $200,000 per year for 1-3 years. (This estimate is based on manipulation of information regarding BPA budget expenditures.)

Costs of RT recommendations to improve habitat to promote recovery of ESA listed species are displayed in Table 3.2-5

Table 3.2-5 Estimated Costs of RT Recommendations for Habitat

No.	Description of Item	Scope of Action	Annual Costs 1,000s 1993 $
1	Moratorium	Ongoing, indefinitely (See discussion).	N/A[1]
2	Designate habitat subcommittee*	Annual, ongoing, indef.	50.0
3	Assess spawning and rearing habitat	6-9 months (See No. 2).	N/A
4	Implement habitat protection and restoration actions	Ongoing, indefinite (See separate sub items).	
	Irrigation diversion screens	Ongoing	N/A
	Grazing/stock holding	Annual, ongoing, 10 yr.	
	Mitigation costs		$1,964.5
	Output loss w/mitigation		$104.0
	Total Mitigation Cost Plus Output Value loss		**$2,068.5**
	Forest practices	Annual, ongoing, 10 yr.	
	Mitigation costs		$1,406.0
	Output loss w/mitigation		$7,333.2
	Total Mitigation Cost Plus Output Value loss		**$8,739.2**
	Mining and other	Annual, ongoing, indef.	N/A
	Recreation	Annual, ongoing, 10 yr.	
	Mitigation costs		$2,890.7
	Output loss w/mitigation		$12,625.1
	Total Mitigation Cost Plus Output Value loss		**$15,515.8**
	Migration corridor activities	Annual, ongoing, indef.	N/A
	Law enforcement*	Annual, ongoing, indef.	$3,500
	Habitat research & Monitoring*	Annual, ongoing, indef. (See Table 3.1-2)	$10,000 (part)
5	Long-term sub basin planning	Annual, ongoing, 2-5 yr.	$100 - 3,000
6	Habitat protection and restoration for sockeye	Annual, ongoing, 1-3 years	
	Control recreation activity*	Annual, ongoing, indef.	$100-150
	Improve fish passage*	Ongoing, 1-3 years	$104
	Lake fertilization experiments*	Annual, ongoing, 1-3 years	$200 (?)

* Cost of recommendation listed is included in another section. Repeated here to illustrate RT Plan approach.

[1] N/A Not applicable because there is not incremental expenses relative to ESA listed species of salmon.

Section 3.3 Improve Freshwater Production of Chinook Salmon

The Recovery Team recommends six broad measures to increase chinook salmon production in the Snake River habitat areas, i.e., to protect and improve spawning and rearing habitat, reestablish viable naturally-spawning fall chinook in three areas, establish coordinating mechanisms, improve hatchery contributions to recovery of natural stocks, improve health and quality of hatchery production fish, and modify hatchery production to minimize ecological pressures on natural stocks. This suite of recommendations consolidates measures from other sections of the Recovery Plan so that the specific efforts to promote chinook recovery can be seen as a coherent plan. Details of recommendations are elaborated and some new recommendations are made. Thus, the costs of measures discussed in this section are not necessarily additive to those of other sections. Furthermore, the benefits of taking these habitat measures may accrue to other species of salmon and to the integrity of the ecosystem, not just to the listed chinook salmon.

Protect and Improve Spawning and Rearing Habitat

The RT recommends measures to control habitat loss due to alteration by conflicting land use activities. Competition from hatchery stocks is the second factor the RT would control. The watershed assessments and ranking efforts discussed in the habitat section (above) cover the main thrust of what is recommended in this section. This section further clarifies the need for long-term quantitative assessments of in-river habitats in order to establish seeding rates and juvenile salmon-carrying capacity on a stock-by-stock basis in addition to assessment of habitat quantity and quality and priority for protection and recovery. Current quantitative assessment programs that are oriented to this sort of detailed observation and monitoring of salmon spawning and rearing habitat are possibly the best guide to what costs for the recommended program would be. Typically, such habitat monitoring projects seem to range in cost from approximately $100,000 yr. (Coeur d'Alene 90-044) to $150,000 yr. (88-015 Lower Clearwater Habitat) (based on BPA 1994 and PMISDATA computer printout 8/15/94). Precisely comparable studies to those recommended by the RT have not been performed. Complicating factors also exist because the size of the area to be covered, intensity and detail of monitoring, etc. have not been defined with respect to Snake River chinook habitats.

If spread throughout the habitat identified for recovery of chinook stocks in the Snake River, an annual cost of these assessments would amount to $600,000 to $900,000 per year over the two to three year period the RT allocates to the task. This gives an estimated total cost of $1.8 - 2.7 million, assuming that six studies in selected high priority river segments would be needed to accomplish the tasks set out by the RT.

Another aspect of improving habitat not specifically recommended by the RT yet which is in use in the Sawtooth area is purchasing and reclaiming habitat. The US Forest Service purchase of a ranch in the Upper Salmon River in 1991 for $2.4 million stopped the practice of diverting water for irrigation which dried up the river bed. BPA contributed $770,000 to fish passage improvements. Already spring chinook are occupying redds in the habitat. This ranch on Alturas Lake Creek was once a spawning area for sockeye salmon and it is thought the passage and flow improvements may assist when out planting of captive broodstock occurs. (BPA Journal, December 1993).

Reestablish Three Naturally Self-Sustaining Fall Chinook Populations

The RT recommends that three areas be considered for reestablishing fall chinook salmon runs for 1) the area below Hells Canyon Dam currently utilized by fall chinook, 2) the Upper Snake River above Brownlee Reservoir and Hells Canyon Dam complex, and 3) the Lower Clearwater River. The cost of considering whether or not to invest in measures to reestablish these chinook populations is not seen as very large given the continual on-going efforts. The cost of trucking of adults around the dam and reservoir barriers is relatively well known. Adult collection facilities would have to be designed and constructed. The chief unknown aspect that must be considered is the need to develop "benign" smolt collectors appropriate for the Upper Snake area. The cost of designing, testing and constructing these collectors is not known.

At this stage of determining feasibility, the cost implications of reestablishing naturally self-sustaining fall chinook runs in these designated habitats are not possible to estimate. The use of habitat immediately downstream of Hells Canyon is likely to be the most feasible as some spawning and rearing occurs there at present. Lower Clearwater re-establishment seems to present no major obstacles, at least, not in comparison to the re-establishment about the Hells Canyon dam complex.

Establish Coordinating Mechanisms

According to the RT, two subcommittees must be established to assist the SOC exert its oversight responsibilities -- a natural production subcommittee and a hatchery subcommittee. Cost implications of these subcommittees are considered in the previous section on Institutional Changes. In that section a total cost of about $300,000 per year is assigned to the support and staffing of all of the subcommittees to be established (in addition to the costs of the SOC and NMFS staff involved with subcommittee work). If this amount were split equally among the six named subcommittees, costs for the natural production and hatchery subcommittees would amount to about $50,000 each per year. These costs reflect the coordination functions for the SOC and NMFS but do not cover the costs of participation by tribes, agencies and other experts.

Existing committees established under NPPC and CBFWA are working on many of the issues raised by the RT. It is the intention of the RT to avoid overlap and duplication of effort. Therefore, to the extent that existing groups have parallel functions, the costs of implementing the RT recommendations can be increased or decreased for each committee. The NPPC has proposed, for example, establishing a Basin Oversight Group that may cover many of the functions of the natural production subcommittee. The Integrated Hatchery Operations Team established by BPA seems well along the way to providing some of the analysis the RT recommends for coordinating fish productions from hatcheries in the Columbia River basin. Its draft report covers many of the topics assigned by the RT to subcommittees (BPA 1994b). However, the chief function of the subcommittee as seen by the RT is to ensure that natural and hatchery production of ESA listed chinook receive high priority in integrated management plans and actions. These functions may differ significantly from the all species all areas orientation of the existing committees. Thus, a single purpose committee for ESA stocks may have considerable incremental work to accomplish and the costs outlined above may be low scale estimates.

Improve Hatchery Contributions to Recovery of Natural Stocks

Artificial propagation to avoid extinction of a natural population of chinook salmon is seen as necessary when aid is needed to recolonize unutilized habitat, where suitable habitat is lost or to conserve a natural stock until habitat is available. In the Snake River Basin the RT "believes that an experimental design..... including full evaluation of existing state programs, is necessary to determine where and to what level supplementation research is necessary to provide the desired information." The separate state plans are seen by the RT as not totally consistent with the needs of ESA listed chinook. Still, the guidelines that the RT would like to see used to coordinate state plans with respect to supplementation and hatchery operations can probably be incorporated into state practices without additional expense, i.e., a reordering of priorities and practices not a wholesale scrapping of current programs. Many of the guidelines and needed research for a chinook propagation program that supplements and does not conflict with natural chinook production are products of other recommendations of the RT with respect to protection of distinct genetic stocks.

Captive broodstock programs recommended for chinook would constitute an added cost. Because there is not a program scale or design specified, the cost for this brood stock program is considered to be comparable to that for the ESA listed Snake River sockeye, i.e., approximately $1.5 million year (BPA 1994a and PMISDATA computer printout 8/15/94). It is likely that some cost savings may arise, given the number of fish hatcheries producing chinook in the Snake River basin, and the likelihood that some production might be precluded as a result of the RT development of a coordinated experimental design for chinook supplementation. The RT believes that increases in hatchery production have contributed, albeit inadvertently, to the decline of natural Snake River salmon. Thus, cost-saving reductions in hatchery production of non-ESA listed chinook stocks could be obtained.

Arguably, if ESA broodstock production offsets or replaces other planned production, the production costs would not be incremental. The economic cost picture would be complicated too, by any loss of production that affects total chinook propagation in "production" hatcheries, i.e., those funded to mitigate losses due to dam construction. Without a definite plan, any estimates of these levels of costs would be purely speculative.

Improve Health and Quality of Hatchery Production Fish

The RT recognizes that current hatchery programs are moving to improve health and quality of hatchery production fish and its recommendations are intended to add support and impetus to this goal. Recommended measures, like disinfecting of waste waters from hatcheries, written protocols for health management at each hatchery, evaluation of water quality at hatcheries, etc. all can result in additional expenses for chinook supplementation and may produce benefits to ESA listed species as well as all stocks of salmon and trout raised in the hatcheries. Because the need for improved hatchery operations to ensure fish health and to prevent the spread of disease is broadly recognized and because measures are already being implemented in this category, we choose not to assign an incremental cost for these measures to recovery of ESA listed chinook salmon.

Modify Hatchery Production to Minimize Ecological Pressures on Natural Stocks

The RT sets forth a guideline that hatchery efficiency should be measured by the smolt viability and adult returns not sheer numbers of smolts released. To accomplish this goal, the RT suggests that hatchery production histories be examined. A conservation directed hatchery program, as opposed to a production for harvest program, might require significant modifications and upgrading of facilities at existing hatcheries. Converting these recommendations into an assessment of economic cost is difficult because the scale of effort required and the specific facility and operational changes are not available at this time. Shutting down of historically poor hatchery performers would produce savings in operational costs yet the sunk capital costs could not be recaptured. Cost of planning of major construction or changes in hatchery configuration might be seen in the context of the new Yakima Hatchery where cost (by category) are: project leadership $2.8 million (BPA 90-58); experimental design $2.7 million (BPA 89-82), final design $1.7 million (BPA 90-65/69), adult and juvenile trapping facilities $3.2 million (BPA 91-45), species interaction studies $7.3 million (88-120) enhancement study natural/hatchery fish $2.5 million (BPA 89-105), environmental assessment $479,000 (BPA 91-48) and supplementation of fish quality $739,000 (BPA 91-55). Also by way of context, the construction and operation and maintenance over 11 years of the Umatilla Hatchery has an accumulated annual cost of $12.1 million (BPA 84-33).

These data illustrate costs of modifying or constructing fish hatcheries under nearly current conditions. For implementation of RT measures, much depends on the type of measure indicated through planning and the extent to which existing facilities can be used or modified to accommodate the requisite measures. At this stage it is not possible to provide a cost associated with this aspect of the RT recommendations.

Costs of RT recommendations for improving freshwater production of chinook salmon are summarized in Table 3.3-1.

Table 3.3-1 Estimated Costs of RT Recommendations for Chinook Production

No.	Description of Item	Scope of Action	Annual Costs $1,000
1	Protect and improve habitat	Annual, ongoing, indef.	$600 - 900
2	Consider reestablishing chinook in three areas	2-3 yr. (No estimate known)	Unknown
3	Establish coordinating mechanism*	Annual, ongoing, indef.	$100
4	Improve hatchery contributions and captive broodstock	Annual, ongoing, indef.	$1,500
5	Improve health and quality of hatchery production chinook	Annual, ongoing, indef.	N/A[1]
6	Modify hatchery production to protect natural stocks	Annual, ongoing, indef.	N/A[2]

Source: See text infra.
* Cost of recommendation listed is included in another section. Repeated here to illustrate RT Plan.
[1] Not Applicable because there are no incremental expenses relative to ESA listed species of salmon.
[2] Not applicable because measures recommended are not adequately defined to allow cost estimation. If existing programs and facilities (are modified, costs and operations could be low. If new facilities are required, costs could be significant).

3.4 Improve Freshwater Sockeye Production

In the late 1800s lakes in the Salmon River headwaters supported enough sockeye salmon that commercial quantities were taken. The current situation differs considerably with Snake River sockeye salmon listed as endangered under the ESA. The known remaining population of sockeye salmon is the foundation for a broodstock program designed to restore the species. The Recovery Team recommends eight broad measures for improving sockeye salmon production in the Snake River Basin -- essentially the headwaters of the Salmon River tributary leading to the Stanley Basin in Sawtooth National Recreation Area. The RT proposes the following measures:

- Continue captive broodstock propagation for four parental stocks.
- Locate and equip hatcheries for captive broodstock program.
- Maintain captive broodstocks to a second generation for release to target lakes.
- Release broodstock progeny into lake of origin and evaluate results.
- Undertake long-term monitoring of captive broodstock and release program.
- Designate genetics and fish culture/fish health working groups.
- Investigate sockeye reintroduction to Wallowa and Warm Lakes.
- Develop a protocol for fostering natural production of sockeye.

Unlike the chinook production section, the sockeye production deals relatively little with habitat measures. Initially, sockeye production focuses almost exclusively on emergency measures to save the remaining population through cultivation in a broodstock program. Habitat measures for sockeye are critical for the long-term recovery of naturally producing stocks. Costs associated with these recommendations are dealt with in the habitat section. Sockeye recovery is definitely a long-term process, taking a minimum of two sockeye generations (6-8 years) to get started and full recovery as much as two decades. RT recommendations, therefore, lean toward measures to release sockeye to its original habitat, to restore sockeye to parts of its former range in the Snake River basin and to encourage natural self-sustaining reproducing populations. The Shoshone-Bannock Tribes and the Idaho Department of Fish and Game in consultation with the National Marine Fisheries Service have chief responsibility for managing this program. A Stanley Basin Technical Oversight Committee is established to bring biologists from the various agencies into a common forum for managing the recovery. Given the endangered status of sockeye salmon in the Snake River, many measures requiring outlay of funds are already underway.

Continue Captive Broodstock Propagation for Four Parental Stocks

This recommendation is one of the more complex and detailed in the Recovery Plan. Four stocks of sockeye salmon are to be maintained as captive broodstock -- three from Redfish Lake stocks and one that is considered an indigenous resident kokanee from Alturas Lake. At least two populations from each broodstock are to be maintained at separate hatcheries in order to reduce threat of catastrophic loss from operating failures or disease. Costs of the captive broodstock program per se represent only part of the total costs of research and other activities necessary to make the rearing program work. Research, comparative studies, habitat analysis, genetic analysis, trapping programs, etc. all must fit together. In addition, the sensitive nature of the captive rearing program demands special security. Because of these factors, it has proven to be difficult to obtain a precise cost of a rearing program. The contracted amounts of all BPA funded work (to IDF&G, Sho-Ban Tribes, NMFS, consultants) was approximately $800,000 in 1991, $1.5 million in 1992, and $2.1 million in 1993 (Table 3.4-1). These BPA contract costs represent only a portion of the total costs of the rearing programs. IDF&G, Sho-Ban Tribes, NMFS, and other agencies supply facilities, equipment and personnel that are probably not accounted for in these estimates. BPA estimates that it pays $1.5 million annually for the captive broodstock program (BPA Journal, Dec. 1993).

It is difficult to project future costs of the captive broodstock rearing program. With four categories of parental stocks from 9 returns of adults (Redfish Lake 1991-1993, Redfish Lake out migrants 1991-1992, Alturas Lake indigenous kokanee out migrants 1991-1992 and Redfish Lake resident kokanee 2-3 years) to be reared in at least two separate facilities, there could be a minimum of 18 stocks being reared in 1994. Thus, it is highly unlikely that the full costs of the rearing program are captured in the presentation of BPA contract costs.

Various factors will probably increase the cost of the rearing and out planting program in the future. Cost of the trapping program may decline as returning adults and resident sockeye stocks are assumed to have completed their full life-cycle under the program. Any reduction in these costs will be greatly offset by increases in the smolt monitoring and returning adult capture and monitoring requirements of the releases from the broodstock program. No calculation of the expected costs of the rearing program is available at this time but an average annual cost of $3-5 million would not seem unreasonable. If extensive modifications and upgrades of hatchery facilities are required to accommodate the rearing program, costs could rise considerably above that estimate.

The number of broodstocks will probably increase as captive broodstocks are bred to ensure wide use of all the genetic material in various year classes. Further, a portion of each broodstock is to be retained from each of these stocks as the fish mature and these captive mature fish would be spawned to continue to build the populations from known genetic material. Because captive fish may mature at different rates, the number of broodstocks may increase to accommodate this phenomenon. In addition, the SOC and Stanley Basin Sockeye TOC may decide it is prudent to continue the captive broodstock program using returning adults from the earlier releases if there are broodstock losses or if returns are lower than hoped. The RT expects that some broodstock programs can be terminated depending on results of genetic testing and overall success relative to objectives. The captive broodstock program quickly becomes quite complex and probably increases in cost arithmetically if not exponentially over time.

Table 3.4-1 Bonneville Power Administration Contract Expenditures for Snake River Sockeye Captive Rearing Program ($1000)

Project	1991	1992	1993
Genetic Analysis of *O. nerka* (BPA 90-93)		124.7	0
Snake River Sockeye Habitat (BPA 91-71)	257.6	385.7	458.4
Redfish Lake Trapping and Rearing (BPA 91-72)	529.7	400.2	1,007.4
Redfish Lake Broodstock Rearing (BPA 92-40)		552.9	425.7
Scoping of Research Needs for Captive Broodstock Program (BPA 93-56)			221.0
Total	**787.3**	**1463.5**	**2,112.5**

Source: BPA 1994. Columbia River Basin Fish & Wildlife Program Annual Implementation Work Plan for FY 1994. (DOE/BP-2321) Division of Fish and Wildlife. Portland, OR. PMISDATA computer printout 8/15/94.

Locate and Equip Hatcheries for Captive Broodstock Program

The RT does not list hatcheries currently involved in the captive broodstock rearing program and does not provide a list of potential hatcheries to be assessed for inclusion in the program. The RT does suggest that Sawtooth hatchery be targeted for possible inclusion but implies that it may require significant upgrading to meet the needs of the program. Undoubtedly, as more hatcheries are brought into the captive broodstock program there will have to be modifications of facilities, and staff will have to be trained to implement the protocols determined by the various genetic and fish culture working groups in consultation with the NMFS, SOC and Stanley Basin Sockeye TOC. No separate estimate of the costs of this hatchery program can be provided at this time.

Maintain Captive Broodstocks to a Second Generation for Release to Target Lakes

Besides the cost of locating and equipping fish hatcheries for the broodstock program, the operations and maintenance costs for rearing second generations of sockeye in captivity represent incremental costs of RT recommendations for ESA listed sockeye. These costs would vary with respect to the obvious factors such as the number of broodstocks and the number of sockeye in each broodstock. Without more information on the scale of the programs it is not feasible to supply cost estimates.

Release Broodstock Progeny into Lake of Origin and Evaluate Results

The RT makes some recommendations with respect to the arrangements for release of progeny from captive broodstocks in terms of timing and locations depending on numbers available. Prior to release, the RT recommends that the fish be tagged so as to be better able to identify results. This represents an additional cost of unknown magnitude. Monitoring of out migration of juveniles and returns of adults also is required but details of the type and location of monitoring are not specified in a way that leads to quantification. Based on the IDF&G rearing and trapping program currently underway in Redfish Lake an estimate of $700,000 annually might be appropriate.

Undertake Long-Term Monitoring of Captive Broodstock and Release Program

Assuming this task is the responsibility of the SOC, NMFS and the Stanley Basin Sockeye TOC, no additional costs are anticipated for this activity beyond those already assigned in the Institutional section above. The long-term monitoring costs would be covered by those for monitoring of releases and returns noted above (unknown at this time).

Designate Genetics and Fish Culture/Fish Health Working Groups

The Stanley Basin Sockeye TOC serves some of these functions at present. The genetics protocol will be developed for the sockeye salmon by the designated Genetics Working Group established as one of the committees to advise the SOC will take on the task. The costs of developing the genetics protocol are included in the Institutional costs for this working group, i.e., approximately $50,000 per committee per year. Considerable direction is given for the genetics protocol in the RT Recovery Plan. Similarly, the question of culture and health working group will be dealt with by the Hatchery and Fish Culture and Health Working Groups established to advise the SOC. Their costs, approximately $50,000 each per year, are included in the Institutional costs section above.

Investigate Sockeye Reintroduction to Wallowa and Warm Lakes

The suite of studies the RT recommends to assess the potential for reintroduction of sockeye to Wallowa and Warm Lakes is considerable. Based on the costs of habitat investigation programs, species interactions studies, lake fertilization studies, etc. it is not unreasonable to expect that the recommended estimations could cost $1-1.5 million dollars per year for approximately three years. The range of total costs for these investigations would then be $3-5.5 million dollars. Part of the investigation of reintroduction must include passage to the lakes. For Alturas Lake in the Stanley Basin, recent purchase of a ranch through which Alturas Lake Creek passes makes it more possible that stream passage and flow can be managed to allow outplanted captive broodstock sockeye to transit the area. (BPA Journal, Dec. 1993).

Develop a Protocol for Fostering Natural Production of Sockeye

The ultimate goal of the Recovery Plan is to achieve a naturally self-sustaining population of sockeye salmon in the Snake River. The combined efforts of federal, state and tribal managers, lead by the SOC is directed to this end. Because the incremental costs associated with the NMFS and SOC are accounted for in the Institutional section, no additional costs are thought necessary here. Again, the costs to states and tribes are assumed to be reprogrammed from existing levels of activity. The near term reprioritization of these state and tribal efforts toward recovery of ESA listed species may cause disruption of existing programs based on all species and areas. Still, many other species and the ecosystem itself are likely to benefit from measures to improve recovery of ESA listed salmon. Therefore, no additional costs are assigned. It must also be remembered that many of the salmon related costs in state and tribal agency budgets come from federal or regional sources under programs like the NPPC process and the Mitchell Act.

Estimated costs of RT recommendations for sockeye production in freshwater are summarized in Table 3.4-2

Table 3.4-2 Estimated Costs of RT Recommendations for Sockeye Production in Freshwater

No.	Description of Item	Scope of Action	Annual Costs 1,000s 1993 $
1	Captive broodstock	Ongoing, 3-7 yr.	$3,000-5,000
2	Locate and equip hatcheries	Ongoing, 1-2 yr. (No estimate known)	Unknown
3	Maintain 2nd. generation of captive broodstock	3-7 yr. (No estimate known)	Unknown
4	Release broodstock and evaluate	Annual, ongoing, 3-7 yr.	$700
5.	Long-term monitoring of juveniles and adult returns*	Annual, ongoing, 3-8 yr. (See Table 3.1-2)	$10,000 (part)
6	Designate genetics protocol group and fish culture/fish health group*	Annual, ongoing, indef.	$100
7	Sockeye reintroduction to Wallowa and Warm Lakes	Annual, 1-3 yr.	$3,000-5,500
8	Protocol for natural sockeye production	Ongoing, indef.	N/A

* Cost of recommendation listed is included in another section. Repeated here to follow RT Plan.

Source: See text infra.

3.5 Improve Survival of Downstream Migrants

The Recovery Team's Final Recommendations contain twenty-seven items for improving downstream survival of salmon smolts. A summary list of these measures is displayed in Table 3.5-1. These endorse ongoing and expanded research, monitoring, coordination, and river system modifications - both structural and operational. Several recommendations affect the hydropower system on the Snake and Columbia Rivers. The RT emphasizes the need to continue to explore four major options: (1) improvement of the existing smolt collection and transportation system, (2) increased use of water stored in upstream reservoirs to augment flows during migration period (flow augmentation) to assist in-river migration, (3) drawdown of Snake River reservoirs, and (4) a smolt collection and transport facility at the head of Lower Granite reservoir. In addition to these major options, the RT endorses a large number of operational measures to improve survival of smolts within the existing system. Because substantial scientific uncertainty concerns the effectiveness and appropriate design of improvements, the RT proposes detailed study of survival through dams and reservoirs under various flow conditions, research on the best smolt release strategies in the lower Columbia River, and biological tests of the drawdown option. Regarding the drawdown test, the RT seeks information to assure that additional hazards to smolt passage are not created inadvertently and that upstream passage of adult salmon is preserved or improved. The Recovery Team Recommendations can be organized in three stages: immediate actions (continued smolt transportation, research on smolt survival, improvements to existing bypass systems), near-term actions, and future decisions to implement various options. The RT expects selection from among the major options to be made after evaluating all information regarding major construction and operation strategies.

Additional specific conclusions are included in the recommendations. The RT concludes that drawdown of the John Day reservoir below the level of minimum irrigation pool (MIP) is unwarranted. It concludes that drawdown on the Snake River should be either to spillway height or to river level. No half-way drawdown levels are seen as helpful. With recommendations 19, 20 and 27, the RT seeks to reinvigorate efforts to restore salmon to areas of historical habitat above Dworshak and Brownlee reservoirs. These actions would significantly increase the total spawning and rearing habitat of fall chinook, and are included under downstream migration survival because the chief obstacle is mortality of juveniles in the reservoirs. Water in the Brownlee reservoir, for example, reaches lethal temperatures for salmon smolts (R. Jones, personal communication). Hence, design and construction of juvenile bypass or collection and transportation facilities would be required to re-establish these spawning and rearing areas.

General Approach to Cost Assessment

In the second column of Table 3.5-1 we categorize the recommendations as construction, operation, research, management, and decisions. The character and timing of economic cost varies among these categories. Construction items have large up-front costs and long project completion schedules; river operational changes have annual costs that vary among water years and can be implemented rather quickly; research involves annual costs for a limited number of years. We assume that management and organizational items do not incur specific costs, but rather help to organize agencies and assign authorities and duties, hence facilitating the process of salmon recovery. Similarly, recommended decisions which focus attention on the need ultimately to choose between competing methods of improving smolt survival, are not assigned cost estimates. Finally, construction and operating costs are assigned to recommendations to "consider" a recovery measure that involved construction and operating costs. We find it necessary to include construction and operating costs along with decisions, because the actual implementation of actions would otherwise not be included. Items of this type include: negotiation of additional water from the upper Snake (15), surface smolt collection systems (22), upstream collector facilities (24), and Snake River reservoir drawdowns (25 & 26).

In assigning costs to these recommendations we generally adhere to the following guidelines:

1. Where federal or state agencies have estimated costs of a particular measure or of a measure very similar to the RT recommendation, we use that cost estimate (sometimes with modification) and note the source of information.

2. Where alternative methods of estimating costs or alternative definitions of cost are available, we exercise our judgement in choosing the version which seems to be most realistic. We provide a brief justification for the choice.

3. We include in Table 3.5-5 the estimated cost of some items that reflect ongoing programs, ongoing research, or currently funded improvements that are responsive to the ESA-listed salmon species even if they are not identical to the RT Recommendations.

Determining the base against which incremental costs of RT recommendations are to be measured is a complicated but sensitive aspect of the cost estimation. The RT has provided an extensive summary and evaluation of information on the nature of downstream migration problems, including an expert review of the scientific evidence. It has provided a structured approach to the research and implementation process. Many of the RT recommendations mirror elements of the NPPC Strategy for Salmon, or the NMFS 1993 or 1994-98 Biological Opinions, or ongoing research and development efforts funded by Bonneville Power Administration. The dilemma for cost assessment is that: (1) if the 1994-98 NMFS Biological Opinion plus the long term aspects of the NPPC Strategy for Salmon are used as the base, there will be almost no costs associated with the Recovery Team recommendations; but (2) the set of actions described and endorsed by the Recovery Team do entail substantial costs in direct construction and implementation by river agencies and in opportunity costs associated with other river uses. To avoid the under-stating the overall costs of implementing a Snake River salmon recovery effort, we provide estimated costs for a wide variety of measures listed in the Recommendations -- even those pertaining to existing programs and projects underway. Where the cost estimate is clearly linked to an ongoing program, this is noted. This approach to reporting the costs makes it possible to construct different versions of Recovery Costs, depending upon what is assumed to be the base program.

Table 3.5-1 Recovery Team Recommendations.

Recovery Team Recommendations for Downstream Migrants	Category of Action
1. Continue expanded smolt survival studies begun in 1993.	Ongoing Research
2. Install PIT tag detection equipment at additional dams in the lower Columbia River and develop techniques for sampling tagged fish downstream from Bonneville Dam.	Construction & Research
3. Study in-river migration to determine when smolts should not be transported.	Expanded Research
4. NMFS should manage and direct the collection and transport program.	Management
5. COE should continue daily operation of the collection and transport program.	Ongoing Operation
6. Develop better methods for counting fish in bypass and holding facilities.	Expand Research
7. Acquire additional barges to facilitate transport and permit testing of release strategies.	Construction
8. Develop better exit portals on the barges.	Design & Construction
9. Test release strategies and locations downstream from Bonneville Dam.	Research
10. Initiate tests to determine the flows needed to improve survival in Lower Granite Reservoir.	Research
11. Develop and improve bypass systems and operations at each dam.	Construction
12. Continue to evaluate extended-length screens and install them at Snake River dams if appropriate.	Ongoing Research, & Construction
13. Direct and coordinate release of stored water in Dworshak and upper Snake River reservoirs.	Management & Operations
14. Evaluate survival data to determine if a test drawdown of Lower Granite Reservoir is needed. If so, design and make the necessary dam modifications.	Design, Research & Construction
15. Negotiate for additional water from the upper Snake River.	Management
16. Design and evaluate surface collection systems.	Research & Construction
17. If a suitable test can be designed, test the drawdown of Lower Granite Reservoir.	Research & Construction

Table 3.5-1 continued

Recovery Team Recommendation	Category
18. Determine if smolt collection facility is needed at the head of Lower Granite Reservoir (see No. 24 for Construction & Operations)	Research
19. Study the actions needed to introduce salmon above Brownlee Reservoir. (No. 27 includes decision, construction, operations).	Research
20. Explore the feasibility of re-introducing salmon above Dworshak Reservoir. (No. 27 includes decision, construction, operations).	Research
21. Continue to plan and evaluate the option of drawing down all four Snake River dams. (Nos. 25 and 26 include decisions, construction, operations).	Research
22. Consider building surface collection systems.	Decision, Construction & Operations
23. If smolt collection and transport do not work, consider other options.	Decision
24. Consider building a collection facility at the head of Lower Granite reservoir.	Decision, Construction & Operations
25. Consider drawing down the four Snake River reservoirs to 33 feet below MOP.	Decision, Construction & Operations
26. Consider drawing down the four Snake River reservoirs to river level.	Decision, Construction & Operations
27. Re-establish salmon above Brownlee and Dworshak reservoirs, if feasible.	Construction & Operations

Many of the RT recommendations endorse studies and system modification currently being considered by the river operation and fishery agencies (Corps of Engineers, Bureau of Reclamation, Bonneville Power Administration, Northwest Power Planning Council) under the System Operation Review (SOR), System Configuration Study (SCS), or Columbia River Fish and Wildlife Plan. We have drawn many cost estimates from current drafts of the SOR and SCS reports. Appendix A provides a brief summary of the cost estimates provided in those reports. These studies represent multi-million dollar efforts, involving facilities engineering, systems analysis, economics, and biological research. As such, they include much of the most reliable and up-to-date information concerning the Columbia River hydroelectric system. While the draft reports may be changed in future versions, they contain much information about the impacts of. many salmon recovery measures. Several of the items listed by the Recovery Team are not specifically analyzed in the reports, but involve similar changes to the downstream passage facilities. In these cases we extrapolate from cost estimates available. Further, we obtained some estimated costs for recovery items directly from individuals at the Corps of Engineers, Bonneville Power Administration, or Northwest Power Planning Council. There are still some elements of the recommendations for which we have no credible cost estimate.

We make one specific modification to the published cost estimates provided by the operating agencies. For river operational options (draw downs, flow augmentations), we use annual opportunity costs for hydroelectric energy based upon the "Purchase Case" rather than the "CT Case". The Purchase Case assumes that most of the energy deficits caused by modified operation of the hydropower system are covered by Bonneville Power Administration's purchasing energy on the spot market or signing long term contracts for energy with electric utilities in the Southwestern states. This approach seems reasonable because the excess generating capacity in the Southwest occurs during the winter when peak demand for electricity in the occurs in the Northwest. Hence, excess energy should be available from the Southwest during times in which the hydropower system will be unable to meet its previous level of firm power supply. The "CT Case" assumes that most of the energy deficits are made up through purchase and installation of additional combustion turbine generating stations in the Northwest. This approach provides more reliability in supply, but it is more expensive because of the additional installed generating capacity. In fact, neither of these pure strategies are likely to be followed by BPA and the utility companies of the Pacific Northwest. As is assumed in the Northwest Power Planning Council's approach to energy cost calculation, some CTs will be purchased and some long-term contracts for energy (and energy exchanges) from the Southwest will be developed. Further, some spot market purchasing will play a role as it has in the past two years. Given the choice of only the two cases, we feel that the Purchase Case is closer to the costs likely to occur than the CT Case.

A major component of construction cost estimates provided by the Corps of Engineers is the "Interest During Construction" (IDC) which amounts to accumulated interest expense on expenditures during construction. This is like the cost of a construction loan that would be required for private sector construction projects. To determine the total funding needed at the Project on Line (POL) date, the IDC is added to construction costs. As a practical matter the COE often seeks reimbursement from the BPA for project improvements, and this accounting practice provides a useful summary measure of the total funding obligation as of the POL date. Reimbursement from BPA begins only after completion of construction. Hence, the IDC plus construction cost is the actual sum for which the Corps is reimbursed. This is an appropriate cost element so long as the interest costs are accumulated in each year only for those portions of a project that are actually financed at that time. We include this interest cost in our cost estimates for the reservoir drawdown options, but not for the miscellaneous system improvements included in the PIES and recent system improvements suggestions. As noted in Chapter 2, we take the present value of construction costs (for system improvements) or present value of construction program including interest during construction (for drawdown options) as the principal of a loan. Then we calculate the annualized cost as the annual loan payment. We discount future values and amortize capital costs using a 3% interest rate, and we assume a 50 year amortization period for most physical system improvements and a 100 year amortization period for major dam construction projects. Estimated annualized costs for major construction projects are included in the SOR estimates of drawdown alternatives which are more fully explained in Appendix C. The reservoir drawdown options involve opportunity costs of energy and of outputs from other sectors, and they require capital expenditures for dam modifications needed to facilitate the drawdown. Hence, these complicated options are sensitive to the interest rate assumed and the calculation of annualized capital costs.

Several of the Recovery Recommendations involve no significant capital expenditures but do incur annual program operating and maintenance costs (O&M). These costs are simply stated as annual amounts expressed in 1993 dollars. No attempt is made to anticipate future inflation or changes in program costs. Finally, the costs associated with complex river system changes (flow augmentations and reservoir drawdowns) vary widely among years due to water release strategies that are contingent on river run-off forecasts, varying opportunity costs of foregone energy generation in dry and wet years, and operation of reservoirs for other objectives like flood control, resident fish populations, and recreation. The annual costs associated with these river operation strategies are based upon computer simulations over 50 water years of record. The costs are reported as annual averages, but the actual costs incurred in any given year can be substantially higher or lower than that average.

The option of using an additional 1.427 million acre feet of upper Snake River water for flow augmentation during spring and summer (Recovery Team Recommendation 15) raises two issues: (a) cost to the hydropower system of re-shaping flows, and (b) cost of obtaining "new" water from the upper Snake water rights holders. As shown in Appendix C below Snake River flow augmentation is included in the System Operation Strategy 3b but not in SOS 3b. The annual average hydropower cost over the 50-year cycle is taken to be the difference in cost between SOS 3a and SOS 3b, which is roughly $11 million to $13 million per year, depending upon the revision to the SOR cost estimate.

A different perspective on the same flow augmentation appeared in Huppert, Fluharty, and Kenney (1992). The estimated cost of an annual 1.427 MAF augmentation from the upper Snake River was a mere $2.63 million. Based upon previous research, expert opinion, and preliminary work on this specific issue, we concluded that some additional water might come from "un-allocated storage", and a modest quantity could be obtained through existing "water banks", but amounts greater than, say, 300 KAF would require reduced consumptive water use by agricultural irrigators in southern Idaho. For this analysis the baseline condition is assumed to be full appropriation of water in the Snake River basin. River flows downstream of Brownlee reservoir (and at Lower Granite dam) are assumed at levels experienced in recent years. Existing "water banks" in the upper Snake, Boise, and Payette rivers make water available for lease to power and agricultural users. Actual sales of water bank water to power companies during 1979-1991 averaged about 225 Kaf per year, but varied among years from zero to 350 Kaf. Water banks also sold to agricultural users. Water sold for power generation becomes in-stream flow. Hence, there has been some flow augmentation associated with the water bank operations which are taken as baseline condition. Any additional flow over and above this amount would contribute to the flow augmentation objective.

The need for enhanced flow is greatest when flows (depleted by diversions and low runoff) are at their lowest. We consider three possible water deliver schedules. The first option is to augment flows only when natural flow is very low; this is the "extreme dry year" option, which is assumed to augment flow in one year out of ten (i.e., 10% of the time). The second option delivers the target flow augmentation in one year out of four (25% of the time). The third option is to deliver the augmented flow every year (100% of time). Both the economic costs and the power benefits will differ significantly among these options.

The cost of obtaining additional water depends heavily upon (1) the procedure or institutional mechanism used to enhance stream flow, and (2) the timing and frequency of flow enhancements. A key assumption is that water marketing institutions permit the lease of water through interruptible contracts or the outright sale of water rights to in-stream uses. Reallocation of water use through voluntary transactions in markets is thought to be the least disruptive and most economically efficient procedure. While current water law may not support the kind of market transactions we envision, we are optimistic that, if the water must be made available, amendments to Idaho water law or practice can be made to facilitate and minimize the costs of accomplishing the task. Other means of re-allocation, such as court-ordered flow requirements under the Public Trust doctrine, would likely be much more disruptive and economically costly.

Our approach is derived from Hamilton, Whittlesey, and Halverson (1989), Hamilton and Whittlesey (Draft 1992), Sommers (Memo, dated April 6, 1992), and Peterson, Whittlesey, and Hamilton (Memos dated April 24, 1992 and May 13, 1992). We focus on the use of interruptible water markets to augment river flow and the ancillary issue of hydropower generation. The interruptible market would permit hydropower firms or other instream water users to contract with farmers having appropriative water rights to supply water in dry years. The farmer would agree to transfer water diversion rights contingent upon run off forecasts. In dry years, which could occur one year out of ten years or one year out of four, the farmer would interrupt the normal irrigation schedule, permitting water released from storage facilities to flow down the river.

The likely range of total costs and hydropower benefits for obtaining 427 thousand or 1,427 thousand acre-feet of additional water are summarized in Table 3.5-3. These estimates assume that existing water banks in Idaho can provide up to an additional 300 KAF at the current rental price of $2.75 per acre-foot. For the 10% and 25% options, the remaining water is obtained through temporary interruption of irrigated farming (assuming an interruptible water market). For the 100% options augmented water comes from permanent retirement of farm land from irrigation. The costs associated with interruption of farming operations is taken to be the net farm income loss for the year; which is the component of economic surplus associated with ownership and use of scarce productive land (i.e., land rent).[4] Based upon several farm operation models, Hamilton and Whittlesey estimate the typical cost as $80/acre for temporary interruption. The actual loss will vary among types of farms and among areas; this is a rough estimate for farm operating in southern Idaho and northeastern Oregon. Each acre of land temporarily taken out of production would release about 3 af of water during the year of interruption. For interruptions in more than 50% of years, we assume permanent retirement of land. Because a variety of fixed costs can be avoided in the long run, the typical cost for retirement (i.e., permanent sale of water right) is lower than $80/acre; Peterson et al. suggest $50/acre as a reasonable estimate of lost net income per acre permanently retired. Each acre of land permanently retired would generate 2 af of additional stream flow per year. While these estimates depend upon a number of assumptions and rough calculations, we take them as the best estimates currently available for costs of obtaining additional flow for salmon in the Snake River.

There are a number of complications with this procedure, including the treatment of junior water rights (those depending upon return flow from fields of senior rights holders) and the effects on recharge of the Snake basin aquifer. Of the 6 acre feet typically applied per acre of farmland per year, about 2 af are "consumed" by crops and evaporation, 2 af return to the river (or may be intercepted and diverted by junior appropriators) and 2 af percolate into the aquifer (which is available as groundwater or eventually returns to the river). Following Peterson et al., we assume that for each acre where irrigation is interrupted infrequently the 2 af normally consumed and 1 af of water that would percolate into the aquifer remain in stream and can be shaped for fish. The reduced aquifer recharge will, in the long run, reduce the flow of springs back to the river. Thus, while 3 af are available in the year of interruption, a long term interruption of irrigation will yield only 2 af sustained increase in river flow. Hence, the amount of flow augmentation for the 100% option is only 2 af per acre retired.

Augmented stream flow will have effects besides those on agriculture. Unless the water is spilled over the spillway, it will enhance hydropower production at numerous generation facilities in Idaho and on the lower Snake and Columbia Rivers. The amount of potential hydropower generation associated with each flow augmentation option was calculated by Peterson, et al. based upon the assumption that each acre foot of new water generates .87 kwh for each foot of head that it passes through. Given the assumed distribution of flow augmentation along the Snake River from American Falls to Brownlee dam, each acre foot of new flow at Brownlee generates an additional 1.526 megawatt-hours system-wide. Assuming that firm power is valued at 3.9 cents/kwh and non-firm power is valued at 1.0 cents/kwh; the following average rates were applied to the energy generated by the flow augmentation:

[4] We do not attempt to adjust estimated net farm income per acre to account for the social costs of farm product price support or other subsidy programs. Doing so would probably reduce the estimated "social costs" for retired agricultural land.

Interruption Frequency	% Firm Power	% Non-Power Firm	Weighted Average Rate
			cents/kwh
10	100	0	3.90
25	60	40	2.74
100	20	80	1.58

The assumed split between firm and non-firm power reflects the likelihood that infrequent interruptions would occur in dry years when water for power is scarce. Adding water in dry years should contribute to firm power production. Additional water every year, especially if available during Spring, would contribute mainly to secondary power in normal or wet years.

Overall, the augmentation of Snake River flows for salmon would reduce farm incomes but increase potential hydropower generation. As noted in Table 1, the net effect is essentially nil for the 10% and 25% interruption options. If the additional water is needed every year, the loss of farm income would exceed the increased hydropower value by $1.74 million for a 427 KAF augmentation and by $2.63 million for a 1.457 MAF augmentation.

There are numerous additional considerations that are not quantified here; including (1) the "transactions costs" associated with establishing an interruptible power market; (2) long term effects of flow augmentation on aquifer recharge and subsequent effects on groundwater users due to increased pumping costs; (3) the significance of crop subsidies and price support programs for calculating social costs of net farm income losses; (4) whether the price paid for unused agricultural water from the water bank should be counted as a real cost, rather than as a transfer payment; (5) whether recreational losses might occur in storage reservoirs when water is drafted for in-stream flows; (6) water quality effects occurring near metropolitan areas during periods of lower flow due to shaping of flows for salmon. Regarding item (5), we suspect that the recreational impacts in reservoirs will be minimal. The water released for salmon does not add to total annual reservoir releases; it simply changes the timing and the end use of the water.

A major assumption of the interruptible water markets analysis is that increased flows for salmon results in increased flow for hydropower. If the extra flow is sent down stream during the spring and early summer and the dams are drawn down or required to spill significant fractions of the flow, then this analysis overestimates the value of that flow for hydropower. Whether this assumption alone accounts for the vast difference between this cost estimate and that of the SOR is currently unknown to the authors. We state both cost estimates in Table 3.5-5 to indicate the full range of cost estimates.

Table 3.5-5 reports a summary of cost estimates for most of the major Recovery Team recommendations and options for future consideration, reporting capital and annualized costs using 3% interest rate. To obtain the numbers reported as "Annual Costs in 1,000s 1993$", the present value of the capital costs were annualized using the annual pay-back formula (equation 2-2 in Chapter 2) and then added to the anticipated operation and maintenance costs. For the Snake River reservoir draw down alternatives (Recommendations 14&17, 21&25, and 21 & 26), the range of cost estimates is taken from Table C-3 in Appendix C. The high and low ends of each range represent the 4-1/2 month and 2 month draw downs respectively. Also, costs for the low end of the ranges represent a judgmental adjustment to the costs reported in the SOR Draft EIS.

Table 3.5-2 Net Gains from Snake River Flow Augmentation in 1993 $

Probability of Interruption	Net Farm Income Losses[1]	Power Gains	Net Income Gain (Loss in Parentheses)
%	--------- millions $ -------		
For 427 KAF Target Flow:			
10	$1.05	$1.53	$0.48
25	$2.43	$2.45	$0.02
100	$6.94	$5.02	($1.93)
For 1,427 KAF Target Flow:			
10	$3.61	$5.34	$1.73
25	$8.86	$9.18	$0.32
100	$31.27	$28.64	($2.63)

[1] From Peterson et al. 1994. Assumes that lost farm income from occasional interruption of irrigation water is $80/acre; that 1 acre of land must be taken out of production for each 3 acre feet of water added to instream flow, and that permanent retirement of land under 100% interruption case will cause a lower net loss of farm income of $50/acre, and release 1 af for hydro.

Table 3.5-3 Flows for Interruption Year

Probability of Interruption %	From Water Bank (af)	Additional Water Needed (af)	Average Acreage Affected (acres)	Reduced Aquifer Recharge (af)
For 427 KAF Target				
10	80,000	347,000	115,667	115,667
25	110,000	317,000	105,667	105,667
100	239,185	187,815	93,908	62,605
For 1,427 KAF Target				
10	80,000	1,347,000	449,000	449,000
25	110,000	1,317,000	439,000	439,000
100	239,185	1,187,815	593,908	395,938

Source: Peterson et al. 1994

Table 3.5-4 Augmented Snake River Flows Annualized over all Years Interruptible Water Market

Probability of Interruption %	From Water Bank (af)	Additional Water Needed (af)	Average Acreage Affected (acres)	Reduced Aquifer Recharge (af)	Increased Flow (af)
For 427 KAF Target					
10	8,000	34,700	11,567	11,567	23,133
25	27,500	79,250	26,417	26,417	52,833
100	239,185	187,815	93,908	93,908	187,815
For 1,427 KAF Target					
10	8,000	134,700	44,900	44,900	89,800
25	27,500	329,250	109,750	109,750	219,500
100	239,185	1,187,815	593,908	593,908	1,187,815

Source: Peterson et al. 1994

Table 3.5-5 Estimated Costs of RT Recommendations.

No.	Description of Item and Source of Cost Information	Description of Cost Estimated	Capital Cost 1,000 1993 $	Annual Costs in 1,000 1993 $ at 3 %
I. Research on Smolt Survival				
1	PIT-Tag Information System (PTAGIS) BPA, personal communication KB	Annual, ongoing indefinitely		$400
2	New PIT-Tag detectors (Appendix A of this report, Table A-1)	Capital costs amortized over 50 years, plus O&M costs	$ 22, 768	$1,415
3	Travel time/smolt survival study, passage survival estimates	Annual, ongoing indefinitely BPA, personal communication K. Beale.		$750 $800
6	Accessing techniques to improve measurement of survival.	Annual, several years. BPA, personal comm. K Beale.		$50
9	Test release strategies and locations downstream from Bonneville Dam. Dispersed release/short hauling and flumes costs. See Appendix A below.	Construction costs in lower Col. R. amortized over 50 years plus O&M expenses.	$ 53,883	$ 5,138

Table 3.5-5 Continued.

No.	Description of Item and Source of Cost Information	Description of Cost Estimated	Capital Cost 1,000 1993 $	Annual Costs 1,000s 1993 $ at 3 %
II. Improvements to Smolt Bypass, Collection, & Transportation System				
7	Additional barges for smolts. (Personal Communication, E. Woodruff, COE)	Capital expense amortized over 50 years.	$ 15,000	$ 598
8	Improved barge exit portals. COE, SCS Append E. p. 6-4	Capital expense amortized over 50 years.	$ 1,514	$ 59
11	Improved bypass systems and operations at each dam. Includes Program Improvement for Endangered Species (PIES)	Capital improvements in PIES program (Appendix A below), amortized over 50 years.	$5,310	$ 206
12	Evaluate and install extended-length screens at Snake River dams.	Capital cost for McNary, Lower Granite and Little Goose dams. Amortized over 50 years.	$46, 923	$1,824
16 & 22	Surface collection at LWG. "Forebay Collection system" COE. SCS App. E.	Capital expense amortized over 50 years.	$104,129	$4,047
18 &24	Design and construct a smolt collector above LWG reservoir. Several options considered in SCS App. D) This is low-cost option #3, using barge transportation to below Bonneville.	Capital expense amortized over 50 years plus annual operation and maintenance expenses.	$317,423	$17,437

Table 3.5-5 Continued.

No.	Description of Item and Source of Cost Information	Description of Cost Estimated	Capital Cost 1,000 1993 $	Annual Costs in 1,000 1993 $ at 3 %
III. Flow Augmentation				
10	Test flows to improve survival @ LWG	Several year study.	None	unknown
13 &15	Flow from Dworshak & upper Snake, same as NMFS' 1994-98 Biological Opinion. 1 MAF from Snake in addition to 427 KAF called for in NPPC Strategy for Salmon.	Low estimate is net cost of purchasing 1.427 MAF from water bank. High cost is from SOR Strategies 3a and 3b.	None	$2.6 million - $13 million
IV. Reservoir Drawdown				
14 & 17	Design and construction for drawdown at LWG SOS 6c & 6d for 2 months or 4-1/2 months	Annual opportunity cost of energy, navigation, agriculture, recreation, and amortized construction cost . "Purchase Case" for energy.	$69,654[1]	$ 28,295 - $57,421
21 & 25	Drawdown of 4 Snake River dams to 33 feet below MOP. SOS 6a & 6b for 2 months or 4-1/2 months	Annual opportunity cost of energy, navigation, agriculture, recreation, and amortized construction cost "Purchase Case" for energy.	$904,969[1]	$60,136 - 106,179
21 & 26	Drawdown of 4 Snake River dams to river level. SOS 5a & 5b or 2 months or 4-1/2 months	Annual opportunity cost of energy, navigation, agriculture, recreation, and amortized construction cost. "Purchase Case" for energy.	$3,170,822[1]	$95,310 - 167,587

[1] Lower range of estimated costs for drawdown options include a 50% reduction in estimated construction costs. See Appendix C.

Table 3.5-5 Continued.

No.	Description of Item and Source of Cost Information	Description of Cost Estimated	Capital Cost 1,000 1993 $	Annual Costs 1,000s 1993 $ at 3 %
V. Restore Chinook to Habitat Above Brownlee and Dworshak				
19	Feasibility of restoring chinook salmon to drainages above Brownlee reservoir. Includes design of facilities, habitat improvements, and plan of operation.	Preliminary design and cost analysis. No current study known.	unknown	unknown
20	Feasibility study for restoring chinook salmon to drainages above Dworshak reservoir. Possibly use smolt collection facility in upstream end of reservoir.	Preliminary design and cost analysis. No current study known.	unknown	unknown
27	Re-establish chinook above Brownlee and Dworshak reservoir.	Construction plus continuing operations and maintenance.	unknown	unknown

Summary

Because the recommendations concerning downstream survival of smolts contains complex measures which require substantial prior research and consideration, there is no simple way of summarizing the costs associated with this section. There are numerous possible outcomes and associated costs. We illustrate this with three hypothetical future sequences of events and decisions.

One Possible Outcome: The recommended research on in-stream survival and river flow shows that improved passage facilities at the eight federal dams, in combination with expanded water budgets and spill during migration season, adequately improve survival. In this case, the decision would be made to minimize smolt collection and transportation, not to engage in the reservoir drawdowns on the Snake River, and not to build the upstream smolt collector. The overall costs in this case would include all the research costs, all the short-term improvements in the transportation and passage systems, and the costs of improved flows, probably including the costs of a 1.427 MAF increase in water flow from the upper Snake River.

A Second Possible Outcome: Drawdown of the four Snake River dams is chosen as the best option for improving smolt survival. Substantial construction to modify adult passage facilities, spillways, and stilling basins must precede full adoption of the four-dam drawdown. The Corps of Engineers (SCS Phase 1 Draft Main Report, p. 6-6) estimates it would take 14 years to fully implement a four-dam drawdown to 33-Ft below MOP. Consequently, this case includes costs of short- and medium-term research and system improvements, including improved collection and transportation of smolts from Lower Granite and Little Goose dams, extended length screens, and flow augmentation until the drawdown is feasible. Finally, opportunity costs associated with the drawdown (irrigation pumping station modification, reduced river navigation, reduced recreation in reservoirs) would begin accruing once the drawdowns are implemented.

A Third Possible Outcome: Research concludes that in-river survival cannot be elevated to necessary levels through drawdown, augmented flows, or improvements to dam passage systems. The expanded collection and transportation by barge from Lower Granite dam and, possibly, an upstream collector at the head of Lower Granite reservoir becomes the long-term preferred option. Because the construction of the upstream collector will take 5-1/2 to 8 years to complete (SCS Phase 1 Draft Main Report, p. 6-32), most of the capital costs associated with improving the existing smolt passage system through the eight federal dams will be incurred in addition to costs of an upstream collector. Hence, even with an upstream collector, it would be possible to use flow augmentation in wet years as an alternative to collection and transportation.

The Recommendations to improve survival of downstream migrants are among the most complex and potentially most expensive of all the Recovery Team recommendations. Partly as a result of this fact, the actual costs likely to be incurred in this effort are highly uncertain and dependent on future research, conclusions, and decisions.

3.6 Measures to Control Salmon Harvest

Because commercial and recreational fishing is a major source of mortality in adult sockeye and chinook salmon of Snake River origin, the Recovery Team recommendations seek reduced levels of harvest during the early stages of recovery planning. Recognizing the complex nature of mixed stock fisheries, the Recovery Team recommends management to achieve both spawning escapement goals and target exploitation rates, but leaves the choice of specific management strategies to the Pacific Fishery Management Council (PFMC) and the proposed Salmon Oversight Committee (SOC). Besides reducing planned harvests of Snake River salmon, the Recovery Team calls for increased enforcement of fishery regulations in the Columbia River. Ultimately, the recovered stocks may increase to support larger annual harvests. If so, the direct economic costs of reduced harvest that occurs in early stages of recovery may shrink or become positive economic benefits as the recovery proceeds. However, the ESA calls for recovery only to non-threatened status, not to population levels supporting increased commercial and recreational harvest. Consequently, we limit our assessment to the costs associated with the recovery effort and do not assess potential benefits.

Of the twelve Recovery Team recommendations for harvest management of sockeye and fall chinook salmon listed in Table 3.6-1, we find that five measures (Numbers 1, 2, 4, 6, and 10) are likely to contribute to measurable economic costs of the Snake River salmon recovery. The first two call for shifts in the structure of the Treaty tribes' in-river fishery. This may have great cultural significance to treaty tribes, and may entail some costs associated with establishing new fishing operations, but there is little or no reduction in expected treaty catch of sockeye salmon below recent levels; hence little overall economic cost or impact in the long run. Still the short-term costs of disruption and adjustment cannot be ignored. Currently, no commercial fishing for sockeye takes place above the confluence of the Snake and Columbia Rivers. To establish a fishery in that area, boats may have to be transported and a new fishing operations devised. However, lacking a means of estimating that cost, we leave these items with the recognition that we may be underestimating some costs of harvest management measures.

The remaining three items comprise a comprehensive change in the structure of the river and ocean fishery to accommodate the needs of Snake River Fall Chinook (SRFC) recovery. The full package includes: an increase in surveillance and enforcement of fishing regulations in the Columbia/Snake Rivers, development of live-capture gear, elimination of gill net fishing in the Columbia River, creation or expansion of gill net terminal fisheries for specific hatchery stocks, reduction of ocean salmon troll fishing capacity, and buy-back of all existing Columbia River gill net licenses. All of these elements have been proposed at times in the past as a means of rationalizing the salmon fishery. Some long-term economic benefits to the salmon fishery will likely result from their implementation, although short-term disruptions and adjustment costs are also inevitable. The focus of our analysis will be the short-term costs of disruption and adjustment in gill net and ocean troll fisheries and the compensation required to entice permit holders out of the fishery. Finally, the enhanced enforcement effort clearly will involve direct economic costs reflected in agency budgets.

Table 3.6-1 Recovery Team Recommendations for Columbia River Salmon Harvests

1. Request the tribes to release marked sockeye and to reduce the take of sockeye in ceremonial and subsistence fisheries.
2. Eliminate directed commercial fishing for sockeye below the confluence of the Snake and Columbia River until selective fishing is developed.
3. Modify the Columbia Fisheries Management Plan to address explicitly the conservation of Snake River sockeye.
4. Strengthen enforcement programs in the harvest sector.
5. Modify Columbia River Fisheries Management Plan to address explicitly the conservation of threatened and endangered S/S and Fall Chinook.
6. Require gear that can capture fish alive. Eliminate gill netting in lower Columbia R by 2002.
7. Manage designated headwaters of hatchery production specifically for fishery harvest. Permit gill nets in these waters.
8. Cap the total exploitation rate of ocean and river fisheries for Snake River fall chinook at 50%. Initially, rates should be less than 50% of the recent levels.
9. Meet four brood year average target of voluntary returns of fall chinook to Lyons Ferry hatchery plus natural fish counted over Ice Harbor or Lower Granite Dam.
10. Reduce fishing capacity with voluntary "buy-back" of all non-Treaty river gill net fishery permits (Zones 1-5) and fifty percent of ocean troll fishing capacity off Oregon (north of Humbug Mountain) and Washington. If reduction in fishing capacity of at least 20%/year is not achieved, use a mandatory "buy-back".
11. Press for a reduction in Canadian catches of threatened Snake River fall chinook through international negotiations
12. Strengthen enforcement programs in the harvest sector.

In addition to the five items which we emphasize, economic costs will likely accompany the Recovery Team's recommendations to incorporate Snake River salmon recovery in existing management plans, to set targets for adult returns to Lyons Ferry hatchery and wild spawning fish counted over Ice Harbor or Lower Granite Dam, and to negotiate reductions in harvest of Columbia River fish in the Canadian fishery off Vancouver Island. We presume these planning and negotiating exercises could be burdensome and expensive, but we do not attempt to estimate the economic costs or impacts of them.

General Considerations

According to the Recovery Team, the river fisheries below and above Bonneville dam take 13% and 19% respectively of the Snake River fall chinook (SRFC) caught in all fisheries (RTR Table IX-1, p. IX-5). Given the average total harvest rate on SRFC of 64.3% (p. IX-11), the river harvest accounts for over 20% of the average run of SRFC. If selective live-capture gear is developed and implemented in both the Treaty and non-Treaty fisheries, essentially all SRFC could be released with little or no mortality in the lower River. Absent a compensating increase in ocean harvest, this action would reduce the SRFC harvest rate to the ocean-only rate of 43.7%, which is below the Team's recommended rate of 50% or less for SRFC.

The costs of developing and deploying fish weirs and traps which capture fish alive could vary substantially depending upon how it is done. Technical aspects of live capture gear should not entail substantial expense. The early history of the Columbia fishery was dominated by fish traps, weirs, and fish wheels, and these could serve as a starting point. Since the migrating salmon are already concentrated at Bonneville dam, traps could be installed at the entrances or exits of the fish ladders. Further, chinook returning to tributaries entering the Columbia below Bonneville dam could be captured in the tributaries. Gear-related direct costs of implementing this approach to harvest should be minimal. However, some reduction in quality and price of salmon would undoubtedly occur.

While capture at Bonneville dam and in tributary streams could be the least expensive means of modifying river harvest to allow live release of non-hatchery fish, and while this could satisfy the Recovery Plan objective, political and social pressures could prevent the adoption of a simple and efficient harvest system that eliminates the established fishery. The existing Columbia River fishery gill net fishery involves 867 licensed fishermen from Washington and Oregon (Table 3.6-4). To retain the small scale, dispersed nature of the river fishing business one option would be to develop and license the use of individual fish weirs and traps dispersed over many sites. This technical solution to live capture may be complicated by the scarcity of sites for placing this gear and by conflicts over use of those sites. Large organizational and transaction costs could be incurred in attempting to resolve property rights and rights-of-way challenges resulting from competition by ex-gill net fishermen for good fish trapping sites. After careful consideration, we conclude that we have no way of estimating the cost of developing a dispersed live-capture river fishery. This would require a separate study. Therefore, we assume that some costs are likely to be incurred in reorganizing the fishery for live-capture.

Significant budgetary outlays will likely be needed for the proposed buy-back of the river gill net fishery and 50 percent buy-back of the ocean troll harvesting capacity. Following the Recovery Team recommendation, the buy-back would include salmon fishing permits, vessels, and gear fishing in Zones 1-5 of the Columbia River (i.e., below Bonneville dam) and fifty percent of the troll fishing capacity north of Humbug mountain off Oregon and off Washington.

Because the ocean catch of SRFC is incidental to the harvest of many other salmon stocks, a reduction in ocean harvest of SRFC could require a reduced overall ocean harvest. The size of this ocean harvest reduction cost will depend upon whether fishery managers successfully "shape" the ocean fishery (through seasonal opening and closing of specific areas, seasonal regulation of species targets, and gear restrictions) to avoid SRFC while continuing to harvest the more abundant stocks with a reduced fishing fleet. Even if shaping of ocean fishing cannot avoid sacrificing some ocean harvest of abundant stocks, terminal fisheries may be expanded to harvest any resulting harvestable surplus. To develop a rough estimate of recovery costs, we assume that fishing capacity in the ocean and terminal fisheries is sufficient to take the annual allowable harvests of all major salmon stocks under effectively "re-shaped" salmon fishing seasons and areas. As a direct implication of this assumption, we anticipate no overall reduction in future gross economic values of commercial or recreational salmon fishing as a result of harvest limitation under the Recovery Team recommendations. Hence, we are concerned mainly with the cost of purchasing existing permanent, transferable fishing licenses issued by Oregon and Washington State for both river gill net fishing and ocean troll fishing. This is a once-for-all cost to the federal agencies.

The assumed capability of harvest managers to avoid sacrificing future harvest levels is likely to be realized in practice if the harvest rate reduction for SRFC is carried out in a flexible and cost-minimizing way. In particular, this would require that most of the SRFC harvest reductions be sought in those fisheries which experience the highest rate of SRFC catch. According to Recovery Team assessments and data, these fisheries are the Columbia River fisheries, the ocean troll fisheries off Washington, Oregon, and the Canadian fishery off the west coast of Vancouver Island. If, on the other hand, the harvest management agencies demand proportionate reductions in all fisheries incidentally taking SRFC (including California and southeast Alaskan fisheries), the costs in terms of fishery disruptions and lost harvest revenues could be substantially higher.

Approach to Estimating Costs of Buying Back the Columbia River Non-treaty Gill Net and Ocean Troll Operations

Each salmon fishing permit represents a right in perpetuity to participate in a specific common property salmon fishery. The amounts of fish available in the specific fisheries, the prices of those fish, and the costs of fishing determine the profitability of owning a license and operating a fishing enterprise in the permit fishery. The value of holding a permit would be equal to the discounted value of future profits, which is computed by the formula:

$$\text{(3.6-1)} \qquad \text{Permit Value} = \sum_{t=1}^{\infty} \frac{(P_t \cdot H_t - C_t)}{(1+d_t)^t},$$

where P represents the price of salmon caught, H is the harvest volume per permit holder, C is the annual operating cost of a fishing operation, and d is the permit holder's discount rate. Each variable carries the subscript t to indicate that the numerical value for that element can change from year to year over the future. For a given year, the ratio of the two terms in parentheses represents the profits of operating the vessel in year t, discounted back to year 0 using the appropriate discount rate. The capital Greek sigma symbolizes the summation of annual discounted profits over all years from 1 year in the future to infinity. If each of the variables (P, H, C, and d) were known with certainty for all future years, one could easily calculate the value of owning a permit. In a simple world, this would represent a value that the owner could command in the market for permits, and it would represent a fair compensatory payment that the government could offer for "buying-back" the fishing permit. The cost to the relevant agency of buying river gill net and ocean troll permits would be roughly equal to the present value of the permits. If all fixed investments used in the fishery, such as fishing vessels, can be shifted to other fisheries, then the owners would need be compensated only for the net earnings in the salmon fishery. This would equal the gross expected sales minus variable costs of salmon fishing and the portion of fixed costs that are attributable specifically to salmon. However, the Recovery Team recommends purchasing the vessels and gear along with the fishing permits. This could increase the cost of buy-back, since owners will need to be compensated for fixed asset values used in both salmon and other fisheries.

Several complications affect this calculation. First, permit owners differ in fishing abilities and productivity. One consequence of this is that harvests per vessel exhibit a "skewed distribution". In the Washington troll salmon fishery, for example, the top ten percent of the fleet (based upon annual catch) took 50 percent of the catch in 1993. Thirty -four percent of the fleet took 90 percent of the catch. If buy-back payments were geared to historic or expected future earnings, some permit holders could be compensated with relatively small payments, others would require much greater compensation. A staged buy-back over 5 years, as suggested by the Recovery Team, might purchase permits and gear from the least profitable operators first. During the four rounds of permit buy-backs administered by the State of Oregon during 1984-1986, greater compensating payments were needed as the program progressed (Chris Carter, personal communication). However, since the RT's buy-back program would eventually eliminate the gill net fleet by compulsion, it is unlikely that the compensation required would increase in this manner. Instead, we will assume that an equal amount will be spent in each year, and the total purchase payment will equal the net discounted value of estimated net earnings.

Second, the present value formula assumes known values for future harvests, costs, and prices, while real world asset markets represent calculated judgments concerning future production and profitability. Expectations of future harvests are undoubtedly very volatile and are sensitive to the discussion and implementation of ESA Recovery Planning. During 1994, for example, the river fishery below Bonneville dam and the ocean troll fishery off the northern Oregon and Washington coasts were completely closed. If this condition continues, then the permits are essentially worthless, although some people may place sentimental value on them. In actuality, there are undoubtedly a wide variety of expectations prevailing among permit holders about the future prospects for salmon fishing. These expectations could reflect beliefs that the salmon populations will recover, possibly encouraged by policy decisions such as the Northwest

Power Planning Council's objective to double the size of Columbia River salmon runs. It is not possible for us to determine what permit holders expect for the future in order to calculate the compensatory value of salmon fishing operations, although in principle one could determine this by holding a sealed bid auction in which each permit holder offers to sell. Instead, we approach this aspect of the problem in a rudimentary fashion by assuming that the future is expected to be something like the recent past. Two alternative assumptions are that permit holders expect future harvest revenues to be on average equal to the past ten-year average (1984 - 1993) or to the past three-year average (1991 - 1993).

If the expected future revenues are the same for each future year, the present value formula is simplified to:

(3.6-2) $$\text{Permit Value} = (P \cdot H - C) / d$$

Third, harvesting costs vary among operators, and they are conceptually divided into fixed and variable costs. Fixed costs represent the costs that cannot be avoided by stopping fishing, and they include amortization of capital investments in vessels, gear, and cost associated with development of human skills and reputation. Variable costs are those costs which accrue as fishing activity occurs; they include costs of fuel, payments to crew, opportunity costs of the permit holder's labor, costs of replacing gear loss, and extra maintenance associated with gear and vessel use. Since the fixed costs are "sunk", a buy-back of gill net and ocean salmon troll vessels, gear and fishing permits would need to compensate for lost return of investment on all these assets. Variable costs are avoided if fishing is curtailed, and permit holders need not be compensated for costs not incurred. Fixed costs that are not avoided after fishing stops will be included in the amount to be compensated. Consequently, only variable costs are subtracted from gross revenues in applying equation 3.6-2. Besides the usual variable input costs listed above, a fishing vessel operator who sells out will be able to avoid such quasi-fixed costs as insurance, mooring, and license fees.

Fourth, if the vessels and gear can be used in other fisheries, the values extinguished by the permit/vessel/gear buy-back can be greater, maybe substantially greater, than the values calculated for the river gill net and ocean troll fisheries alone. In this case, the buy-back price for each permit holder would equal the full discounted earning in all fisheries in which the vessel and gear are used. Since we have little information about fishery participation patterns for the subject permit holders, we simply note here that the buy-back cost estimates based upon salmon fishing in the subject fisheries could underestimate the actual amount that would be required to buy-back the permits and fishing gear/vessels.

Fifth, owners and operators of salmon fishing vessels in the Columbia River may be enjoying a benefit -- a so-called "worker satisfaction bonus" (C. Smith, 1981 or Anderson, 1980) -- that is not reflected in the net earnings. As a consequence of this, the permit holders might require more compensation than the discounted value of future expected earnings. This is another reason that our estimates based upon earnings could underestimate the actual compensation required.

A final complication is the legal/institutional aspect of buying back the permits. For example, State legislation needs to be modified to facilitate the fishing capacity reduction and to assure that the fishing capacity reduced through the buy-back program is permanently extinguished. Oregon's legislation reportedly requires issuance of new gill net permits when the active fleet drops below a minimum cut-off level. Triggering of this provision would hamstring the buy-back effort. Further, the detailed structure of the buy-back systems can have a significant effect on the ultimate agency outlay needed to accomplish the desired capacity reduction. A silent auction or sealed-bid auction in which permit holders make offers to sell can result in greatly differing aggregate cost depending upon whether it is a once-for-all, take-it-or leave-it sale or whether the permit holders expect additional rounds of bidding later. Moreover, if the government announces its intent to invoke a mandatory buy-back in the near future (with implied absence of negotiation over price), a round of bidding will likely yield a larger number of lower offers to sell. These sources of variation in cost of buy-back cannot be predicted at the current time. Hence, the estimates presented below should be taken as only roughly indicative of costs likely to be incurred.

Estimated Cost of Permit Buy-Back

To estimate the costs of buy-back we calculate the aggregate value of future earnings likely to occur in the river gill net and ocean troll fisheries. For the river gill net fishery, the buy-back is 100% - all future earnings potential is extinguished. For the ocean troll fishery, fifty percent of the future earnings capacity of trollers operating north of Humbug mountain is extinguished. Since essentially all of Washington's troll fleet operates north of Humbug mountain, the buy-back requires a reduction of 50% in gross and net salmon fishing revenue for the Washington fleet. Oregon's troll fleet operates north and south of Humbug mountain, but during the past eight years about 96% of the salmon caught by Oregon trollers were taken north of Humbug mountain (Pacific Fishery Management Council, 1994). Hence, a 50% reduction in the fishery north of Humbug is taken to represent a 48% reduction in the Oregon troll fleet's gross and net earnings.

We assume that all permits are purchased at a price approximately equal to the net discounted value of expected future harvests. These "fair price" estimates are based upon assumed constant future revenue expectations on the part of permit holders, which equal gross revenues minus a proportionate variable cost. Tables 3.6-4 and 3.6-5 present recent information about the aggregate salmon fishing revenues in the ocean troll and Columbia River non-Treaty gill net fisheries. Two alternative extrapolations of past gross earnings are represented by the 3-year and 10-year annual average revenues. The 3-year average obviously yields a more pessimistic expectation of the future, due to lower annual harvests and lower real prices (in 1993 $) experienced in recent years. The 10-year average would represent an expectation that conditions in the fishery will return to "normal". One could easily add a third extrapolation of the future reflecting even more pessimistic expectations -- closure of the river fishery and substantial curtailment of the ocean troll fishery for an extended period . We do not include this last possibility for two reasons. First, this pessimistic forecast simply implies that the fishing permits and fishing business operations are worthless; buying them up would be essentially costless. That result is obvious without calculation. Second, the Salmon Recovery Team enunciated the principle that purchase prices for fishing permits should be related to past catch histories in the fishery. Using 3-year and 10-year averages is essentially one way to implement this approach.

Fishing cost information is fragmentary for these salmon fisheries. Researchers grappling with this problem in the past have recommended use of standard proportionate levels of cost. For example, Rettig and McCarl (1984) conclude that net revenues for salmon fishing operations typically fall within the range of 50 to 90 percent. The Draft SOR analysis (Jan. 1994 Draft, Appendix O, p. 3-58) provides a breakdown of cost elements per year and per pound of harvest for salmon gill netters and trollers. The average cost per pound is $1.24 for trollers and $0.79 for river gill netters. These costs include the standard variable cost items (vessel/engine repairs, gear repair and replacement, fuel and lubricants, food and supplies, ice and bait, dues, transportation, crew shares) and some costs which are fixed annually for operating units (insurance, moorage, licenses, and miscellaneous). The only costs not included are interest payments, capital equipment purchase prices, or opportunity costs associated with investment in the fishing vessel or firm. Assuming these costs per pound are independent of catch level or fish price, we can compute the net revenues earned in the two fleets under various circumstances. Table 3.6-2 illustrates these calculations using the 3-year and 10-year average prices and revenue for the salmon fleets. Under these assumptions, Washington trollers would have net earnings of 49% and 40% of the landed salmon value in the two periods. Oregon trollers would have net earnings of 52% and 34% of landed price based on 10-year and 3-year average prices. Gill net earnings would be 46% based on the 10-year average price and 26% based on the 3-year average price. All of these estimates are at or below the 50% net earnings rates suggested by Rettig and McCarl.

Although a wide range of costs for the buy-back program could eventually occur, the costs estimated in Table 3.6-3 using the 3-year average net revenues seems most likely. Hence, we use these numbers to represent the total value that must be bought back over the proposed five year period. We convert from this lump sum, capital cost to five annual installment payments using the formula for level annual payments to amortize a loan. In keeping with the procedures followed throughout this report we compute the annual payments needed to amortize the estimate value at 3% a interest rates.

Costs of Strengthened Enforcement of Harvest Regulations

The Team's discussion of enforcement focuses on the need to reduce illegal harvests in the Columbia River in order to attain the exploitation rate objective of 50 %. The level of effort suggested by the RT seems equivalent to the increased enforcement effort funded by the Bonneville Power Administration during 1992-1994. In the last two years, the fishery law enforcement enhancement effort has more than doubled the number of people and staff hours below Bonneville dam, and has substantially increased the level of enforcement effort above Bonneville, including in the Snake River below Lewiston (see RTR, Table XI-3, p. XI-21). As the Team recommends a continuation of that effort, we estimate the annual total cost of the enforcement program as equal to the BPA budget for 1994 - $3.5 million. We note that the enhanced enforcement effort may have benefits for fish stocks other that the threatened and endangered Snake River stock. Since the recommendation is specific to the Snake River Salmon Recovery, however, we attribute the full costs to the Endangered Species Act program.

Summary

The estimated cost of buying out the Columbia River gill net fleet and buying up half of the ocean troll fishing capacity north of Humbug mountain is necessarily somewhat speculative. We assume that the amounts paid to buy the fishing permits and vessels must equal the discounted, expected future earnings from the fishery. Expected future earnings are dependent on assumed future catches, salmon prices, fishing cost levels, and discount rates. It is most likely that poor recent seasons and poor prospects for the future lead permit holders to expect future earnings reflecting the pessimistic 3-year average rather than the more typical 10-year average. Our best estimate of the total buy-back cost is $38.9 million in present value, or $8.5 million in annual pay-out over the five-year buy-back program.

The costs of strengthening the fishery enforcement program in the Columbia River is expected to be about $3.5 million in annual expenditure. Hence, the best estimate of total expenditure for fishery management actions recommended by the Recovery Team is $12 million per year. It is important to note that the payments for buying back permits from existing fishing permit holders are not real economic costs, like payment for construction or enforcement would be. No significant real economic resources are used up by the act of reducing the number of existing permits (other than the administrative cost of running the buy-back program itself). And there is unlikely to be a significant loss of future fishery harvests due to insufficient harvesting capacity after the reductions. Hence, the expenditures for permit buy-backs are largely compensatory payments to existing fishing vessel owners. If the program is financed by the Bonneville Power Administration, the payments would be treated as costs to be covered by ratepayers.

Table 3.6-2 Average Net Earnings and Present Value for Proposed Buy-Back Salmon Fishing Fleet Based Upon Average Price, and Average Fishing Cost.

	Average Cost per Pound	Net Earnings per Pound with		Annual Earnings for Buy-Back Fleet		Present Value of Net Earnings at 3.0 %	
		10-Yr. Ave.	3-Yr. Ave.	10-Yr. Ave.	3-Yr. Ave.	10-Yr. Ave.	3-Yr Ave.
				---------- 1,000 1993 $ ----------			
Washington Troll	$ 1.24	$ 1.21 (49%)	$ 0.84 (40%)	$393	$223	$13,086	$7,445
Oregon Troll	$ 1.24	$ 1.37 (53%)	$ 0.65 (34%)	$2,342	$427	$78,064	$14,224
Col. R. Gill Net	$ 0.79	$ 0.93 (54%)	$ 0.31 (28%)	$4,247	$517	$141,573	$17,245
Total				$6,982	$1,167	$232,724	$38,914

Source: Average Costs from Draft Environmental Impact Statement, Columbia River System Operation Review. January 1994. Appendix O Economic and Social Impacts, p 3-62. Assumes the buy-back involves all gill net vessels, 48% of Oregon and 50% of Washington ocean troll fishing capacity.

Table 3.6-3 Permit Buy-Back Cost, Present Value, and Annual Over Five Years in 1993$ and using a 3% discount/interest rate.

Assumes the 3-Yr. Ave. Net Return	Present Value of Net Revenue for Buy-Back Fleet	Annual Cost over a Five Year Buy-Back Program
Washington Troll	$7,445	$1,626
Oregon Troll	$14,224	$3,106
Col. R. Gill Net	$17,245	$3,766
Total	$38,914	$8,497

Table 3.6-4 Ocean Troll Fishery Off Oregon and Washington, 1981-1993

	Washington Troll				Oregon Troll			
	Licensed Vessels	Vessels Landing Salmon	Dressed Landings	Value of Landings 1993 $	Licensed Vessels	Vessels Landing Salmon	Dressed Landings	Value of Landings 1993 $
	#	#	1,000 Lb.'s	$1,000	#	#	1,000 Lb.'s	$1,000
*1981	2,603	2,439	2,678	$9,321	3,926	3,615	4,897	$15,069
1982	2,512	2,253	2,671	$9,975	2,646	3,269	5,060	$14,665
1983	2,328	2,045	653	$2,087	3,439	2,951	1,753	$3,270
1984	2,071	381	197	$560	3,203	771	621	$2,177
1985	1,650	1,259	964	$2,106	2,993	2,050	2,514	$7,597
1986	1,531	1,252	659	$1,506	2,739	2,288	5,275	$10,195
1987	1,401	883	758	$2,434	2,626	2,111	7,098	$20,807
1988	1,337	650	798	$2,794	2,597	2,061	7,723	$25,744
1989	1,306	883	696	$1,408	2,569	1,937	5,528	$11,476
1990	1,170	897	850	$1,807	2,523	1,557	2,815	$7,280
1991	1,013	811	612	$1,188	2,048	1,217	2,106	$3,292
1992	806	604	583	$1,332	2,101	649	1,219	$2,781
1993	667	474	398	$795	1,800	611	770	$1,671
Mean Value, 3 Yr.		630	531	$1,105		826	1,365	$2,582
Mean Value, 10 Yr.		809	652	$1,593		1,525	3,567	$9,302
Mean Price/Lb. 3 Yr.				$2.08				$1.89
Mean Price/Lb. 10 Yr.				$2.45				$2.61

Table 3.6-5 Columbia River Non-Treaty Gill Net Fishery, 1981-1993

Year	Wash. No. of Permits	Oregon No. of Permits	Chinook Harvest	Value of Chinook Harvest	Coho Harvest	Value of Coho Harvest	Sockeye Harvest	Value of Sockeye Harvest	Chum Harvest	Value of Chum Harvest	Total Salmon Harvest	Value of Harvest in 1993 $	Average Price in 1993 $
			1,000 Lbs	*$1,000s*	*1,000 Lbs*	*$1,000s*	*1,000 Lbs*	*$1,000s*	*1,000 Lbs*	*$1,000s*	*1,000 Lbs*	*$1,000s*	*$/Lb.*
1981	534	665	765	$1,315	461.9	$197	0.0	$0	18.5	$30	1244.9	$2,427	$1.95
1982	511	622	1935	$1,955	1574.3	$1,354	0.0	$0	22.3	$11	3531.9	$4,921	$1.39
1983	475	609	625	$843	44.5	$47	0.0	$0	2.0	$1	671.1	$1,270	$1.89
1984	436	561	1212	$1,782	1612.6	$1,854	31.8	$37	22.1	$12	2878.4	$5,029	$1.75
1985	373	519	1298	$1,324	1632.4	$1,371	111.6	$129	7.5	$2	3049.9	$3,718	$1.22
1986	370	512	2744	$2,580	6724.0	$6,724	6.7	$7	20.2	$7	9495.1	$11,944	$1.26
1987	370	509	6219	$8,643	1299.7	$2,443	107.5	$165	14.1	$13	7640.3	$13,990	$1.83
1988	356	514	7251	$14,348	2644.8	$5,825	61.4	$112	30.2	$20	9987.2	$24,271	$2.43
1989	356	519	3258	$2,964	2668.3	$2,321	0.0	$0	17.3	$8	5943.5	$6,060	$1.02
1990	355	520	1300	$2,278	494.3	$606	0.0	$0	9.4	$6	1803.9	$3,168	$1.76
1991	354	517	995	$1,503	2685.5	$2,107	0.0	$0	4.2	$2	3684.4	$3,810	$1.03
1992	350	517	427	$629	299.0	$248	0.0	$0	6.9	$2	732.5	$901	$1.23
1993	350	517	342	$357	265	$216	0	$0	0	$0	607.0	$573	$0.94
3-Yr. Average			588	$829	1083	$857	0	$0	4	$1	1675	$1,761	$1.10
10-Yr Average			2505	$3,641	2033	$2,372	32	$45	13	$7	4582	$7,346	$1.72

Sources: Pacific Fishery Management Council. 1994. Review of Ocean Salmon Fisheries 1993. Portland, Oregon. Oregon Department of Fish and Wildlife and Washington Department of Fisheries. 1993. Status Report - Columbia River Fish Runs & Fisheries, 1938-92.

3.7 Reduction of Predation - Competition

Juvenile salmon of the threatened and endangered stocks, like all other living elements of the river ecosystem, are subject to predation and competition. Predators include native fish species (e.g., northern squawfish), introduced fish species (e.g., shad, smallmouth bass, channel catfish, walleye), birds, and marine mammals. Competitors of natural spawning salmon for food and space include hatchery-reared salmon and trout, shad, and other species. The Recovery Team's seven recommendations listed in Table 3.7-1 can generally be categorized as (1) reducing the populations of predators, (2) separating juvenile salmon from predators in time and space, and (3) reducing abundance of competitors in salmon habitat. The mechanisms by which these actions can be accomplished vary considerably. The northern squawfish program, for example, currently involves a recreational and commercial bounty program and ongoing research on energetics, food habits and behavior of squawfish. Anglers are rewarded $3 for each squawfish measuring over 280 millimeters (11 inches). As additional inducements to harvesting squawfish, there are monthly drawings for $1,000 and $300 prizes, and end-of-season drawing offering a $5,000 prize, and lower and upper Columbia River Northern Squawfish Tournaments that award prizes for a total of $13,000. The RT calls for a substantial decrease in the squawfish population abundance, which we presume would involve doubling of the existing program, which is currently funded at $5.4 million per year.

The American shad was introduced from the Susquehanna River in Pennsylvania to the Columbia River in 1885.[5] It has become well established in the Columbia River and its tributaries, including the Snake River. This species expanded its range upriver as the hydroelectric dams were constructed. In 1992 over 22,000 shad passed the Lower Granite Dam. The number entering the river has been growing over recent years, with at least 4.0 million estimated in 1990 (3.7 million passing The Dalles dam). Annual commercial harvests during the past decade have ranged from 50,000 to 160,000 fish -- a rather insubstantial amount in relation to the shad population size. There are also small recreational and tribal fisheries for shad in the Columbia River. Efforts to eliminate the shad from the Columbia River above Bonneville dam could involve operations at the fish ladders to prevent passage of shad. We do not have information to estimate the feasibility or cost of accomplishing this, but it seems that significant structural changes in the fish ladders at Bonneville would not necessarily be needed. According to one expert at BPA, a modest reduction of water depth at the overflow weirs could significantly reduce shad passage at the dam. However, a system for collecting and disposing of millions of shad would be required during beginning years of a shad removal program. Since Oregon law does not permit the disposal of these fish at landfills, a more innovative approach to effective utilization of the shad is necessary. A rough guess at the cost of such a program is $1 million per year for five years.

Reduction of non-indigenous predatory sport fishes would be accomplished by relaxing catch regulations on these species, by eliminating stocking of these species in habitats of endangered and threatened salmon, and by direct elimination of nuisance fish. Walleye,

[5] Information on the Columbia River shad is from Oregon Department of Fish and Wildlife and Washington Department of Fisheries, 1993, *Status Report Columbia River Fish Runs & Fisheries, 1932-92.*

smallmouth bass, and channel catfish are introduced species which could be reduced in numbers by unrestricted sport fishing. Hatchery plantings of trout, steelhead, and chinook salmon would be adjusted to avoid direct competition with the naturally-spawning threatened species. It is not clear whether there are any significant direct economic costs to this element of the predator control effort. There could be some reduction in abundance of recreational species as a result of this effort, but the magnitude of this effect is as yet rather speculative. If a reduction in planted fish for anglers is not compensated by increased availability of other species, this could result in reduced economic values for recreational fishing in the Columbia River basin -- an obvious opportunity cost of salmon recovery. We do not attempt to quantify this cost.

While birds feed on juvenile salmon in a variety of circumstances, they seem to be a particular danger as predators below the dams where juveniles first emerge from the turbines, spillways, or from the bypass systems. The fish are typically disoriented and relatively easy prey for birds at that stage. Once the fish have recovered from the stress of passage through the dam, they dive into deeper water and are no longer as susceptible to bird predation. The bird species of most import as predators varies among areas and seasons. Caspian terns are in great abundance in the estuary. Ring-billed gulls are documented predators of salmon at some dams. Mergansers, kingfishers and other piscivorous birds may be more effective predators of salmon due to stream channel alterations and obstructions. One non-lethal approach to reducing bird predation is to hang wire obstructions over the areas of concern. The "bird wire" prevents the birds from flying freely, thus reducing the incidence of predation at fish release sites. According to the Corps of Engineers (E. Woodruff), bird wire has been installed at all sites where it is "convenient". To include other dam sites will require construction of piers or other structures from which to hang the wire. These will often need to be built to withstand fast moving currents of tailraces -- a potentially expensive construction and maintenance prospect. Development of this option was mentioned in early versions of the System Configuration Study, but we find no cost estimates in the April 1994 draft. Hence, we currently have no cost estimates for the bird wire option.

Marine mammal predation occurs in the Columbia River below Bonneville dam. Both harbor seals and California sea lions are known to feed on salmonids in the estuary. It is unknown how the National Marine Fisheries Service would proceed to reduce predation by marine mammals. A 1994 amendment to the Marine Mammal Protection Act does permit the lethal taking of nuisance animals. Whether lethal takes or non-lethal forms of protection would be feasible and successful in the Columbia River is not known. Hence, we do not provide a firm estimated cost for this item, but we assume that a research effort funded at around $ 0.5 million/year would be needed during the next few years.

Table 3.7-1 Recommendations for Reducing Predation and Competition

Measures	Explanation of Recommendation and Source of Cost Information	Est. Cost (1,000 1993 $)
1. Northern squawfish population management and research.	Expansion of program funded by BPA at $ 5.4 mil. in 1993. Squawfish management effort causes a 20 % exploitation rate on fish greater than 280 mm in length, reducing predation of juvenile salmonids by up to 50 percent (BPA Journal, July 1994). The RT wants a greater exploitation rate and more research. Assume doubling of program costs.	$10,800/yr.
2. Reduce shad population	Attempt to eliminate American shad population from river above Bonneville dam and to reduce population of shad below Bonneville dam. No specific control program has been described. Involves operation of fish ladders, problems handling large quantities of fish at Bonneville dam, maybe tribal harvest issues. No cost estimate available.	$1,000/yr. for five years
3. Reduce predation by other non-indigenous fishes.	This involves (a) eliminating bag limits for smallmouth bass, walleye, and channel catfish in mainstem Columbia and Snake Rivers; (b) monitoring populations of non-indigenous fish; and (c) using provisions of the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990 to reduce populations of these fish. No specific program has been developed and no cost estimate is available.	unknown
4. Reduce negative effects of stocking steelhead on ESA listed species.	RT recommends review and evaluation of steelhead release programs, scheduling time and place of releases to minimize impacts on listed salmon species, and moratorium on steelhead hatchery expansions until a study determines that sufficient habitat rearing capacity exists. Rough estimate of study costs for next few years.	$ 500/yr
5. Reduce negative effects of stocking hatchery trout in waters of ESA listed species.	RT recommends that no hatchery trout be released into waters essential for spawning and rearing of listed species. In areas of special concern, an evaluation of native trout on survival of listed species should be attempted. Study of trout effects could cost $.5 mil/yr.	$ 500/yr
6. Reduce bird predation on smolts and control birds without harming bird populations	RT recommends continuing monitoring and assessment of bird predation in Columbia and Snake River reservoirs, and a study of salmonid consumption by birds in the Columbia R estuary. Use of netting, bird wire, and other non-lethal means of control should be tried.	unknown
7. Reduce marine mammals predation on ESA species	RT recommends seeking authority for non-lethal deterrence and lethal removal of pinnipeds that impact weak stocks of salmon and steelhead, and collecting data on marine mammal distribution and abundance and on food habits.	$ 500/yr. for five years

3.8 Improvement of Adult Upstream Migration Survival

The Recovery Team places highest priority on measures to improve the survival of adult fish during their migration from Bonneville dam up to spawning areas in the Snake River Basin. Because adult fish have already survived most of the risks associated with their life cycle, improved survival at this stage can provide substantial and immediate improvements in spawning stock level. The RT estimates that between 25 and 30 percent of adult salmon counted at Bonneville Dam do not reach Lower Granite Dam and that as many as 50 percent overall of the in-river fish die before reaching spawning grounds. Upstream migration survival involves complex issues concerning physical facilities at dams, operational aspects of fish ladders and water supplies, water temperature and clarity, dissolved gas in waters below dams, and fish disease control. All of these conditions and issues are the subject of ongoing research and project planning. The Recovery Team specifically lists a set of projects currently underway, called the Project Improvements for Endangered Species (PIES), and calls for additional research and development. Several alternatives for structural modifications to improve adult upstream migration have been reviewed and assessed in the draft reports of the System Configuration Study (SCS). We draw most of our cost estimates from the SCS reports, from budgetary cost estimates of ongoing programs funded by the Bonneville Power Administration, and from various experts providing information directly to the authors. PIES and SCS cost data are summarized in Appendix A. More detailed explanations of projects and cost estimates are available in the referenced SCS reports.

In Table 3.8-1 we list the Recovery Team recommendations. We include rough cost assessments assembled from the SCS studies (Appendix A) and personal communications with agency experts. However, it is clear that not all these costs are incremental costs associated with actions taken under the Endangered Species Act. Many of the measures listed below were undertaken to assist salmon survival before the ESA listing compelled more aggressive implementation schedules. Also, many of these measures are beneficial to salmon stocks not listed under ESA. Further, some of these measures may prove detrimental to fish stocks and wildlife not targeted for special treatment by the regional authorities. To convert the vast amount of existing information into a concise estimate of incremental costs attributable to recovery efforts for the listed stocks is difficult, and we do not claim to have done the definitive and final work on this.

The first recommendation listed in Table 3.8-1 reflects ongoing studies of survival and interdam losses. An estimate to the annual cost for such a study is provided by an ongoing study of fish behavior funded by BPA. That study is funded at $150,000 per year. The second item refers to immediate to short-term projects to improve the survival of adult salmon migrating through existing facilities at hydropower projects. As noted before, most of the specific improvements mentioned in the Recovery Team report are contained in ongoing studies or projects. For example, the Project Improvements for Endangered Species represent a collection of specific improvements that are authorized for implementation. As explained in Appendix A, a portion of these projects pertain to upstream passage through hydropower dams. The estimated costs of these projects are listed in Table 3.8-1.

The third recommendation, planning and design for longer term passage improvements, is too broad to assess thoroughly, but a rough notion of costs for this activity can be gleaned from the ongoing studies of major project improvements under the Systems Configuration Study (SCS) effort. Items being considered in this category include (a) improved control of water temperature in fish ladders, (b) additional fish ladders at Lower Granite and Little Goose dams, (c) modifications to fish ladder entrances and better use of water flow to attract fish to the ladders, (d) improvements to the fish ladders exits at McNary dam, (e) modified adult collection channel facilities at McNary dam to improve velocity of water flow, and (f) extensions of the fish channels at Lower Granite and Little Goose dams to improve access to the fish ladders during turbulent water conditions caused by spilling water over the dam spillway. As shown in Table 3.8-1, these projects involve a total capital expense of around $242 million. The estimated annualized expense is from $9.8 when capital costs are amortized at a 3.0% annual interest rate.

The fourth recommendation, enhanced enforcement of fishery regulations, is a repeat of the recommendation discussed in section 3.6. We list again the actual cost currently associated with the enhanced enforcement program funded by BPA. The fifth recommendation concerns use of water stored at Dworshak reservoir to reduce water temperatures in the Snake River during upstream migration of fall chinook. This would apparently involve a shift in the water budget release strategy in the Snake River, moving some portion of flow augmentation from the spring to the mid-summer. It is not clear that this shift would cause additional direct economic costs, but we have not done a detailed study to determine the full implications of this recommendation. Hence, we list the cost as unknown, but we suspect that it would be rather small in comparison to the costs of major structural modifications to the hydropower system.

The sixth recommendation is a study of best flow management practices to protect upstream adult migrants from the effects of gas supersaturation. We roughly estimate the costs of such a study at $200 thousand per year. Gas supersaturation seems to be a problem when significant quantities of water are spilled. That problem could be addressed through structural modifications of the spillways and stilling basins. The SCS study estimated costs of these modifications are listed in Appendix A. We do not include those construction costs here, because it is not clear that the Recovery Team is recommending a structural solution to the problem.

The seventh recommendation is for a study of the upstream passage problems when reservoirs are drawn down below normal levels. One problem is that current fish ladders are designed to operate within normal reservoir operating levels. With drawdown to spillway height or below, the fish ladders would be de-watered, and access to the ladder entrances from below may be precluded as well. The System Configuration Study includes a preliminary consideration of this problem.[6] The estimated costs depend somewhat on which drawdown option is chosen. To simplify this presentation we focus on the options of a 33-foot drawdown and a natural river option. After modifying the cost estimates to reflect 1993 price levels and excluding interest cost during construction, we obtain a preliminary cost assessment for re-constructing the adult

[6] A detailed discussion of proposed construction to mitigate effects of drawdown on the adult passage system is contained in SCS Phase I; Appendix A Lower Snake Reservoir Drawdown, Appendix A Feature Modifications - Technical Discussions, Section 1 - Adult Collection and Ladder Systems and Appendix C - Cost Data.

passage systems in the Snake River in Table 3.8-2. As noted in Appendix C of this report, Corps of Engineers estimates of these costs have been contested by Natural Resources Defense Council and others based upon using rock weirs to extend the lower reach of the fish ladders and upon alternative computations of annualized cost. It is likely the case that we should be examining lower-cost alternatives to the initial COE approach to adult passage with drawdown. Whether the rock weir approach will meet design specifications for adult passage is not yet clear. For now, we take the estimates listed in Table 3.8-2 as upper bound estimates. In Appendix C, we include a lower bound cost estimate as well. The study recommended by the Recovery Team should help to resolve differences in design and cost estimation for adult upstream passage.

Recommendation 8 is to study the use of drug treatments to control diseases of upstream migrating Snake River chinook. One possible element of this study would involve the inoculation of naturally spawning fish with erythromycin. This could be accomplished at adult passage facilities at one of the dams. Since treatment of all hatchery and naturally-spawning fish might be impractical, tagging of all hatchery fish to facilitate identification of wild fish is a prerequisite to this idea. BPA is currently pursuing an effort to obtain Food and Drug Administration approval to use erythromycin for treatment of salmon diseases. That project is currently funded at $350 thousand per year. The cost of a full-blown inoculation program could be higher or lower than this amount. It will depend upon where the treatment occurs (Bonneville or Ice Harbor, for example), how many fish are treated, and whether the fish can be immediately released or require a holding period. The last recommendation is a broad request for exploration of new ideas for improving survival of upstream migrants. Included in the broad request is consideration of collection and upstream transportation of specially marked adult fish at Bonneville dam for transport to locations in the Snake River. This option is apparently not being considered under existing system operation and configuration studies. Hence, we have no estimate of construction or operating costs for adult collection and transportation. We suspect that study of this and other options would need to be funded for a few years at a level of at least $550 thousand.

Table 3.8-1 Improve Adult Upstream Migration Survival

Mesure	Explanation of Recommendation and Source of Cost Information	Capital Cost 1,000 1993 $	Annual Cost [1] @ 3.0 %
1. Evaluate survival and interdam losses for adult salmon migrating upstream, including behavior in fishways and methods for reduction of fallback at the dams.	Some studies within this group are underway. Additional study of fish behavior has been funded by BPA.	$ 0	$ 150
2. In short-term improve the physical and operational conditions of adult fishways at dams along the lower Snake and Columbia Rivers for use at present pool elevations.	Several items from Project Improvements for Endangered Species (PIES) that are currently authorized and underway reflect the RT recommendations here. The adult passage portion of PIES has a capital cost of about $12.53 mil (Appendix A). This is a rough indication of what these measures are likely to cost.	$ 12,530	$ 487
3. Start planning and design for long term passage improvement in the physical and operational conditions of adult fishways for use at present pool elevations.	Several items under the System Configuration Study (SCS), including additional fish ladders and extended entrances at Lower Granite and Little Goose dams, and modified ladder exits and collection channel at McNary dam.	$212,347	$ 9,861
4. Continue vigorous law enforcement and explore its long-term use to protect recovering stock and deterring illegal fishing	Current Enhanced Fishery Enforcement Program which is funded by the BPA should be continued and improved by consultation between NMFS, NPPC, the State fishery agencies and the tribes. Estimated annual program cost of $3.5 million per year.	$ 0	$3,500
5. Evaluate use of Snake R water budget to reduce water temperature in lower Snake R during fall chinook upstream migration, and determine whether this can be done via late-summer flow augmentation from Dworshak Reservoir.	This is a research project to improve future management of temperatures.	$ 0	unknown

[1] Annual cost includes amortized capital construction cost and annual research, operations, or maintenance cost.

Table 3.8-1 Improve Adult Upstream Migration Survival Continued

Measure	Explanation of Recommendation and Source of Cost Information	Capital Cost 1,000 1993 $	Annual Cost [1] @ 3.0 %
6. Determine the best flow management to protect adult upriver migrants against problems of dissolved gas supersaturation, including daily monitoring when supersaturation levels exceed 110%.	This is a research project to reduce gas saturation levels below mainstem dams. BPA has a project to evaluate allowable gas supersaturation levels for adult upstream migration. This is an example of what such a study might entail.	$ 0	$ 200
7. Analyze problems and options for adult passage at dams should reservoir drawdown to used.	This is a research project to design fish ladders for operation when reservoirs are below current design levels.	$248,728	$9,667
8. Study use of drug treatments to control diseases, such as BKD, in adult salmon during upstream migration.	BPA is currently funding studies of erythromycin registration and fungal infection in spring/summer chinook. This is an example of possible research program and cost.	$ 0	$ 550
9. Explore new ideas, including collection and transportation, for improving adult upriver migration conditions or for giving a short-term boost in survival during critical phases of recovery.	The prospective new studies which would include evaluation of moving adult fish upstream via collection and transportation from Bonneville dam, and extension of study to chinook salmon at Hells Canyon dam complex. No ongoing study. Assume at least $1/2 mil.	$ 0	$ 500

[1] Annual cost includes amortized capital construction cost and annual research, operations, or maintenance cost.

Table 3.8-2 Costs of Modifying Adult Passage Facilities at Snake River Dams to Accommodate 33-Ft. and Natural River Drawdowns.

	Estimated Construction Costs		Annual Costs @ 3%	
	33-ft.	Natural River	33-ft.	Natural River
	1993 $			
Lower Granite Dam (LWG)	$89,498,454	$85,719,830	$3,297,411	$3,158,194
Little Goose Dam (LG)	$89,244,593	$86,763,606	$3,288,057	$3,196,650
Lower Monumental Dam (LWM)	$71,859,870	$71,859,870	$2,647,548	$2,647,548
Ice Harbor Dam (IH)	$8,106,172	$4,384,390	$298,657	$161,535
Total	$258,709,089	$248,727,695	$9,531,674	$9,163,927

Source: US Army Corps of Engineers. April 1994. Columbia River Salmon Mitigation Analysis, System Configuration Study, Phase I. Lower Snake River Drawdown Technical Report, Appendix A. Appendix C, pp. C-4 and C-40. Note these numbers include a 50% contingency factor in addition to estimated direct construction costs and do not include inflation until implementation date.

4.0 CONCLUSIONS

The foregoing sections clearly show that many of the recommended actions to recover endangered and threatened Snake River salmon may involve substantial economic costs. Understanding the use of economic costs to guide decisions on Snake River salmon recovery, however, remains a difficult task. Perhaps the most useful way to conclude this report is by providing some interpretations of the cost estimates, some perspective on the magnitude of the costs, and to offer a means of grappling with the complexity of the economic trade-offs inherent in Snake River salmon recovery.

At the most basic level, the economic decisions being made in the salmon recovery effort involve collective choice of a mix of environmental conditions, aesthetics, and economic commodities for human consumption. During the decades of Columbia River hydropower system development (mid-1930s through early 1970s), the people of the Northwest region and the United States gave up some desirable characteristics of natural flowing river systems, including much of the freshwater salmon habitat, in exchange for hydropower, irrigated farmland, improved river navigation, reservoir recreation, and flood control. During that period, the Federal agencies most responsible for river basin development (US Corps of Engineers, Bureau of Reclamation, Federal Energy Regulatory Commission, Bonneville Power Administration) provided numerous analyses of these multiple-purpose projects, including the impacts on salmon and other wildlife. To a large extent the effects on salmon populations were anticipated by fish and wildlife agencies, and the main actions to redress these effects involved construction of fish passage devices (fish ladders) and hatcheries to mitigate the loss of salmon spawning and rearing habitat. After the last major dam was constructed in 1974 (Lower Granite dam), marked declines in returning salmon runs signaled a new era of enhanced concern for the fish. The Northwest Power Planning Act, which created Northwest Power Planning Council, called for equitable treatment of fish and power. The current depressed state of Snake River chinook, sockeye, and some other Columbia River salmon populations leads many observers to regard past salmon conservation efforts as a failure.

In marshaling resources to save the remnants of the salmon populations, however, it would be economic nonsense to ignore the widespread benefits achieved by the existing river projects. Our economic cost estimates reflect this perspective by adopting the *status quo* as the baseline from which we measure costs of salmon recovery. Some people oppose this procedure based on the notion that the fish have rights, or the users of fish have rights, and that these rights dictate that the *status quo* should be a river without salmon-killing hydropower dams. In response to this, we note that there are a plethora of rights, duties, and responsibilities defined by major legislation and court decisions in the Columbia River basin regarding wildlife protection, economical electricity supply, flood control, water supply, and navigation. To take any specific element of this suite of obligations as the single ruling obligation does not make sense to us. Consequently, we adopt the standard procedure for assessing economic costs, benefits, and impacts; we take the existing circumstances as the baseline and reckon as costs any net reduction in economic value of the whole mix of economic commodities that is affected by the change. In short, we express cost of salmon saving measures in terms of reduced economic value of the other river system uses.

As we noted in the Introduction, the linkages between decision processes and between fish populations make separation of costs attributable to recovery actions conceptually fraught with difficulties. Most of the potentially costly measures recommended by the Snake River Salmon Recovery Team at least partly duplicate prior decisions such as the Northwest Power Planning Council's "Strategy for Salmon" or the operating rules agreed to under ESA Section 7 consultations during 1992 and 1993. Further, separating salmon recovery costs by specific stocks involves essentially arbitrary accounting decisions. A good example is the release of additional water from Columbia River storage reservoirs to assist downstream migration of smolts in the spring. There are a number of salmon stocks in the mainstem Columbia River and its tributaries which could be assisted by this action. Should some of the opportunity costs of flow augmentation, measured in terms of reduced hydropower values, be assigned to the other stocks? The underlying issue, well known to economists, is that of allocating joint costs to multiple outputs. Accounting conventions used in assessing federal water project require costs to be assigned to components of multi-purpose project. For example, costs of a multi-purpose dam are allocated to flood control, navigation, recreation, irrigation, hydropower, etc. If we apply similar reasoning to the salmon recovery case, we might assign overall costs of recovery actions to various stocks in proportion to the size of the stocks or in proportion to the incremental gain the stocks experience. Obviously, given the biological uncertainty attached to the proposed recovery measures, this would be an impossible task. Because the ESA action has precipitated the specific actions under consideration by the Salmon Recovery Team, we have assigned all costs to the Snake River stocks. Given ancillary benefits to other stocks, however, this probably overstates the costs of recovering the specific stocks in question.

Ongoing Operational and Organizational Measures

Many recommended actions could begin relatively soon and would continue indefinitely. The institutional changes, and freshwater habitat-related actions are of this type. The rehabilitation of spawning and rearing habitat would occur over decades, but most of the direct economic opportunity costs -- represented as reductions in value of commodities produced -- would begin occurring immediately and continue at relatively constant rates per year. If Snake River salmon are to be rehabilitated, reduced levels of livestock grazing, timber production, and recreation in riparian zones would likely be a permanent condition. Further, these habitat improvements would almost certainly be necessary regardless of what other actions are eventually chosen to improve downstream migration of smolts and upstream migration of adults. The costs associated with changing the fishery and fishery management sectors, however, are concentrated during the first five years as the Columbia River gill net licenses are bought up.

A general summary of the estimated annual costs for these items is provided in Table 4-1 for all elements except hydropower system changes which are included in Table 4-2. To construct Table 4-1 we have eliminated duplicative cost elements, for example the enhanced enforcement costs in the rivers. Where ranges of cost estimates were reported in earlier tables, we have chosen the midpoints of the ranges except in the case of sub-basin planning where we expect the costs of the plans to be closer to the high end of the range than to the low end of the range. Table 4-1 includes essentially all items from Sections 3.1 - 3.4, 3.6, 3.7 and some items from Sections 3.5 and 3.8 which we feel will be implemented regardless of which major, long-term options are chosen for modifying the hydropower system.

Despite the admitted incompleteness and imprecision in the estimated costs presented in Table 4-1, examination of this summary is instructive. First, even disregarding major changes to the hydropower system, the total of $98.7 million per year over at least the next few years suggests that preservation of salmon stocks in the heavily developed Columbia-Snake River system can be very expensive. Second, substantial costs would occur under several categories. The largest expense categories pertain to forming new institutions for managing and monitoring salmon populations and habitats, curtailing recreational opportunities in salmonid habitats on federal lands, restructuring salmon harvesting in the Columbia River, and maintaining depressed populations of key predators like the northern squawfish. Finally, it should be noted that accomplishment of these recovery measures is likely to enhance the populations of other salmon stocks (while perhaps also reducing the populations of competing species).

Table 4-1. Summary of Recovery Costs Without Major Hydropower System Changes[1]

	Category of Recovery Action	1,000s $ per year	Time Schedule
1	Institutional Changes and Monitoring	$ 12,194	Ongoing[2]
2	Protect and Restore Spawning and Rearing Habitat		
	a. Forest Service/Bureau of Land Management:[3]		
	Range Management	$ 2,069	Ongoing
	Timber Management	$ 8,739	Ongoing
	Recreation	$ 15,516	Ongoing
	b. Sub-basin Planning	$ 3,000	2 - 5 Years
	c. Habitat Protection for Sockeye Salmon	$ 429	Ongoing
3	Improve Freshwater Production of Chinook Salmon.	$ 2,250	Ongoing
4	Improve Freshwater Production of Sockeye Salmon	$ 5,950	Ongoing
5	Limit Harvest & Improved enforcement	$ 12,000	5 years, then reduced to $ 3,500
6	Reduction of Predation - Competition	$ 13,300	Ongoing
7	Research on Smolt Survival[4]	$ 8,553	Ongoing
8	Improve Existing Smolt Bypass Systems[5]	$ 2,687	Indefinite
9	Improve Adult Upstream Migration[6]	$ 11,758	Indefinite
	TOTAL	**$ 98,231**	

[1] This Table does not include the costs of major options for re-organizing or re-structuring the hydropower system. All costs listed are mid-point of range given in previous tables except for sub-basin planning where the high end of the range is given.

[2] "Ongoing" means until recovery occurs (likely 12 to 20 years) or until the measures are not longer needed.

[3] These values calculated using a 4% discount rate.

[4] Includes items 1,2,3,6, and 9 of Table 3.5-4.

[5] Includes items 7, 8 11 and 12 from Table 3.5-4. Duration is indefinite because these costs include 50-yr amortizations of capital investment items.

[6] Includes items 1, 2, 3, 6, 8, & 9 from Table 3.8-1 (not including construction of fish ladders for use with drawdown option and enhanced enforcement which is included under Limit Harvest). Duration is indefinite because these costs include 50-yr amortization of capital investment items.

Major Changes to the Hydropower System

Additional costs are associated with the various alternatives for modifying in-river facilities and hydropower system operating procedures to enhance survival of migrating fish. As noted in Sections 3.5 and 3.8, the Recovery Team recommends continued research and development to determine which options are preferable. Many of the major options (drawdowns of Snake River reservoirs, upriver smolt collection facilities, improved smolt passage facilities, enhanced smolt transportation) are posed as future decisions to follow a period of research, experimentation, and learning. The Table 4-2 shows the gross relationships between costs of options. Clearly, if improving the collection and transportation of Snake River smolts were an effective means of recovering the species, this would be the least expensive option, even if we choose the more expensive sub-option -- constructing a new collector facility at the head of Lower Granite reservoir. Flow augmentation appears to be the next least expensive, but we have to caution that the particular flow analyzed is not the most ambitious or most costly of the alternative being considered by the agencies. This is simply our best guess as to the flow augmentation scheme that the Recovery Team seems to endorse.

Table 4-2 Costs of Major Hydropower System Changes Using 3% Interest Rate to Amortize Capital Costs.

	Description of Hydropower Options	1,000s $ Per Year
1	Improve and expand smolt transportation.	
	a. Design and install surface collector at Lower Granite dam.	$ 4,047
	b. Design and construct a smolt collector above Lower Granite reservoir. Barge transportation from there.	$ 17,437
2	Flow augmentation from Dworshak, upper Snake River, and Columbia River (1994-1998 NMFS Biological Opinion).	$ 2,600 - 13,000
3	Drawdown of Snake River reservoirs.	
	a. 4-1/2 month drawdown of Lower Granite reservoir to near spillway height.	$ 28,295 - 57,421
	b. 4-1/2 month drawdown of 4 reservoirs to near spillway height.	$ 60,136 - 106,179
	c. 4-1/2 month drawdown of 4 reservoirs to natural river level.	$ 95,310 - 167,587

Some actions incorporated in estimates for Table 4-2 are formulated as contingencies -- actions which would be undertaken only after some triggering event. Implementing a contingent action may involve some initial cost to construct the means to make the contingency plan feasible, and a varying annual cost depending upon whether the contingent action is taken. Examples of contingent actions are the purchase of water from the Idaho water bank during dry years (i.e., the "dry-year option") and using a sliding-scale flow augmentation schedule in which releases of stored water during the spring-summer are dependent upon water run-off forecasts. The actual costs will be the sum of a relatively fixed initial cost (e.g., flood control costs of maintaining higher reservoir elevations in the winter and early spring) and the varying annual costs over future years as the triggering events occur. Dry water years in Idaho, for example, are not predictable. The amount of water needed and actual costs of supplementing Snake River water flows by diverting water from irrigation will depend upon the total run-off, the hydrologic forecasts of river flow, and the price of water. An average or "expected" cost can be calculated, if we assume future frequency of dry years will follow observed past frequencies.

Mutually exclusive options may have been included in the list of Recovery Team recommendations. For example, a drawdown of Snake River reservoirs is not needed if the upstream collector and barge transportation option is selected as the best means of recovery. Similarly, modifications to dam spillways to reduce the gas supersaturation problem is not needed if either enhanced smolt transportation or improved smolt passage facilities are selected. By this reasoning, it is entirely wrong to "add up" the estimated costs from all the tables presented above, because several of the major recovery options are mutually exclusive or duplicative.

Some analysts might argue that each option should be kept open for possible adoption in future years, implying that improved passage facilities, improved smolt transportation system, and modified dams for drawdowns be implemented during the next fifteen years. By this view, we have insufficient knowledge to judge which option is best; we must learn through experimentation. This approach could be consistent with an adaptive management strategy, and perhaps with the recently touted "precautionary" approach to fishery management. Unfortunately, the overall cost of implementing the multiple options to support this approach to species recovery could be prohibitive. Our interpretation of the Recovery Team's recommendations suggests that the Team members wanted to avoid this approach. To avoid having to construct facilities to implement every conceivable recovery action, the RT approach calls for mixing immediate preservation steps (captive broodstocks, reduced harvest, dam passage improvements) with crucial tests of alternative means of improving river migration.

Concluding Comments

The most difficult problem for Snake River salmon recovery is the need to improve understanding of salmon mortality in the river system. This might be addressed by structuring a sequence of informative experiments which have the potential to improve our ability to conserve salmon. Along with this scientific-engineering problem is the political problem of marshaling enough support over enough time to actually learn to conserve salmon. As noted by Kai Lee[1],

[1] 1993. Compass and Gyroscope, Integrating Science and Politics for the Environment. Washington D. C.: Island Press.

adaptive management requires the patience to wait for experimental results to inform decisions, a big budget for monitoring outcomes of decisions, and willingness to treat mistakes as learning experiences. It is unclear that patience and willingness to make mistakes are consistent with the salmon recovery effort occurring under the threat of species extinction or that the cumulative intelligence of regional salmon experts has focused sufficiently on design of experiments and a monitoring system. A major weakness in both the recovery effort and the available cost assessment is the lack of a well-designed river/habitat/fish monitoring system to support adaptive management. Whether the Pacific Northwest region learns how to preserve salmon populations or simply spends lots of money on politically popular "solutions" over the next decade will depend upon the careful design and monitoring of adaptive steps. In the long run, the most costly program of salmon recovery is one that vacillates between ill-considered "emergency measures" without accumulating the wisdom to preserve the habitats of endangered species in a cost effective manner.

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APPENDIX A. Estimated Cost of River System Improvements

The tables contained in this appendix display more details concerning the estimated construction, operating and maintenance, and annualized total costs for salmon recovery measures that have been assessed in recent reports of the Corps of Engineers and others. Table A-1 covers the items included in the package of items called the Program Improvements for Endangered Species (PIES). These cost estimates were provided to us by Ed Woodruff of the Army Corps of Engineers, North Pacific Division, Portland, Oregon. Various acronyms used in displaying that information are as follows: JBS - juvenile bypass system, P.H. - powerhouse, U/S - upstream, BON - Bonneville dam, JDY - John Day dam, TDA - The Dalles dam. These PIES items are those that were not year completed in December 1993.

Table A-2 covers several items addressed in the Corps of Engineers' System Configuration Study. The cost figures are taken from the April 1994 Columbia River Salmon Mitigation Analysis System Configuration Study, Phase I reports, particularly the Main Report, Appendix E - Improvements to the Existing System (Snake River and McNary dams), and Appendix F - System Improvements Technical Report Lower Columbia River. The numbers reported here differ from the total cost figures listed in those reports, because all figures in the reports were divided by .975 to account for conversion of 1992 dollars to 1993 dollars based upon the GNP price deflator.

Table A-1. Estimated Costs for Various Improvements to Existing Dam Passage Systems.

Program Improvements for Endangered Species(PIES)	Construction Costs ($1,000 '93$)	Upstream Passage Items
Bonneville Dam		
Spillway Pattern Modification	$3,940	$3,940
Re-Route JBS Water to Adult Collection Channel	$1,330	$1,330
Modify Downstream Downwell	$150	
Direct Capture netframes in Tailrace	$310	
Modify U/S Fish Entrance Gates	$470	$470
Orifice Debris sensors	$220	
P.H. & Spillway U/S Fishway Control Upgrade	$330	$330
Bonneville Sub-Total	**$6,750**	**$6,070**
The Dalles Dam		
Spare Winding Fishwater Unit	$480	$480
Spill Pattern Modification	$120	$120
Adult Fish Attraction Emergency Water Supply	$1,950	$1,950
The Dalles Sub-Total	**$2,550**	**$2,550**
John Day Dam		
Modify South Ladder Diffuser	$110	$110
Fishwater Pump Spare Parts	$50	$50
Modify Count Station	$340	$340
John Day Sub-Total	**$500**	**$500**
Multiple Project Measures		
Fishway Water Quality Improvement - BON, TDA, JDA	$540	$540
Orifice Inspection System - BON, JDA	$440	
Gate Slot Debris removel system - BON, TDA, JDA	$140	
Turbines within 1% Efficiency - All Projects	$1,250	
Upgrade Juvenile Orifice Entrance - BON, JDA	$500	
Mulitple Project Sub-Total	**$2,870**	**$540**
McNary Dam		
Extend Juvenile Transport Season 1 month	$310	
Upgrade Fishway Control	$350	$350
Replace 5 Fish Trailers	$790	
Mc Nary Sub-Total	**$1,450**	**$350**
Ice Harbor Dam		
Design & Install 3-D CAM - Turbine control	$140	

Table A-1 Continued.

Program Improvements for Endangered Species(PIES)	Construction Costs ($1,000 '93$)	Upstream Passage Items
Lower Monumental Dam		
Replace Mechanical Fishway Controls	$100	$100
Design & Install 3-D CAM - Turbine control	$130	
Rebuild Turbine fish pumps	$720	$720
Extend Trap and Transport	$120	
Lower Monumental Dam Sub-Total	**$1,070**	**$ 820**
Little Goose Dam		
Extend Juvenile Transport Season 1 month	$210	
Rebuild Turbine fish pumps	$720	$720
Design & Install 3-D CAM - Turbine control	$130	
Install Fishway Shading	$500	$500
Re-route water from collection Facility to Fishway	$480	$480
Little Goose Sub-Total	**$2,040**	**$1,700**
Lower Granite Dam		
Design & Install 3-D CAM - Turbine control	$130	
Extend Juvenile Transport Season 3 months	$340	
Lower Granite Dam Sub-Total	**$470**	**$0**
TOTAL	**$17,840**	**$12,530**
Converted to Annual Cost in 1,000s of 1993 $		
50-year amortization @ 3%	**$693**	**$487**
50-yr amortization @ 8.25%	**$1,500**	**$1,054**

Table A-2 Estimated Costs of Various Projects Examined by the US Army Corps of Engineers in the System Configuration Study.

New Projects and Improvements to Existing System, from System configuration Study	Construction Costs	Operation and Maintenance Costs	Total Annual Costs in 1,000 1993 $	
			at 8.5 %	at 3.0 %
New Juvenile fish Collection System				
A. Upstream Collector (SCS. App D., p. ES -3) Alternative 3, Barge Transportation from collector to BNA	$317,423	$5,231	$31,925	$17,567
Juvenile Fish Transportation System				
1. Net Pens Alternative to Existing Barges (SCS p. 6-38)	$21,590	$4,761	$6,576	$5,600
2. Barge Water Temperature Control (SCS p. 6-39)	$49,862	$2,299	$6,493	$4,237
3. New Barges (E. Woodruff)	$15,384	$164	$1,458	$762
4. Improved Barge Exit Portals (SCS, Append E, p. 6-4)	$1,514	$0	$127	$59
5. New Transportation Facility at John Day	$38,460	$440	$3,674	$1,935
Sub-total	**$126,809**	**$7,664**	**$18,329**	**$12,593**
Juvenile Fish Systems				
1. Surface Collection System @ LWG (SCS App. E, p. 6-4)	$104,129	$0	$8,757	$4,047
2. Dispersed Release/Short-haul barging				
At Bonneville, open channel flume bypass outfall (SCS App. F, p. 9-20, 21)	$50,557	$596	$4,848	$2,561
At McNary, Little Goose, Lower Monumental, Lower Granite	$3,326	$10	$290	$140
3. Extended Length Screens/40-foot screens				
At Lower Monumental, Ice Harbor	$46,923	$135	$4,081	$1,958
At John Day	$62,269	$487	$5,724	$2,907
4. Intake screen for fish ladder, McNary	$24,963	$63	$2,163	$1,033
5. Improved Fish Guidance Efficiency at Bonneville	$30,665	$939	$3,518	$2,131
6. Replace Turbines to Improve Passage Survival AT The Dalles, John Day, and Bonneville	$296,532	$0	$24,938	$11,525
7. PIT-tag detection systems at BNA &JDY	$22,768	$530	$2,445	$1,415
Sub-Total	**$642,133**	**$2,761**	**$56,762**	**$27,718**

Table A-2 Continued

New Projects and Improvements to Existing System, from System configuration Study	Construction Costs	Operation and Maintenance Costs	Total Annual Costs in 1,000 1993 $	
			at 8.5 %	at 3.0 %
Adult Upstream Survival Measures				
1. Fish Ladder Water Temperature Control (4 Snake R. dams)	$12,764	$141	$1,214	$637
2. Additional Fish Ladders (LWG & LG)	$154,741	$300	$13,313	$6,314
3. Fish Ladder Entrance and Attraction Water (4 dams)	$20,287	$0	$1,706	$788
4. Fish Ladder Exits (McNary)	$878	$0	$74	$34
5. Adult Collection Channel Modifications (McNary)	$362	$1	$31	$15
6. Fish Channel Extensions (LWR & LG)	$53,338	$0	$4,486	$2,073
Sub-Total	**$242,371**	**$442**	**$20,824**	**$9,861**
Dam Modifications -Spillway/Stilling Basins to Reduce Gas saturation				
1. Modify Structures at 4 Snake R. dams	$140,987	$0	$11,857	$5,480
2. Modify John Day spill pattern, flip-lips	$23,454	$0	$1,972	$912
Sub-total	**$164,441**	**$0**	**$13,829**	**$6,391**
GRAND TOTAL	**$1,493,177**	**$16,097**	**$141,669**	**$74,130**

Source: Modified from US Army Corps of Engineers. 1994. Columbia River Mitigation Analysis, System Configuration Study.

APPENDIX B. Detailed Cost Estimates for Institutional Recommendations

Table B-1 Estimated Costs for Placing NMFS in Charge of Salmon Recovery

Staff Requirements (Includes salary and benefits)			
Fisheries administrator, GS-480-14	$ 79,200		
Fishery Biologist, GS-482-13		67,000	
Fishery Biologist, GS-482-12		56,300	
Fishery Biologist, GS-482-11		47,000	
Computer Specialist, GS-0334-11		47,000	
Secretary, GS-0318-6		29,000	
Total Staff Requirements			325,500
Office			
GSA Office Space in Portland, OR 1,500 sq. ft. @ $16.12 sq. ft.		24,200	24,200
Equipment (One-time expense)			
Computers (7 @ $2,000)		14,000	
Laser Printer		1,500	
Facsimile Machine		2,500	
Office furniture (Partitions/work surfaces)		21,000	
Chairs (7 @ $300)		2,100	
Other Chairs (10 @ $150)		1,500	
Bookcases/files		3,000	
Copier		6,000	
Maintenance of Equipment		500	
Total Equipment			52,100
Operations/Services/Supplies			
Printing		2,000	
Postage		-	
Misc. supplies		1,000	
Telephones		2,500	
Total Operations			5,500
Travel/Transportation			
Domestic		18,000	
Permanent Change of Station (est. 2 people)		75,000[1]	
Total Travel			93,000
GRAND TOTAL			**$500,300**

[1] Predicated on average cost of permanent change of station and staff turn-over.

Table B-2 Estimated Costs for Salmon Oversight Committee

Staff Requirements		
5 SOC Members (Senior Executive Schedule Contract Employees)	$480,000	
5 Assigned Staff: Program Level		
1 @ $60,000	60,000	
2 @ $49,000	98,000	
2 @ $40,000	80,000	
1 Assigned Staff: Research Level	60,000	
1 Secretarial	30,000	
1 Clerk	22,000	
Staff benefits at 26% (SSI, Life/Health Ins., Retirement)	84,000	
Total Staff Requirements		914,000
Office		
Space (3000 sq. ft. est. @ $20.00 sq. ft.)	60,000	60,000
Equipment (One-time expense)		
Desks	7,000	
Chairs (13 @ $300)	3,900	
File Cabinets (5 @ $300	1,500	
Bookcases (13 @ $200	2,600	
Conference Table and Chairs	3,000	
Other Chairs	1,500	
Partitions	20,000	
Computers (13 @ $2,000)	26,000	
2 laptops	5,000	
LAN includes software and server	7,000	
Laser Printers (2 @ $1,500	3,000	
Facsimile machine	2,500	
Copier	6,000	
Property Insurance	800	
Total Equipment		89,800
Operations/Services/Supplies		
Contracts:		
Research - 2 or 3 studies/year	350,000	
Peer Review (6 @ $3,000)	18,000	
Publications - Annual Report	15,000	
Postage	5,000	
Telephone	3,500	
Total Operations		391,500
Travel/Transportation[2]		
SOC members (based on ESA Recovery Team)	55,000	
Staff	10,000	
Others (Consultants, Reviewers)	2,000	
Vehicle Rental	3,600	
Total Travel		70,600
GRAND TOTAL		**$1,525,900**

[2]Predicated on no moving costs for Senior Executive Service and no permanent change of station for staff. Perhaps a low estimate.

APPENDIX C. Explanation and Interpretation of Costs Estimated for the Columbia River System Operation Review

A comprehensive evaluation of economic costs associated with changing the operation of the Columbia River facilities operated by the Corps of Engineers and Bureau of Reclamation is a has been drafted under the "Columbia River System Operation Review" (SOR). Various estimates provided by the SOR in its July 1994 Draft Environmental Impact Statement (SOR DEIS) are used in this report, especially those elements found in Appendix O "Economic and Social Impact". Appendix C provides a brief summary of that work with the objective of giving the reader insight into the breadth of the analysis and the kinds of assumptions used.

The SOR has examined seventeen System Operation Strategies (SOS's), including pre-Salmon Summit operations (SOS 1a), and a strategy optimized for hydropower production, i.e. pre-Northwest Power Planning Act (SOS 1b). We exclude SOS 1b from consideration here for obvious reasons. SOS 1a is characterized as the pre-endangered species listing condition and could be taken as the without action or baseline case for analysis of ESA-related costs. There are three strategies which are called "Current Operations", any one of which could serve as a base case from which to measure impacts of additional Snake River salmon protection strategies. We concur with the authors of the SOR Appendix O in choosing to use SOS 2c for a base case. This option is considered the "No-Action" alternative because it is structured to mimic the operations of the system under the Final SEIS in 1993. However, to measure costs of all ESA-related actions including those undertaken in 1993, one could take SOS 1a as a baseline. SOS 2c includes Columbia River flow augmentation of up to 3.0 MAF from Grand Coulee dam in addition to the existing water budget, an additional 770 KAF from Dworshak (300 in spring and 470 in summer) for flow augmentation in the Snake River; and 427 KAF of upper Snake River water for flow augmentation during appropriate periods. SOS 2c also calls for operation of the lower Snake River reservoirs within 1 foot above minimum operating pool (MOP) from April 15 to July 31, and lowering of the John Day pool to minimum irrigation pool (elevation 262.5 feet) from April 15 to August 15. Table C-1 briefly describes the System Operation Strategies of most interest for assessing Snake River Salmon Recovery measures. Table C-2 describes in more detail the strategies involving significant flow augmentation and spill actions.

System Operation Strategies 3a and 3b represent attempts to use additional flow augmentation to move salmon smolts down river more quickly. SOS 3a provides monthly flow targets at Priest Rapids dam based on Jan.-July runoff forecast ranging from 70 kcfs in March to 140 kcfs in May (water coming from Grand Coulee). SOS 3a also establishes minimum monthly flows at Dworshak dam (see p. 4-8 Appendix O, Draft SOR EIS), and calls for pulsing of water flows at Lower Granite dam (increasing by 30 kcfs) at night every third day during April 16-June 30 when flow falls below 100 kcfs. SOS 3b add up to 1.427 MAF from upper Snake River to be released from Brownlee reservoir during April - July (see p. 4-8 Appendix O, Draft SOR EIS). Hence, cost differences between SOS 3a or 3b and SOS 2c can be regarded as incremental costs of the specific flow augmentation schemes incorporated in those strategies. The Salmon Recovery Team did not recommend these flow alternatives, but we include them in this Appendix for reference.

Among the remaining 10 System Operation Strategies, there are six Snake River reservoir drawdown options which are pertinent to the recommendations of the Salmon Recovery Team. The different Snake River reservoir drawdown options as described in Table C-1 are combined with a 3.0 MAF flow augmentation in the Columbia River during May and June and drawdown of John Day reservoir to minimum pool (elevation 257) from May through August. The first two drawdown strategies (5a and 5b) bring the reservoirs down to natural river level for 2 months and 4-1/2 months respectively. Because these two options require substantial re-construction of the dam's spillways, powerhouses, and fish facilities, it is assumed that these could not be "on-line:" until the year 2010. The second two strategies (6a and 6b) bring the four Snake River reservoirs down to near spillway height for two months and 2 months and 4-1/2 months respectively. These options require less extensive construction, and are assumed to be "on-line" in 2005. Finally, the last two strategies (6c and 6d) bring the Lower Granite reservoir down to near spillway height for 2 months and 4-1/2 months respectively. These two strategies require substantial construction only at Lower Granite Dam and can be completed in time for operations in the year 2000.

The final three System Operation Strategies included in the SOR analysis represent operations to meet objectives worked out in coordination with the US Fish and Wildlife Service and the National Marine Fisheries Service. SOS 7a reflects the Coordination Act Report, including elements of drawdown, flow augmentation, and stable storage pools. SOS 7b reflects the NMFS Incidental Take Statement flow target and is similar to the baseline case SOS 2c except that it is based on flow targets at control points rather than flow augmentation volumes from specific projects. SOS 7c represents the NMFS Conservation Recommendations which establish flow targets somewhat higher than SOS 7b at McNary and Lower Granite dams during April - July. Details of these strategies are list in Table C-2.

Nine categories of net economic costs are evaluated for each of the System Operation Strategies. **Recreation** at Columbia River system reservoirs may be negatively affected by drawdowns. If some reservoirs are maintained at higher levels during the winter period in order to improve prospects for flow augmentation, **flood damages** may increase in certain areas of the basin. **Farm income** losses may occur in those regions which depend upon pumping irrigation water from Ice Harbor and John Day reservoirs when they are drawn down. In addition, various **municipal and industrial water** (including water for wildlife) users who pump water from reservoirs would be affected by drawdowns. Shallow draft **navigation** on the Snake River will clearly be affected during drawdowns, since the navigation locks will be out of service. Transportation of logs on the **Dworshak** reservoir will be affected by all strategies that call for using Dworshak as a source of additional flow augmentation in the Snake River. **Hydropower system costs** (i.e. reduced value of hydropower from the base case plus cost of replacement power) increase as a result of both the reduced capacity of Snake River dam hydropower plants during drawdowns and increased flow of water during spring and summer. Commercial and recreational value of the **anadromous fish** fishery are affected by the strategies as populations of fish grow or decline over future decades. Finally, **implementation** costs for the construction projects needed vary greatly among drawdown strategies.

Each of these categories of cost present the analyst with huge complexities and data shortages. Each cost category was examined by a team of experts and economists from the operating agencies. Any practical analysis of these costs must rely upon a series assumptions and choices of baseline data -- assumptions and choices which are subject to critical review and modification as the SOR DEIS is finalized. The objective of the following brief paragraphs is simply to characterize the analytical approaches taken in the SOR, to highlight some critical assumptions, and to suggest possible biases or errors that may affect the total cost estimates.

Recreational impacts occur when the drawdowns make reservoir unsuitable for boating, fishing, or camping. Some of the recreational services lost are due to the disabling of boat ramps and other facilities. The Recreation Work Group used a new recreational survey to estimate a recreation participation model, and then used that model to estimate reductions in use of each project reservoir under varying conditions. The SOR analysts use recreation day use values from economics literature which represent consumer surplus values accruing to recreational users. The recreational loss estimates equal the economic value per day of recreational activity at the affected sites multiplied by the estimated reduction in recreation activity during the proposed drawdown. A weakness of the analysis is that it did not examine possible mitigating measures for facilities that are disabled during drawdowns (e.g., reconstructing boat ramps). The recreational costs may be overstated to the extent that existing sites or attractive alternative sites can be made available to recreational users of project reservoirs. We think this could be a significant factor, and include a lower bound estimate of reservoir recreation losses of 50% of the SOR estimate in Table C-5, Revisions 2 and 3.

Estimates of flood damage under any system operation strategy are based upon costs of property damage at specific Damage Centers under the river conditions likely to occur over time. Damages are calculated using the Corps of Engineer's Hydrologic Engineering Center program Expected Annual Damage (EAD). Damages occur in several categories: residential structures and contents; commercial structures and contents; industrial buildings, materials, inventories, etc.; agricultural crops and buildings; public property losses, such as parks, schools, utilities; and costs of emergency aid during floods.

Farm income loss is associated with increased costs of pumping from drawn down reservoirs. The main elements of this estimated cost are for modifications to pumping stations in Ice Harbor and John Day reservoirs, and increased operating costs (i.e., additional electrical energy needed to pump from a greater depth) in Ice Harbor, John Day, and at Grand Coulee's Franklin D. Roosevelt Lake. This approach to cost estimation assumes that the quantity and timing of water pumped for irrigation use does not change when the reservoirs are drawn down; each irrigation pump operator simply incurs the cost of modifying facilities to operate on a "normal" schedule. In some cases this approach to cost estimation will over-state the costs likely to be incurred. In practice, the modifications required to operate during drawdowns increase the average cost per acre-foot of irrigation water used. As intelligent and adaptive economic decision makers, farmers are likely to assess other possible responses -- including reduced acreage under irrigation and modified cropping patterns. Where net incomes from irrigated crops are very small to begin with, the extra cost of pump modifications may exceed the net value of the drops. Where alternatives to current irrigation practices involve lower overall reductions in farm income, they could be adopted by farmers making rational choices, and the irrigation costs estimated in SOR would be over-stated. As a reasonable lower bound estimate of these farm income losses, we suggest 50% of the SOR estimate. This lower cost in included in Revision 2 and 3 in Table C-5. It should be noted that there has been no attempt to consider the implications of Federal subsidies to irrigation systems in the agricultural sector. Whether elimination of farm production represents a true economic when some of the farms are producing only because of crop or water supply subsidies should be further assessed.

Municipal and Industrial water users have basically the same cost increases as the farm irrigators - costs of modifying pumping facilities and of increased energy charges needed to pump over greater elevations. Again, the SOR estimates of cost are likely to be high-end estimates because some water users may find lower-cost strategies in response to reservoir drawdowns. For example, some may find it preferable to store larger quantities of water for use during the drawdown periods. There may be some over-statement of costs inherent in the SOR estimates.

River navigation is important for delivery of agricultural and forest products from the Snake River basin to the port of Portland, Oregon and for upriver transportation of petroleum products and other agricultural inputs. During reservoir drawdowns the navigation locks will be out of service, and the river may be too shallow for barge traffic. During the period when river transportation is unavailable, shippers will have to adopt different shipping and marketing strategies. The SOR analysis uses a transportation model to determine how shippers would ship the base period amounts of products seasonally using alternative storage and shipping modes. To the extent that more fundamental shifts in regional shipping patterns and costs would be triggered by the disabling of the river barge system, this analysis may mis-state the cost actually occurring under drawdowns. It is likely that the SOR analysis errs in over-stating the cost of adapting to the interruption in operation of the navigation locks. It is unclear how much the over-statement might be, but some analysts have suggested that systematic shifts in regional shipping patterns could alleviate much of the increased costs associated with reduced availability of low-cost river barge shipping (Michael Martin et al. 1992). As an reasonable lower bound estimate of navigation costs we suggest 50 % of the SOR estimates. This lower cost is included in Revision 2 in Table C-5.

Rafting of logs from log dump sites on Dworshak reservoir to pick-up sites near the dam is a low-cost method of transporting logs from timber operations to sawmills. When Dworshak is drafted to provide flow augmentation in the Snake River, the reservoir drops below the level of the log dumping facilities. Operators could then store logs during the draw down period or ship by alternative, higher-cost modes of transportation. The Snake River drawdown alternatives considered by SOR actually improve the log rafting operation by keeping the reservoir full and stable during the spring and summer for use in re-filling the Snake River reservoirs. Hence, there is a slight benefit to log operations at Dworshak associated with reservoir drawdowns.

Shifts in hydropower production due to reservoir drawdowns may impose significant costs on the Pacific Northwest region. As described in Appendix I Power of the SOS Draft EIS, the analysis of these costs is the most complex and extensive of any cost category. Briefly, to determine how specific river flow or drawdown strategies affect hydropower production, the analysts simulate the entire hydropower system operation over a fifty-year water cycle. For each System Operation Strategy deficits and surpluses in monthly power production (relative to projected power demand) are calculated. The cost of making up the deficits can be calculated in number of ways. The two main options for making up deficits are the "CT case" and the "Purchase Case". In the CT case monthly energy deficits in regional power (load exceeding generation with existing generating plants) caused by altering the hydropower system are filled in by installing gas combustion turbine generators and operating them during periods of energy deficit. In the Purchase Case monthly energy deficits are filled by purchasing energy from companies in the American southwest or British Columbia. On one extreme, we could build sufficient CT capacity to satisfy regional demand all the time. On the other extreme, we could simply plan to enter the "spot market" for energy when deficits occur. Neither of the strategies modeled by the SOR analysts are this extreme. The CT Case assumes that sufficient new generating capacity is installed to cover all but the most extreme deficits. The "Purchase Case" assumes sufficient energy is available on the spot market except in the most extreme deficit situations. The final tables included in the SOR Draft EIS Appendix O "Economic and Social Impacts" assume the CT Case, while we think that the Purchase Case is probably a more cost-effective approach.

To calculate the cost of meeting monthly regional power demand the analysts at BPA developed a spread-sheet model which applies standardized cost rates to each monthly power deficit. The first step in the analysis is to run a hydropower simulation model which generates a 50-year series of monthly power deficits and surpluses based upon the standard 50-water-year data base. For each option, a set of 50 12-month power deficits/surpluses is produced. The surpluses are sold and the deficits are filled (using either CT or purchase methods); the net change in total cost of supplying BPA customers with power is calculated for each year; the years are averaged; and the rate impacts of the increased cost are determined. The Purchase Case assumes that BPA can purchase power at the following escalating rates: 35 mils per kwh for the first 1,000 MW, 40 mils for the next 1,000 MW; the 45 mills for the next 1,000 MW; then 50 mills; then 150 mill for purchases in excess of 4,000 MW in a month. These costs of power were based upon earlier information. More recent estimates would lower the initial step to closer to 22 mills. The CT Case assumes combustion turbine power can be provided for an average cost of 37 mills (=$37 per MW), which is made up of 19 mills of fixed cost and 18 mills of variable cost. The CT case turns out to be more expensive than the Purchase Case mainly because the fixed cost of CT must be born all the time, while the extra generating capacity of some CTs is needed in only a few months. Overall, inter-regional energy marketing provides for greater utilization of generation facilities than does full self-sufficiency of each region.

Ideally, the hydropower system for each recovery option would be adjusted to optimize the power system while implementing the new salmon-conservation measures. The SOR Draft analysis could not incorporate all the optimizing steps that would normally be expected to occur in practice. For example, nuclear power plant maintenance schedules need to be shifted in order to better match the periods of power surplus under each option. In a report sponsored by the Natural Resources Defense Council (NRDC) Karen Garrison and David Marcus (1994) developed a modified analysis of the power impacts of reservoir drawdowns by rescheduling the WPPS II nuclear plant maintenance from July showing how overall costs or power generation are reduced. Further, some observers and critics of the SOR analysis point to additional opportunities for inter-regional marketing of surplus power which were not incorporated in the power impact analysis. Finally, as noted in Appendix A, critics have purported to find cost savings in the Corps of Engineers estimates of dam construction costs. As a result of these suggested adjustments to the SOR cost analysis, the NRDC indicates that the estimated cost of a spillway crest drawdown scenario could be reduced from the Northwest Power Planning Council estimate of $213 million/year to $116 million/year. This nearly 50% reduction in cost gives us some notion of the range of costs for drawdown type measures that can reasonably be estimated.

Without engaging in a detailed engineering analysis of either the SCS or NRDC information, we cannot choose a particular cost estimate as being the most accurate possible. The SOR analysts themselves regard the estimated costs as useful for relative comparisons only, not as accurate predictors of absolute costs. The critics of the SOR and Power Planning Council estimates have made some valid points. The authors of this report are aware of the degree to which the initial estimates can be modified by application of a little ingenuity. We suspect that initial estimates of power costs in the Draft SOR EIS will prove to be over-estimates. There may be errors of underestimation in the SOR study as well, but we think that the tendency is for cautious initial cost estimates to be on the high side. As the planners and operators begin to confront the new set of problems posed by salmon conservation measures, they will find numerous adjustments in the system and opportunities for trading on the regional power grid which may ultimately lower the power costs of drawdowns and flow augmentation. This will not be as true for spilling water over the spillways to increase smolt guidance efficiency around the turbines, because spills clearly nullify opportunities to generate power regardless of seasonal schedule.

To the extent that hydropower system changes for salmon conservation increase the costs of providing power, and assuming that the costs are born by Bonneville Power Administration, the electricity rates charged by BPA will have to increase. The "rate impacts" estimated in the SOR work are summarized in Table C-3. Simple demand theory predicts that increased rates will cause some consumers to cut back on energy use, thereby decreasing the size of the estimated monthly regional energy deficits and reducing the amount of either combustion turbine construction or market purchases needed. To calculate this cost requires that rate impacts and demand impacts be estimated iteratively to find the equilibrium in the regional energy market. The cost of replacing the amount of energy demanded at the new, higher price is termed the "net replacement cost". This cost estimate is the one displayed in Table C-4. As noted in Chapter 2, an important concept is that of consumer surplus lost in the process of reducing demand as electricity rates rise. Both the net replacement cost and consumer surplus estimates require estimates demand elasticity. Both are displayed in the SOR DEIS, but the main summary Tables 5-5 and 5-9 in SOR DEIS, Appendix O are based solely on the CT Case of net replacement cost. We have settled on the net replacement cost estimate as a reasonable concept for consideration here, because the consumer surplus estimate is highly sensitive to the price elasticity of demand used, and that elasticity estimate is (we think) not well established. The CT Case estimates of net replacement cost are listed in Table C-4, line 7, and the Purchase Case estimates are in Table C-5. Total system wide costs based upon the purchase case are displayed in the revised total system costs in Table C-5.

Anadromous fish are valuable as commercial product from the various fisheries and as an target of recreational fishing. During the implementation of any of the proposed System Strategies, one would expect improvements in the survival of downstream migrants and of upstream migrating adult fish. If so, the populations of the Snake River and Columbia River salmon stocks would be increasing over time, and the economic value of commercial and recreational salmon fisheries would be increasing as well. The SOR analysts used a computer model called SLCM (for Salmon Life-Cycle Model) to estimate the trajectory of stocks of fall chinook, spring chinook, steelhead, and sockeye after implementation of each System Operation Strategy in 1995. To accomplish this computation for the drawdown options, the analysts assumed that SOS 2c would be followed until the POL date of the projects. So, for example, since SOS 5a was assumed not to be on line until the year 2010, the estimated anadromous fish benefits for that option are equivalent to SOS 2c for the first fifteen years. Catches were assumed to increase or decrease proportionately with the fish populations; catches were distributed over fisheries based upon historical catch data; and the catches were valued based upon gross ex-vessel commercial value and estimated consumer surplus for recreation. No attempt was made to estimate "existence" values for salmon. The estimated anadromous fish catches would increase under all the System Operation Strategies examined, but the increase in harvest and economic value would be lower under all the drawdown alternatives than under the base case SOS 2c.[1] While this result may seem counter-intuitive (it says that drawdowns do not work), the results are consistent with survival rate estimates through reservoirs, dams, and in barge transportation that are being used by, for example the passage model CRiSP. Whether this is an accurate assessment of these options will undoubtedly receive significant attention by agency biologists. We noted at the end of Chapter 2 that Recovery Team recommended against using the results of the salmon survival models literally to estimate salmon population changes under recovery options. It would be consistent with this view to leave the anadromous fish costs out of the final cost estimates. Our Revisions 2 and 3 Total Cost estimates in Table C-5 leave out this cost component.

Implementation costs of each drawdown alternative estimated by the Corps of Engineers under the System Configuration Study are used in the SOR DEIS. These consist of construction costs, interest during construction, contingency costs, and increased operating, maintenance and repair (O&M) costs. The construction, interest, and contingency costs are assumed to accrue until the project on line date (POL). The O & M costs accrue from that date on. To obtain the annual costs listed in Table C-4, the total project cost is discounted to 1995 and then amortized over 100 years at 3% interest. While the Corps of Engineers and its contractors have substantial experience in river dams and hydroelectric projects, the estimates presented here and in the SOR must be considered preliminary. Phase II of the System Configuration Study will involve more detailed planning and cost estimation for projects of this sort. Garrison and Marcus reference a study by McClean which provides alternative estimates of dam construction/modification costs. The McClean report proposed to use lower-cost rock weirs below the dams as a substitute for construction of extended fish ladders and lower contingency costs, among other things. As reported in Garrison and Marcus, McClean's estimate of costs associated with modifications for four-dam spillway crest drawdowns is about half of the Corps of Engineers estimate.

[1] See SOR DEIS, Appendix O, page 4-24.

We take this estimate as a lower bound of the likely costs for dam modification and construction. If the capital costs are halved, the annualized costs would also be halved, and this lower end cost estimate is included in line 14 of Table C-5, "Revision 3".

Table C-1. Drawdown Options Considered in System Operation Review

SOS #	Description of System Operation Strategies	Assumed POL Date
2c	Base Case, Equivalent to operation described in Corps of Engineers SEIS for 1993.	1995
3a	Flow Augmentation. Monthly flow targets at Priest Rapids and Lower Granite	1995
3b	Flow Augmentation. Same targets as 3a plus 1.427 MAF from upper Snake	1995
5a	Drawdown 4 Snake River Reservoirs to Natural River level for 2 Months	2010
5b	Drawdown 4 Snake River Reservoirs to Natural River level for 4-1/2 Months	2010
6a	Drawdown 4 Snake River Reservoirs 30 - 35 ft. below MOP for 2 Months	2005
6b	Drawdown 4 Snake River Reservoirs 30 - 35 ft. below MOP for 4-1/2 Months	2005
6c	Drawdown Lower Granite Reservoir 30 - 35 ft. below MOP for 2 Months	2000
6d	Drawdown Lower Granite 30 - 35 ft. below MOP for 4-1/2 Months	2000
7a	Coordination Act Report Operation. Flow targets at The Dalles and Lower Granite, and spill at McNary and lower Snake projects.	1995
7b	NMFS Incidental Take Statement Flow Targets and McNary and Lower Granite	1995
7c	NMFS Conservation Recommendations with Higher Flow Targets at McNary and Lower Granite	1995

Table C-2. Explanation of System Operation Strategies depending principally on Flow Augmentation.

	Grand Coulee	Dworshak	Brownlee	Upper Snake	Lower Columbia
SOS 2c	Storage for flow augmentation Jan. - April; Release up to 3 MAF above Water Budget in Many and June based upon sliding scale runoff forecast.	Release up to 600 KAF in May (SOS 1a) plus: 900 KAF or more from April 16 - June 15 based on runoff forecast; up to 270 KAF above 1.2 kcfs from June 16 to Aug. 31; up to 200 KAF above 1.2 kcfs in July and/or Aug. ; maintain 1.2 kcfs flow Oct. - April. Shift flood control to Grand Coulee if runoff forecasts are 3.0 MAF or less at Dworshak.	Release up to 100 KAF in May for Water Budget as needed, based on target flow of 85 kcfs at Lower Granite dam (same as pre-Salmon Summit).	Release up to 427 KAF for flow augmentation - 190 KAF April 16 - June 15; 137 KAF in August, and 100 KAF in Sept.	Same at SOS 1a: Normal operations a 4 lower Columbia R projects (within 3 to 5 feet of full pool with daily and weekly fluctuations); restricted operation at Bonneville second powerhouse. Plus: Lower John Day to minimum irrigation pool April 15 - Aug. 31; operate within 1.5 feet forebay range.
SOS 3a	Operate at minimum elevation 1,208 feet all year. Supplemental release to meet variable monthly Priest Rapids flow targets, based on runoff forecasts.	Operate to meet the following min. flows: 1.2 kcfs Oct. - Mar. , 2.0 kcfs April 1 - 15, 4.5 kcfs April 16 - 30, 15.0 kcfs May, 7.5 kcfs June , 5.0 kcfs July 1.2 kcfs Aug., 6.0 kcfs Sept.	Same as SOS 2c	Same as SOS 1a. Normal operations; no Water Budget flows.	Same as SOS 2 except operate John Day within 2 feet above elevation 262.5 feet April 15 - August 31.
SOS 3b	Same as SOS 3a	Same as SOS 3a	Release up to 1.427 MAF of upper Snake water: 285 KAF April 16-30, 571 KAF May, 428 KAF June, 143 KAF July.	Up to 1.427 added inflows to Brownlee.	Same as SOS 3b.

Table C-2 Continued.

	Grand Coulee	Dworshak	Brownlee	Upper Snake	Lower Columbia
SOS 7a	Operate to meet the following flow target at The Dalles: 300 kcfs Apr. 15 - June 15, 200 kcfs June 16 - July 31, 160 kcfs Aug.	Shift flood control to Grand Coulee and supplement releases as follows: 10 kcfs (180 MAF) April 16 - June 30; 4.4 kcfs (400 KAF) July - Aug. 15.	In addition to base operation (up to 110 KAF in May for Water Budget): draft up 10 137 KAF July 1 - Aug. 15, and draft 100 KAF in Sept.	Provide the following additional flows: 1.2 kcfs (180 KAF) April 16 - June 3; 7 kcfs (637 KAF) July 1 - Aug. 15.	Spill % at McNary of 48% during April 16 - June 15, and 62% during June 16 - Aug. 31. Operate John Day within 1 foot above elev. 262.5 feet April - June, 264.2 feet July - August.
SOS 7b	Operate to meet the following flow targets at McNary dam: 200 kcfs April 20 - June 30, 160 kcfs July 1 - 31.	Operate to meet specific flow targets at Lower Granite dam: 85 kcfs April 10 - June 20, 50 kcfs June 21 - July 31.	Same as SOS 7a	No additional flows.	No additional spill stipulated, and John Day operated within 2 feet above elev. 262.5 April 15 - Aug. 31.
SOS 7c	Operate to meet the following flow targets at McNary dam: 220 kcfs April 20 - June 30, 200 kcfs July 1 - 31.	Operate to meet the flow targets at Lower Granite dam: 85 kcfs April 10 - June 20, 55 kcfs June 21 - July 31.	Same as SOS 7a	No additional flows.	No additional spill stipulated, and John Day operated within 2 feet above elev. 262.5 April 15 - Aug. 31.

Table C-3 Net System Generation Costs for drawdown options, Combustion Turbine (CT) and Purchase Case estimates. Estimated rate changes consistent with increases in Net System Generation Costs, BPA Wholesale and Average Pacific Northwest Retail.

SOS	Equivalent Annual System Generation Costs for Each Option (million 1993 $)		Difference in Annual Cost from Base Case SOS 2c (million 1993 $)		Estimated Rate Changes, Purchase Case Only	
	CT Case	Purchase Case	CT Case	Purchase Case	Wholesale, Priority Firm	Retail, PNW Region wide
2c	996	922	0	0	0	0
3a	1256	1136	260	214	8.1%	2.8%
3b	1288	1147	292	225	na	na
5a	1092	967	96	45	17.3 %	6.0%
5b	1093	982	97	60	na	na
6a	1092	956	96	34	6.5%	2.3%
6b	1091	956	95	34	na	na
6c	1086	943	90	21	na	na
6d	1094	949	98	27	2.9%	1.0%
7a	1463	1246	467	324	7.6 %	5.4 %
7b	1331	1041	336	119	na	na
7b	1374	1909	378	168	na	na

Source: Columbia River System Operation Review, Draft Environmental Impact Statement, Appendix O Table 4-44 (p.4-69) and Table 4-38 (p.4-63).

Table C-4 Estimated Annual Equivalent SOR Costs for Drawdown Alternatives for Each Economic Sector Using 3.0 % Discount Rate.[1]

	SOS 3a	SOS 3b	SOS 5a	SOS 5b	SOS 6a	SOS 6b	SOS 6c	SOS 6d	SOS 7a	SOS 7b	SOS 7c
	1,000 s of 1993 $										
Recreation Costs	$2,362	$2,424	$7,560	$10,691	$7,919	$10,864	$6,359	$8,343	$ 7,455	$ 1,535	$ 4,202
Flood Damage Costs	$94	$94	$13	$6	$7	$7	$7	$7	1,698	-74	-119
Farm Income Loss	$0	$0	$5,265	$5,332	$4,803	$4,834	$3,374	$3,374	0	0	0
M & I Water Costs	$0	$0	$747	$749	$717	$718	$713	$713	270	0	0
Navigation Costs	$0	$0	$9,408	$13,631	$13,326	$18,376	$1,421	$2,145	1,964	0	0
Dworshak Dam[2]	$190	$189	($67)	($52)	($102)	($120)	($102)	($221)	221	97	129
Power Generation Costs -CT Case	$260,000	$292,000	$97,000	$97,000	$96,000	$95,000	$90,000	$98,000	467,000	336,000	378,000
Anadromous Fish	$1,100	$2,950	$280	$230	$12,250	$12,520	$13,350	$13,860	11,470	440	-480
Implementation	$0	$0	$77,000	$77,000	$24,980	$24,980	$2,200	$2,200	0	0	0
SOR Total Costs	**$263,366**	**$297,279**	**$196,206**	**$204,587**	**$159,900**	**$167,179**	**$117,322**	**$128,421**	**$489,636**	**$337,804**	**$381,474**

[1] From the SOR Draft EIS, Appendix 0, Table 5-9, p. 5-20.

[2] The effect of drawdowns on Dworshak logging operations is a net benefit.

Table C-5. Revised SOR Costs. (1) Using "Purchase Case" for Power Generation Costs, (2) Taking a 50% reduction in Recreation, Farm Income, Navigation costs, and a 100% reduction in Anadromous Fish Costs; and (3) Decreasing Anticipated Capital Expenses by 50% for Implementation of Alternatives Requiring Structural Modifications to Dams.

	SOS 3a	SOS 3b	SOS 5a	SOS 5b	SOS 6a	SOS 6b	SOS 6c	SOS 6d	SOS 7a	SOS 7b	SOS 7c
	1,000 s of 1993 $										
Power Generation Costs -Purchase Case	$214,000	$225,000	$ 45,000	$ 60,000	$34,000	$34,000	$21,000	$27,000	$ 324,000	$ 119,000	$ 168,000
Revision 1 Total Cost	**$217,366**	**$230,279**	$145,206	$167,587	$97,900	$106,179	$48,322	$57,421	$346,636	$120,804	$171,474
Revision 2 Total Cost	$215,085	$226,117	$133,810	$152,530	$72,626	$76,622	$29,395	$36,630	$330,457	$119,597	$169,853
Revision 3 Total Cost	$215,085	$226,117	$95,310	$114,030	$60,136	$64,132	$28,295	$35,530	$330,457	$119,597	$169,853

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