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by

Jonathan Platt

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Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Acronyms and Abbreviations

AC	average cost
AKFG	Alaska Department of Fish and Game
AR	average revenue
BCA	benefit cost analysis
CDFG	California Department of Fish and Game
CPE	common property equilibrium
EFIN	Economic Fisheries Information Network
EIS	Environmental Impact Statement
ITQ	individual transferable quotas
MB	marginal benefit curve
MC	marginal cost
MR	marginal revenue
MSY	maximum sustainable growth or yield of the fishery
NMFS	National Marine Fisheries Service
NPFMC	North Pacific Fishery Management Council
NOAA	National Oceanic and Atmospheric Administration
ODFW	Oregon Department of Fish and Wildlife
P&Gs	*Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*
PACFIN	Pacific Coast Fisheries Information Network
PFMC	Pacific Fisheries Management Council
PPE	private property equilibrium
PSMFC	Pacific States Marine Fisheries Commission
R&M	repair and maintenance
Reclamation	Bureau of Reclamation
RMPC	Regional Mark Processing Center
SAFE	Review of Ocean Salmon Fisheries
T&E	threatened or endangered
TB	total benefit
TC	total cost
TR	total revenue
WDFW	Washington Department of Fish and Wildlife
WOC	Washington-Oregon-California

Contents

Page

Figures

Tables

1.0 Introduction

This paper examines how water management practices can influence commercial fishing activities and their economic benefits. Government water management agencies, at both the Federal and state level, can influence fisheries habitat and populations. Most of the discussion in this report is universally applicable, but emphasis is placed on water management activities by the Bureau of Reclamation (Reclamation) in the western United States, including Washington, Oregon, Idaho, and California. With the possible exception of tribal commercial harvest, which often takes place on the rivers themselves, commercial fishing activities within the United States are typically pursued within the nation's estuaries, bays, and oceans. While actions by Reclamation and other similar agencies are typically limited to inland locations such as reservoirs and rivers, they can often play a significant role in providing necessary habitat for certain commercially attractive fish species.

1.1 Water Management Activities

Water management agencies' actions can positively affect fish populations by providing backwaters for spawning and rearing, instream flows for outward and inward migration, warm or cold water reservoir releases to maintain adequate instream water temperatures, pulses of clean water to dilute pollution effects, etc. However, the actual facilities of water management agencies—dams, canals, hydroelectric facilities—can adversely affect migration and fish survival. These facilities can hamper fish passage by:

1) Blocking migration paths thereby slowing upstream and downstream migration leading to increased predation, increased exposure to higher water temperatures within reservoirs, and increased risk of bacterial infections

2) Subjecting fish to potentially harmful nitrogen gas supersaturation just downstream of the dam

3) Destroying juveniles as they pass through hydroelectric turbines

This paper focuses on the potential impacts to commercially attractive migratory fish species. Given Reclamation's western U. S. jurisdiction, migratory fish species of the West Coast are emphasized (e.g., various species of anadromous fish including pacific salmon – Chinook, coho, sockeye, chum, pink; and anadromous trout or steelhead). These anadromous migratory fish spawn in rivers, migrate downstream to the ocean, spend a substantial portion of their lives in the ocean, and then as adults migrate back upstream to spawn and often die. Given various fishery management harvest restrictions, these adult anadromous fish are typically only available for non-tribal commercial harvest within the ocean on their migration back to their native streams to spawn.

Water management activities on a given river system could also impact estuary water conditions and therefore commercial fishing activities within the estuary and associated ocean areas supported by the estuary. For example, the San Francisco Bay Delta estuary is critically dependent on both the quantity and quality of the flows from the Sacramento and San Joaquin river systems.

While the intent of most fishery oriented water management activities is to improve conditions for native fish[1], those actions would likely simultaneously benefit hatchery fish populations. Numerous hatchery operations have been in place for many years to supplement fish populations adversely impacted by dam construction. As natural or native fish populations have declined (dramatically in many cases to the point where state and federal fishery agencies have listed them as threatened or endangered (T&E) species) hatcheries have had to try and pick up more and more of the slack. Today, most of (perhaps better than 80 percent) the commercially caught "wild"[2] salmon in the Pacific Northwest and northern California reflect hatchery fish. Hatchery fish are considered by many experts to be inferior to native fish as they have less genetic diversity. Hatchery fish tend to suffer from lower survival rates, are less adaptable to changing ocean conditions, and are more susceptible to predation (Buck and Dandelski, 1999). In addition, hatchery fish complete for habitat and food sources with native fish. As a result, considerable efforts have gone into stemming the decline in native anadromous fish.

1.2 Hatchery and Native Fish

From an economic perspective, despite the likely indistinguishable differences in meat, it is possible that healthy populations of native fish may be commercially valued higher than hatchery fish by some people for environmental reasons. In this case, native fish may be able to demand a higher price if native and hatchery fish could be easily distinguished. Unfortunately, it may not be straightforward to track populations of native versus hatchery fish. This is especially true when significant numbers of hatchery fish breed with native fish and spawn in the river. The intermingling of fish stocks creates problems in trying to distinguish native and hatchery populations. One way to improve the chances that fish are native is to harvest them as they re-enter rivers known for not having hatchery operations. Alternatively, some hatcheries have started fish tagging operations to help

[1] The terms "native fish" or "natural fish" are used interchangeably and refer to unmanipulated fish. In contrast, manipulated fish include hatchery fish and farmed fish.

[2] The term "wild" salmon refers to both native and hatchery salmon and is used to distinguish commercially caught fish from farmed fish.

distinguish native and hatchery fish. However, these tagging operations are often initiated within river systems where the native populations have been listed as T&E, implying no allowable harvest of native fish. At present, retailers typically do not differentiate between native and hatchery fish, perhaps due to the dominance of hatchery fish in many areas.

Genetically distinct runs[3] of salmon of the same species have been defined for each river system and sometimes even for tributaries within a given river system. This has created fishery management difficulties as so many of these salmon runs have been declared T&E species. A great deal of fisheries research, with varying degrees of success, has gone into understanding the timing of the runs and the migratory path of these species. Given that it is often impossible for even the most skilled eye to differentiate the various salmon species by river system and run, fishery managers have had no choice but to close down entire geographic areas to salmon fishing when T&E species have intermingled with healthy runs. Since the late 1980s to early 1990s, many salmon fisheries have been severely restricted or completely shut down. Although some commercial fishing operators have been able to stay in business by targeting other species or traveling to more remote locations in search of salmon, the restrictions on West Coast salmon harvests have significantly reduced the number of salmon fishing operations—in some areas by 90 percent or more (Associated Press, 2003).

1.3 Farmed Fish

Another component of the salmon market is the influence of farmed fish. Although hatcheries have worked hard to try and maintain wild salmon populations, the continued decline of native salmon populations has lead to an increase in the number of T&E runs, thereby resulting in a virtual collapse of the Pacific Northwest and California salmon fishery by the early to mid-1990s. To make up for this loss in supply, internationally (e.g., Chile, Norway, United Kingdom, Canada) and to some extent domestically (e.g., Washington state[4]) produced farmed salmon supplies have increased dramatically. Currently, about 80 percent of the salmon sold in the U.S. comes from fish farms (Associated Press, 2003).

The flood of farmed salmon has driven market prices down, creating further problems for commercial fishing operations. The problem for commercial fishermen is that salmon products are not always differentiated at the retail level between wild and farmed fish. While fish farms have hurt the commercial fishing

[3] Many salmon of the same species, within the same river system, include more than one population or run within a given year (e.g., separate Chinook runs during spring, fall, and winter).

[4] Fish farms are currently prohibited in Alaska for economic and environmental reasons and rough shoreline conditions preclude such operations along the Oregon and northern California coasts. Several operations exist in the calmer waters of Puget Sound in Washington State and numerous operations exist in British Columbia, Canada.

sector, they have also created substantial increases in consumer demand for salmon products. If wild fish, and perhaps even native fish, can be legitimately differentiated as a higher quality product and identified as such through consumer labeling, the commercial fishing sector may be able to carve out a high end market niche and demand higher prices compared to farmed fish. To a significant extent, especially at grocery stores (but to a lesser extent within restaurants), this product differentiation is already occurring between wild and farmed salmon.

Commercial fishermen may be able to justifiably claim that wild fish (especially native fish), are more natural, more flavorful, and less environmentally destructive compared to farmed fish. Some experts claim that farmed fish are inherently unnatural given they are fed to maximize their growth and weight; are treated with antibiotics, pesticides, and other chemicals to control disease and parasites; have much more saturated fat and toxics than wild fish; require artificial pigmentation to achieve the desired coloration; and may have undergone genetic experimentation.

Historically, fish farm operations have also created serious environmental degradation including:

1) Water pollution from pesticides and the enormous amounts of fish waste

2) Contamination of nearby wild fish populations from uncontrolled diseases and parasites

3) Harvest of vast amounts of ocean fish to use in producing fishmeal (estimates indicate it takes 3 to 4 lbs of wild fish – anchovies, sardines, mackerel - to produce 1 lb. of farmed salmon (Ryan, 2003))

4) Farmed fish frequently escape from their shoreline pens in large numbers and compete for food and sometimes breed with natural Pacific salmon

The breeding issue may not be as problematic as once thought since the majority, but not all, of farmed salmon in the Pacific Northwest are Atlantic salmon which apparently do not breed with Pacific salmon. Furthermore, despite disputes by industry, the escapees do appear capable of reproducing among themselves in the wild, thereby establishing long-term populations in direct competition with wild populations.

These issues lead the Canadian province of British Columbia to restrict fish farming for six years while regulations on waste disposal were developed. The restrictions were lifted in 2002. The placement and enforcement of strict regulations on fish farming operations would likely result in localized environmental benefits, but may place farming operations at a disadvantage within the very competitive worldwide fish farming industry unless environmental regulations are imposed through worldwide treaties (Dean and Schwartz, 2003). Recent expansion of the industry into use of tank based systems may address some, but not all, of the problems associated with fish farming.

1.4 Report Organization

This report presents a discussion of fisheries economic theory issues in Chapter 2 prior to diving into the range of methodological options in Chapter 3.

The heart of the paper, the methodology chapter, breaks potential commercial fishing economic analyses down into three harvest based sections:

1) "Constrained total harvest" where economic benefits are measured in terms of cost savings

2) "Insignificant changes in harvest" where prices are assumed to remain stable but revenues and possibly costs would need to be addressed

3) "Significant changes in harvest" where prices are expected to change and revenues and costs would need to be addressed.

The methodology chapter is followed by a fairly brief presentation in Chapter 4 of economically oriented commercial fishing data and data sources based on a preliminary review of data collection efforts at various state, Federal, and quasi-governmental entities.

2.0 Economic Theory of Commercial Fishing Benefits

Fisheries, unlike many other resources, represent a public good as opposed to a private good.5 Only upon capture do fish become private goods. As a public good, fishery resources are common property, owned by society as a whole and not individuals. Their public good nature often implies that fisheries are characterized as open access and non-exclusive—meaning anyone can use the resource and one person's use does not prevent use by another. As will be shown below, the lack of private ownership or property rights creates difficulties for the economic analysis. The discussion starts with a static single-year orientation before progressing into the more realistic dynamic multiyear perspective.

2.1 Static Common Property Equilibrium Analysis: Economically Inefficient

The theory presented in this section is drawn primarily from Hartwick and Olewiler (1998). To introduce the economic theory of a common property open access fishery, we need to start with a biological discussion. Figure 1 illustrates a simple biological growth function (G(P)). This function shows the growth of the fish population as a function of the size of the population (P). For salmon and other anadromous fish species, growth of the population is driven by the size of the spawning or reproducing adult population. Given the migratory lifecycle of these fish can involve several years, it is necessary to track fish populations by age class or cohort when estimating stock sizes over time.[6]

At low spawner population levels, birth greatly exceeds natural mortality, and the population grows at an increasing rate. The peak of the growth function reflects the maximum growth rate, the point where birth exceeds mortality by the greatest amount. To the right of the peak, natural mortality increases, perhaps due to increased competition for food, such that the rate of growth begins to decline. Where the function touches the horizontal axis at point k, population is at its maximum carrying capacity. The biological equilibrium occurs at this point k where growth equals zero.

[5] Public goods are owned by society whereas private goods are owned by individuals.

[6] While the discussion generally focuses on salmon, the basic biological concepts apply to non-anadromous fisheries as well. The primary difference being that for the other species, growth is typically driven by biomass and not number of spawners. The economic concepts hold regardless.

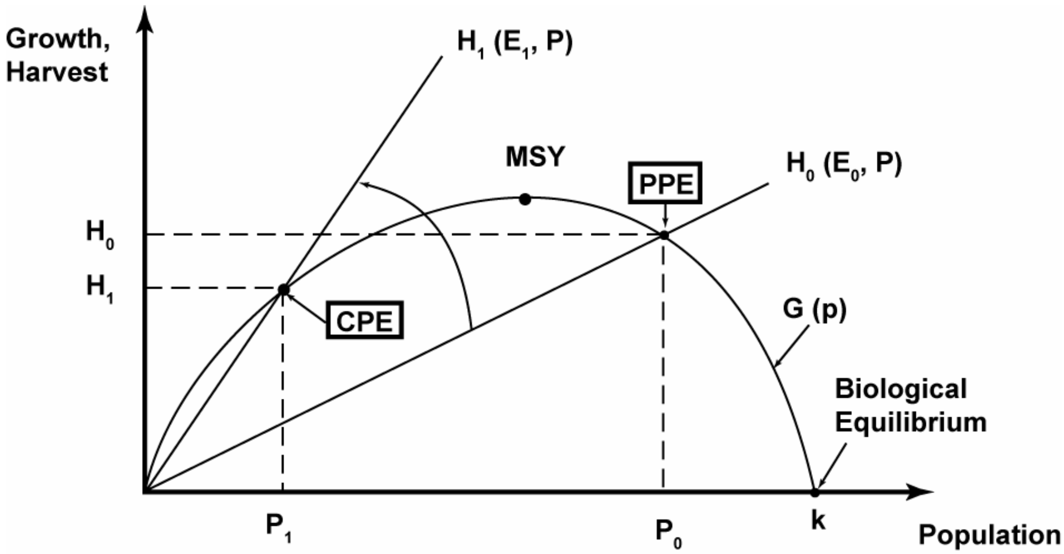

Figure 1. Biological growth and harvest functions.

As shown on Figure 1, economic activity enters through the harvest function (H). For salmon, commercial harvest occurs as fish are returning to spawn and as a result, the fish are only available for a limited period of time. Typically, only one or two age classes of a given species will be harvested each season. The level of harvest is influenced by both the size of the fish population (P) and the level of effort (E) devoted to catching fish. Effort can be defined as the number of commercial fishing boats targeting a fishery, the number of days fished, etc. Combined biologic and economic or "bioeconomic" equilibrium occurs at the point where fish population doesn't change, where harvest equals fish population growth at the intersection of the growth and harvest functions. Starting at the pre-harvest biological equilibrium at point k, introducing the harvest function H_0 produces a bioeconomic equilibrium at a population of P_0. As will be discussed later, this reflects the economically efficient private property equilibrium (PPE).

Given the common property open access nature of the fishery, the profits received by the industry at harvest level H_0 will attract additional effort into the fishery. Effort and harvest will continue to increase, as illustrated by the upward pivoting harvest function, until the peak of the growth function. This point reflects the maximum sustainable growth or yield of the fishery (MSY). From this point on, additional increases in effort result in reduced harvest as populations continue to decline. At P_1, the economically inefficient common property equilibrium (CPE), the level of harvest is less than that at P_0. Compared to P_0, P_1 is both economically and biologically inefficient because less harvest occurs ($H_1 < H_0$) with both a higher level of effort ($E_1 > E_0$), and a lower overall population level ($P_1 < P_0$). As illustrated in Figure 1, it is inefficient to operate to the left of MSY.

With several simplifying assumptions, we can expand the above discussion to include more of an economic perspective. If we assume that the fishing industry is perfectly competitive such that each firm is a price taker in both the output and input markets, this implies that a firm's activities do not affect prices. If we further assume that these prices are fixed on a per fish basis, we can sketch out linear total cost (TC) functions. If we also normalize the fixed prices by setting them equal to one, the biological growth function also serves as a total revenue function and thereby measures both total revenue and harvest simultaneously. Figure 2 displays the total, average, and marginal cost and revenue functions. Note that the horizontal axis now reflects effort as opposed to population.

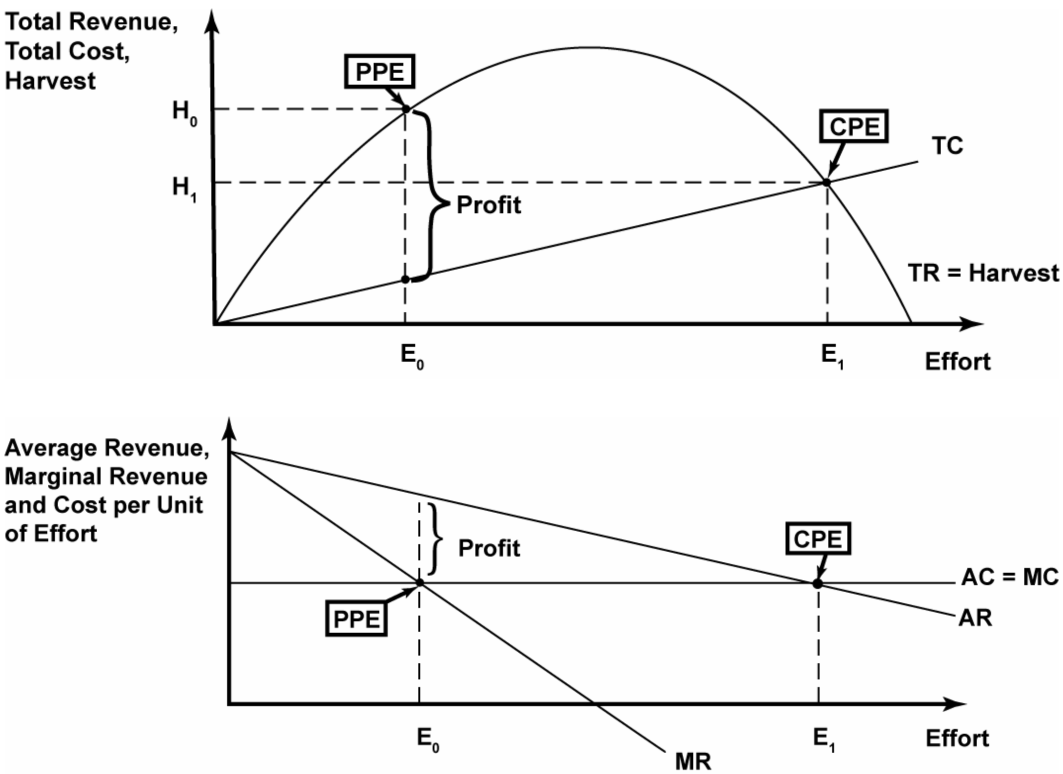

Figure 2. Total, average, and marginal cost and revenue functions.

The open access CPE occurs where total revenue (TR) equals total cost (TC) or average revenue (AR) equals average cost (AC). Alternatively, the PPE occurs where marginal revenue (MR) equals marginal cost (MC). As depicted in Figure 2, due to overfishing, CPE involves a lower level of harvest ($H_1 < H_0$), but a higher effort level ($E_1 > E_0$) compared to the PPE. The common property open access nature of a fishery results in over-fishing because each fishermen has the incentive to harvest as much of the available resource as possible. Left unmanaged, an open access fishery would ultimately lead to market failure and perhaps species extinction. Fishermen impose unaccounted for costs or externalities on each other by over-harvesting fish and therefore reducing the overall supply of harvestable fish–this is referred to as the "stock effect." At the CPE, the profits witnessed at PPE are "fully dissipated" so that industry profit equals zero (note that certain operators will continue to earn profits and others suffer losses due to skill differences, Boyce 1993). This is not a desirable situation, either economically or biologically.

To attempt to prevent or remedy this open access overfishing situation, fishery managers have attempted a wide range of management actions to reduce effort and harvest. For salmon fisheries, restrictions apply to all salmon of a particular species and have included such traditional fishery management regulations as harvest quotas, seasonal and area closures on T&E species spawning rivers and ocean areas, gear restrictions (e.g., net size restrictions, prohibition of drift nets), and limited entry programs for vessels (controls the number of operators targeting the fishery). As noted in the introduction, given the difficulty in distinguishing between the same species of salmon stemming from different river systems, if a seasonal closure of a particular river system is required to protect a T&E salmon species, chances are that harvests of other non-T&E salmon of the same species may be impacted to the extent that they intermingle within their ocean based migratory range. This has lead to periodic short term closures of entire species specific salmon fisheries within certain geographic areas (e.g., Pacific Northwest).

Although fairly uncommon in the U.S., attempts have also been made in other fisheries to use individual transferable quotas (ITQ) to help manage harvest (e.g., Mid Atlantic and New England clam/quahog, South Atlantic wreckfish, and Alaskan halibut and sablefish). Such systems create private property rights for commercial fishermen by allowing markets to develop for fixed annual harvest allotments or quotas. These individual transferable harvest quotas are exchanged through markets, resulting in market prices for different quota levels. Total harvest can be managed by governmental fisheries agencies by controlling the number and size of available quotas and by allowing non-fishermen (e.g., environmental groups) to buy up quotas. Ultimately, the goal of all of these fishery management actions is to help push the industry away from CPE toward PPE.

Unfortunately, for many anadromous fisheries, harvest management activities alone have proven to be of limited use. While strict harvest management is still essential to try and maintain healthy long-run fish populations, for anadromous fisheries in particular, it is not the only piece of the puzzle. Given their extensive migratory path, which takes them from river headwaters to ocean settings, anadromous fish can be affected by a wide range of natural and human influenced conditions (e.g., ocean temperatures, natural predators, dams and hydropower facilities, pollution). Attempting to control harvest is obviously an important component of salmon management efforts, but the influence of these other factors on salmon populations creates additional challenges for fishery managers.

2.2 Static Private Property Equilibrium Analysis: Economically Efficient

As mentioned above and as illustrated in Figure 2, the PPE occurs at the point where marginal revenue (MR) equals marginal cost (MC). This is the point that maximizes profit. Beyond this point on the MR curve, costs exceed revenues for each unit sold, resulting in diminishing profitability. Profit maximization is achieved at PPE, with a higher harvest level than CPE and significantly less effort.

The economic value of commercially caught fish is defined by the maximum amount consumers are willing to pay for the fish rather than spend their money on other goods or services. For a given period of time (e.g., week, month, year), a consumer's willing to pay for each additional fish increases, but at a decreasing rate. It is even possible for the consumer to become satiated, or so tired of consuming fish that additional fish would actually be valued negatively. This diminishing value concept, referred to as the law of diminishing returns, allows for the mapping of total and marginal benefit curves. Note that total and marginal benefit curves presented below represent aggregated curves, or the summation of curves across individual consumers and producers.

Figure 3 presents some of the same general logic as in Figure 2, but relaxes many of the simplifying assumptions. As a result, the curves are no longer linear. In addition, the horizontal axis now reflects harvest, the standard economic measure of quantity for a fishery. Figure 3 shows a total benefit curve (TB) on the top and a marginal benefit curve (MB), also referred to as a demand curve, on the bottom. The total benefit curve shows the total economic value for each quantity of fish harvested and consumed. The marginal benefit or demand curve, shows the marginal or incremental economic value associated with each additional fish harvested and consumed. The vertical height of the total benefit curve or the area under the marginal benefit curve for a given quantity of fish provides an estimate of total economic value to both producers and consumers. Total economic value for the specified time period is maximized at the peak of the total benefit curve or at the point where marginal economic benefit goes to zero. Beyond this point, marginal or incremental economic value becomes negative for each additional fish harvested and consumed and as a result, the total economic value begins to fall.

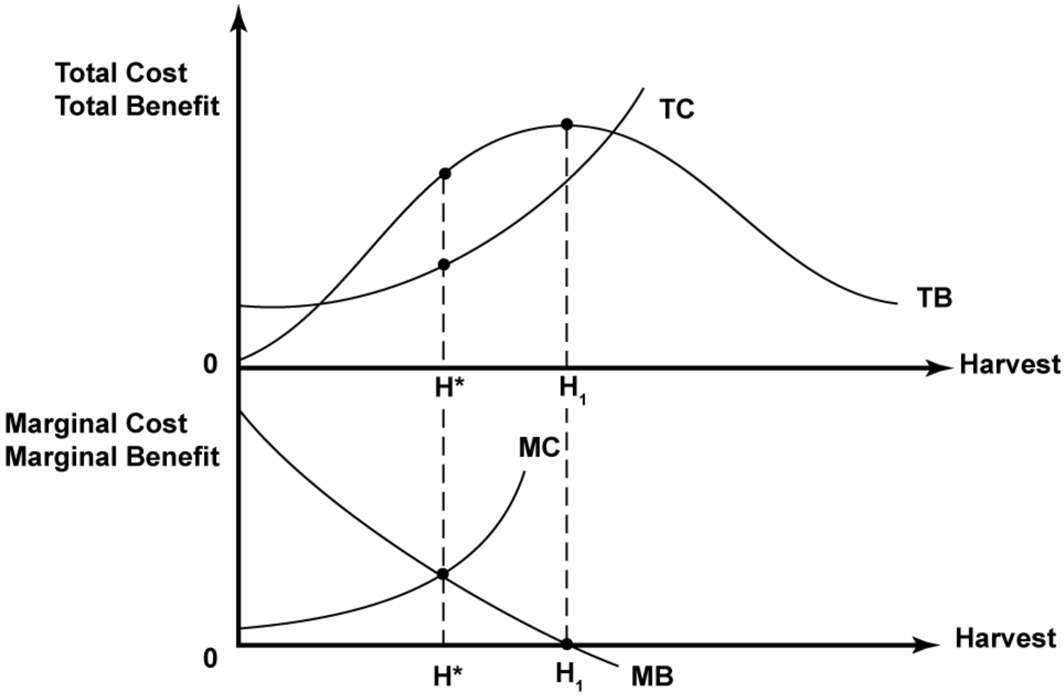

Figure 3. Total and marginal benefit curves.

Figure 3 also presents the total cost curve and marginal cost curve, otherwise referred to as the supply curve. As harvests increase and populations decrease, fish often become more difficult to locate, thereby increasing harvest costs. This upward pressure on harvest costs leads to the upward sloping supply curve.[7] As with the benefit curves, the total and marginal cost curves reflect the total cost associated with harvesting a given quantity of fish as well as the marginal or incremental cost of harvesting additional fish. Combining the total and marginal benefit and cost curves provides information for measuring commercial fishing benefits. The "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies" (P&Gs), provide guidance for measuring the economic benefits of commercial fisheries for Reclamation projects (U. S. Water Resources Council, 1983). According to the P&Gs, national commercial fishing benefits are conceptually measured by the change in consumers' and producers' surplus as a result of plan implementation.

Figure 4 presents the marginal benefit/demand and marginal cost/supply curves in greater detail. For the consumer, for each quantity of fish consumed, the area under the demand curve provides an estimate of total value. Total value can be broken down into two components: consumer expenditures and consumer surplus. Consumer expenditures reflect how much the consumer actually paid for the quantity of fish. Based on the initial supply curve (S_o) in Figure 4, consumer

[7] As effort continues to increase to harvest more fish, marginal costs continue to rise. Once effort achieves the maximum harvest level equal to MSY, additional effort results in reduced harvest. Continued increases in marginal cost are therefore associated with diminishing harvest levels resulting in a backward bending supply curve. While interesting, the backward bending supply curve is not displayed in any of the figures since it doesn't contribute to the discussion.

expenditures are represented by the rectangle $0P_oCH_o$. The area beneath the demand curve and above price, represented by the area P_oBC, reflects consumer surplus. Consumer surplus measures how much more the consumer would be willing to pay over and above what they actually had to pay. Consumer surplus, or net willingness to pay, reflects the benefits of commercial fishing from the perspective of the consumer.

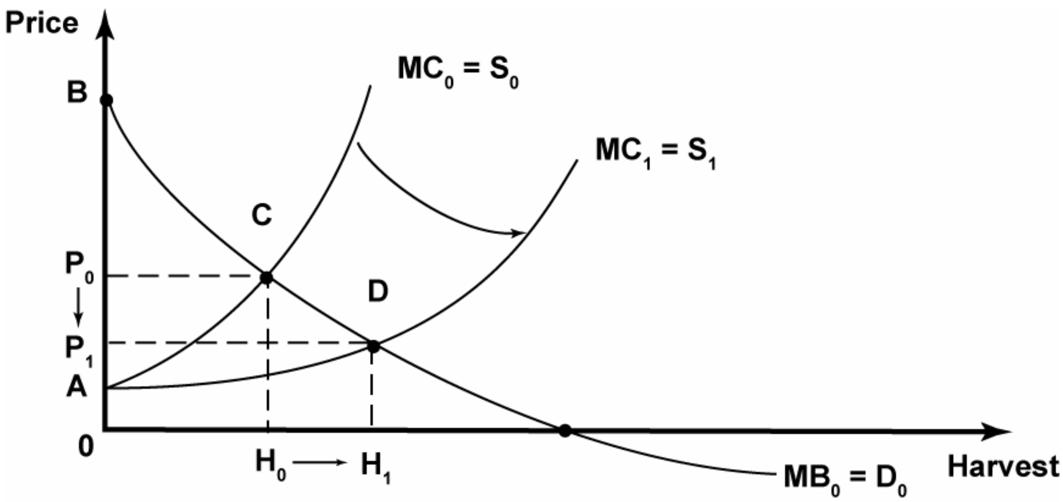

Figure 4. Marginal benefit (demand) and marginal cost (supply) curves.

In addition to benefits accruing to consumers, there are also benefits or net economic values associated with producers of commercial fish—commercial fishermen or harvesters, processors, wholesalers, and retailers. Theoretically, to measure total fisheries benefits of a given action, one would want to measure benefits at each of these levels/sectors of production to combine with consumer benefits. One could conceivably construct separate stand alone partial equilibrium supply and demand curves to estimate producer benefits for each sector of the seafood market. To address some of the problems with partial equilibrium analysis, complex multiple equation interconnected general equilibrium models have been constructed which simultaneously account for the interrelationships between sectors of the same overall market. Thurman and Easley (1992) note that one could focus on a single intermediate level of production within the analysis (e.g., ex-vessel), hold constant demand and supply conditions (but not prices) in related sectors within the seafood market, and assume the resulting demand and supply curves are at general equilibrium. It has been shown (Just and Hueth, 1979; Just et al., 1982) that the area behind intermediate level general equilibrium demand curves measure the sum of producer benefits in all higher sectors plus consumer surplus. Just et al. (1982) also suggest that this result would have practical applicability for situations where a proposed action may lead to changes in prices only within the directly impacted sector and not within other vertically linked sectors. This single sector price change situation is often assumed within commercial fishing analyses, especially for studies with fairly localized harvest impacts (e.g., Reclamation studies) where the effects on harvest are expected to be relatively minor compared to production levels of subsequent processing, wholesale, and retail sectors. Furthermore, it is also often assumed that commercial fishermen are price takers within the ex-vessel or harvest sector, implying that changing harvests would likely have little effect on ex-vessel prices. Therefore, depending on the magnitude of the change in harvest associated with an action, it is possible that even harvest sector prices may not be significantly affected. Given the above discussion, many commercial fishing analyses, especially those with more localized impacts, focus exclusively on the harvest sector when measuring benefits.

Despite the case for focusing exclusively on the harvest sector, it should be noted that the processing sector is also sometimes included in the analysis. This is especially true for smaller communities, given that there is typically no substitute for the local primary processor[8] and because primary processing may be at least partially provided as part of the harvesting process and is therefore inseparable from harvest costs. Most economic evaluations of commercial fishing focus exclusively on the harvesting sector and, occasionally, also include the processing sector (Radtke, et al., 1999).

Assuming Figure 4 reflects a combination of the harvest or ex-vessel sector and all vertically linked sectors (i.e., processing, wholesale, retail), the difference between producer revenues for the quantity sold and costs of production for the quantity sold, provide a measure of all producer benefits otherwise known as producer surplus. Referring to the initial supply curve (S_o) in Figure 4, revenue is shown by the rectangle $0P_oCH_o$, costs of production by the area beneath the supply curve $0ACH_o$, and producer surplus is shown by the area beneath the price line and above the supply curve AP_oC. This producer net economic value in practice is typically approximated by producer profitability, although the cost of production theoretically should be based on resource opportunity costs. Resource opportunity costs reflect the economic value forgone in using factors of production (capital such as fishing vessels, labor, etc.) to produce one good over another. When markets for resources are competitive and when the change in the amount of resources used is small enough to not affect resource prices, current market prices for the factors of production will approximate resource opportunity costs. As a result, the costs or expenditures that commercial fishing businesses incur in the process of production can normally be used to help calculate producer surplus. However, differences may exist from an accountant's estimate of profit and an economist's concept of producer surplus, especially in terms of the need to account for all the costs of factors of production within the producer surplus estimate. Bottom line, from a practical perspective, the benefits of commercial fishing are typically approximated by using estimates of harvest sector profitability.

In addition to illustrating the concepts of consumer and producer surplus, Figure 4 also shows how commercial fishing benefits might react to an increase in fish population as a result of a proposed fishery improvement project. With more fish

[8] Initial level of processing to move fish out of the region (e.g., dressing, icing, and packing).

available for harvest, fishermen would be able to catch more fish with the same level of effort. This would imply an outward shift in the supply curve from MC = S_0 to MC = S_1. Price of fish drops from P_0 to P_1 , thus creating an additional consumer surplus (P_1BD minus P_0BC). The change in producer surplus is ambiguous (AP_1D minus AP_0C), since the harvest has increased but the price has dropped. If the increase in harvest outweighs the drop in price, and the additional harvest costs are insignificant, then the producer surplus would also increase. Overall, the change in the total consumer and producer benefits is positive (ABD minus ABC).

In addition to the more traditional consumer and producer surplus measures of commercial fishing benefits, some economists have suggested that commercial fishermen may also experience lifestyle benefits (Hundloe, 2002). These non-market benefits derive from the satisfaction associated with the activity of fishing. These benefits may manifest themselves through lower wages that labor is willing to accept to work in the industry. In cases where skippers and crew are paid employees of the owner, this benefit is measured through standard market mechanisms in terms of the additional profit earned by the owners. However, under the not infrequent situation where the skipper and crew are also owners of the business, these lifestyle benefits may not be measured using the standard market based procedures. Depending on how the owner-operators handle this situation (i.e., to what extent they pay themselves and their family members an unrealistically low wage for their services and/or are willing to accept lower levels of profitability compared to non-operator owners) will influence the degree of adjustment necessary to measure these lifestyle benefits. For example, if the economist adjusted wages upward to reflect a more reasonable wage for skipper and crew services for owner operators, it could be that the result would be that the business would be running at a loss. Presumably, the degree of loss would provide an estimate of the lifestyle benefit. In practice, measuring this lifestyle benefit could be extremely difficult and is often ignored.

2.3 Multiyear Benefit Cost Analysis

Commercial fishing benefits refer to the gains in net economic value stemming from increased commercial fishing activity as a result of a proposed project. These gains in commercial fishing value and activity are measured against a no action or baseline alternative, a concept referred to as “with” versus “without” project analysis. These additional or incremental benefits, or costs in the case of a reduction in commercial fishing value and activity, can be combined with other incremental project benefits (e.g., project outputs in terms of agriculture, hydropower, recreation) and other incremental project costs (e.g., construction costs, operating costs, other lost project benefits) to estimate net national benefits within the context of a benefit cost analysis (BCA). If incremental project benefits exceed incremental project costs, this implies the proposed action results in a gain in net national benefits compared to the baseline alternative.

While the previously described static equilibrium discussions focused on economic values incurred over a single year, the benefits and costs used in a BCA look at the range of current and projected future impacts incurred over the entire study period – for Reclamation studies, typically 50 to 100 years. Benefits and costs accruing in different years are discounted to a present value before being combined to estimate net national benefits. Due to timing differences, impacts which occur in the near future are discounted less and therefore weighted more in the BCA than impacts incurred in the more distant future.

The rate of discount used in BCAs can be controversial. The higher the discount rate, the lower the value of future benefits and costs (e.g., a 3 percent discount rate implies it takes 78 years for an annual impact to fall to 10 percent of it full value, whereas at a 9 percent discount rate the 10 percent of full value threshold occurs in only 27 years). For resources which take many years to recover, such as fisheries, some economists suggest use of the intergenerational equity principle which recommends not discounting future benefits and costs, especially in cases where the analysis results in the selection of an alternative which drives the resource to extinction.

The BCA boils down to the selection of the alternative which maximizes the present value of annual net benefits subject to the long term biological sustainability constraint. The biological sustainability constraint suggests that harvest cannot exceed population growth or vice versa in the long run. Should harvest exceed population growth in the long run, the species would ultimately be driven to extinction. On the other hand, should population growth exceed harvest in the long run, at some point the population would bump up against the carrying capacity of the habitat. Mathematically, this maximization problem could be described as follows:

Maximize:

$$\text{Net Benefits} = TR_0 (H_0, P_0) - C_0 (H_0, P_0) + (TR_1 - C_1) (1/(1+r)) + (TR_2 - C_2) (1/(1+r)^2) + \ldots + (TR_n - C_n) (1/(1+r)^n)$$

Subject to: $H(t) = G[P_t] - P_{t+1} + P_t$

$P_t > 0$

TR_t = Total revenue in year t (where t goes from 0 to n)

C_t = Total costs in year t

r = Discount rate

H_t = Harvest in year t

$P_{t, t+1}$ = Population in year t, t+1

$G[P_t]$ = Population growth in year t

In the long run "steady state" situation where fish populations remain fairly stable over time ($P_{t+1} = P_t$), harvest H_t would equal population growth $G[P_t]$ since population in the future (P_{t+1}) would essential equate with current population (P_t). In a short run situation with growing fish populations ($P_{t+1} > P_t$), population growth ($G[P_t]$) could exceed harvest (H_t). Conversely, in short run situations with declining fish populations ($P_{t+1} < P_t$), harvest (H_t) would exceed population growth ($G[P_t]$).

The intertemporal nature of the analysis suggests that a fishermen's decision to harvest currently not only imposes an adverse stock effect on other current fishermen but also a forgone opportunity to harvest more and possibly larger fish in the future. This adverse effect on future harvest is imposed on both the fishermen himself as well as other fishermen. Short run harvests in excess of sustainable levels, often associated with unrestricted open access fisheries, can have adverse effects on long run harvest given fishermen typically fail to consider these stock effect costs associated with overfishing the resource.

3.0 Commercial Fishing Benefit Evaluation Methods

Before economic methods can be applied to valuing changes in a renewable fishery resource, complex biological relationships must be evaluated and applied to estimate how water management agency actions might impact habitat and fish populations. Biologists would first need to determine what population of fish they are interested in evaluating (i.e., natural/native fish or a combination of natural and hatchery fish referred to as wild fish). If the emphasis is on natural fish, as is sometimes the case, the influence of hatchery fish on natural fish populations would also need to be considered.

In addition to the strictly biological effect of the proposed action, estimates would also need to be made as to the potential effects of changes in anadromous fish populations on harvest. The estimates of commercial harvest provide the basis for the economic commercial fishing analysis. The commercial harvest estimation process would likely need to take into account projected fish populations, historical harvest rates, harvest capability (e.g., based on such factors as the size and harvest capacity of the commercial fishing fleet), and expectations with regard to future harvest and effort restrictions.

For anadromous fisheries in particular, it may be extremely difficult to account for the wide range of complex harvest and effort restrictions within the economic analysis. Given that fisheries are a publicly owned common property resource, managing harvests in the U.S. falls under the jurisdiction of fisheries management councils and federal and state fisheries agencies (e.g., Pacific Fishery Management Council, National Marine Fisheries Service, California Department of Fish and Game, Washington and Oregon Departments of Fish and Wildlife). As anadromous fish migratory paths extend for thousands of miles in some cases, regional and international agreements and treaties have been enacted to attempt to control harvests. For salmon, such understandings allocate harvests between tribal and non-tribal harvesters, prohibit high seas harvesting, and attempt to ensure that those countries from which salmon originate get the primary benefit of the harvest. Fisheries management councils in cooperation with Federal, State, Tribal fisheries agencies set harvests by species on an annual basis. For anadromous fish, total harvest targets by species and run are set based on expectations as to returning fish populations. The total harvest targets are then allocated across the various types of ocean and in-river harvest (e.g., commercial, sport, and tribal). The allocated harvest targets by species and run are used in developing harvest management restrictions.

Restrictions on hatchery production can also play an important role in estimating fish populations and setting harvest limits. In addition, various runs of salmon and steelhead have been designated as T&E under Federal and State Endangered Species Acts, an action which can have severe repercussions on harvest management. For example, since T&E salmon from a particular river system cannot be differentiated from non-T&E salmon from other river systems, the entire salmon fishery within a given geographic area can be temporarily closed during times when the T&E fish are expected to migrate through the area. All of these influences go into developing a broad range of management procedures to aid in controlling commercial fisheries harvest and effort including harvest quotas, area closures, season limits, gear use restrictions, limited entry systems,[9] etc.

Fish population projections may need to simultaneously take into account both the biological effect of the proposed action and the annual change in harvest when developing population estimates over the life of the proposed action Population projections influence harvest projections and vice versa, perhaps implying the need for complex simultaneous system models to aid in the harvest estimation process. When the application of complex models is not possible due to lack of data or time/budget limitations, harvest estimates are often based on historical harvest, considering expected future fishery management actions and international treaties and understandings. While biologists need to provide the biological component of the fish population estimation task, the harvest estimation component is often a collaborative effort between both biologists and economists. Once the annual commercial harvest estimates have been developed by species and alternative over time, the analysis progresses into the realm of economic valuation.

The theory discussion in Chapter 2 suggests that the goal of the commercial fishing analysis should be to estimate changes in producer and consumer surpluses, the theoretically appropriate measure of economic benefits. However, in practice, the economic benefits of commercial fishing are often approximated by using estimates of harvest sector profitability. Presented below are descriptions of possible benefit estimation methods for estimating changes in harvest sector profitability under three commonly experienced fisheries harvest situations – constrained total harvest, insignificant changes in total harvest, and significant changes in total harvest.

[9] Many fisheries are characterized as "open access," meaning that they allow for unrestricted movement of commercial fishing operations into and out of the fishery. However, there are also many fisheries where access or entry is limited. This is especially relevant for fisheries in decline. The west coast commercial salmon fishery is managed using a permit system thereby limiting entry into the fishery. Such systems are often used to not only limit entry, but reduce effort through governmental boat purchase programs.

3.1 Constrained Total Harvest

When fishery regulations prevent the take of additional total commercial harvest, as in the case of a constraining quota system[10], commercial fishing benefits of a proposed Reclamation water management action which are expected to result in increased fish populations could be measured in terms of cost savings. As fish populations increase, it presumably becomes easier for commercial fishermen to catch the existing quota. For example, fishermen may not have to travel as far to find the targeted species and the industry as a whole may take fewer and/or shorter trips. Ultimately, as fish populations increase cost savings in terms of the variable costs of fuel, labor, repair and maintenance, etc. may result due to a combination of shorter travel times, fewer trips, and possibly shorter trips.

Assuming the existence of excess harvest capacity based on available space in returning vessel holds under without project conditions, commercial operators may be able to catch more per trip and therefore take fewer trips. Conversely, if certain vessels consistently stay out on trips until their holds are full under both with and without project conditions (e.g., large ocean going vessels), it is possible that fishermen may catch more per hour or day and therefore take the same number of trips but with each being of a shorter duration. Given that many fisheries, including the salmon fishery, are currently characterized by excess harvest capacity (i.e., potential for available vessel hold space), it is probably more likely that trip length would remain relatively stable and the higher hourly/daily catch rates would manifest themselves in fewer trips as opposed to shorter trips. This is because once a vessel gets to its fishing grounds, fisherman would likely try and catch as much as they could each trip. However, given total harvest is constrained, it would still be unlikely that vessel holds would consistently fill up, implying trip length may not change significantly. Only if vessel holds consistently fill up under the improved with project condition would shortened trips result. Note that if the increase in fish populations and harvests are expected to be significant enough to consistently fill up vessel holds, the analyst may want to verify the underlying assumption of a constrained harvest. Since we are assuming a situation of constrained harvest under both with and without conditions, it is unlikely that such a dramatic increase in fish populations and harvest per trip would apply, and as a result the shortened trip scenario may also not apply.

[10] Note that salmon fishery management actions are implemented by species and constrained by the weakest or most limiting stocks within the region. Therefore, non-limiting stocks could gain in population, but still be prevented from experiencing additional harvest (i.e., constraining quota system).

3.1.1 Reduced Travel Distance Cost Savings

When the number of trips are not expected to change significantly, cost savings may still accrue to the commercial fishing industry due to travel cost savings as a result of reduced travel distances. Estimates of per trip offshore travel miles would need to be developed for both with project and without project alternatives. Reduced round-trip travel distance could occur as fish populations increase and fishing grounds expand. Information on possible increases in fish habitat and fishing grounds would need to be obtained from biologists and fishery harvest managers. Commercial salmon operators often follow the migrating fish and therefore don't fish from the same port all season. Therefore, expanded fishing grounds and reduced travel miles would need to be estimated for each port. In addition, fishing grounds might diminish over time under the without project alternative, thereby expanding the travel distance differential between alternatives.

Applying the travel distance per trip estimates by alternative to the number of trips per alternative would allow for estimating travel miles saved. The last step would be to apply an estimate of travel costs per mile to the travel miles saved. Travel costs per mile may include fuel costs, labor costs, repair and maintenance costs, etc. Fuel cost savings may be easiest to calculate assuming estimates of average fuel consumption per mile were available or obtainable since fuel cost data are readily available. Labor cost savings would only occur with a fixed number of trips when the duration of the trips varied across the alternatives. When relevant, labor cost savings may be fairly straightforward to calculate, but can be complicated by variation in labor compensation (e.g., hourly versus crew share options). Repair and maintenance would probably be the most difficult of the cost savings to calculate and would depend on repair and maintenance differentials between travel and fishing time (for more elaboration on all three of these variable costs, see the discussion in the next section). Finally, note that travel costs vary by size of the boat, so it may be necessary to separate trips and travel miles saved based on vessel size or calculate a weighted average travel cost per mile.

An example of an analysis of commercial fishing travel costs was funded by the U. S. Army Corps of Engineers in a dredging study along the Oregon coast (Northwest Economic Associates, 1988). This study looked at commercial operator's increased travel costs for accessing fishing grounds if ports were not periodically dredged. While the procedures used to estimate the increased travel costs of moving to more distant dredged ports would not be directly applicable for estimating reduced travel costs to locate fish under conditions of increased fish populations, the logic of the analysis is similar.

3.1.2 Reduced Trips Cost Savings

To calculate cost savings due to a reduction in trips, estimates of the number of trips by alternative would need to be applied to estimates of the variable costs per trip by alternative. The first step in the analysis involves estimating the increase in per trip catch and the associated reduction in number of trips. A reasonable approach may be to assume that catch rates per trip increase in proportion to fish population increases. Dividing the fixed level of overall harvest (i.e., the harvest quota) by the increased total catch rate per trip provides an estimate of the number of trips for the with project alternative (see Table 1 for an example based on a 25 percent increase in fish population). Taking the without project trip estimate, obtained based on historical data, and subtracting the with project trip estimate, provides an estimate of the reduction in trips. Multiplying the reduction in trips by an estimate of the average variable cost per trip calculates cost savings. As with the travel cost per mile noted above, the variable cost per trip may also include fuel costs, labor costs, repair and maintenance costs, etc. However, the variable costs per trip in this case would be based on the entire trip and not simply the costs of getting to and from the fishing grounds.

Table 1. Trip calculation (Numbers are purely for illustrative purposes)

	Without Project Alternative	With Project Alternative	Difference	
			Numeric	Percent
Fixed Quota *	100	100		
Fish Population *	1000	1250	250	25
Number of Trips	20 *	16 (100/6.25) **		
Catch per Trip **	5 (100/20)	6.25 (5 x 1.25)		

* = Obtained from biologists/fishery managers based on historic data or fish population models
** = Calculated

To estimate fuel cost savings between the "with and without" project alternatives, information may be required on the different fishing areas used to target the species under each alternative, the number of species targeting trips taken to each fishing area annually by alternative, the distance and time spent traveling to each fishing area by alternative, the average time spent fishing per trip by alternative, the average fuel use per hour when traveling to the site and when fishing at the site, and the per unit cost of fuel. To estimate fuel based travel cost savings (see Table 2), the analyst could estimate the total annual travel time differential in hours between alternatives (based on the travel distance differential per trip, the number of trips, and the average hourly speed by vessel type) and multiply it by the vessel type fuel cost per hour (gallons per hour times price per gallon). Similarly, one might also need to estimate changes in fuel based fishing costs by looking at differences in time spent fishing between alternatives applied to estimates of associated fuel costs per hour. If trip length remains relatively fixed, with the potential for shorter travel times to fishing grounds, it is possible that fishing time per trip may increase. In summary, to estimate per trip fuel costs for application to the change in number of trips, the analyst may need to take into account differences in travel time versus fishing time between the with and without project alternatives.

Table 2. Fuel cost savings

Date Element/Calculation Step	Fishing Area A	…	Fishing Area N	Total
(1) Traveling Costs				
Annual Trips by Species & Area	T_A		T_N	
Times: Round Trip Distance to Area	• D_A		• D_N	
Annual Total Miles Traveled	M_A	…	M_N	
Divided by: Average Vessel Traveling Speed (miles/hour)	÷ S		÷ S	
Annual Traveling Hours	TH_A	…	TH_N	
Times: Average Vessel Fuel Usage per Hour when Traveling (gallons/hour)	• F/hr		• F/hr	
Total Fuel Usage when Traveling (gallons)	FT_A	…	FT_N	
Times: Cost of Fuel ($/gallon)	• C		• C	
Total Fuel Cost of Traveling:	TCT_A	+…+	TCT_N	= Fuel Cost Traveling
(2) At-Site Costs				
Annual Trips by Species & Area:	T_A		T_N	
Times: Average Time Spent Fishing per Trip by Area (hours):	• H/T_A		• H/T_N	
Annual Total Hours Spent Fishing:	H_A	…	H_N	
Times: Average Fuel Usage/Hour when Fishing (gallons/hour):	• F/hr		• F/hr	
Annual Total Fuel Usage when Fishing (gallons):	FF_A	…	FF_N	
Times: Cost of Fuel ($/gallon):	• C		• C	
Total Fuel Cost of Fishing:	TCF_A	+ … +	TCF_N	= Fuel Cost Fishing
(3) Incremental Fuel Cost Savings by Alternative:				
Action Alternative Fuel Cost Savings: Action Alternative: Total Fuel Cost Traveling + Total Fuel Cost Fishing = Total Fuel $Cost_{ACTION}$ No Action Alternative: Total Fuel Cost Traveling + Total Fuel Cost Fishing = Total Fuel $Cost_{NO\ ACTION}$ Incremental Savings: Total Fuel $Cost_{ACTION}$ - Total Fuel $Cost_{NO\ ACTION}$				

Labor costs for the captain and crew may be paid in the form of wages, or as is commonly seen based on a percentage of the gross value of the catch (i.e., crew shares), or a combination of both options. If labor is paid solely based on a standard percentage of harvest revenue (e.g., for illustrative purposes say 25 percent), the analysis could implicitly account for labor costs by simply focusing on the remaining revenue (i.e., 75 percent). In this situation, since the labor costs are a function of industry harvest revenue which does not change given the harvest is fixed, no labor cost savings would be expected. However, if labor is paid based solely on hourly wages, increased catch rates per trip may result in fewer trips, thereby implying the potential for labor cost savings. As noted above, the possibility of reduced travel time would likely imply longer harvest time since trip length is assumed relatively fixed, therefore reduced travel time would not result in any labor cost savings. The labor cost savings would therefore be driven by the change in number of trips between the two alternatives. To estimate labor costs per trip from an economics perspective, the analyst would need to account not only for the standard laborers, but also for unpaid or significantly underpaid labor provided by the owner-operator and family members. Such estimates could be based on the average costs paid by other operators or how much it would cost to hire a captain and crew within the local labor market.

Differences in repair and maintenance (R&M) costs between the "with and without" alternatives with respect to capital items such as vessels and gear may also need to be estimated. Under a constrained harvest situation, since harvest would be equal between the two alternatives, the initial inclination might be to assume the R&M costs would also remain unchanged. Starting with vessel R&M, the most obvious savings would likely come from the reduced use of the vessel if fewer trips are taken. Estimates of per trip vessel R&M could be applied to estimates of number of trips with and without the project to estimate cost savings. If reduced vessel travel times are also involved, there may be additional R&M cost savings but only if differences exist in the hourly R&M between travel time and harvest time. If vessel R&M costs are higher during travel time as compared to harvest time due to less intensive use of the engines during harvesting, and reduced travel distances and times imply greater harvest times per trip given trip length is assumed relatively fixed, a vessel R&M cost savings could result on a per trip basis. This analysis would require estimation of not only hourly R&M costs for travel and harvest time, but also, like the fuel cost analysis, estimates of travel versus harvest time. This vessel R&M costs savings would be amplified if the number of trips taken also decreased.

Looking at gear R&M, the focus would be on number of hours annually the gear would be used multiplied by an estimate of hourly gear R&M between the with and without alternatives. With catch per hour and per trip increasing, the fixed quota implies that number of trips would likely decline. If travel time decreases, implying that harvest time per trip would likely increase under the assumption of relatively fixed trip lengths, then gear R&M costs per trip would also likely increase given the extended harvest time per trip. Applying the potential increase in R&M costs per trip to the expected reduction in number of trips results in an ambiguous change in gear oriented R&M costs. If however the average harvest hours per trip do not increase and the number of trips decline, then gear R&M costs would also logically decline, except for the fact that the catch rate per hour has increased which still might imply that hourly gear R&M costs may increase.

The level of detail and data requirements involved in conducting a full scale vessel and gear R&M analysis may be daunting, in which case an abbreviated analysis may be necessary.

Despite the potential increase in harvest per trip and the subsequent need for fewer trips to land the same level of constrained harvest for each alternative, fixed costs (e.g., number of vessels) would presumably remain stable unless the increase in harvest per trip is significant, which is unlikely under the assumption of constrained harvest.

Data on some of the above described variable costs of harvest by fish species over time may be available from governmental sources. Unfortunately, while fisheries managers often gather information on harvests, prices, and capitalization (e.g., number of vessels) for various fisheries, they seldom gather detailed cost data (Boyce, 1993). If sufficient data do not currently exist, cost and earnings surveys could be conducted on a random sample of commercial fishing operators in order to estimate variable costs. See Appendix A for further discussion of cost and earnings surveys.

3.1.3 Reduced Length of Trip Cost Savings

Although the expectation for reduced trip length is much less than that for the reduced trip scenario, the possibility still exists that trip lengths might decrease due to increased harvests per hour/day. The first step in the trip length based cost savings analysis would be to estimate the reduction in average trip length. A similar logic to that used to estimate the reduction in number of trips (see Table 1) could be used to estimate the change in trip length, but instead of focusing on catch per trip, the emphasis would be on catch per hour or per day. As with the reduced number of trips analysis, savings may accrue in terms of fuel, labor, and repair and maintenance costs with shorter duration trips despite no change in the overall number of trips. Consistent with the length of trip analysis, instead of focusing in on per trip costs, this analysis would develop savings estimates based on per hour or per day costs.

The above discussion focused on cost savings as a result of increased fish populations due to a Reclamation action. The opposite could also be true, that is harvest costs could increase for Reclamation actions which adversely affect fish populations. Of course, adversely affecting fish populations would also likely involve a reduction in actual harvest which would need to be valued. The next two sections discuss methods for valuing changes in harvest depending on whether or not the change is significant enough to affect market price.

3.2 Insignificant Changes in Harvest

This section deals with a harvest situation where the anticipated change in harvest is not significant enough to affect market price. From the perspective of Reclamation studies, this scenario may be the most likely of the three harvest scenarios presented in this chapter.

The first step in the economic analysis is to evaluate whether the estimated change in harvest may significantly affect market prices for the particular species of fish. To do so, the analyst would need to research the characteristics of the market. Two important interrelated issues involve determining the size of the market and the degree of product differentiation within the market. Evaluating the size of the market involves ascertaining whether the species is only available and demanded within the local or regional area as opposed to having national or international availability and appeal. With only local or regional demand and supply (i.e., a regional market), it is more likely that a change in population and harvest could have an impact on market price. Conversely, for species that are available and sought after nationally or internationally, it is less likely that a change in population and harvest within a given region would have an impact on market price. Product differentiation implies that the market might be separable into submarkets. If a market is highly differentiated, the analyst may need to treat each submarket separately, which in turn may have repercussions in terms of the assumed size of the submarket and the potential impact of the estimated change in harvest on prices within that submarket. The smaller the submarket, the more likely a given change in population and harvest might significantly affect market price.

As suggested previously, salmon tends to be the primary species of interest for most Reclamation water management actions affecting commercial fishing activities. Within the salmon industry there is an international market: salmon are caught or produced not only in the United States, but also in Canada, Chile, Norway, United Kingdom, etc. As a result, the salmon industry is characterized by a wide range of geographic substitutes. Should supplies of natural salmon from a given geographic region diminish, supplies from other geographic areas and countries may be able to offset the loss.

Similarly, supply reductions in natural salmon may be offset to some extent by increases in hatchery production as is the case throughout the Pacific Northwest (i.e., Washington, Oregon, and northern California). For chinook salmon, hatchery output currently reflects nearly all of California production and about 75 percent of Columbia River production.

In addition, many consumers may be willing to substitute increasing supplies of farm raised salmon for wild salmon. Farm raised salmon now constitute about 50 percent of the world salmon market (U. S. Army Corps of Engineers, 2002). The result is an extensive and varied supply of salmon which creates strong price competition. In relatively recent years, given that farmed salmon has dominated the overall world market, the price of salmon within the fresh and frozen markets has generally been set or at least strongly influenced by the price received for farmed salmon (U. S. Army Corps of Engineers, 2002). Unless the various types of salmon can be product differentiated, as the supply of one form of salmon declines creating upward pressure on price, consumers will likely shift to another salmon product. This implies a relatively flat demand curve for salmon. As illustrated in Figure 5, if salmon fishermen attempt to raise prices even by a small amount, the associated reduction in demand would likely outweigh the price increase, resulting in a loss of revenue. Since fishermen normally cannot raise prices without suffering significant adverse demand reactions, they are typically considered price takers. Real ex-vessel prices of troll-caught Chinook salmon have actually dropped from $5 per pound in the 1980s to less than $1.50 per pound today during a time when real prices for most other seafood products have remained constant (U.S. Army Corps of Engineers, 2002).

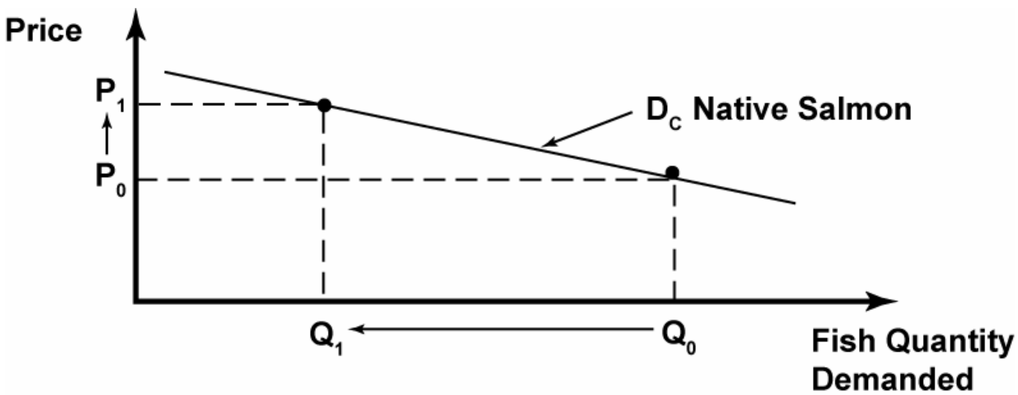

Figure 5. Demand curve for native salmon.

While competition within the salmon markets remains intense, in recent years, the market has shown signs of becoming much more product differentiated. Product differentiation occurs to some extent by species (e.g., general categories such as Atlantic versus Pacific salmon, or individual species as with chinook, coho, sockeye, chum, pink), but probably to a greater extent based on source of production (e.g., harvested wild as with natural or hatchery fish versus farmed fish). Should this trend toward product differentiation between wild and farmed salmon continue, one might expect fishermen to have more price flexibility within their particular salmon submarket. However, even the emerging wild salmon submarket tends to be international in scope, suggesting that population and harvest changes stemming from Reclamation water management actions would still typically be relatively insignificant and therefore not influence market price.

The above salmon market discussion focused mainly on higher level, wholesale and retail markets. Since commercial fishing economic valuations normally center on the harvest sector, ex-vessel market prices would be of primary interest to the analysis. If the assumption is made that wholesale and retail prices would be unaffected by changing harvest levels stemming from a Reclamation action, is it still possible for ex-vessel salmon prices to be affected? At the retail level, differentiated products imply different prices for wild and farmed salmon. While prices vary between the submarkets, the price in each submarket can influence prices in the other submarket. Without product differentiation, the retail price of wild salmon might be constrained by the price of farmed salmon. With product differentiation, the price of wild salmon is influenced by, but probably not constrained by, farmed salmon prices.

Similarly, retail prices and factors which affect retail prices may in turn affect prices obtained in lower level markets; therefore, the retail price of farmed salmon could impact the ex-vessel price of wild salmon. Finally, it is likely that ex-vessel prices of wild salmon would be more variable than wholesale and retail level prices. While wholesale and retail prices could be affected by variations in national and international demand, ex-vessel prices could be affected by those same factors as well as various local influences (e.g., the degree of competition between processors and other fish buyers in each region or port). This explains some of the variation in ex-vessel prices for commercially harvested salmon found in various databases (e.g., ex-vessel prices in the PACFIN database vary by species and state). Given the increased potential for variation in ex-vessel market prices, it is certainly possible for a change in species specific local prices to result if the change in harvest by species associated with a Reclamation action were for some reason centered in a particular area (as opposed to being distributed across the salmon's entire migratory range). Since it is more likely that the change in salmon harvest due to a Reclamation action would be distributed across a wide geographic area, it is probably still reasonable to assume that the change in both retail and ex-vessel prices would be insignificant. Obviously, it would be important to not only estimate the change in salmon harvest but also the geographic distribution of that change in harvest.

To verify the lack of a significant price effect related to a given change in fish harvest, the analyst would need to study the industry's price flexibility. Boyce (1990) defines price flexibility as the percentage change in price due to a one percent change in quantity—note that this reflects the inverse of price elasticity which looks at the percentage change in quantity resulting from a change in price. Perhaps the easiest way to gauge the potential magnitude of a price effect would be to rely on previously conducted studies. For example, Boyce (1990) found extremely small or near zero price flexibilities for various species of Alaskan salmon. In two studies of salmon prices and harvests in California, Hanemann (1986) found no price effect with a small 0.5 percent change in harvest and Hydrosphere (1991) found a fairly negligible 0.8 percent decline in price associated with approximately a 5 percent increase in salmon landings. Based on an international salmon trade model, Mittelhammer et al. (1990) noted an inelastic 3.8 percent decrease in price associated with a 10 percent increase in harvest. This suggests that as the change in salmon harvest exceeds 10 percent of the current harvest level or the current overall supply of salmon, the analyst may want to consider studying the potential price effects in greater detail. See section 3.3

for more discussion on estimating and incorporating potential price changes into the commercial fishing analysis.

Assuming increased (decreased) fish populations due to a Reclamation water management action would result in an increase (decrease) in commercial harvest, and if the projected increase (decrease) in fish harvest is small enough so as not to substantially affect market price, information on recent or historic market prices might be used to value the expected increases (decreases) in fish harvest. Since the analysis concentrates on the ex-vessel\harvest sector, the emphasis would obviously be on ex-vessel market prices.

When selecting ex-vessel market prices for use in the analysis, a decision must be made as to which prices to apply—recent prices or historical prices. This question is complicated by the fact that ex-vessel prices vary across years, seasons, and even months based on the supply of harvested fish available at the time. Initially, the analyst may consider applying average or median values of historical annual, seasonal, or monthly prices (e.g., 5-10 year average/median values), as opposed to current prices, so as not to be overly influenced by current harvest levels. Depending on the number of observations in the price series, it may be appropriate to use some sort of normalized average where high and low values are dropped. However, if historical harvests were unsustainably high or overly constrained across the period of record of the price data, recent prices may actually be a more appropriate indicator of future long run conditions, especially if fishery managers are now restricting harvests or reasonably loosening controls to achieve sustainable harvest levels. Chances are the analyst may have no idea whether historical harvests were excessive or overly constrained, implying the use of historical average/median values may be preferable.

Recent prices, and perhaps even historical prices, may need to be weighted based on harvest levels given possible variation by year, season, and month. For example, monthly prices could be converted to a weighted annual average. Due to inflationary effects, historic prices may need to be indexed to current dollars, using an appropriate price index (e.g., consumer price index, producer price index), before being used in the analysis. From a practical perspective, determining whether to use recent or historic prices may be difficult and may simply hinge on the exclusion of price information associated with extreme high or low harvest conditions. Either recent market prices or historical averages of market prices over time can be applied to the projected increase (decrease) in fish harvest, as compared to the baseline alternative, to provide an estimate of the additional (reduced) commercial fishing revenue.

Estimating changes in commercial fishing revenue involves applying the appropriate ex-vessel price by species to the change in commercial harvest by species. Since ex-vessel prices are typically measured on a per-pound basis, the change in commercial harvest would also need to be measured in pounds. Oftentimes, changes in harvest are measured in terms of number of fish. To convert to changes in harvest to pounds, the analyst would need to apply estimates of the average weight per harvested fish. One would need to be careful to use the appropriate weight per fish (e.g., dressed weight – gutted with head and tail often removed, round weight – whole fish without any processing). Weight per fish can vary by species and run of salmon, by area harvested (state, ocean versus in-river), and by harvest method (troll versus net). Salmon harvested in the ocean are typically not landed (i.e., dropped off at port) round, but landed dressed—other than that, no other at sea processing occurs. Conversely, salmon harvested in-river is typically landed round.

From the increase (decrease) in revenue, the analyst would need to deduct an estimate of the additional (reduced) costs associated with obtaining the increased (decreased) harvest to obtain an estimate of commercial fishing profitability, the typically used proxy for producer surplus. The emphasis of the cost analysis is typically placed on variable costs (e.g., labor, fuel, repair and maintenance) which fluctuate directly with the level of harvest. Using the approaches described in the previous section, the analysis would need to apply any potential change in variable costs per fish, between the baseline and action alternatives, to the change in harvest.

Should the increase (decrease) in harvest be sufficiently large, additional (reduced) capital costs for boats may require evaluation. While this section deals with insignificant changes in harvest from the perspective of prices, that doesn't necessarily preclude the possibility that the change in harvest might affect either variable or fixed costs. Fixed costs remain stable in the short run, but can vary in the long run. Changes in capital costs for vessels may also affect other fixed cost items such as gear and insurance. Investments in gear (e.g., nets) and costs of insurance would likely be estimated as a function of the number and cost of vessels within the industry.

As noted in Chapter 2, costs should theoretically be measured in terms of opportunity cost, or the value of an item in its next best alternative use. Market prices can be used to reflect opportunity costs when markets are competitive. For many of the variable costs (fuel, labor, etc.) mentioned above, markets tend to be fairly competitive and as a result, market prices are typically applied in the analysis. The same is generally true for fixed capital costs, such as vessels and fishing gear. Market price of a vessel may be fairly easy to determine within an unrestricted fishery characterized by low levels of harvest, effort, and capitalization. However, if the industry suffers from overcapitalization (i.e., too many boats and too much effort), determining vessel market price may be more difficult. Price estimation would need to take into account alternative uses of the capital equipment. For example, if a vessel could be adjusted for use in other commercial or recreational fisheries, in theory, the present value of the long run profitability from the alternative uses over the remaining useful life of the vessel could provide an estimate of market price. Subtracting the vessel adjustment costs to partake in the alternative fishery from the market price would reflect an estimate of the fixed cost of the vessel. If limited entry systems exist within most alternative fisheries to prevent or reduce the movement of vessels into these fisheries, it is possible that the opportunity cost of a vessel could be very low.

Notice that fixed costs from an economics perspective can be significantly different from the undepreciated value suggested by an accountant. This alternative fishery based price estimation approach would seem most reasonable for measuring reductions in fixed capital costs when a vessel exits a fishery, whereas full retail market price may be most reasonable for the addition of new vessels into an undercapitalized fishery. While government subsidies may be less common today than in the past, if a subsidy is offered to encourage vessel purchases within an overcapitalized fishery, the value of the subsidy should probably be added into the purchase price of the vessel when determining fixed costs, since the subsidy may otherwise distort market price.

To evaluate whether an increase in harvest might affect fixed costs, the analyst could consider the degree of excess harvest capacity associated with the current commercial fishing fleet. If the expected increase in harvest could be absorbed by the existing harvest capacity of the fleet (a likely scenario for the salmon industry currently), no increase in vessels or fixed costs would be required to harvest the additional fish. If an increase in harvest exceeded the current harvest capacity of the existing fleet, the assumption could be made the additional vessels would likely enter the fishery, thereby increasing fixed costs. Since harvest capacity is influenced by the number of fishing trip taken, the analyst would also need to consider how possible variations in the length of the commercial fishing season might impact harvest capacity. For a decrease in harvest, boats would likely exit the fishery when the marginal operations became unprofitable. Unfortunately, information on profitability levels for individual operators may be extremely difficult to obtain. If adequate data were available, vessel entry/exit models could be developed, thereby providing a method for evaluation of the size of the fleet, harvest capacity, and ultimately fixed costs. Entry/exit models assist in determining fleet size based on such factors as operator profitability, fish populations, vessel salvage value, etc. For a discussion of entry/exit models see Tomberline (2001) or Ward and Sutinen (1994).

Within the context of a benefit-cost analysis, the proper method to account for capital costs is the cash flow approach, where expenditures are considered in the year incurred, as opposed to accrual methods where costs are depreciated over time. As a result, when additional investments are made in vessels and gear, total costs in those years will be disproportionately high. Since capital costs may be one time payments, the evaluation of profitability over time would take into account the one time or periodic nature of "fixed" costs compared to annual nature of variable costs. However, commercial operators often do not purchase expensive capital items outright and therefore do not own their vessels and gear, but make monthly payments to the bank. In such cases, the monthly payments should be treated as fixed costs (Hundloe, 2002).

It is also possible that relatively small increases in harvest may be obtained without any additional fixed or variable costs if there is enough excess harvest capacity within the region. That is, if the additional catch could be obtained without taking additional trips, without incurring additional labor costs, etc., then the additional harvest could be valued strictly based on the revenue associated with the additional harvest. Despite the full employment assumptions inherent in most benefit cost analyses, this excess capacity assumption is plausible for the commercial salmon fishery, since both the harvesting and processing sectors are currently greatly overcapitalized (Radtke, et al., 1999).

It would have to be demonstrated that sufficient excess harvest capacity exists on a per trip basis to cover the additional harvest before applying this assumption. Information on the size of the fleet (i.e., number of vessels by type) multiplied by the average carrying capacity by vessel (i.e., average pounds of fish capable of being carried in a vessel's hold) provides an estimate of industry carrying capacity per trip. Comparing industry carrying capacity per trip to the average harvest by species per trip across all vessels in the industry (assuming trips harvest a single species) would provide information on excess carrying capacity per trip for the fleet. Multiplying excess harvest capacity per trip by the current number of trips taken by the fleet would provide an estimate of the total excess carrying capacity associated with the current level of effort. If the increased harvest were less than this estimate, the assumption could be made that the additional harvest could be obtained with no additional cost. Similarly, it is also possible that relatively small reductions in harvest may not result in significant reductions in harvest costs. In this case, the decreased harvest could also be valued based on reductions in revenue. It would have to be shown that the reduction in harvest was small enough not to affect the number of trips, average length of trip, vessel travel distances, or crew sizes.

When trying to estimate differences in profitability between with and without project alternatives associated with a proposed Reclamation action, the emphasis needs to be on revenues and costs associated with the impacted fish species. Unfortunately, while this is intuitive, in practice this may be very difficult. On the revenue side, it may be fairly easy to separate revenues by species given harvests and prices are tracked by species, but cost separation by species often creates problems. For example, many operators participate in more than one fishery. It may be difficult to separate costs, especially fixed costs by fishery. The salmon fishery is a good example of shared fixed costs. Because the salmon fishing season is short, most salmon operations also participate in other fisheries. As a result, investments in boats and gear are shared between salmon and other fisheries. One approach is to separate costs based on the time spent fishing each species. Another example occurs when an operation has more than one boat, and each boat targets different species. If separate records are kept by boat, species separation is not a problem. However, when records are combined, cost allocations would be necessary. Finally, since we are typically only focusing on the value of the harvest activity and some operations include processing as well, additional cost and revenue separation may be required. Bottom line, it may be difficult to allocate species-specific harvest level costs.

Finding detailed variable and fixed cost information may be difficult, especially when searching for such information for a particular species. As an alternative to estimating costs, information on profitability percentages may be available for commercial fishing operations by species and geographic region. Multiplying profitability percentages by the previously developed estimates of total revenue change provides an estimate of profitability change. Profitability data typically is collected using complex cost and earnings surveys. Converting profitability and/or cost information into a percentage of revenue allows for easy application across a wide range of studies.

In a frequently referenced study, Rettig and McCarl (1984) recommend using a range from 50 to 90 percent of ex-vessel price to reflect the net economic value of a change in commercial salmon fishing harvest. Radtke and Davis (1994) applied profitability percentages ranging from 35 to 100 percent of revenue in their study of the Columbia River salmon gillnet fishery. In a relatively recent analysis of Snake and Columbia River salmon fisheries, a midpoint of 70 percent of ex-vessel revenues was used as a measure of average commercial salmon fishing value (Radtke et al., 1999). In the Economics Technical Appendix of the Final Programmatic Environmental Impact Statement for Pacific Salmon Fisheries Management (NMFS and AK Fish & Game, 2003), a conservative net income coefficient of .40 was used for the Columbia River Basin based on a literature review of salmon studies. The coefficients from this literature review varied considerably based on whether they represented average (total profit divided by total harvest) or marginal (change in profit divided by change in revenue) effects. The values of the average coefficients ranged from .07 to .54 whereas the values of the marginal coefficients, which seem more applicable to Reclamation fisheries analyses, ranged from .427 to .99. The midpoint of this range in marginal coefficients is .71, consistent with the midpoints of the range in coefficients applied in the studies listed above. The difference between the average and marginal coefficients is at least partially due to the underused capacity within the commercial salmon fishing industry. In many cases, this excess capacity allows for additional harvest at very little cost. The differences between marginal and average coefficients declines as the change in harvest increases.

A couple of recent studies (Fluharty, 2000 and Huppert et al., 2004) suggest the application of different profitability percentages when dealing with depressed or declining fisheries versus healthy and expanding fisheries. For depressed or declining fisheries, both studies recommend the use of low profitability percentages (e.g., 10 percent). Depressed fisheries imply low revenue due to reduced catch and relatively high costs due to the increased effort necessary to try and maintain catch levels. The combination results in reduced profitability percentages. While one would expect that salmon prices might increase as harvest drops, competition from farmed salmon since the early to mid-1990s has kept salmon prices depressed. Both of these studies were published prior to the recent increase in salmon prices (since 2004) due perhaps to successful product differentiation efforts. For healthy expanding fisheries, Fluharty (2000) suggests using profitability percentages around 50 percent. Note that both of these studies appear to be focusing on average and not marginal profitability percentages. The very low average profitability percentages for the depressed fishery are markedly different from the marginal percentages discussed above. This underscores the need to focus in on marginal profitability percentages in most Reclamation studies. Table 3 presents logic for a series of suggested marginal profitability percentage ranges for both depressed and healthy fisheries under a range of conditions and changes in fish populations/harvests.

Table 3. Suggested marginal profitability percentages

Fish Population Scenario	Price Effect	Cost Effect	Marginal Profitability Percentage Range
I. Depressed Fishery: Industry characterized by significant Excess Harvest Capacity, may include a vessel Limited Entry System (no additional vessels allowed). This situation reflects most salmon commercial fisheries currently. While on average, the profitability percentage for a depressed fishery is likely to be low, the marginal profitability % (change in profit as a percentage of the change in revenue) can vary considerably depending on the situation.			
Minor Increase in Fish Populations	Prices Fixed	With Limited Entry: Additional harvest caught using same or very similar level of fishing effort (i.e., # of boats, trips, days). No additional fixed costs (boats) due to limited entry, limited additional variable costs (fuel, labor) needed to land the minor increase in harvest. Most of the revenue increase reflects a profitability gain implying use of a high marginal profitability %.	High (70 – 90%)
		Without Limited Entry: Theoretically, additional boats could enter the fishery, but given the increase in harvest would be minor, a change in number of vessels and overall effort would be unlikely. Therefore, this situation is likely to mirror the with limited entry case.	High (70 – 90%)

Fish Population Scenario	**Price Effect**	**Cost Effect**	**Marginal Profitability Percentage Range**
Minor Decrease in Fish Populations	Prices Fixed	With Limited Entry: Reduction in harvest insignificant enough so as to not affect effort - no reduction in fixed costs (boats), limited reduction in variable costs (fuel, labor). Most of the revenue decrease reflects a profitability loss implying use of a high marginal profitability %. Without Limited Entry: Limited vessel entry systems have no constraining impact with reductions in harvest. Therefore, this situation is likely to mirror the with limited entry case.	High (70 – 90%) High (70 – 90%)
Significant Increase in Fish Populations	Price Drops	With Limited Entry: Additional boats could not enter the fishery (no change in fixed costs) due to limited entry, but effort (number of trips, hours/days per trip) and variable costs would likely increase significantly for current fishery participants. With increasing variable costs and decreasing prices, the marginal profitability % declines compared to the minor fish population increase scenario, but not as much as if entry wasn't limited. Without Limited Entry: Under this scenario, additional boats could enter the fishery causing both fixed and variable costs to increase. Since new operators are likely to be less efficient than current operators, the marginal profitability % continues to fall.	Moderately High (50 – 70%) Moderately Low (30 - 50%)
Significant Decrease in Fish Populations	Price Rises	With Limited Entry: With significant population and harvest decreases, effort would also be expected to drop significantly – many fishermen may exit the fishery (e.g., substitute to other fisheries or attempt to sell their boats). While revenues should drop, possible price increases might moderate the decline. This combined with the cost declines would result in reductions in the profitability % compared to the minor decrease in fish population scenario. Without Limited Entry: Limited vessel entry systems have no constraining impact with reductions in harvest. Therefore, this situation is likely to mirror the with limited entry case.	Moderately High (50 – 70%) Moderately High (50 – 70%)

Fish Population Scenario	Price Effect	Cost Effect	Marginal Profitability Percentage Range
II. Healthy Fishery: Industry may be characterized as having Excess Harvest Capacity, but is unlikely to include a Limited Entry System. While on average, the profitability percentage for a healthy fishery is generally high, the marginal profitability % (change in profit as a % of the change in revenue) can vary considerably depending on the situation.			
Minor Increase in Fish Populations	Prices Fixed	No Excess Harvest Capacity: If the industry has insufficient excess capacity, even a small increase in harvest would require the entry of additional vessels. Both fixed costs (boats) and variable effort based costs (fuel, labor) would increase. The minor increase in revenue would be associated with a relatively large increase in costs thereby suggesting the application of a low marginal profitability %.	Low (10 – 30%)
		Excess Harvest Capacity: With sufficient capacity, the industry could harvest the additional fish with little additional cost. Most of the revenue increase reflects profit suggesting the application of a high marginal profitability %.	High (70 – 90%)
Minor Decrease in Fish Populations	Prices Fixed	No Excess Harvest Capacity: Neither fixed nor variable costs would likely drop appreciably for a minor decrease in harvest. Therefore, the reduction in revenue would be mainly comprised of lost profit implying the application of a high marginal profitability %.	High (70 – 90%)
		Excess Harvest Capacity: Excess capacity has no effect implying this situation would mirror the no excess capacity case.	High (70 – 90%)

Fish Population Scenario	**Price Effect**	**Cost Effect**	**Marginal Profitability Percentage Range**
Significant Increase in Fish Populations	Price Drops	No Excess Harvest Capacity: While a significant increase in fish population is biologically unlikely when the fishery is already healthy, assuming this occurs, a lack of excess capacity in this case would require a significant increase in vessel entry. Revenue is likely to increase significantly although it might be tempered to some extent by the possible price reduction. Combining the tempered revenue increase with the significant fixed and variable cost increase suggests the application of a moderately low profitability % to the estimated increase in revenue.	Moderately Low (30 – 50%)
		Excess Harvest Capacity: With excess harvest capacity, a portion of the significant harvest increase could be obtained with little additional cost implying application of a moderately high profitability % to the estimated increase in revenue.	Moderately High (50 – 70%)
Significant Decrease in Fish Populations	Price Rises	No Excess Harvest Capacity: The reduction in both fixed costs (boats) and effort based variable costs (fuel, labor) is likely to be significant. The possible price rise would likely temper the revenue reduction implying a moderated loss in profits and thereby application of a moderately low marginal profitability % to the revenue loss.	Moderately Low (30 – 50%)
		Excess Harvest Capacity: Excess capacity has no effect implying this situation would mirror the no excess capacity case.	Moderately Low (30 – 50%)

As described in section 4.2, for water management actions which result in additional harvest, there may also be harvest cost savings benefits associated with the proposed action's "without project" harvest level due to the increased fish populations (e.g., reduced vessel travel costs). As a result, impacts may extend beyond those associated solely with the increased harvest. For decreases in harvest, potential increases in per unit costs applied to all harvest—not only the decrease in harvest—may also need to be accounted for in the analysis.

Finally, the effect of fishery substitution is an issue which would theoretically needs to be considered, but which may be quite difficult to estimate. If operators move into or depart from other fisheries as fish populations deteriorate or improve within the fishery of interest, the effect of such fishery substitution may offset to some extent the profitability gain or loss associated with increasing or decreasing fish populations within the fishery of interest. If the analyst has some insight into which substitute fishery the operators might be substituting into or from, some profitability approximations may be possible.

3.3 Significant Changes in Harvest

If the projected change in harvest due to changes in fish populations stemming from a Reclamation water management action is expected to be large enough to affect ex-vessel market price, the analysis may become significantly more complex since the expected change in market price would need to be estimated and applied to the entire "with project" harvest to estimate total revenue. From these "with project" harvest revenues, harvest costs would need to be deducted to provide an estimate of commercial fishing profitability.

3.3.1 Accounting for the Price Effect

Given that the change in harvest due to a Reclamation action is likely to be relatively small compared to the overall supply of salmon, it is unlikely that wholesale and retail prices would be significantly affected, and therefore this significant price change scenario would likely not come into play for those market levels. However, since the current salmon market appears to be at least somewhat product differentiated (implying separate but interrelated submarkets for wild and farmed fish) one might speculate that changes in harvests may impact wholesale and retail prices within the wild salmon submarket. As suggested in the last section, based on previously completed studies, it appears that price changes may occur when the change in harvest exceeds 10 percent of the supply within the wild salmon submarket. Nevertheless, the potential for Reclamation actions to affect wholesale and retail price still appears to be fairly remote. This is because the differentiated market for wild salmon is still international, and even within the domestic market, the impact of salmon harvest from California, Oregon, and Washington is overshadowed by the Alaskan harvest, at least currently. However, as noted above, prices within the lower level ex-vessel and processing submarkets are more susceptible to local influences (e.g., the degree of local competition) and therefore can vary both by salmon species and geographically by state and port. Therefore, if evidence existed which indicated that the projected change in harvest due to a Reclamation action is expected to be concentrated in a particular area (as opposed to the typical assumption of a widely distributed harvest area), and the concentrated increase in harvest reflected in excess of 10 percent of the local supply of wild salmon by species, it is possible that impacts to localized ex-vessel prices could result. A fairly brief discussion of options for dealing with this potential price change scenario is presented in the event of its occurrence.

3.3.1.1 Option 1: Application of Price Flexibilities

Section 3.2 briefly introduced the concept of price flexibility. Several studies were presented which estimated the change in price associated with a change in the supply of salmon. Bottom line, unless the change in salmon harvest due to a Reclamation action was reflected in over 10 percent of the supply of salmon by species, the results from those studies indicated the that potential price effect appeared to be fairly minor.

Assuming the concentrated harvest concept suggested above, if the percent change in harvest due to the Reclamation action exceeds 10 percent of salmon harvest by species within the impacted area, it would appear that the commercial fishing analysis may want to take into account potential price effects. The easiest way to incorporate the price effect into the analysis would be to apply a price flexibility measure from an existing study. It would be useful to gather a series of salmon studies by state and species to provide a range of price flexibility estimates. Since price flexibilities are generally derived from statistically estimated demand curves, be aware that price flexibility values may vary with harvest quantity depending on the functional form of the underlying demand curve. Therefore, the analyst may need to match harvest level percentage changes between the studies unless a constant elasticity demand curve was estimated (e.g., one may not be able to apply a price flexibility value associated with a 10 percent change in harvest to estimate a price effect for a 25 percent change in harvest).

Note that three of the four price flexibility studies listed in section 4.2 are state specific, and only one addressed the overall international market. The analyst would need to be careful when applying the price flexibility measures from existing studies so as to match species, market size, and market levels.

In the case of a significant reduction in harvest, resulting in an increase in market price, the analyst may also need to take into account the possible dampening effect of the price increase on consumer demand through use of price elasticities. This assumes two things: 1) that the ex-vessel market prices could actually increase as harvest levels decline (i.e., that fishermen would be able to increase prices), and 2) that the increase in ex-vessel price would carrying through to the retail markets. Price elasticities of demand measure the change in consumer demand associated with a given change in price. Such elasticities would need to be pulled from vertically linked general equilibrium supply and demand studies incorporating the retail market (see below). Conversely, with a significant increase in harvest leading to a decline in ex-vessel prices, the assumption is typically made that the level of excess international demand is sufficient to absorb the additional harvest.

Applying the selected price flexibility measure to current price provides an estimate of the with project revised price. The revised price would then need to be applied all harvest within the appropriate market to estimate the change in commercial fishing revenue and not simply the change in harvest generated by the project. From this change in revenue, estimates of the change in costs would need to be deducted.

3.3.1.2 Option 2: Supply and Demand Curve Estimation

While typically extremely complex, time consuming, and data intensive, the estimation of fishery specific supply and demand curves is often identified as the most appropriate and therefore the preferred approach for dealing with potentially significant changes in harvest and price. As noted above, the complexity involved in the development and application of supply and demand curves may not be warranted when the required analysis is fairly straightforward. Even in cases where the use of supply and demand curves would be deemed most appropriate, it is unfortunately often the case that such curves are either unavailable or sufficient data is lacking to allow for statistical estimation. Nevertheless, if available, or when sufficient data exists for estimation, demand and supply functions/curves could be used to estimate changes in market price due to changes in harvest. As shown in Figure 4, back in Chapter 2, the shifting harvest supply curves associated with significant changes in fish population, map out price changes along the demand curve. Demand curve derived market prices could be applied to with project harvest to estimate revenue from which harvest costs would need to be deducted to estimate changes in commercial fishery specific industry profitability (or the areas under the demand and supply curves could be integrated to estimate these values).

For years, economists have shifted between the use of price and quantity as the dependent variable in demand models. The following discussion presents the results of a couple of modeling studies oriented towards salmon.

DeVortez (1982) present three options for time series modeling of the demand for both canned and fresh/frozen Canadian salmon:

1) Single equation price model
2) Single equation quantity model
3) Multiple equation simultaneous model

Separate models for each of the three modeling options were estimated for each salmon species (sockeye, pink, chum, and coho) and each market (canned and fresh/frozen) based on wholesale level data inclusive of both domestic and international demand. Separate models were estimated for the export markets. The results indicated that the price models proved consistently superior compared to the quantity models. This would indicate that price adjustment and not quantity adjustments would result in equilibrium in the salmon market.

1) Single Equation Price Model (Price Dependent Inverse Demand Equation): The basic single equation canned and fresh/frozen price model estimates own price as a function of quantity, income, and

price of substitutes – beef, poultry, and tuna: Price = f (Quantity, Income, Price $_{SUBSTITUTE}$, etc.).

2) Single Equation Quantity Model (Quantity Dependent Demand Equation): The basic single equation canned and fresh/frozen quantity model estimates quantity as a function of own price, income, and price of substitutes: Quantity = f (Price $_{OWN}$, Income, Price $_{SUBSTITUTE}$, etc.).

3) Multiple Equation Simultaneous Model: Finally, the canned salmon multiple equation simultaneous model was set up as follows:

4) Quantity Demanded (Q_D) = f (Price $_{CANNED}$, Income, Price $_{SUBSTITUTE}$, etc.)

5) Quantity Supplied (Q_S) = f (Price $_{CANNED}$, Harvest, Price $_{FRESH/FROZEN}$, etc.)

6) $Q_D = Q_S$

7) The simultaneous multiple equation model used a 2 stage least squares (2SLS) statistical estimation technique. The 2SLS technique regresses own price on all exogenous variables (P_{CANNED} = f (Q_{CANNED}, $P_{SUBSTITUTE}$, Income), and the resulting estimate of price (instrumental variable) is then used in a regression to explain Q_D. The fresh/frozen salmon market was set up similarly.

Boyce (1990) compared three models in terms of their ability to predict ex-vessel prices for Alaskan salmon. The following discussion focuses on the 2SLS simultaneous multiple equation model since it performed the best. Ex-vessel supply of harvested salmon is fixed by governmental restriction; therefore, it is considered predetermined or exogenous to the model (i.e., harvest supply can't react to price). The important effect to consider is the ex-vessel price responsiveness to harvest supply (Q_X). The processing sector allocates ex-vessel harvest into canned and fresh/frozen categories based on relative prices. This model describes how market prices for canned (P_C) and fresh/frozen (P_F) products at the processing level, as well as other factors from higher levels in the market chain, affects ex-vessel price (P_X). Wholesale and retail data was not available so the assumption was made that processor level conditions would be reflective of wholesale and retail conditions as well.

3.3.1.2.1 Estimating Supply and Demand

The objective of the multiple equation model was to estimate a price dependent inverse demand equation at the ex-vessel level ($P_X = f(Q_X, P_C, P_F)$). This model allows one to estimate ex-vessel price changes associated with changes in harvest quantity. The six equation simultaneous model was comprised of the ex-vessel level inverse demand equation, canned and fresh/frozen processor level price dependent inverse demand equations (see below), canned and fresh/frozen processor level supply equations (i.e., $Q_{CANNED} = f(P_C, P_F, Q_X)$ and $Q_{FRESH/FROZEN} = f(P_F, P_C, Q_X)$) and the ex-vessel identity (i.e., $Q_D = Q_S$). This model estimates ex-vessel prices based on the internally estimated processing level prices plus harvest levels. The 2SLS approach creates instrumental variables—the fresh/frozen and canned processor level prices (by regressing those prices on all of the exogenous variables, all variables except ex-vessel harvest quantity)—which are then used as explanatory variables in the price dependent ex-vessel demand function. As shown below, the processor level price dependent inverse demand equations for Fresh/Frozen and Canned products were similar and much more complex than the other equation

Price $_{FRESH/FROZEN}$ = f (Quantity $_{FRESH/FROZEN}$, Price $_{SUBSTITUTE\ (TUNA)}$, Real Interest Rates, Population $_{US+JAPAN}$, US/Japan Real Exchange Rate, Weighted Real Per Capita Income $_{US+JAPAN}$, Fresh/Frozen Inventory)

Price $_{CANNED}$ = f (Quantity $_{CANNED}$, Price $_{SUBSTITUTE\ (TUNA)}$, Real Interest Rates, Population $_{US+UK}$, US/UK Real Exchange Rate, Weighted Real Per Capita Income $_{US+UK}$, Canned Inventory)

This salmon model expands on the DeVortez work by directly accounting for a more complete range higher level market influences and by including international salmon market considerations. Since the quantity variable includes both domestic and export demand, Boyce believed it important to include population, real exchange rate, and real income variables inclusive of both US and international markets (i.e., Japan and United Kingdom). As noted above, because data on wholesale and retail prices was lacking, it was assumed that processor level conditions would be reflective of those higher level markets which implies that these models reflect a partial equilibrium as opposed to general equilibrium price response.

Ideally, estimation of supply and demand curves could be included within the context of an overall bioeconomic model. As discussed in Chapter 2, given the degree of interrelationship between the biology and economics of a fishery, complex bioeconomic models incorporate both the biologic and economic aspects of a fishery into a multiple equation modeling process. Many economists believe that bioeconomic models provide the most reasonable means for estimating economic value. For some examples of bioeconomic models related to salmon see Costello et al. (1998), Laukkanen (2001), and Routledge (2001).

3.3.1.2.2 Account for Changes in Cost

As described in the previous section, from the estimated increase (decrease) in revenue, the analyst would need to deduct an estimate of the additional (reduced) costs associated with obtaining the increased (decreased) catch. While emphasis is typically placed on variable costs (e.g., labor, fuel, and bait) which fluctuate directly with the level of harvest, should the increase (decrease) in harvest be sufficiently large, additional (reduced) capital costs for gear and boats may require evaluation. Likely, there would be more need to address changing fixed costs within the analysis with fairly large, significant changes in harvest.

The excess carrying capacity of the commercial fleet in the region is a potential factor to consider when measuring the costs of harvesting additional fish. With a large increase in harvest, it is less likely that the addition harvest could be obtained at no additional cost. However, given the fluctuating effort within many fisheries, the potential may exist. This would reflect an extreme case, but the fact remains that if excess capacity exists, the costs of harvesting the additional fish would likely be lower, perhaps significantly lower than the current average cost per fish or pound harvested.

There may also be a harvest cost savings benefit (cost) associated with the "without project" harvest level due to the increased (decreased) fish populations. For example, if a per unit harvest cost savings materialized as a result of economies of scale from implementing the project alternative, the reduced per unit harvest costs should be applied to all harvest and not just the change in harvest associated with the project.

4.0 Economically Oriented Commercial Fishing Data and Data Sources

Various Federal, State, quasi-governmental agencies and entities collect a range of economic data on commercial fishing activities. Given Reclamation actions would have the most impact on anadromous fish species along the west coast of the United States, the focus of this section will be on salmon and steelhead data collection efforts in the states of California, Oregon, Washington, and Alaska.

4.1 State Government

While Federal agencies have fisheries management jurisdiction from 3 to 200 miles from the U. S. coast, state fisheries agencies have jurisdiction within 3 miles from shore.

A. California: *California Department of Fish and Game (CDFG)*

CDFG gathers commercial fishing landings and revenue data by species and area <http://www.dfg.ca.gov/mrd/fishing.htm>. This information is incorporated into the PACFIN database and the annual PFMC Review of Ocean Salmon Fisheries Reports discussed below.

B. Oregon: *Oregon Department of Fish and Wildlife (ODFW)*

ODFW gathers ocean commercial fishing landings and revenue/value data by species, area/port, and gear < http://www.dfw.state.or.us/fish/commercial/landing_stats>. This information is incorporated into the Pacific Coast Fisheries Information Network (PACFINO database and the annual Pacific Fisheries Management Council (PFMC) Review of Ocean Salmon Fisheries Reports discussed below. In addition, Indian and non-Indian commercial fishing landings data (e.g., number of fish and total pounds harvested) are available by species for the Lower Columbia River <http://www.dfw.state.or.us/OSCRP/CRM/comm_fishery_updates_06.html>. Note that ODFW and the Washington Department of Fish and Wildlife (WDFW) coordinate the Columbia River data collect and report the results on the ODFW website.

C. Washington: *Washington Department of Fish and Wildlife (WDFW)*

WDFW gathers commercial fishing landings data by species <http://wdfw.wa.gov/fish/creel/columbia/index.htm>. This information is incorporated into the PACFIN database and the annual PFMC Review of

Ocean Salmon Fisheries (SAFE) Reports discussed below. The Department also gathers a range of biological data including salmon and steelhead adult returns.

D. Alaska: *Alaska Department of Fish and Game (AKFG)*

AKFG gathers revenue, pounds of catch, number of fish caught, average weight per fish, and price per pound data by region and species (<http://www.adfg.state.ak.us> under commercial fishing, salmon, preliminary salmon catches & ex-vessel values). Time series data are available.

4.2 Federal Government

A. *National Marine Fisheries Service (NMFS) also known as National Oceanic and Atmospheric Administration (NOAA) Fisheries*:

NFMS, a division of the Department of Commerce, is the Federal agency responsible for the stewardship of the nation's living marine resources and their habitat. NMFS is responsible for the management, conservation, and protection of living marine resources within the United States' Exclusive Economic Zone (3 to 200 miles offshore). Using the tools provided by the Magnuson-Stevens Act, NMFS assesses and predicts the status of fish stocks, ensures compliance with fisheries regulations and works to reduce wasteful fishing practices. Under the Marine Mammal Protection Act and the Endangered Species Act, NMFS recovers protected marine species without unnecessarily impeding economic and recreational opportunities. With the help of the eight fishery management councils, NMFS is able to work with communities on fishery management issues. NMFS works to promote sustainable fisheries and to prevent lost economic potential associated with overfishing, declining species, and degraded habitats. NMFS strives to balance competing public needs.

1. Environmental Impact Statements (EIS) and Species Recovery Plans: NMFS develops EIS (e.g., West Coast Salmon Harvest Programmatic EIS, Puget Sound Salmon Harvest EIS) of proposed fishery management regulations and recovery plans for T&E species (e.g., salmon and steelhead). Such documents can be found on the NMFS Northwest Region website at <http://www.nwr.noaa.gov>. These documents provide a wide range of fishery habitat, population, harvest, and economic data for evaluation of the proposed fishery management regulations.

2. Office of Science and Technology, Fisheries Statistics Division: The Fisheries Statistics Division collects data and coordinates information and research programs to support the science-based stewardship of the nation's living marine resources. The website <http://www.st.nmfs.gov/st1> describes how and why NMFS conducts all these programs, provides access to key databases (commercial fisheries landings, foreign trade, marine recreational fisheries catch and effort), and contains relevant links and references.

4.3 Quasi-Governmental

A. Pacific Fisheries Management Council (PFMC):

PFMC is one of eight regional fishery management councils established by the Magnuson Fishery Conservation and Management Act of 1976 for the purpose of managing fisheries 3-200 miles offshore of the U. S. The PFMC is responsible for fisheries off the California, Oregon, and Washington coasts.

1. Annual Review of Ocean Salmon Fisheries: Found on the PFMC website under "fishery management", "salmon" and "SAFE documents" at <http://www.pcouncil.org/salmon/salsafe.html>. Note that SAFE refers to the annual "Stock Assessment and Fishery Evaluation" process. Chapter IV of this report provides detailed information regarding salmon fisheries not only for the past year but also for a 15 year time period (e.g., commercial effort (trips) and landings data by species, state, management area, and port; fish population (spawner) estimates, including hatchery; nominal and real ex-vessel revenue and prices per pound by species and state; Columbia River harvest, revenue, and price per pound by species separately for Indian and non-Indian harvest, etc.). Appendix D of the annual report includes a wide range of historical economic data (including dressed weights per fish by species, area, and state). Since so much of this data is by species and state, information on ocean harvest percentages by species and state stemming from the river system of interest would be needed to calculate weighted averages (see PSMFC RMPC data listed below). The SAFE report typically comes out each February.

B. Pacific States Marine Fisheries Commission (PSMFC):
Formed by Congress more than 50 years ago, PSMFC helps resource agencies and the fishing industry manage Pacific Ocean fisheries resources in a five-state region (i.e., Alaska, Washington, Idaho, Oregon, and California). PSMFC serves as a forum to collaboratively maintain shared fisheries management responsibilities. PSMFC's primary goal is to promote and support policies and actions to conserve, develop, and manage fishery resources in the region. They accomplish this through coordinating research activities, monitoring fishing activities, and facilitating a wide variety of projects. They work to collect data and maintain databases on salmon, steelhead, and other marine fish for fishery managers and the fishing industry.

1. Fisheries Economics Data Program/Economic Fisheries Information Network (EFIN): Cooperative effort between PSMFC, NMFS, and the PFMC and the North Pacific Fisheries Management Council (NPFMC). This program conducts cost and effort surveys. Cost categories considered include raw fish (processors), labor, fuel, packaging, shipping, additives, maintenance and repair, protection and indemnity insurance, food and consumable supplies, etc. Much of the information on this website is evolving <http://www.psmfc.org/efin>. The website includes links to other economic data sources.

2. Regional Mark Processing Center (RMPC): The RMPC maintains a database of coded wired tag hatchery fish return information. Hatchery fish are implanted with coded wire tags as they leave the hatchery and the location (state & area of the state for Alaska) where the fish are "returned" is recorded upon harvest. The database includes both the location of harvest and the river of origin for each recovered fish. As a result, the database can be queried for fish from a given river system in terms of which states the recovered fish were harvested. This data can be used to estimate the percentage of ocean harvest by state and species useful for application to state by state data (e.g., PFMC SAFE Reports). The database is at the RMPC website <http://www.rmpc.org/> but the easiest way to use it is to have RMPC personnel do the database queries (go to contracts link to request database query assistance).

3. Pacific Coast Fisheries Information Network (PACFIN) Database: Collects data on ocean commercial fishing off California, Washington, Oregon, Alaska, and British Columbia. Data on in-river harvest would need to be obtained from other sources (e.g., state fisheries agencies). PACFIN data is available at <http://www.psmfc.org/pacfin>. A detailed description of the database is included in the report "A Description of the Pacific Coast Fisheries Information Network (PACFIN) 1981-1996", found on the website under "reports". The following list focuses on the 1981-present Washington-Oregon-California (WOC) all species reports found on the website's "data" page.

WOC Report #316:	Commercially landed catch, revenue, price per pound, # of vessels, # of processors all by management group (generic grouping of similar species) for the entire WOC region from 1981 to present. Since this report is not species specific, it may not be of much interest.
WOC Report #307:	Commercially landed catch, revenue, price per pound by specific species for the entire WOC region from 1981 to present. Price data reflects a weighted average based on prices seen in each state. This report may be of greater or lesser interest since it covers the entire three state region as compared to the individual state reports (listed below) depending on the application.

WOC Report #311:	Commercially landed catch, revenue, and price per pound by gear type and management group (generic grouping of similar species) for the entire WOC region from 1981 to present. Since this report is not species specific, it may not be of much interest. The report does provide some idea as to the allocation of catch by gear.
WOC Report #308:	Commercially landed catch, revenue, price per pound by species for California from 1981 to present.
WOC Report #309:	Commercially landed catch, revenue, price per pound by species for Oregon from 1981 to present.
WOC Report #310:	Commercially landed catch, revenue, price per pound by pecies for Washington from 1981 to present
WOC Report County Delimited Data:	This report includes four exclamation point delimited data files, so it is a bit difficult to work with.

Catch by County Data:	State, county, pounds landed across all species, revenue, # of trips, # of vessels, # of processors.
Catch by County by Species:	State, county, species ID, pounds landed, revenue, # of trips, # of vessels, # of processors.

Species ID:

All Salmon = SAMN
Unspecified Salmon = USMN
Chinook Salmon = CHNK
Coho Salmon = COHO
Pink Salmon = PINK
Rarely Caught:
Chum Salmon = CHUM
Sockeye Salmon = SOCK
Steelhead = STLH

Counts by County Data:	Subset of Catch by County Data - State, County, # of trips, # of vessels, # of processors.
Counts by County by Species:	Subset of Catch by County by SpeciesData - State, county, species ID, # of trips, # of vessels, # of processors.

5.0 Summary and Conclusions

This report describes methods for estimating commercial fishing economic benefits stemming from actions of State or Federal water management agencies such as Reclamation. Given Reclamation's influence on anadromous fish habitat across the western U.S., salmon is expected to be the primary commercially sought-after fish species impacted by Reclamation activities. As a result, the this report focuses on salmon commercial fishing activities along the coasts and within the rivers of California, Oregon, Washington, and Idaho.

The salmon market is very competitive and is characterized by a wide range of consumer choices. Various types of salmon (e.g., Chinook, coho, sockeye) are available from both domestic and international sources (e.g., Canada, Chile, Norway, and the United Kingdom). Salmon products derive from the harvest of wild fish (natural or hatchery) or from fish farms. If the supply of salmon products from one source declines for whatever reason, chances are the other sources may be able to compensate. This suggests that consumers are indifferent between salmon products and therefore may be willing to freely substitute. In recent years, efforts have been made to differentiate wild and farmed salmon. The commercial salmon fishing industry has been fairly successful in making the case that wild fish may be a higher quality product compared to farmed fish. It is fairly common to find wild and farmed fish labeled as such at the supermarket, with wild fish generating higher prices. However, within the differentiated salmon submarkets, international production still creates intense competition.

As suggested in Chapter 2, the theory section of the paper, commercial fishing analyses often focus exclusively on harvest or ex-vessel markets for benefit estimation. Ex-vessel prices, which tend to be more susceptible to local influences compared to retail prices, generally vary by salmon species and geographically by state and port. Even within these more localized ex-vessel salmon markets, the potential impact of Reclamation actions on salmon populations and the supply of harvested wild salmon is not likely to be significant (with certain exceptions – see section 3.3). As a result, this report concludes that impacts of Reclamation actions on salmon prices would typically not be required, and the "constrained total harvest" or "insignificant changes in harvest" methodological scenarios, as described in Chapter 3, would likely be applicable to most Reclamation commercial fishing analyses.

6.0 Bibliography

Associated Press. 2003. "Farmed salmon foe to fishermen." The Seattle Times, July 21 2003.

Boyce, J. 1990. "A Comparison of Demand Models for Alaskan Salmon." Prepared for: Fisheries Research and Enhancement Division, Alaska Department of Fish and Game.

Boyce, J. 1993. Using participation data to estimate fishing costs for commercial salmon fisheries in Alaska. *Marine Resource Economics* 8:367-394.

Buck, E., and J. Dandelski. October 1999. Pacific Salmon and Anadromous Trout: Management Under the Endangered Species Act. Congressional Research Service (CRS) Report for Congress. 98-666.

Costello, C., R. Adams, and S. Polasky. 1998. The value of El Nino forecasts in the management of salmon: a stochastic dynamic assessment. *American Journal of Agricultural Economics*. 80(4):765-777.

Dean, A. and M. Shwartz, September 2003. Fish farms pose threat to ecology, jobs, report says: Competition from aquaculture puts salmon fisheries at risk. Stanford University, Center for Environmental Science and Policy. Palo Alto, CA.

DeVortez, D. 1982. An Econometric Demand Model for Canadian Salmon. *Canadian Journal of Agricultural Economics* 30: 49-60.

Edwards, S. 1990. An Economics Guide to Allocation of Fish Stocks between Commercial and Recreational Fisheries. NOAA Technical Report NMFS 94. U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Center, Woods Hole, MA.

Fluharty, D. 2000. Characterization and Assessment of Economic Systems in the Interior Columbia Basin: Fisheries. Interior Columbia River Basin Ecosystem Management Project: Scientific Assessment. Thomas Quigley, editor. USDA Forest Service. Pacific Northwest Research Station – Portland, OR. General Technical Report: PNW-GTR-451.

Hannemann, M. 1986. Economic Valuation of Changes in the Catch of Sacramento River Chinook Salmon. Berkeley, CA. Prepared for EA Engineering, Science, and Technology. Lafayette, CA.

Hartwick, J. and N. Olewiler. 1998. The Economics of Natural Resource Use, Second Edition. Addison-Wesley Educational Publishers, Inc., Reading, MA.

Hundloe, T. 2002. Valuing Fisheries: An Economic Framework. University of Queensland Press, St. Lucia, Australia.

Huppert, D., G. Green, W. Beyers, A. Subkoviak, and A, Wenzl. 2004. Economics of Columbia River Initiative. Final Report to the Washington Department of Ecology and CRI Economics Advisory Committee. January 2004.

Hydrosphere. 1991. Evaluation of Economic Impacts of Alternatives for Designation of Winter-Run Chinook Salmon Critical Habitat in the Sacramento River. Boulder, CO. Prepared for the National Marine Fisheries Service, Terminal Island, CA.

Just, R. E. and D. L. Hueth. 1979. "Welfare measures in a multimarket framework." *American Economic Review* 69(5):947-954.

Just, R. E., D. L. Hueth, and A. Schmitz. 1982. Applied Welfare Economics and Policy. Prentice-Hall Inc., Englewood Cliffs, NY. 491 p.

Laukkanen, M. 2001. A bioeconomic analysis of the Northern Baltic salmon fishery: Coexistence versus exclusion of competing sequential fisheries. *Environmental and Resource Economics*. 18(3):293-315.

Mittelhammer, R. M. Hermann, and B. Lin. 1990. An Economic Analysis of the Pacific Salmon Industry: Effects of Salmon Farming. Prepared for the National Marine Fisheries Service.

National Marine Fisheries Service, Northwest Region and Alaska Department of Fish and Game. November 2003. Final Programmatic Environmental Impact Statement for Pacific Salmon Fisheries Management off the Coasts of Southeast Alaska, Washington, Oregon, and California, and in the Columbia River Basin. Appendix D: Economics Technical Appendix.

Northwest Economic Associates. January 1988. Economic Analysis of Benefits for Coastal Projects Authorized for Commercial Fishing Purposes. Prepared for: Portland District, U. S. Army Corps of Engineers, Portland OR.

Radtke, H. and S. Davis. 1994. "Some Estimates of the Asset Value of the Columbia River Gillnet Fishery based upon Present Value Calculations and Gillnetters' Perceptions." The Research Group. Corvallis, OR.

Radtke, H., S. Davis, and R. Johnson. October 1999. "Lower Snake River Juvenile Salmon Migration Feasibility Study, Anadromous Fish Economic Analysis." Prepared for: Foster Wheeler Environmental Corporation and U.S. Army Corps of Engineers.

Rettig, B. and B. McCarl. 1984. "Potential and Actual Benefits from Commercial Fishing Activities". NOAA Technical Memorandum. National Marine Fisheries Service. F/DWR-8.

Routledge, R. 2001. Mixed-stock vs. terminal fisheries: A bioeconomic model. *Natural Resource Modeling*. 14(4):523-539.

Ryan, J. 2003. "The Wonders of Aqua-Alchemy." World Watch Magazine, Sept/Oct 2003.

Thurman, W. and J. Easley, Jr. 1992. "Valuing changes in commercial fishery harvests: A general equilibrium derived demand analysis." *Journal of Environmental Economics and Management* 22: 226-240.

Tomberlin, D. 2001. Modeling California Salmon Fleet Dynamics. Proceedings of the First North American Fisheries Economic Forum. April 1-4, 2001. New Orleans, LA.

U.S. Army Corps of Engineers. 2002. Final Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement, Appendix I – Economics. February.

U.S. Department of Commerce, National Marine Fisheries Service, Northwest Regional Office and Alaska Department of Fish and Game. November 2003. Final Programmatic Environmental Impact Statement for Pacific Salmon Fisheries Management Off The Coasts Of Southeast Alaska, Washington, Oregon, and California and in the Columbia River Basin. Appendix D: Economics Technical Appendix.

U.S. Water Resources Council. 1983. Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. U.S. Government Printing Office, Washington D.C.

Ward, J. and J. Sutinen. 1994. Vessel entry-exit behavior in the Gulf of Mexico Shrimp fishery. *American Journal of Agricultural Economics*. 76(4): 916-992.

Appendix A: Cost and Earnings Surveys

Since detailed cost data are often lacking, cost and earnings surveys could be conducted on a random sample of commercial fishing operators in order to estimate costs. Although fairly unusual, if the number of commercial operators within a fishery was very limited, it might be possible to actually conduct a census of all operators. With a census, data could be summed to provide industry-wide estimates. In practice, surveys typically sample a portion of the overall population of commercial operators for budgetary reasons. When using a sample, the results of the survey would need to be expanded to provide industry-wide estimates (i.e., multiple average cost per vessel by the number of vessels in the industry). Conducting a cost and earnings survey may be unrealistic for most Reclamation studies, nevertheless steps on survey development are presented below for information purposes.

As adapted from Hundloe (2002), the following key steps are involved in developing and conducting a cost and earnings survey:

1) What is the objective of the survey: To estimate current costs and earnings or changes in costs and earnings? Surveys could be used to gather not only current cost information, but also operator's expectations on how variable costs might change as a result of changing fish populations.

2) Identify the information required (e.g., harvest, per unit variable costs, fixed costs, price) and how the information would be used.

3) Design the questionnaire: Develop survey sections (e.g., introduction, costs, revenues, socioeconomics/demographics) and construct the questions.

4) Pretest the questionnaire: Test the questionnaire on a small sample of knowledgeable individuals. Depending on the results of the initial pretest, this step may require more than one round.

5) Define the population of commercial operators or vessels by fish species: Names and addresses can often be obtained from boat registration or license data. Since not everyone with a license for a particular species may actually fish, it is important to be careful to exclude inactive operators. To increase the accuracy of the survey results, it might be worthwhile to categorize the population and sample from a certain sub-population (e.g., those operators that keep logbooks).

6) Draw a random sample from the population: Sample size will depend on the required accuracy of the results, the importance of the fishery, and the funds available.

7) Conduct the survey: The elicitation approach (e.g., mail, phone, in-person interview) influences both the accuracy and survey sample size. The selection of elicitation approach may ultimately depend on the accessibility of the operators – seasonal operators may respond to mail and phone surveys whereas year round operators may require personal interviews. Mail surveys tend to be popular due to their low cost, but typically suffer from low response rates and accuracy questions. Phone and personal interviews are more expensive, but imply higher response rates and are attractive should questions require explanation. Personal interviews are the most expensive, but may be required for very complex surveys where more in-depth information is sought (e.g., separating out species specific costs for a commercial operator who targets more than one species may prove difficult). For some operations, the most direct source of data may be the operation's accountant.