ECONOMIC BENEFITS OF THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY'S PROPOSED BAY-DELTA STANDARDS

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C-110436

CONTENTS

LIST OF TABLES v

LIST OF FIGURES x

LIST OF ACRONYMS xiii

1. INTRODUCTION 1

2. COMMERCIAL FISHERY BENEFITS 7
2.1 Salmon Commercial Fishery 7
2.1.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions 7
2.1.2 Effects of Other Factors 16
2.1.3 Benefits 17
The Commercial Salmon Harvesting Sector 19
The Salmon Processing Sector 29
The Salmon Retail Sector 36
The Salmon Import/Export Sector 39
Indirect and Induced Impacts 41
Summary 44

2.2 Starry Flounder Commercial Fishery 49
2.2.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions 49
2.2.2 Effects of Other Factors 51
2.2.3 Benefits 52

2.3 Bay Shrimp Commercial Fishery 55
2.3.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions 55
2.3.2 Effects of Other Factors 56
2.3.3 Benefits 56

2.4 Pacific Herring Commercial Fishery 59
2.4.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions 59
2.4.2 Effects of Other Factors 59
2.4.3 Benefits 59

3. RECREATIONAL AND NON-USE BENEFITS 61

3.1 Salmon Recreational Fishery 61
3.1.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions 61
3.1.2 Effects of Other Factors 61
3.1.3 Benefits 63

3.2 Striped Bass Recreational Fishery 73
3.2.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions 73
3.2.2 Effects of Other Factors 77
3.2.3 Benefits 80
3.2.3.1 Low Value Scenario 83
3.2.3.2 High Value Scenario 85

3.3 Sturgeon Recreational Fishery 87
3.3.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions 87
3.3.2 Effects of Other Factors 89
3.3.3 Benefits 89

3.4 American Shad Recreational Fishery 90
3.4.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions 90
3.4.2 Effects of Other Factors 90
3.4.3 Benefits 90

3.5 White Catfish Recreational Fishery 91
3.5.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions 91
3.5.2 Effects of Other Factors 92
3.5.3 Benefits 92

3.6 Starry Flounder Recreational Fishery 92
3.6.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions 92
3.6.2 Effects of Other Factors 92
3.6.3 Benefits 92

3.7 Other Use Benefits 93

3.8 Non-use Benefits 97
General Non-use Benefits 97
De-listing Benefits 102
Sacramento Winter-Run Chinook Salmon 103
Sacramento Spring-Run Chinook Salmon 104
Sacramento Late Fall-Run Chinook Salmon 105
Delta Smelt 105
Longfin Smelt 106
Splittail 107

4.0 SUMMARY AND CONCLUSIONS 109

5.0 REFERENCES 113

6.0 APPENDICES 134
APPENDIX A - THE DUMAS AND HANEMANN (1992) SALMON POPULATION MODEL 134
APPENDIX B - ECONOMIC INEFFICIENCY IN THE CALIFORNIA SALMON FISHERY 135
APPENDIX C - REVIEW OF ANALYSES OF THE WORLD MARKET FOR SALMON 137

LIST OF TABLES

Table 2.1	Distribution of 1992 California chinook salmon spawning run
Table 2.2	Annual estimates of adult chinook spawning escapement in the San Joaquin River 1957 to 1986
Table 2.3	Chinook salmon environmental requirements and life history stages
Table 2.4	Annual adult natural fall-run chinook salmon spawning escapements
Table 2.5	Annual adult hatchery fall-run chinook salmon spawning escapements
Table 2.6	Distribution (percent) of total midwater trawl catch of chinook smolts by month at Chipps Island from 1978 to 1991
Table 2.7	Summary of troll salmon fishing regulations for 1992
Table 2.8	Average days at sea by vessel size and expected catch
Table 2.9	Average real value per vessel in California salmon commercial trolling industry 1977 to 1991
Table 2.10	Sectors of the 1982 California interindustry fisheries model
Table 2.11	Economic data - small salmon trolling vessels
Table 2.12	Economic data - large salmon trolling vessels
Table 2.13	Economic data - crab-lobster vessels
Table 2.14	Economic data - salmon-albacore vessels
Table 2.15	Economic data - herring gillnetting vessels
Table 2.16	Economic data - diveboat vessels
Table 2.17	Budget for salmon trolling vessel
Table 2.18	Salmon commercial trolling fishing permit utilization

C-110440

Table 2.19	Estimated ownership and operating costs for representative Eureka crabber-troller vessels
Table 2.20	Salmon commercial harvesting sector sales - 1982
Table 2.21	Salmon commercial harvesting sector input purchases - 1982
Table 2.22	Estimated commercial catch of salmon under various regulatory regimes for two water year types
Table 2.23	Average dressed weights of California troll-caught salmon
Table 2.24	Average nominal and real ex-vessel prices per dressed pound for troll-caught California chinook salmon, 1980-1992
Table 2.25	Price indices
Table 2.26	U.S salmon cold storage holdings, 1981-1983
Table 2.27	California fish processor purchase data, by processor type - 1982
Table 2.28	California salmon dealers- 1990
Table 2.29	Representative budget for salmon fish processor
Table 2.30	Price and cost structure for West Coast salmon processor
Table 2.31	Dumas' best estimate of annual economic impacts per fish increase in annual commercial catch of California Central Valley chinook salmon marketed through processors
Table 2.32	Dumas' best estimate of annual economic impacts per fish increase in annual commercial catch of California Central Valley chinook salmon marketed directly through farmers' markets to consumers
Table 2.33	Hanemann's conservative estimate of the increase in household income associated with a one fish increase in the commercial catch of Sacramento River chinook salmon
Table 2.34	Hanemann's average estimate of annual economic impacts per fish increase in annual commercial catch of Sacramento River chinook salmon
Table 2.35	Leidy et al.'s estimate of the economic gain associated with a one fish

increase in the commercial catch of Sacramento River chinook

Table 2.36 King and Flagg's estimate of the increase in California household income associated with a one fish increase in the commercial catch of Sacramento River chinook salmon

Table 2.37 Meyer's estimate of the economic gain associated with a one fish increase in the commercial catch of Sacramento River chinook salmon

Table 2.38 Mean monthly net Delta outflow (cfs) under Decision 1485 Standard

Table 2.39 Mean monthly net Delta outflow (cfs) under Decision 1630 Standard

Table 2.40 Mean monthly net Delta outflow (cfs) under EPA Proposed Standard

Table 2.41 Log_{10}-transformed mean of March-June monthly net Delta outflows

Table 2.42 Log_{10}-transformed starry flounder abundance index

Table 2.43 Regression results of starry flounder pounds landed vs. log_{10}-transformed starry flounder abundance index

Table 2.44 Starry flounder abundance and landings data, 1979-1991

Table 2.45 Estimated starry flounder landings under three regulatory standards for three water year types

Table 2.46 Starry flounder price data, 1982-1992

Table 2.47 Starry flounder historical catch data, 1916-1968

Table 2.48 Starry flounder historical catch and value data, 1960-1986

Table 2.49 Bay shrimp historical catch and value data, 1916-1986

Table 2.50 Bay shrimp historical inshore bait catch and value data, 1963-1976

Table 2.51 Mean of March-May monthly net Delta outflow

Table 2.52 Bay shrimp abundance index under three regulatory standards for three water year types

Table 2.53 ***** Data not yet available *****

Table 2.54	Bay shrimp abundance index and landings, 1979-1989
Table 2.55	***** Data not yet available *****
Table 2.56	***** Data not yet available *****
Table 3.1	Summary of recreational salmon fishing regulations for 1992
Table 3.2	Data on ocean recreational salmon fishery
Table 3.3	Estimated salmon escapement, commercial and recreational catches, and ocean and inland angler trips under three regulatory standards for two water year types
Table 3.4	Expenditures per trip for various recreational activities in California
Table 3.5	Charter boat operator expenses per passenger day
Table 3.6	Destination expenditures of ocean recreational salmon fisher
Table 3.7	Participation by U.S. population 16 years of age and older in fishing and hunting in California, 1985
Table 3.8	Saltwater recreational fishing by Bay Area anglers, 1985-1986
Table 3.9	Mean of average April-July net Delta outflows (cfs) under various hydrological conditions
Table 3.10	Proportional sensitivity of striped bass population to proportional changes in values of each input variable in CDFG striped bass population model
Table 3.11	Estimated effect of EPA Standards on adult striped bass population under two water year types
Table 3.12	Recreation activity in California, 1980 and 2000, by region of origin
Table 3.13	Freshwater recreation at selected sites in California, 1985
Table 3.14	Estimated total hours of recreational activity on the Sacramento River, 1990
Table 3.15	Rafting on some popular California rivers, 1983

C-110443

Table 3.16	Participation by Californians 16 years of age and older in nonconsumptive wildlife-related recreation, 1985
Table 3.17	Annual visitation at wetland refuges in California
Table 3.18	Estimated consumer surplus per trip for various California recreational activities
Table 3.19	Annual WTP for individual programs in San Joaquin Valley drainage program study
Table 3.20	Annual willingness to pay to protect Mono Lake
Table 3.21	Estimated winter-run chinook salmon spawning past Red Bluff Diversion Dam, 1967-1992
Table 4.1	Estimated catches and benefits for an Above Normal water year
Table 4.2	Estimated catches and benefits for a Critically Dry water year

LIST OF FIGURES

Figure 1.1 Process schematic

Figure 2.1 Chinook salmon, adult illustration

Figure 2.2 Life history stages for Chinook salmon

Figure 2.3 Mean monthly salvage of Chinook salmon, State Water Project fish protective facility, 1968-1986

Figure 2.4 Location map, irrigation diversion points

Figure 2.5 Location map, agricultural drainage return points

Figure 2.6 Model timeline

Figure 2.7 Map of significant points on the United States west coast

Figure 2.8 Number of vessels landing salmon in California by year, 1980 - 1990

Figure 2.9 Commercial salmon troller

Figure 2.10 Starry flounder

Figure 2.11 Starry flounder life cycle

Figure 2.12 Catch of starry flounder through time

Figure 2.13 Regression of log (abundance index (yr + 1) +1) vs. log March-June monthly outflow (yr) of one-year-old starry flounder

Figure 2.14 Regression of log (abundance index (yr + 1) +1) vs. log (habitat area (m^2) (yr = 0)

Figure 2.15 Regression of log (habitat area (m^2)) vs. log (average March-June monthly outflow for YOY starry flounder at Chipps Island

Figure 2.16 Annual total commercial landings of starry flounder in the San Francisco Bay Area, 1960 - 1990

Figure 2.17 *Crangon franciscorum*

Figure 2.18	Life cycle of *Crangon franciscorum* in the San Francisco Bay-Estuary
Figure 2.19	Abundance indices of 5 species of shrimp in otter trawls of the Bay Study, 1980 - 1989
Figure 2.20	Relationship between the annual abundance index of immature *Crangon fransicsorum* (May-October) and $\log_{10}$ average monthly outflow at Chipps Island, March-May, 1980 - 1990
	Relationship between the annual abundance index of mature *Crangon fransicsorum* (January-April and average monthly outflow at Chipps Island, March-May the previous year, 1979 - 1989
Figure 2.21	Relationship between the annual abundance index of immature *Crangon fransicsorum* (May-October) and the annual habitat index (April-June), 3.0-18.1 ppt, shoals only, 1980 - 1990
	Relationship between the annual habitat index for *Crangon fransicsorum* (April-June, 3.0-18.1 ppt, shoals only) and the average monthly outflow at Chipps Island, March-May, 1980 - 1991
Figure 2.22	Pacific herring
Figure 3.1	Striped bass
Figure 3.2	The San Francisco Bay-Delta estuary
Figure 3.3	Spawning migration of the striped bass (*Morone saxatilis*)
Figure 3.4	Trend in legal-sized stripped bass abundance in the Sacramento-San Joaquin estuary, 1969 - 1991.
Figure 3.5	Trend in mark-recapture estimates of age 3 striped bass abundance in the Sacramento-San Joaquin Estuary, 1969 - 1991
Figure 3.6	White sturgeon
Figure 3.7	Scatterplot of white sturgeon year class index from trawl catches versus mean daily outflow for April to July in the Sacramento-San Joaquin estuary.
Figure 3.8	Trend in white sturgeon year class indices for the Sacramento-San Joaquin estuary developed from trawl catches by the San Francisco Bay Outflow Study

Figure 3.9 American shad

Figure 3.10 White catfish

Figure 3.11 Starry flounder catch and fishing effort in San Pablo Bay based on Commercial Passenger Fishing Vessel log data from 1964 - 1990

Figure 3.12 Delta smelt

Figure 3.13 Trends in delta smelt as indexed by seven independent surveys

Figure 3.14 Longfin smelt

Figure 3.15 Longfin smelt life cycle

Figure 3.16 Longfin smelt annual abundance in CDFG Striped Bass Fall Midwater Trawl Survey sampling from 1967 - 1991

Figure 3.17 Relationship between the $\log_{10}$ of the average February through May outflow at Chipps Island in cubic feet per second and the $\log_{10}$ of the CDFG Striped Bass Fall Midwater Trawl longfin smelt abundance index

Figure 3.18 Splittail (*Pogonichthys macrolepidotus*)

Figure 3.19 Association between splittail abundance and Delta outflow during the primary spawning months

Figure 3.20 Marginal economic costs and benefits of Mono Lake program alternatives

LIST OF ACRONYMS

BASES	NMFS Northern California Bay Area Sportfish Economic Study
CDFG	California Department of Fish and Game
CDPR	California Department of Parks and Recreation
CDWR	California Department of Water Resources
CVP	Central Valley Project
EEZ	Extended Economic Zone
EPA	United States Environmental Protection Agency
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PFMC	Pacific Fisheries Management Council
SWP	State Water Project
SWRCB	State Water Resources Control Board
USBR	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service

1. INTRODUCTION

In principle, any changes in the benefits derived from the San Francisco Bay-Delta Estuary that might result from the United States Environmental Protection Agency's (EPA) proposed standards would arise from the interaction of two types of complex processes: hydrological/biological processes and biological/economic processes.

Hydrological/biological processes determine the response of biological measures, such as the survival of juvenile salmon, to changes in controllable hydrological variables, such as minimum streamflows, pulse flows, water diversions, water diversion screening, and water export pumping, given constant conditions in the biological/economic processes. Models of hydrological/biological processes have been developed by the United States Fish and Wildlife Service (USFWS), the California Department of Fish and Game (CDFG), the California Department of Water Resources (CDWR), the United States Bureau of Reclamation (USBR), and the National Marine Fisheries Service (NMFS), and by various consulting firms. These models "map" hydrology into biology.

Over 200 species of fish, shrimp, and crabs are known to inhabit the Bay-Delta Estuary (CDFG 1992). These species are classified variously as marine, anadromous, estuarine, or freshwater. Marine species use the higher salinity areas of the Bay as nursery areas. Anadromous species migrate through the estuary on their way to and from spawning grounds in the inland rivers and streams. Estuarine species use the brackish-water portions of the estuary as a nursery. Freshwater species occur mainly upstream of the estuary but interact with it during at least one stage of their life cycle or during certain water year types.

During 1990, CDFG re-evaluated the relationship between species population abundance and water year type for the 70 most abundant species of fish, shrimp, and crab. They found that there was no clear relationship for 55.6% of these species. However, a majority of the *estuarine* species were strongly more abundant in Wet water years. Thus, water year type and associated water flows appear to be associated with environmental quality conditions in the Bay-Delta. The EPA's proposed Bay-Delta standards are based in part on an emerging consensus in the scientific community that salinity within the Bay-Delta may be an appropriate policy control variable for gaging Bay-Delta environmental quality until more data become available to aid in the process of unraveling the complex hydrological/biological relationships at work (San Francisco Estuary Project 1993). We assume that EPA's proposed regulations will focus on attaining target salinity levels at specified locations within the Bay-Delta (San Francisco Estuary Project 1993). We expect that implementing these regulations will result in increased salmon smolt survival and increased Net Delta Outflows of water. For the purposes of this report, we use salmon smolt survival in the Bay-Delta and Net Delta Outflow as policy control variables. Salmon smolt survival in the Bay-Delta is a critical determinant of salmon population abundance (Dumas and Hanemann 1992). We assume that the proposed regulations will result in salmon smolt survival levels in the Bay-Delta as supplied by Palma Risler of the EPA. Management actions that improve salmon smolt survival also are expected to improve conditions for several other estuarine-dependent species, including several species currently listed, or potentially listable, as threatened or endangered. However, we will majority of our analysis will focus on fall-run salmon, striped bass, starry founder, and bay shrimp. Net Delta Outflow has been correlated with abundance indices for

C-110450

striped bass, starry flounder and bay shrimp. We assume that Net Delta Outflow will be regulated under EPA's proposed rules to achieve flows given by DWRSIM output data supplied by Bruce Herbold of the EPA. We have chosen to consider the species listed above, because (1) they appear to be affected by water quality conditions in the Bay-Delta and (2) they have supported commercial or sport fisheries and/or have critically depressed populations.

Biological/economic processes determine the interactions between biological variables, such as fish population abunances, and a number of economic variables, such as fish harvest levels and prices, profits and wages in fish processing and retailing industries, the number of recreational fishing trips taken, etc. These processes affect, and are affected by, any environmental or commercial regulations that might be in effect. Models of various aspects of these processes have been developed by resource economists. These models "map" the interactions between biology and economics.

Increasing the protection of the San Francisco Bay-Delta Estuary through improved water quality standards may result in several distinct types of economic benefits. For ease of discussion, and following standard economic practice, these benefits may be classified into two types: *use benefits* and *non-use benefits*. Use benefits are associated with the commercial or recreational use of resources, in our case the natural resources assoicated with the Bay-Delta. Use benefits may be either *consumptive*, for example, hunting and commercial and recreational fishing, or *non-consumptive*, for example, boating/water-skiing and wildlife viewing. Non-use benefits involve no direct interaction between individuals and the natural environment. Non-use benefits discussed in the economics literature include "existence value," "bequest value," and "option value." Existence value refers to the value individuals may place on knowing that an ecological system exists and remains healthy. Bequest value arises from an individual's desire to ensure that a natural resource will be available for future generations to enjoy. Option value arises from an individual's desire to protect a natural resource in order to preserve the option of using it in the future.

Improving the health of the Bay-Delta Estuary might result in an additional type of benefit known as a "de-listing" benefit. Species listed as "threatened" or "endangered" under Federal or California law, either currently or in the future, might impose costly restrictions on the management flexibility of Central Valley water managers. If EPA's proposed regulations result in the "de-listing" of currently listed species, or prevent the listing of additional species, management flexibility would be restored or maintained. The avoided loss of management flexibility is the de-listing benefit. While difficult to quantify, the scale of efforts undertaken by federal agencies, state and local governments, and private firms to avoid the severe sanctions of the Endangered Species Act attest to the significance of de-listing benefits.

There is a relatively large amount of economic information available on commercial consumptive use benefits, but much less is available on recreational consumptive use benefits, and very little is available on non-consumptive use benefits or non-use benefits. This distribution of the data is unfortunate, because a significant portion of the benefits resulting from increases in wildlife populations and improved ecosystem health may well be attributable to non-consumptive use and non-use benefit sources. Nonetheless, we will review the existing information and make our best estimate of the benefits resulting from the proposed Bay-Delta water quality standards.

The benefits of EPA's proposed standards must be measured against an appropriate baseline in order to separate the benefits of EPA's proposed standards, *per se*, from benefits resulting from other factors that might influence the Bay-Delta system, such as the cessation of droughts or El Nino events. We consider two baselines against which to compare the estimated results of EPA's proposed standards. The first baseline is defined as the annual benefits derived from the Bay-Delta system following a long succession of Above Normal[1] water years without implementation of EPA's proposed standards. The second baseline is defined as the annual benefits derived from the Bay-Delta system following a long succession of Critically Dry[1] water years without implementation of EPA's proposed standards. We compare the annual benefits under each baseline to the annual benefits derived from the Bay-Delta system under the identical respective water year regime with implementation of EPA's proposed standards. For each water year regime, it is the *difference* between the annual baseline benefits and the annual benefits under EPA's proposed standards that is the appropriate measure of the benefits resulting from EPA's proposed standards.

Given models for each of the hydrology/biology and biology/economics processes, it is the *interaction* of these processes that will determine the benefits of the proposed policy (Figure 1.1). We organize our description of the interaction of these processes by species in the following sections of this report. For each species, we first briefly review its life history. We then proceed to consider the effects of various factors on species abundances in order to establish the relative influence of the policy control variables used in this report. Next, we estimate changes in species abundances resulting from EPA's proposed standards. Finally,

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[1]As defined by CDWR.

we estimate the economic benefits expected to result from the estimated changes in species abundances.

2. COMMERCIAL FISHERY BENEFITS

2.1 Salmon Commercial Fishery

2.1.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions

Five species of Pacific salmon have been found in California (Hallock and Fry, 1967). While Chinook, or King Salmon (*Oncorhynchus tshawytscha*) is the most abundant species, Chum Salmon (*O. keta*), Pink Salmon (*O. gorbuscha*), Sockeye Salmon (*O. nerka*), and Silver Salmon (*O. kisutch*) can also be found. Chinook salmon account for most of the California offshore commercial and recreational fishery catch, as well as most of the inland recreational fishery catch. Coho salmon make up a small but significant portion of the catch in each of the three fisheries. Pink salmon appear sporadically in only the offshore commercial fishery (PFMC, 1993). Sockeye and Silver salmon are so rare that they do not show up in the catch statistics. We exclude Pink, Sockeye, and Silver salmon from further analysis.

As anadromous fish, salmon live most of their adult lives at sea but return to inland rivers and streams to spawn. Chinook salmon spawn principally in the Klamath River basin in Northwestern California and in the Sacramento and San Joaquin River basins in the California Central Valley. Chinook salmon spawning in the California Central Valley would likely be affected by the proposed Bay-Delta standards. Because Coho salmon spawning is insignificant in the Central Valley (Moyle, Williams and Wikramanayake, 1989), we assume that changes in Bay-Delta environmental quality would not significantly change the Coho stock, and so there would be no change in benefits attributable to changes in the Coho salmon stock. Thus, Coho salmon will be excluded from further analysis, and we now focus our attention on California Chinook salmon (Figure 2.1).

There are four races of Chinook salmon native to California: fall run, late fall run, winter run and spring run. "Run" is an abbreviation of "spawning run," and the runs are named for the time of year during which the race swims upstream to spawn (Figure 2.2). In 1992, the total number of spawning adult Chinook salmon was distributed across the four runs as shown in Table 2.1.

Focusing on the Sacramento and San Joaquin rivers of the Central Valley, from Table 2.1 we learn that the fall run alone currently accounts for 87% (84300/97100) of Central Valley spawning. The Sacramento River portion of the fall run accounts for 85% of Central Valley spawning. In the mid-1940's Shasta dam cut off 50% of the salmon spawning habitat in the Sacramento River basin, while Friant Dam essentially eliminated all salmon spawning habitat in the San Joaquin River basin. Since that time, the San Joaquin River basin has not contributed a large share of total Central Valley spawning (Table 2.2). Thus, in the following description of the salmon life cycle and its links to Central Valley water flows and environmental quality in the Bay-Delta, we limit discussion to the Sacramento River fall run Chinook Salmon population[2].

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[2] The only anadromous fishery in the San Joaquin River is a fall run of chinook salmon to tributary streams; no spawning occurs on the mainstem (CDWR 1993). Fall run populations in the Merced, Tuolumne, and Stanislaus river tributaries are now at dangerously low levels. However, these low levels have occurred previously. For example, the salmon runs on the Merced had dwindled to less than 100 fish per year in the early 1960s because of diversion of water for irrigation when the Exchequer Dam was enlarged and its storage increased (Feinberg and Morgan 1980). A spawning channel and rearing ponds were constructed, six irrigation diversions were screened, and a flow commitment of enough water to support a run of 2000 spawners was made. Since then, as many as 1000 salmon in a season have used the channel and several hundred thousand yearlings have been raised in the ponds and released. Low spring flows, however, remain the limiting factor.

Adult salmon require the presence of home-stream water to guide them to their spawning grounds. Salmon using the San Joaquin River are seriously affected by SWP and CVP operation, since at many times virtually all San Joaquin River water is being exported. The population rebounded in the 1980's in response to high flows. There are currently no minimum flow requirements for the mainstem of the San Joaquin River. Minimum flows are

We first describe the life history of naturally-spawned Sacramento River fall run Chinook Salmon (refer to Table 2.3). This will be followed by a description of the life history of hatchery-spawned Chinook Salmon. While the absolute number of adult fish spawning in hatcheries has remained around 24,000 from 1988 to 1992, the number of adult fish spawning naturally has declined from 197,000 in 1988 to 61,000 in 1992 (Tables 2.4 and 2.5). Thus, the relative number of fish spawning in hatcheries has increased from 12% to 26% over the past five years. While some of the shift toward hatchery fish is due to the temporary effects of the recent drought on recent natural spawning, Cramer (1990) used cohort reconstruction to estimate that "hatchery fish have comprised an average of 30% of the fish spawning *naturally* throughout the basin [emphasis added]." Similarly, the Pacific Fisheries Management Council (PFMC 1993) estimates that "a majority" of the fish spawning "naturally" are actually descended from hatchery-spawned fish. These results imply that the relative number of hatchery-*influenced* fish is in fact much larger than the number of fish that are released by hatcheries each year. An increase in the relative number of hatchery-influenced fish may weaken the genetic integrity of the fish stock (National Council on Gene

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maintained on the Merced, Tuolumne, and Stanislaus tributaries below the dam on each. Jones & Stokes Associates (1990) recently completed a study considering restoration of salmon runs on the San Joaquin River. Before the completion of Friant Dam in 1945, the combined historic spring and fall runs of chinook salmon totaled about 45,000 fish on the upper San Joaquin River. The restoration effort would seek to reestablish a fall-run chinook salmon run escapement of approximately 50,000 fish. The restoration effort would be restricted to fall-run chinook salmon. It is considered impractical to reestablish a spring-run salmon population because it would require substantially higher summer flows to sustain low water temperatures required by the spring-run. An estimated 38,000 of these would be caught by sport anglers, leaving 12,000 fish for natural or artificial spawning. Approximately 1,500 of the 12,000 fish would be trapped at the top of the fish ladder on Mendota Dam for artificial spawning at San Joaquin Hatchery, the remaining 10,500 salmon would be allowed to ascend the fish ladder on Mendota Dam and spawn naturally in the upper San Joaquin River. Spawning is expected to occur throughout the upper San Joaquin River above Mendota Pool, with concentrated activity in riffle habitat above Highway 41. However, there would be enough suitable spawning habitat to accommodate only 5,000 [more with more gravel restoration work] of the estimated 10,500 spawning fish, and this small amount of habitat, together with low expected spawning success, is not expected to sustain an annual fishery without hatchery supplementation.

Resources, 1982; Hershberger, 1988; Hilborn, 1992; Moyle, 1992). If the proposed standards result in increased survival of naturally spawning fish, either in spawning areas or during emigration through the Delta, relative to that of hatchery-influenced fish, any resulting strengthening of the genetic integrity of the salmon stock would be an added, although as yet unquantifiable, benefit of the proposed standards.

Naturally spawning fall run Chinook Salmon begin life in late fall as small eggs nestled in the gravel beneath the cool, shallow water of an inland stream. After incubating for six to thirteen weeks, depending on temperature, the eggs hatch into yolk-sac fry, or alevins. Alevins spend another two to four weeks, again depending on temperature, hiding and growing in the gravel before they emerge as fry. Fry spend the next three months feeding and growing, either as residents in their hatching reaches or as migrants in downstream reaches, depending on flows and competition for resources from other fry. Unusually large flows may flush fry as far downstream as the Delta or San Francisco Bay, where rearing mortality is generally higher than for fry rearing in the headwater streams.

Both resident and migrating fry and smolts suffer mortality from a variety of factors including starvation, predation, low water flows resulting in "dewatering" of incubation and rearing gravel, high water flows resulting in "scouring" of incubation and rearing gravel, and high water temperatures. Despite this plethora of potential sources of mortality, much of the discussion of juvenile salmon mortality has focused on water flows. This is because water flows are often related to the other sources of juvenile mortality. Low flows leave salmon eggs stranded above the water line where they desiccate; this is referred to as "dewatering" mortality. Unusually high flows may flush salmon eggs from the protective gravel and break them; this is referred to as "scouring" mortality. Generally, moderately high water flows are associated with reductions in several sources of mortality. Such flows result in (1) higher turbidity, decreasing predation risk, (2) lower risk of both dewatering and scouring mortality, (3) lower water temperatures, decreasing direct mortality associated with high water temperatures. High water temperatures also have indirect adverse affects. As examples, high water temperatures increase food requirements and thus increase the risk of starvation, and high water temperatures are associated with increased risk of disease. However, in the past, water temperature was associated with water flow, and so water flow sometimes served as an index of the complex set of interacting factors affecting juvenile mortality. However, The U.S. Bureau of Reclamation currently plans to install a water temperature control device on Shasta Dam (USBR News Release, August 9, 1993). When this occurs, the link between water temperature and water flow would be weakened to some extent in the river reaches immediately below the dam, and one would need to devote more consideration to modeling these factors separately. In addition, several Central Valley water management agencies are implementing "pulse flow" water releases at times critical to the salmon life cycle, for example, when juvenile fish are migrating downstream. It is hoped that these pulse flow releases will help benefit fish populations with a minimum of water use. Unfortunately, consideration of the potential effects of pulse flows is beyond the scope of this analysis.

Toward the end of the rearing period (when the fish are about 70mm in length) fry undergo the physiological transformation of "smoltification" that leaves them better adapted to survive in a more saline marine environment. After this process is complete, the fish are known as smolts. Smolts soon migrate downstream through the Delta and San Francisco Bay

C-110459

and out into the ocean. Significant juvenile mortality occurs during migration through the Delta. Many factors are thought to contribute to low Delta survival, including low water flows, high water temperatures, diversion from the mainstem Sacramento River through the Delta Cross-Channel at Walnut Grove into the interior of the Delta (Kjelson, Greene, and Brandes, 1989; SWRCB-WRINT-USFWS-7, 1992), entrainment by the SWP and CVP water export pumps (Figure 2.3), agricultural irrigation water diversions (Figure 2.4), water pollution from agricultural return flows (Figure 2.5), and predation. During times of low water flow, the period over which juvenile fish are exposed to these adverse conditions is increased due to altered water flows in the Delta caused by SWP and CVP pumping. Most fall-run chinook salmon juveniles migrate through the Delta from April through June (Table 2.6). Thus, conditions in the Delta during this three month period have a large impact on the survival of the entire year class of juvenile salmon.

Once in the ocean, juvenile salmon grow free from fishing pressure for about one and a half years but are subject to high natural mortality during this period. At about Age 2 these fish "recruit" to (become large enough to be caught by) the ocean fishery. Some Age 2 fish are large enough to catch, but most are still too small for fishermen to legally keep. Sub-legal sized fish are thrown back, but some are killed in the process; these fish are known as "shakers." Age 2 fish may also succumb to natural mortality. A proportion of the surviving Age 2 fish leave the ocean to spawn in inland rivers and streams.[3] Age 2 fish

[3] A relatively large proportion of the two-year-old salmon leaving the ocean are immature, male fish known as "jacks." Although these fish swim upstream to spawn, they do not contribute to reproduction. An implication of this is that if the age distribution of spawning salmon shifts to younger-aged fish, not only will reproduction be less because younger fish are smaller and smaller female fish produce fewer eggs, but reproduction will also be less because jacks will comprise a larger proportion of the spawning population.

remaining in the ocean become Age 3 fish in the spring, just in time to greet the new fishing season. Age 3, 4, and 5 fish may be similarly caught by the fishery, killed by natural mortality, induced by instinct to spawn, or advanced to the next age class. Age 3 and older fish, however, are not subject to shaker mortality.

Salmon eluding ocean fishing mortality and ocean natural mortality "escape" inland to spawn. These fish spend three to five weeks swimming upriver and fighting against the current until they reach either a fish hatchery intake ladder or a stream with suitable spawning gravel. Fasting all the while, the migrating fish must avoid being side-tracked by dams and caught by inland anglers. Once they reach adequate spawning sites, female salmon create depressions in the spawning gravel, known as "redds," with their tails and deposit eggs inside. Male salmon then fertilize the eggs. After spawning, the eggs are covered with gravel and the adults soon die.

The incubating eggs, however, are not yet safe. There is the possibility that a concurrently or subsequently spawning pair of fish may destroy the eggs while building a redd of their own. This phenomenon is called "superimposition of redds" and is thought to be a source of density-dependent mortality in the chinook salmon life cycle.

We now turn to a description of the life cycle of hatchery-raised salmon -- salmon that are spawned artificially in a hatchery rather than naturally in the wild. The lifecycle of hatchery salmon differs from that of wild salmon primarily in the inland phase; the life cycles of the two types of salmon are similar in the ocean phase.

All hatchery salmon originally came from spawning wild salmon. Spawning wild salmon are collected by hatchery managers or enter a hatchery themselves by climbing a fish ladder leading into the hatchery. Hatchery managers then collect the eggs from all of the spawning wild fish. The eggs are then raised in the hatchery and become "hatchery salmon." Hatchery managers allow spawning fish to enter the hatchery until the hatchery reaches its egg capacity. The eggs are then fertilized, incubated, hatched, and reared until the juvenile fish are approximately smolt-sized. Fish raised in a hatchery exhibit much lower average rearing mortality than do naturally-rearing fish. However, a disease outbreak can wipe-out crowded hatchery stocks. Assuming hatchery fish survive the rearing period, they are then released into an adjacent stream at the time natural fish are migrating downstream, or they are trucked downstream to avoid the mortality associated with downstream migration. Of the three major salmon hatcheries in the Sacramento River basin, Coleman Hatchery, Nimbus Hatchery, and Feather River Hatchery, Coleman trucks up to 100% of its smolt releases to points below Red Bluff Diversion Dam, Nimbus trucks up to 50% of its releases to points below the Delta, and Feather up to 100% of its releases to points below the Delta. However, fish trucked downstream are less likely to find their way back to the hatchery as adults than are fish released directly into the neighboring stream. Trucked fish, as spawning adults, often "stray" to other reaches of the river system to spawn. In this way fish of hatchery origin are introduced into natural populations. There is some concern that this process might be weakening the genetic integrity of natural populations (National Council on Gene Resources, 1982; Hershberger, 1988; Hilborn, 1992; Moyle, 1992).

The stages of the fall-run chinook salmon life cycle described in the preceding section are captured in a model of the Sacramento Basin Fall-Run Chinook Salmon population (Dumas and Hanemann, 1992). The model was constructed using the STELLA II® systems-analysis programming language and is based on a Fortran model of the Sacramento River chinook salmon population developed by Biosystems Analysis (1989) and a STELLA® model of the San Joaquin River chinook salmon population developed by EA Engineering (1991).

Our modeling efforts are constrained by the available data. While much is known about the Sacramento River fall run chinook salmon population both inland and at sea, much is still in question. Many key physical and biological parameters are not available for the relevant locations or time periods. For those parameters that have been estimated; some are not direct estimates but are derived from values for similar species or similar systems; some are subject to variation, but the type of variation is unknown; and some are contested by various interests. We have attempted to bring together the best estimates from many sources. We rely heavily on the previous salmon modeling efforts of Dettmann and Kelley (1987b), Kope (1987), Biosystems Analysis (1989), Kjelson, Greene, and Brandes (1989), Kelley, Greene, and Mitchell (1990), Cramer (1990), and EA Engineering (1991). Figure 2.6 presents a timeline of the important biological and management events addressed by the model. See Appendix A for further description of the Dumas and Hanemann model.

We now turn to a brief summary of some simulation results from Dumas and Hanemann's model. These simulations focused on the effects of drought, and the potential effects of global climate change, on the Sacramento fall-run chinook salmon population. These simulations emphasize the importance of both upstream water flows and timing, and salmon smolt survival in the Bay-Delta, to the salmon population. For further discussion, see Hanemann and Dumas (1992).

The direct effects of a one year drought on the salmon population may continue to be

C-110463

felt for two to five years, due to the anadromous life cycle of chinook salmon. Smaller, indirect effects on the salmon population, working through succeeding yearly spawning cohorts, may last much longer. In our "four-year drought" simulations, the salmon population level was reduced by 25% in the worst year, with reductions greater than 5% occurring in eight years. These population reductions led to similar reductions in escapements and catches. Most of these effects were felt in years following the end of the drought, due to lags caused by the salmon life cycle. The population reductions were caused by moderate decreases in spawning habitat due to smaller fall flows and large increases in mortality in the Delta for juveniles migrating to the sea caused by smaller spring and summer flows. While not significant in our simulations, we suspect that smaller winter flows could lead to increased dewatering mortality for eggs and juveniles under drought conditions.

2.1.2 Effects of Other Factors

The salmon population is in decline as a result of several factors. Historically, mining wastes, dams and irrigation projects, and overfishing have led to large declines in the salmon population. Various attempts have been made to mitigate the harmful effects resulting from these sources. While the decline of some races of salmon was possibly slowed, the 1986-1992 drought exacerbated the continuing problems. Factors other than water flow, water temperature, and water exports from the S.F. Bay-Delta affect the salmon population. The following list contains some of the factors that have been identified:

(1) Continued spawning habitat loss
(2) Continued unscreened agricultural diversions
(3) Predation

C-110464

(4) Continued pollution[4]
(5) Continued over-fishing[5]
(6) Foreign catch during ocean migration

If these other factors are not controlled, the proposed regulations probably will not generate the full potential environmental benefits.

2.1.3 Benefits

The economic benefits associated with an increase in the commercial *harvest* of the Central Valley salmon stock would, in principle, come in three ultimate forms: changes in the profits of firms, changes in the wages of employees, and changes in consumers' surplus.

Impacts on profits and wages might occur in each of several industrial sectors, which Hanemann (1986) classifies as: the Salmon Harvesting Sector, the Salmon Processing Sector, the Salmon Retail Sector, and Other Sectors. These effects might be felt by employees and business owners living either inside or outside California. These effects may also be classified as *direct* impacts, *indirect* impacts and *induced* impacts. An increase in the California salmon harvest would increase the profits and wages of the salmon harvesting sector. These are the *direct impacts* of a change in the California salmon harvest. *Indirect*

[4] Saiki, et.al. (1992) investigated the effects of selenium in agricultural drainage of the fish in the San Joaquin Valley. They report that "High concentrations of environmental selenium can adversely affect the reproduction, growth, or survival of fish, and require public health advisories for humans who eat affected fish (p.380)." Further, high concentrations of selenium were found in fish from canals and sloughs tributary to the San Joaquin River. Although conclusive evidence of selenium toxicity to these fish is still lacking, the California Department of Health Services has urged people to limit consumption of fish from this region. To the extent that the reallocation of water from agriculture to the environment results in improved water quality through either a reduction in agricultural drainage or a reduction in its toxicity, current damages to the environment from these sources would be reduced.

[5] A short, historical review of overfishing and economic inefficiency in the California salmon fishery is presented in Appendix B.

impacts are the increased profits and wages in other sectors of the economy (the salmon processing sector, salmon retail sector, and other sectors) due to increased purchases by the fish harvesting sector. *Induced impacts* are the further increases in profits and wages in all sectors of the economy due to the general increase in purchases by households due to increased income from the increased profits and wages associated with direct and indirect impacts. We will consider direct, indirect and induced impacts in this report. Although government tax revenues would also be affected by changes in salmon catch, we do not consider tax revenue effects in our analysis and work with figures on a pre-tax basis.

Indirect and induced impacts may also affect wages, profits and consumers' surplus outside California. With regard to potential effects on employee wages, Hanemann (1986) observes that "it is likely that the harvesting and processing of commercially caught Sacramento river chinook salmon takes place mainly within California." Thus, we assume that the effects on out-of-state employee wages in the salmon harvesting and processing sectors are zero. However, within the retail sector there is probably some spillover to non-California residents. With respect to the profits of business owners, Hanemann reasonably speculates: "although detailed information on the ownership of firms in these sectors is not readily available, . . . it is possible that . . . the effects of a [change in] profits in the harvesting and processing sectors are largely confined to [owners residing within] California." Thus, we assume that there are no out-of-state owners of California firms in the salmon Harvesting and Processing Sectors. However, there may be out-of-state effects in the Retail Sector, and this possibility will be considered later.

Turning to potential effects on consumers' surplus, we assume that these effects will be negligible for consumers residing both inside and outside California, because the California Chinook salmon harvest represents a relatively small share of the potential total salmon supply available to California consumers, which includes salmon from other states in the U.S. and from other countries (i.e., the supply curve for salmon is horizontal at the retail level). Thus, we expect that increased supplies of California Chinook salmon (1) would substitute for salmon that is currently imported into the state, (2) would result in little effect on price, and (3) would not result in any significant increase in consumer surplus as a result of non-price factors, because California Chinook salmon is not yet sufficiently differentiated from substitute products in terms of quality, etc. in the minds of most consumers.

In summary, we expect most of the economic effects of the estimated increase in the commercial California Chinook salmon harvest to fall within the state of California. While we do expect direct, indirect, and induced impacts on the California economy, we do not expect significant changes in consumer surplus associated with salmon consumption. We now move on to investigate the direct, indirect, and induced effects in more detail.

The Commercial Salmon Harvesting Sector

To put the California salmon harvest in perspective, we will first review some statistics on U.S. fisheries. Total U.S. commercial fisheries landings amounted to 9,404 million pounds in 1990. Of this total, the various species of Pacific salmon totaled 733 million pounds, with Chinook salmon contributing 26 million pounds (U.S. Dept. Commerce, 1992). Thus, although Pacific salmon represents approximately one-tenth of the U.S. commercial fisheries landings, Chinook salmon comprises a relatively small share of the total Pacific salmon landings. All of the Pacific salmon, including all of the Chinook salmon, was caught within the 200 mile Extended Economic Zone (EEZ) of the United States. Seventy-nine percent of the Chinook salmon catch occurred within 3 miles of shore. Therefore, the California Chinook salmon fishery is a near-shore fishery under U.S. regulation.

The total commercial harvest of chinook salmon landed at California ports has averaged about 540,100 fish/yr over the period 1976-1985. However, not all of these chinook originate from the Sacramento or San Joaquin Basins: some derive from the Klamath River Basin, other North Coast Rivers, or rivers in Oregon. Because salmon of various rivers of origin are mixed when caught at sea, it is necessary to estimate the component of the total California chinook salmon harvest composed of fish originating in the California Central Valley. PFMC assumes that all salmon landed south of Point Arena (i.e. those landed at Monterey and S.F. Bay) originate in the Central Valley. That assumption yields an estimated commercial harvest of Central Valley chinook of about 263,500 fish/yr over the period 1976-1985. Dettman, Kelly and Mitchell (1987) employ a different procedure based on the assumptions that (a) 95% of the chinook landed at Monterey come from the Central Valley, and (b) the ratio of chinook landed at Monterey and tagged as coming from the Central Valley to the estimated total harvest of Central Valley chinook landed at Monterey can be extrapolated to other ports along the California coast and in Oregon. This yields an estimated commercial harvest of Central Valley chinook averaging 351,400 fish/yr over the period 1976-1985, which is significantly higher than the PFMC estimate. However, both estimation methods imply a roughly constant commercial harvest of Central Valley chinook over the 30 years preceding the recent drought.

The commercial harvesting sector is currently regulated by the Pacific Fishery

Management Council (PFMC) (see Table 2.7 with reference to Figure 2.7) in coordination with CDFG and NMFS. PFMC sets escapement targets for various salmon populations. The current escapement target range for Sacramento fall-run chinook is 122,000-180,000 adult spawners. PFMC then regulates the fishery by various means in an attempt to meet the escapement target. As of mid-May, 1993, PFMC limits the commercial fishing season from Point Arena south to the Mexican border to the period May 1 through August 7. However, the region from Point Reyes to Point Arena is closed for all of June, and from Point Arena north to Shelter Cove, PFMC's plan allows fishing in August and September only. From Shelter Cove to the Oregon border the plan allows fishing in September and October only. Some of the more stringent regulations affecting Central Valley salmon fisheries are actually intended to protect Klamath river salmon fisheries. However, because salmon from the two river basins are mixed at sea, the fisheries of both basins are often affected by regulations pertaining to only one basin or the other. In addition to PFMC limits on the salmon fishing season, in 1979 the California legislature imposed a moratorium on the number of vessels allowed to operate in the salmon fishery. The moratorium was subseqently relaxed with the establishment of a Limited Entry Program. The Department of Commerce (1992) estimates that there were 3,675 commercial fishing vessels (>5tons) and 2,921 commercial fishing boats (<5tons) fishing for all fish species in California in 1990. Of these, PFMC (1992, Table D-4) estimates that 2,115, or 32% of total fishing craft, landed salmon in 1990. Thus, changes in California's commercial salmon harvest would affect a large segment of California's commercial fishing craft.

The California commercial salmon troll fleet now expends about 50,000 days of effort per year (PFMC 1986). Fletcher and Johnston (1984) conducted an economic study of the Crabber-Salmon Troller vessels operating from Eureka, California. These vessels are similar to the vessels that fish exclusively for salmon. Fletcher and Johnston's (1984) results, presented in Table 2.8, show that the amount of fishing effort measured in average days at sea depends strongly on estimates of the stock size as measured by the expected catch. Therefore, increases in expected catch resulting from increases in salmon abundance due to EPA's proposed regulations would likely result in increased fishing effort in addition to increased catch-per-effort. Of course, fishing effort also depends on the price and expected catch of substitute species, the prices of target and substitute species, weather conditions, government regulations, and marketing restrictions.

PFMC (1992) data, presented in Figure 2.8, show that the total number of vessels in the salmon fishery declined from 4,738 in 1980 to 2,115 in 1990, a decline of approximately 60%. The decline occurred in two steps, one from 1980 to 1984 and one from 1990 to 1992. The first decline was probably caused by the combination of the 1981-1982 recession and the low catches resulting from the 1983 El Nino. The second decline is probably the result of the recent recession, the recent drought, and increased water exports from the Delta. The majority of the California fleet consists of small vessels, each landing a small catch — in 1985, only 6% of the vessels landed more than 6,000 lbs/vessel (King 1987). The recent decline in the total number of craft in the fishery resulted in a small decrease in the proportion of small (<= 32 ft. in length) boats in the industry but a small increase in the proportion of vessels landing 90% of the catch. Thus, the effects of the recent decline in the number of boats in the industry on industry structure are ambiguous; they do not seem to

C-110470

overwhelmingly favor either large or small commercial operators.

Troll fishing for chinook salmon is especially attractive to California's commercial fishery, industry groups say, because relatively little fishing gear is needed in troll fishing and because salmon bring a high market price (Western Water 1992). "Trolling" is the only type of commercial fishing technology permitted in California. Trolling involves relatively small fishing boats operating close to shore pulling several long fishing lines, each with several hooks (Figure 2.9). A drawback of this fishing method is that immature fish are often hooked accidentally and must be shaken from the fishing lines, resulting in significant "shaker" mortality.[6] Another potential problem with the troll fishery is that it may have shifted the age structure of the salmon population to younger-aged fish by selectively keeping the larger fish. The size of California chinook harvested by the commercial fishery has declined somewhat over the past 30 years. Cope and Slater (1957) found that the average weight of a gill-net caught salmon was 22.23 pounds during 1947-1949, while PFMC (1986) reported that the average weight of a commercially caught salmon in 1985 was 10 pounds. In addition, younger, smaller fish mean fewer and/or smaller eggs, since older, larger female salmon lay more and/or larger eggs (Hankin and McKelvey, 1985). Furthermore, the practice of trolling over feeding grounds close to major river inlets, where fish of different natal streams are mixed together, makes selective management of particular salmon stocks much more difficult.

The dockside value of total U.S. commercial fishery landings amounted to $3.5 billion in 1990. Of this total, all species of Pacific salmon taken together were valued at $612

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[6] Crutchfield (1977) found that ocean trolling led to the mortality of sub-legal sized fish through shaker losses and that even legal sized fish were probably caught at sub-optimal sizes. If left in the ocean for one or more seasons, a sub-optimally-sized fish would gain more weight on average than it would suffer expected mortality,. contributing more to catch.

million (California's share: $12 million), with Chinook salmon contributing $47.2 million (California's share: $11.4 million) (U.S. Dept. Commerce 1992). More recently, in 1991 Pacific salmon was the third most important species to U.S. commercial fisheries in terms of value, and in 1992 Pacific salmon was the FIRST most important species in terms of value (U.S Dept. of Commerce 1993). Thus, the Pacific salmon fishery is a highly valuable component of the U.S. commercial fishery.

Chinook salmon ex-vessel (i.e., dockside dressed) prices rose rapidly during the 1970s but levelled off during the 1980s due to increased competition from Alaskan salmon and fresh "farm-reared" Norwegian imports (King 1987). According to PFMC (1993), over the past five years ex-vessel prices have averaged about $2.68/lb in real 1990 dollars. The total ex-vessel value of the annual commercial harvest of Central Valley chinook in real 1990 dollars has ranged from an extraordinary high of $46 million in 1988 to an extraordinary low of $4.1 million in 1992. This large variation in ex-vessel value results from large variation in landings, while ex-vessel prices have remained relatively stable. Ex-vessel prices have remained relatively stable, because ready substitutes for California salmon exist in the form of imported Alaskan, Canadian, and Norwegian salmon. Korson (1984) found that ex-vessel prices did not increase in response to a 70% reduction in commercial landings in the 1983 El Nino year; this is evidence of the extent to which a world market for salmon breaks the link between landings of California salmon and the price of salmon in California.

The average real gross value of the salmon catch per vessel has varied by a factor of six over the past decade (Table 2.9). The variation in these values closely corresponds to variation in estimates of fish stock size over these same years.

In response to the lack of information on the potential effects of proposed fishery management regulations on the fishing and seafood industries, King and Flagg (1984) conducted surveys of fish harvesters and seafood processors in 1980. The survey collected production, cost, and market data that was then used to construct an input-output model of the California fishing industry. The model provided estimates of Employment, Income, and Output multipliers for 20 California fish-harvesting sectors and nine California seafood-processing sectors based on information from a U.S. Dept. of Interior input-output model of the entire California economy (Table 2.10). In updated form, this information is still used in policy discussions (Grader, 1992).

Tables 2.11-2.16 present revenue and cost data from King and Flagg (1984) for the types of California fishing vessels that earned at least 10% of their revenue from salmon. Data for small and large salmon trollers are presented in Tables 11 and 12. Carter and Radtke (1986) also present a budget for a large salmon troller (Table 2.17). Ueber (1993), notes that since the 1960's, salmon and herring catches have sustained the majority of these vessels. But as salmon stocks have decreased over the last ten years, many vessels have found it not worthwhile to utilize their salmon fishing permits (Table 2.18), and as herring stocks have undergone a dramatic decline in the last two years, fishers find themselves without two of their major "cash crops." However, some vessels catch significant numbers of other species, indicating that some substitution may be possible between harvested species if regulations were tightened for any particular species. Commercial troller Matson (1988) notes, "Many commercial salmon fishermen harvest herring, crab, an other saltwater species when salmon season is closed." Fletcher and Johnston (1984) conducted an economic study of "Crabber-

Salmon Troller" vessels operating from Eureka, California. These vessels switch between target species depending upon market prices and relative fish populations. A cost analysis for a Eureka Crabber-Salmon Troller is presented in Table 2.19. Many of the low-volume producers may in fact be recreational fishermen. According to King (1987) only 13% of California salmon trollers earn all of their income from commercial fishing. Moreover, the most active vessels earned more from other fishery revenues than from salmon fishing revenues.

Because the salmon spawning run is seasonal, the commercial salmon harvest provides only seasonal employment, "A tendency," notes Crutchfield (1977), "that has been greatly augmented by management techniques designed to adjust for excess capacity by shortening fishing periods and by restricting movement among fishing areas." However, Crutchfield also found that, "An overwhelming majority of the capital and labour employed in the salmon fishery is utilized off-season in other fishing occupations, in non-fishing work for the vessel and crew, or shoreside work for crew members. . . . Underemployed fishermen are likely to spend a good deal of time maintaining their idle vessels."

With regard to entry into the industry, Crutchfield concluded that the high profits earned during "good" (high fish stock) years were sufficient to attract new entry but that exit did not seem to occur during "bad" (low fish stock) years. Perhaps this is due to the possibilities for alternative employment of capital and labor during bad years, as mentioned in the preceding paragraph.

Tables 2.20 and 2.21 present data from King and Flagg on total sales and input purchases in 1982 for the two major salmon-harvesting vessel types. All large vessels together generated about three times the revenue generated by all small vessels. Large and medium-sized fish processors bought most of the harvesting sector's output, with only very small amounts being exported.

For the purposes of this report, we follow Hanemann (1986) in making the following assumptions in our analysis. We assume that EPA's proposed regulations will result in an increase in salmon catch above the Decision 1485 baseline of between 30-50%, depending on water year type, as estimated by the Dumas and Hanemann (1992) hydrological/biological salmon population model (Table 2.22). We measure catch in numbers of salmon. We then assume an average (dressed) salmon size of 10 pounds (Table 2.23). We assume an ex-vessel price for salmon of $2.68 per dressed pound, the 1988-1992 average real price (Table 2.24). We choose 1990 as a base year and convert nominal prices from other years into 1990 dollars according to the price index used by PFMC (1993, Table D-22) presented in Table 2.25. We assume that this estimated increase in harvest will not affect the ex-vessel price of chinook salmon in California. This is consistent with Bird's (1986) and DeVoretz and Salvanes' (1993) analyses of the world salmon market (see Appendix D) and with the observed lack of an effect of the 1983 El Nino on California salmon prices as reported by Korson (1984).

As a measure of the change in economic welfare in the harvest sector, we take the increase in employee wages plus the increase in profits accruing to the owners of firms. This measure of economic gain is calculated as the increase in firms' revenue, net of non-wage costs, resulting from the change in the salmon catch. We assume that there are no non-California employees or owners of California fish harvesting firms. In support of this assumption, we note that PFMC (1993, Table D-16) data on the number of vessels owned by residents of other states landing salmon in California from 1978 to 1992 show that non-residents land a very small proportion of the California harvest.

An issue to consider at this point is the appropriate measure of non-wage costs. King and Flagg (1984) provide information on *average* non-wage costs for two classes of salmon trollers, large and small. Non-wage average costs are 46.8% of revenue for large salmon trollers (Table 2.12) and 61.8% of revenue for small salmon trollers (Table 2.11). Meyer (1985) and Leidy et al. (1984) cite studies of *marginal* costs *including wages* for salmon harvesters. These estimates of marginal costs range from 0% to 15%. Meyer uses a value of 10% and Leidy et al. recommend a value of 9%. The substantial fixed costs associated with the purchase of fishing vessels drives the divergence between King and Flagg's estimate of average costs and Meyer and Leidy et al.'s measure of marginal costs. If the increase in the salmon catch could be harvested without employing any additional vessels, then marginal cost would be the appropriate cost measure. Even if it is necessary to employ additional vessels, marginal cost still would be the appropriate cost measure if significant overcapacity (idle vessels) exists in the harvesting sector as a result of previous historical declines in the fish stock. In fact, data from PFMC (1993) show that only 36% (1083) of the 2970 vessels with permits to land salmon actually landed salmon in 1992 (Table 2.18), indicating that significant overcapacity probably exists in the salmon harvesting sector. However, if these "idle" vessels were catching chinook salmon from other (non-Central Valley) stocks or alternative (though lower-valued) species, as evidence presented above suggests, then the opportunity costs of foregoing these catches would raise the true marginal cost of employing these "idle" vessels in the salmon harvest sector. Thus, the estimates of marginal cost presented above may be

C-110476

understated. But, the estimates may be *over*stated, because they include wages. From an economic welfare point of view, changes in wages are properly tallied as changes in household income, not as changes in costs. If wages are incorrectly counted as costs, the gain in economic welfare associated with an increase in the salmon catch would be underestimated. However, if fishers were attracted away from alternative employment that had paid the same wages, then the wage-including cost measures used by Meyer and by Leidy et al. would *not* overstate costs. Given the complexity of the foregoing discussion and the limited data available, we believe that a reasonable value for *non-wage* marginal costs would be 10% of revenue. This is the assumption used in this report.

<u>The Salmon Processing Sector</u>

The fresh market salmon industry was well established in California by 1850 (Clark 1929). The first cannery opened in 1864 on the Sacramento River, and from 1873 to 1910, as many as 21 canneries throughout California processed an average of 5 million pounds of salmon each year (CDWR 1984). In the record year, 1882, the commercial catch on the Sacramento River alone reached 12 million pounds, and 181,000 cases of canned salmon were produced. The cannery fishermen caught fish in the rivers using gillnets, a method so efficient that the fishery promptly collapsed, with the last two canneries closing in 1919 (Clark 1929).[7] In fact, several other factors contributed to the demise of the canning industry in California (Feinberg and Morgan 1980). Mining pollution fouled salmon spawning areas in the rivers, further reducing fish stocks; new ocean salmon fisheries (whose higher-quality fish was sold on the competing fresh market) were getting underway, spurred by the development

[7] The salmon canning industry survives in Alaska and Canada.

of the gasoline-powered boat engine in the early 1900's; and a new salt-curing process provided an alternative preservation technology. Today, over 90% of the U.S. canned salmon pack originates in Alaska (U.S. Dept. Commerce 1992). Meyer (1985) finds that the canning of California salmon is negligible. Since the closure of the California canneries, and with the subsequent development of freezer technology, most of the salmon caught in California is either sold fresh or processed as frozen fillets and steaks. Most of the California catch is sold within the state (Feinberg and Morgan 1980). King and Flagg (1984) estimate that California fish processors buy more salmon, in dollar terms, than any other *seafood* (not just fish) except tuna and wetfish, and most tuna is canned while most wetfish is either canned or exported (Table 2.27). Thus, salmon is a dominant product in California's fresh/frozen seafood processing market.

U.S. Department of Commerce (1992) records show that in 1990, there were 1,784 seafood processing plants in the U.S., employing 59,162 people. In California in the same year, 145 plants employed 5,526 people. In 1990, there were 2,786 seafood wholesaling establishments in the U.S., employing 13,065 people. In California in the same year, 337 establishments employed 1,741 people. In 1990, NMFS (1990) listed 132 seafood dealers handling salmon in California. See Table 2.28 for a breakdown by geographical location and type of business (e.g., wholesaler, processor, importer, exporter, and broker). Most processing plants are located at the larger harbors: Crescent City, Eureka, Fort Bragg, and San Francisco. Importantly, most establishments on the list handle several types of seafood, although salmon is one of the most profitable items. We believe this reflects diversification in the face of the uncertain or seasonal harvests of many species. Note that listing in the NMFS publication is voluntary; not all seafood dealers are necessarily on the list. Also, NMFS, Long Beach, staff (personal communication, June 1993) reported that the recent recession put many of these firms out of business.

Until 1983, almost all of the salmon caught in California went directly from the fishermen to the buyers representing the processing plants (Feinberg and Morgan 1980, Korson 1984). Crutchfield (1977) concluded that the waterfront market structure for salmon was oligopsonistic. Fishermen typically dealt with a limited number of buyers who dominated purchases at the few ports accessible to the typical small salmon boat. In addition, the high degree of uncertainty in salmon fishing led to considerable vertical integration. Some vessels are actually owned by processing companies and manned by skippers and crews subject to the buyers' orders; others are financed by waterfront buyers with the implicit understanding that the firm will have first call on the boat's landings.

However, Ueber (1993) points out that California salmon marketing has undergone several changes since the early 1980's. First, Ueber doubts that the regional dockside demand curve for salmon is downward-sloping; if salmon supply increased, he would not expect a price change. Second, whereas 15 to 20 years ago about 99% of catch went to fish processor/buyers, now many fishermen sell their catch at retail, directly to the public through farmer's markets or smoke houses, cutting out the middlemen. Ueber estimates that 50% of the catch is now going to these farmer's markets, such as the one in Marin county and the three in San Francisco. In fact, Ueber mentions that some harvesters are now working cooperatively by pooling their catches and sending one member of the group to the farmers' markets to sell the combined catch. Some fishers are now even smoking their own fish.

Korson (1984) gives a possible explanation for this general change in salmon marketing. The extremely low El Nino harvest of 1983 resulted in very low ex-vessel prices bid by processors for California salmon. Apparently, processors either shut down or obtained more certain supplies of salmon elsewhere. In any event, harvesters were pressured into searching out new markets for their catch. Many began selling directly to restaurants and retail farmers' markets instead of processors. The number of California fishermen obtaining licenses to sell salmon directly as wholesalers and retailers increased from 1500 in 1982 to 6000 in 1983.

CDFG collects data on the ex-vessel price of each salmon sold at dockside in California by requiring the commercial salmon harvester to fill out a "fish ticket" for each salmon sold and to submit the ticket to CDFG (Seger 1993). (CDFG also uses the fish tickets to gather other information about the fish that is useful for management purposes.) CDFG then reports average ex-vessel prices to PFMC. We use the annual ex-vessel prices for California chinook salmon published by PFMC to calculate the five-year average price of around $2.68/lb used in this report. Ueber (1993) reports that the distribution of dockside, or "ex-vessel," prices may range from $2 to $6 per pound of dressed salmon, with retail/smoker/farmer's market prices at the high end of this range. It appears that retail/smoker/farmer's markets pay a premium in order to get the highest quality fish and to ensure supply. The buyer/processors pay prices at the lower end of the range and take the lower quality, "surplus" fish. However, it is difficult to reconcile (1) Ueber's market share estimates of 50% processor and 50% farmers market/restaurant, (2) Ueber's market price estimates of $2 for processor salmon and $6 for farmers market/restaurant salmon, and (3)

C-110480

PFMC's average price of $2.68/lb. Using Ueber's estimates, the average price should be about $4.00/lb. instead of $2.68/lb. Perhaps data collection errors cause PFMC's price to be an underestimate of the true average price. Perhaps Ueber is overestimating the processor price and/or the farmers' market/restaurant price, or perhaps Ueber is overestimating the farmers' market/ restaurant market share.

Salmon that is purchased by buyer/processors is trucked to the processing plants where the fish are washed and re-iced, having already been dressed and iced by the fishermen. Since salmon are bought already dressed, they are one of the easiest fish to process. Most of the salmon is refrigerated and sold immediately to restaurants, markets, or to a fish broker, who may buy several loads of salmon to ship to Los Angeles, San Francisco, the Midwest, or the East Coast Fresh, iced salmon has a shelf life of two to three weeks. The remainder of the salmon catch is frozen, stored, and marketed after the commercial season ends, when no fresh California salmon is available. Because the fishing season is short, the yearly catch is concentrated into a few months, and processors run large volumes of fish through their plants at once (Feinberg and Morgan 1980). Commercial freezers can store salmon for about a year. Cold storage stocks are drawn down in the late fall, winter, and spring and built up in the summer and early fall (Table 2.26). Although freezing and storing costs can increase the market price of salmon, Wessels and Wilen (1993) found that holding costs are a relatively small fraction of wholesale price in the Japanese salmon market and that they had a negligible impact on Japanese processors' storage decisions. At the end of 1990, 32,868,000 pounds of dressed salmon were held in cold storage in the U.S.

Carter and Radtke (1986) present a representative budget for an Oregon fish processor

(Table 2.29) and a schedule of the components of a processor's contribution margin per pound of raw fish input (Table 2.30). Total variable costs are approximately 8-times larger than total fixed costs, with the raw fish input accounting for about 80% of total variable costs. The contribution margin amounts to $0.97 per pound of raw fish input in 1990 dollars.

DeVoretz (1982) developed an econometric demand model for Canadian salmon at the wholesale level and noted that results for United States salmon were similar. DeVoretz found that (1) a price model explained salmon market adjustments better than a quantity model, (2) elasticities of demand are greater than one and are greater for individual salmon species than for salmon in general, (3) income elasticities are greater than one, and (4) canned tuna (rather than chicken, beef, etc.) is the major substitute for canned salmon.

For the purposes of this report, we make the following assumptions in our analysis. Although Hanemann (1986) cites King and Flagg's analysis to support his assumption that "virtually the entire catch of California salmon trollers is sold to California establishments in the wholesale, processing, and distribution sector," the recent evidence from Ueber cited above prompts us to make the assumption that approximately half of the California Central Valley chinook salmon harvest will be marketed directly to consumers by the harvesting sector itself, while the other half of the harvest is marketed through traditional processor channels.

Although salmon are already dressed when sold at dockside, as salmon pass through the processing sector there may be some "shrinkage" in the weight of the fish due to losses in processing. Carter and Radtke (1986) estimate shrinkage at 2.5% of the ex-vessel raw product. We follow Hanemann (1986) in assuming that this is negligible.

We assume that the processing sector applies a mark-up to the ex-vessel price to determine the wholesale price it will charge retailers. Hanemann cites Meyer (1985, p.15), who cites a PFMC (1983) mark-up estimate of 90% for both Marin and Mendocino counties. Leidy et. al. use a 65% mark-up derived from an Oregon State University (1978) study of Humboldt County, CA. Carter and Radtke (1986) estimate a 44% markup for an Oregon processor of troll-caught Chinook.

We now turn to estimates of processor costs. From information provided in King and Flagg (1984), we estimate *average* processing costs *excluding wages* to be 84.1%, 90.4%, and 79.1% of wholesale revenues for small, medium, and large fish processing firms, respectively. Meyer (1985) and Leidy et al. (1984) both cite studies by Penn (1980) and Barclay and Morley (1980) suggesting that the *marginal* processing costs *including wages* amount to 75.4% of wholesale revenues. For our analysis, we conservatively assume that *marginal* processing costs *excluding* wages are equal to 75.4% of wholesale revenue.

We assume that California fish processors would utilize existing idle capacity to process any increase in the catch of California salmon. Given the excess capacity in the salmon processing industry due to shutdowns caused by the recent recession and to the decline in salmon harvests, this is not an unwarranted assumption. However, if California seafood processors were to find it necessary to increase investment in capacity or to reduce the processing of other seafoods to accomodate an increase in salmon processing, then the net increase in economic welfare derived from the processing sector would be smaller than our estimates indicate.

Finally, we assume that these impacts affect California households, i.e. we assume that there are no out-of-state employees or owners of California fish processing firms.

The processors of California salmon may find it increasingly difficult to market their seasonal salmon product to large fish buyers, such as those purchasing for national restaurant chains. In a study of the New England market for fresh and frozen salmon, Anderson and Bettencourt (1993) found that "buyers for 'expensive seafood restaurants' prefer seasonal over year-round salmon products, which is consistent with these restaurants' desire to vary their menu according to seasons, and with consumers' perceptions of the appropriate times to eat certain seafood products. 'Fish market' buyers significantly prefer year-round to seasonal salmon." Korson (1984) notes that Norwegian farmed salmon is supplied fresh on a year-round basis to California markets and "competes directly in the high-quality, fresh-frozen troll salmon market."

The Salmon Retail Sector

California salmon is sold fresh in farmers' markets, retail fish stores, restaurants, and institutions (e.g., military bases). U.S. annual per capita consumption of commercial fish and shellfish has increased steadily over the past thirty years (U.S. Dept. Commerce, 1992). The annual per capita consumption of fresh and frozen commercial fish and shellfish products increased from 7.9 lbs. in 1980 to a peak of 10.7 lbs. in 1987. Similarly, annual per capita consumption of canned commercial fish and shellfish increased from 4.3 lbs. in 1980 to a peak of 5.4 lbs. in 1986. Annual per capita consumption in 1990 amounted to 9.6 lbs. of fresh and frozen fish and shellfish products and 5.1 lbs. of canned fish and shellfish products. U.S. annual per capita consumption of canned salmon has remained relatively stable over the past ten years at about 0.5 lbs. However, DeVoretz and Salvanes (1993) find a relatively large income elasticity for salmon on the world market (Appendix C). This supports earlier results in the literature which found that salmon is a luxury good. Thus, world demand for salmon may increase, both in the short run as the current recession subsides and in the long run as purchasing power increases in the developing world.

We determine the retail price of California salmon by applying a markup factor to the wholesale price. We follow Meyer (1985) by assuming an average retail markup of 106% over the wholesale price. [Meyer's estimate of the average retail markup is based on national data in NMFS (1980). Meyer assumes that 14% of salmon are sold to retail fish stores, 82% go to restaurants, and 4% go to institutions. The retail fish store markup for salmon over wholesale price is 18%, the restaurant markup for fish in general is 123%, and the institutional markup for fish in general is 66%. Forming a weighted average gives 106%.] Given the availability of salmon from California North Coast rivers, from Oregon, Washington, Alaska, and from Norwegian imports, it is not likely that moderate changes in the commercial harvest of California Central Valley salmon would have a substantial impact on retail prices. However, in the long run, if world demand for salmon increases as DeVoretz and Salvanes (1993),this may lead to increased retail prices for salmon in general, and for California salmon in particular, leading to higher future benefits from increased harvests of California salmon.

We require an estimate of the *marginal* profit rate in the retail sector. Meyer (1985) estimates that the *average* profit rate in the retail sector amounts to 20.9% of the value increment.[8] [Meyer's estimate of the average before tax profit in the retail sector is based on

[8] The value increment is defined as the difference between the wholesale price paid for salmon and the retail price received for salmon.

national all-fishery data over the period 1972-1977 from NMFS (1980). Meyer calculates a weighted average of profit margins in the fresh fish retail store, restaurant, and institutional sectors.] We simply assume that the marginal profit rate is equal to Meyer's estimate of the average profit rate. To the extent that retail establishments substitute sales of California salmon for sales of other fish or food products, our profit rate assumption would overestimate the true marginal profit rate, because the opportunity cost of the foregone sales of the other fish or seafood products would not have been netted out. However, assuming that a retail establishment is operating on the downward-sloping portion of its average cost curve, our profit rate assumption would underestimate the marginal profit rate. These two effects would be expected to cancel to some extent. Since California salmon are sold at retail almost entirely within California, we assume that any increase in retail profits mainly accrues to firm owners residing in California.

Because sales of California salmon comprise a relatively small share of total sales in the fresh fish retail store, restaurant, and institutional sectors, we believe that any reasonable increase in California salmon sales would result in little increase in employment in these sectors. Thus, we assume that there would be no significant change in employee wages in the salmon retailing sector as a result of an increase in California salmon retail sales.

Recently, the California Salmon Council has been promoting locally-caught salmon with a 'California King Salmon' logo, in silver and blue with a leaping salmon and a crown (San Francisco Chronicle, May 19, 1993). This seal will appear on in-store signs, package labels and restaurant table cards. To the extent that such efforts are successful in differentiating California salmon from other salmon, perhaps retailers will be able to raise the

(PFMC 1993). Undoubtedly, some portion of these landings would be available for "export" to California markets if the price differential (net of transportation costs) between states became significant. In summary, California salmon landings make up a relatively small proportion of all salmon consumed in California, and this is not expected to change in the foreseeable future.

Turning to exports, in 1990 the U.S. exported 2.6 million pounds of salmon fillets, steaks, or portions valued at $5.8 million, 308 million pounds of whole fresh and frozen salmon worth $666 million and 49 million pounds of canned salmon worth $104 million. Total U.S. fishery product exports were approximately $5.6 billion. Japan and France are the leading importers of U.S. fillets, steaks, portions, and whole fresh and frozen salmon. The U.K., Australia, Netherlands, and Canada are the leading importers of U.S. canned salmon. In 1991, Alaskan plants accounted for 94% in quantity and 95% in value of the U.S. canned salmon pack.

Since the 1976 implementation of the Fishery Conservation and Management Act (FCMA), when foreign fishing vessels were excluded from the U.S. 200-mile EEZ at sea, U.S. exports of fresh and frozen Pacific salmon to Japan have been rising rapidly (Johnston, 1988). (But see Wessells, 1990, and Wessells and Wilen, 1993, on the implications of recent storage innovations and increased domestic catch of chum salmon in Japan.) However, Pacific salmon now faces new competition in both domestic markets and traditional export markets from farm-raised Atlantic salmon produced by several foreign countries, especially Norway (Rogness and Lin, 1986). Although the relatively low price of Pacific salmon improves its competitive position with respect to Atlantic farmed salmon, the seasonal

C-110487

availability of Pacific salmon is not as desirable to retailers as the year-round availability of farm-raised Atlantic salmon. The supply of farmed Atlantic salmon is projected to increase dramatically, and its anticipated reduction in price may make it more price competitive with Pacific salmon in the future (Lin, et. al., 1989). Thus, any existing exports of seasonally-available California salmon are expected to face increased price competition from farm-raised Atlantic salmon available year-round. In summary, we expect that King and Flagg's (1984) finding that salmon exports from California processing establishments are negligible will remain true for the foreseeable future.

Indirect and Induced Impacts

The economic welfare impacts of a change in the California Chinook salmon harvest on the California salmon harvesting sector are termed the direct effects of the change in harvest. Indirect effects are the ripple effects on all other sectors in the economy caused by the increased output and increased input purchases of the harvesting sector. The indirect effects on two sectors of the economy, the salmon processing and salmon retail sectors, have been discussed above in detail. Induced effects are due to the increased spending by households that results from the direct and indirect effects.

Input-output models enable estimation of indirect and induced impacts. Hanemann (1986) mentions two relevant input-output models, King and Flagg's (1984) California Interindustry Fisheries Model and the 1976 California Input-Output Table (CDWR 1980). Each of these models exhibits three inconsistencies with Hanemann's modeling approach: (1) each examines the effects of an exogenous change in final demand rather than an exogenous change in the output of a sector[9] (2) each does not consider out-of-state impacts and (3) each makes use of average, rather than marginal, technology coefficients.

With respect to the first inconsistency, Hanemann (1986) shows that while the measure of direct plus indirect impacts calculated by King and Flagg is "conceptually distinct from, and larger than," the correct measure, the difference is negligible for the California harvesting sector. Hanemann shows that the same is true for the appropriate measure of direct plus indirect plus induced impacts.

With respect to the second inconsistency, Hanemann estimates that any indirect and induced impacts on out-of-state economic welfare are "likely to be an order of magnitude smaller than the corresponding impacts on California." Having already assumed that there are zero direct out-of-state impacts and zero indirect out-of-state impacts associated with the California salmon processing and retail sectors, Hanemann assumes that the indirect impacts associated with all other sectors in the economy, and all induced impacts, on out-of-state economic welfare are one-tenth of the respective California impacts.

With respect to the third inconsistency, Hanemann shows that using *marginal*, rather than *average*, technology coefficients makes a difference in the estimated size of impacts. Using marginal coefficients results in larger direct impacts on the salmon harvesting industry and larger indirect impacts on the salmon processing and retailing industries. However, we use King and Shellhammer's (1981) average technology coefficients to calculate the indirect impacts on sectors other than the salmon processing and retailing sectors, because it would be beyond the scope of this project to develop marginal coefficients for all sectors. Assuming

[9] In this case, the salmon harvesting sector.

these other sectors are operating on the downward sloping portions of their average cost curves, using average technology coefficients is conservative in the sense that it would underestimate the benefits from an increase in the California chinook salmon harvest.

We will follow Hanemann in structuring our analysis of indirect and induced impacts of a change in Central Valley chinook landings. Hanemann distinguishes between impacts inside California and impacts outside California. With respect to impacts inside California, Hanemann uses data from King and Shellhammer's (1981) California Interindustries Fisheries Model to develop an estimate of the indirect impact of a change in the Central Valley chinook salmon harvest on all sectors in the California economy *except the salmon processing and salmon retailing sectors* (for which indirect impacts have been estimated separately and in more detail). These indirect impacts within California amount to $0.1628 per dollar of revenue in the California salmon harvesting sector. Hanemann borrows from King and Flagg (1984, Table 3-2) an estimate of the total induced impacts within California of a change in the Central Valley chinook salmon harvest of $0.3932 per dollar of total direct plus indirect impacts within California. Turning to indirect and induced impacts outside California, Hanemann notes that there is little data available to guide the analysis and suggests that such impacts would be at least an order of magnitude smaller than such impacts within California. Thus, he assumes that the SUM of indirect and induced impacts outside California amount to one-tenth of the sum of indirect impacts on sectors in the California economy (other than salmon processing and retailing[10]) AND the induced impact on the California economy.

[10] Recall that we have assumed that there are zero indirect impacts outside of California in the salmon processing and retailing sectors.

Summary

Dumas and Hanemann (1992) have developed a California Sacramento Basin Fall-Run Chinook Salmon Population Model. This model ignores non-fall-run salmon stocks in the Sacramento Basin and all salmon stocks in the San Joaquin basin. However, each of these stocks contributes only a small portion of the total salmon catch, thus an analysis focusing on the Sacramento Basin fall-run should be sufficient to describe the major effects of changes in the policy target. While catch proportions may change in the future (IF Delta protection measures are successful), the analysis of such changes is beyond the scope of this report. We use the salmon population model to calculate the equilibrium salmon commercial and recreational harvest levels under several scenarios. For each of two year types, Above Normal and Critically Dry, we calculate the equilibrium commercial and recreational chinook salmon harvests under Decision 1485, Decision 1630, and the proposed EPA regulations and operating rules.

A key parameter in the salmon population model is the percent survival of seaward-migrating juvenile salmon smolts in the Sacramento/San Joaquin Delta. We obtained values for salmon smolt survival in the Delta from SWRCB Decision 1630 (April 1993, Table D) for the 1485 and 1630 rules scenarios and from Palma Rissler of the EPA for the EPA proposed rules scenario. We assume that if EPA's proposed regulations are not sufficient to achieve the target salmon smolt survival, then other actions (such as juggling the proportions of Net Delta Outflow attributable to Delta inflow, diversions, and exports; temperature regulation; construction of additional physical structures; etc.) would be taken by Delta managers to achieve the target. We assume that headwater flows in salmon spawning areas are managed to achieve the levels corresponding to the normal and drought scenarios based on PROSIM model output described in Dumas and Hanemann (1992).

With respect to salmon hatcheries, we assume that EPA's proposed rules would result in no significant changes from the assumptions made in Dumas and Hanemann (1992) regarding hatchery capacity and operations. The assumptions made in Dumas and Hanemann are based on the recent historical record.

We let the salmon population model and the salmon smolt survival estimates describe the hydrological/biological processes affecting salmon. The salmon population model output consists of values for the annual escapement of California Sacramento basin fall-run Chinook salmon, ocean catch of salmon, and inland catch of salmon. We delay further discussion of the inland catch of salmon until Section 3 of this report. We have modified the ocean module of the Dumas and Hanemann (1992) model to accommodate the following assumption regarding ocean fishery regulation: we assume that PFMC sets an escapement target (we use a round number of 150,000 adult salmon, taken from the middle of PFMC's 1992 target escapement range), and that the total ocean catch will then equal all immigrating fish in excess of the escapement target. We assume that the escapement target is successfully enforced such that it is always achieved. (The salmon stock is large enough to at least meet the escapement target in all scenarios we consider.) The total ocean catch is partitioned into the ocean commercial catch and the ocean recreational catch. PFMC has no formal mechanism to allocate the California salmon harvest between the commercial fishery and the recreational fishery (Coon 1993). In effect, PFMC adjusts the season length to acheive the escapement target in response to realized fishing effort . We choose to partition total ocean catch between commercial ocean catch and recreational ocean catch in the following way. We use the results of two regressions (described in Section 3.1.3 of this report) to determine the responses of ocean recreational catch and ocean recreational trips to an index of salmon abundance. We then assume that ocean recreational catch has priority over ocean commercial catch such that:

Ocean Commercial Catch = Total Ocean Catch - Ocean Recreational Catch

We delay further consideration of the recreational catch to Section 3 of this report. Our salmon population simulations indicate that the proposed regulations might result in an increase in the commercial catch of California Central Valley chinook salmon of between 90,000 and 130,000 fish.[11]

We assume that a dressed salmon weighs 10 pounds. We assume that marginal harvesting costs associated with any increase in the catch of California salmon would be less than average harvesting costs due to excess capacity in the salmon harvesting sector (as evidenced by the excess of vessels purchasing salmon harvesting permits over vessels actually landing salmon) and the apparent ability of regional fish harvesters to substitute the more highly-valued salmon for alternative target species relatively easily. We assume that the marginal cost net of employee wages in the harvesting sector is 10% of ex-vessel price paid by processors for salmon. We assume little change in the ex-vessel price of salmon due to the availability of imported salmon. We assume that the ex-vessel price per pound of salmon is $2.68. We assume that half of the salmon landed is sold by harvesters to processors and

[11] Korson (1984) documents the effects of El Nino on the California salmon industry in 1983. Commercial ocean troll landings (in pounds dressed weight) in 1983 decreased 70% relative to landings in 1982. Such effects exemplify the exogenous, natural shocks that are not included in our deterministic model but which could affect the California salmon harvest and modify the benefit estimates developed in this report.

that half is marketed by harvesters directly to consumers.

For salmon sold to processors, we assume that processors apply a 90% mark-up to the ex-vessel price to obtain a wholesale price and that processor marginal cost net of employee wages is 75.4% of the wholesale price. We assume that California salmon processors would utilize excess capacity to process additional salmon. We expect little change in the wholesale price of California salmon sold by processors to retailers, because California salmon is only a small proportion of the world salmon market, which appears to be essentially competitive at the present time and for the foreseeable future. We assume that California salmon retailers would substitute California salmon for imported salmon, perhaps for quality (freshness) reasons or perhaps due to partial success at differentiating California salmon from imported salmon and comparable substitute fish species. However, we do not have sufficient evidence to support the position that salmon retailers would be successful in charging higher prices for California salmon. We assume that the retail sector applies a 106% mark-up to the wholesale price to obtain a retail price, and we assume that average profit in the retail sector is a weighted average of profits in the fishmarket, restaurant, and institutional sub-sectors, equal to 20.9% of retail price less wholesale cost. Turning to indirect impacts within California in all sectors other than salmon processing and salmon retailing, we assume that these amount to $0.1628 per dollar of sales in the harvesting sector. Induced impacts within California are then $0.3932 per dollar of direct plus indirect impacts. We then assume that indirect plus induced impacts outside California amount to one-tenth of the sum of the indirect impacts in California in sectors other than salmon processing and retailing and the induced impacts within California. A breakdown of these impact per fish for processor-marketed salmon is

C-110494

presented in Table 2.31.

Turning to salmon marketed directly to consumers by the harvesting sector, the marginal costs of harvesting are as described above, and we assume that there are no marketing costs for salmon marketed directly. Indirect impacts within California per pound of salmon sold directly are assumed to equal those described above for "sectors other than salmon processing and retailing." Induced impacts within California are assumed to equal $0.3932 per dollar of the sum of direct-marketing revenue less marginal cost plus indirect impacts in sectors other than salmon processing and retailing. Out of state impacts associated with directly-marketed salmon are assumed to equal one-tenth the sum of the indirect impacts in "sectors other than salmon processing and retailing" in California and the induced impacts within California. A breakdown of these impacts per fish for directly-marketed salmon is presented in Table 2.32.

Based on the assumption that about half of the increase in catch would be marketed by harvesters to processors and about half would be marketed by harvesters directly to consumers, the weighted-average increase in household income per California salmon comes to $82.07/fish; this is the benefit value used for commercially-caught salmon in this report. Several other estimates are presented in Tables 2.33 through 2.37. Our value is bracketed by these other estimates. We expect the salmon harvesting sector to receive a large proportion of household income benefits of any increases in California salmon catch. We also expect the salmon processing and retailing sectors to see some increases in household income benefits associated with the portion of the increase in catch marketed by harvesters to processors.

2.2 Starry Flounder Commercial Fishery

2.2.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions

Starry flounder (*Platichthys stellatus*) (Figure 2.10) occur naturally from Santa Barbara, California northward to Alaska (CDFG 1992). As adults, starry flounder inhabit offshore, shallow, coastal marine water. During late fall and winter, adult starry flounder migrate to spawning areas. Spawning occurs principally near the mouths of rivers and sloughs between November and February. The initially pelagic eggs and larvae settle to the bottom about two months after hatching. Juvenile starry flounder appear to be estuarine-dependent, and from March through June they seek out the fresh to brackish water of bays and estuaries for use as nursery areas. Larvae appear to depend upon favorable ocean currents and tides to aid their migration. The life cycle of starry flounder is presented in Figure 2.11. Due to its relatively large size, the San Francisco Bay and Delta is thought to be the most important nursery area for starry flounder in California. Larvae "rear" (feed and grow) in the estuarine nursery areas for one to two years. Herbold et al. (1992) note that "Starry flounder occur in San Francisco Bay in high numbers for all life stages." As they mature, starry flounder move gradually to more saline waters. Most males mature by the end of their second year of life. Most females mature later at age 3 or 4. Starry flounder exhibit two areas of concentration within the Bay: (1) near Alcatraz island and (2) San Pablo Bay. The population near Alcatraz island has declined to some extent but "the population in San Pablo Bay has drastically declined . . . There may be two populations, an offshore one whose young appear near the mouth of the Bay and a resident one which appears to breed and stay year-round in the northern reaches of the Bay." (Herbold et al. 1992)

C-110496

Herbold, et al. (1992) note that "A sharp decline is apparent in the starry flounder catch since 1983 (Figure 2.12); the last four years of the study are the four years of lowest flounder abundance. The decline has been sharpest in San Pablo Bay, which from 1985 to 1988 yielded less than 10% of the starry flounder captured at the same stations in 1980 to 1984." Possible explanations for the decline include overfishing, unfavorable changes in Bay-Delta conditions, and/or unfavorable changes in offshore ocean conditions (CDFG 1992). The coincidence of the decline in the estuarine recreational catch and the increase in the offshore commercial catch suggests that larger juvenile starry flounder began in the mid-1970's to migrate offshore earlier.

CDFG (1992) hypothesized that freshwater outflow (1) helps adult starry flounder find spawning areas at the mouths of rivers and bays, (2) assists larvae and juveniles in locating estuarine nursery areas, (3) improves larval and juvenile survival by increasing the area of nursery habitat and by reducing its salinity. CDFG has developed two measures of the abundance of juvenile starry flounder in the San Francisco Bay-Delta: the "young-of-the-year (YOY) index" and the "one-year-old (ONEPPLUS) index." Since potential sampling bias associated with the YOY index was discovered, efforts have focused on the ONEPLUS index. CDFG has assumed that the ONEPLUS abundance index is directly related to the beneficial effects of outflow.

To investigate the relationship between freshwater outflow and starry flounder abundance, CDFG regressed the February-May ONEPLUS abundance index on March through June Delta outflows from the previous year. The outflow period from March through June (the period of larval and juvenile immigration to the estuary nursery) was judged the

C-110497

most critical. The results for this outflow period indicate a significant positive relationship ($p < 0.05$) between the ONEPLUS abundance index and average March-June monthly outflow at Chipps Island (Figure 2.13).

There is evidence that freshwater outflow affects starry flounder abundance by determining the amount of nursery habitat available to juvenile starry flounder and by determining the distribution of juvenile starry flounder within the nursery habitat (Figures 2.14 and 2.15). During low outflow years the preferred low-salinity nursery habitat conditions are restricted to the West Delta and Suisun Bay. During high outflow years, the low-salinity conditions reach down into San Pablo Bay, making available additional, extensive, shallow mud-flat areas for use as nursery habitat. Other factors, such as ocean conditions, are known to affect abundance as well. CDFG infers from Figures 2.14 and 2.15 that while only weaker year classes result from low outflow years, both stronger and weaker year classes may result from high outflow years. Thus, high freshwater outflow appears necessary, but not sufficient, for stronger year classes of starry flounder.

Herbold, et al. (1992) conclude that "the future of starry flounders in the Bay appears to be that they will cease to maintain a separate inland population and will . . . only use the Bay for a brief period as a nursery area for young of year. . . . Bottom-dwelling habits, feeding on the benthos, and wide salinity tolerances may allow young [starry flounder] to continue using the Bay [at least as a nursery area] despite most projected changes in physical conditions."

2.2.2 Effects of Other Factors

As noted above, ocean conditions are known to affect the abundance of starry flounder. In addition, Herbold, et al. (1992) cite studies by Spies et al. (1988), Spies et al. (1990), and Davis et al. (1991) finding that "the concentrations of toxic PCB's [found in San Pablo Bay] in adult starry flounder have been shown to be sufficient to reduce reproductive success."

2.2.3 Benefits

CDFG (1992) has developed a regression model that explains an abundance index of 1+ year-old starry flounder as a function of average March-June monthly net Delta outflow. We use CDFG's model together with flow data from CDWR's DWRSIM hydrology model output supplied by Bruce Herbold of EPA to describe the hydrological/biological processes affecting starry flounder in the San Francisco Bay-Delta. There are two series of DWRSIM flow data: the first constructed under assumptions consistent with SWRCB's Decision 1485 and 7.1 MAF demand, the second constructed under assumptions consistent with EPA's proposed regulations to maintain the health of the San Francisco Bay-Delta and 7.1 MAF demand.

Starry flounder are a moderately important part of the commercial fisheries of the Pacific Northwest (CDFG 1992). Although they are a small component of the flatfish catch (2 percent by weight), they rate second in price per pound at the dock. Commercial landings of starry flounder in the San Francisco Bay Area between 1960 and 1991 have varied between a maximum of 486,000 pounds in 1980 and a minimum of 40,000 pounds in 1990 (Figure 2.16). Offshore commercial landings increased in 1976 to relatively high levels. These large landings were maintained until 1986, at which time landings declined to their current low levels. The NMFS (personal communication, July 1993) provided recent

C-110499

information on catch its total value for the starry flounder fishery. In 1992, the total California catch of starry flounder was 77,900 lbs. Of this total, 44,251 lbs., worth $19,544, were landed in the San Francisco Bay area. We assume that these value estimates are based on ex-vessel prices.

Mean monthly net Delta Outflow data (supplied by Bruce Herbold, EPA) for the months relevant to calculating the abundance of starry flounder are presented in Tables 2.38-2.40. The starry flounder LOG10 abundance index is calculated in Tables 2.41-2.42 for various representative water year types under each of the rules standards under consideration. Results of a regression of starry flounder commercial landings on starry flounder LOG10 abundance index are presented in Table 2.43, based on data presented in Table 2.44. From the preceding information, estimates of starry flounder pounds landed for various representative water year types under each of the standards considered in this report are presented in Table 2.45. The available data on average price of commercially-caught starry flounder is presented in Table 2.46. This information will be used in Section 4 of this report, where we will estimate the total benefits of EPA's proposed rules.

Estimates of starry flounder commercial catch under each of the alternative scenarios are presented in Tables 4.1 and 4.2. (Additional data on historical catches of starry flounder are presented for comparison in Tables 2.47 and 2.48). Assuming vessels fishing for other species could easily switch to high-valued starry flounder upon increases in the starry flounder population, the only relevant costs would be marginal costs net of employee wages which we assume are 10% of ex-vessel prices. We use an ex-vessel price averaged over the past few years of $0.32 per pound. Benefits associated with estimated changes in the starry

C-110500

flounder commercial catch are presented in Tables 4.1 and 4.2.

As a link in the estuarine food web, the abundance of starry flounder affects other estuarine species. Striped bass, marine mammals, and piscivorous birds are known to utilize starry flounder as a food source. Thus, an increase in the abundance of starry flounder may increase the populations of these other, interacting species and may thereby increase any benefits associated with these other species (CDFG 1992).

2.3 Bay Shrimp Commercial Fishery

2.3.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions

Several species of shrimp are found in San Francisco Bay, including *Heptacarpus cristatus*, *Palaemon macrodactylus*, and several species of Bay Shrimp, *Crangon spp.* Of these, *Crangon franciscorum* (Figure 2.17) was the most abundant shrimp species prior to 1987. The life-history of *C. franciscorum*, is presented in Figure 2.18. Commonly called grass shrimp by anglers and bait sellers, these species of shrimp seldom exceed 70mm in total length (Herbold, et. al., 1992). Herbold, et. al. (1992) plot recent otter trawl abundance index data for *C. franciscorum* from Herrgesell (1990) in Figure 2.19.

CDFG (1992) developed a regression model for the shrimp *Crangon franciscorum* that relates the abundance of both juveniles and adults to log average March through May Delta outflow (Figure 2.20). CDFG reported that:

> Strong positive relationships were found between March through May outflow and both juvenile and the subsequent years mature shrimp. The March through May period was chosen as the critical period for juvenile shrimp since this is the period of time in which the juveniles are recruited into the estuarine nursery areas and grow rapidly. Freshwater outflow affects *C. franciscorum* throughout their life cycle. No other species of shrimp had a significant relationship between abundance and outflow. [Most of the other shrimp species are much less dependent on the estuary.] In years with low freshwater outflow, juvenile *C. franciscorum* are concentrated in Suison Bay or the West Delta, where there is much less shallow water habitat than in San Pablo Bay [Figure 2.21 shows the relationship between habitat and outflow]. . . . The size of [this area] is important to juvenile *C. franciscorum* for several reasons, including increased food and space, reduced inter- and intra-specific competition, and reduced predation.

As additional evidence of the effects of flow on Bay shrimp, Herbold, et al. (1992) cite Herrgesell's (1990) finding that "all three Crangon shrimps captured by the Bay Study show obvious responses to flow patterns . . . [although species other than *C. franciscorum*] appear to respond more to Bay salinity." Herbold et al. also discuss regression results for *C. franciscorum* very similar to those discussed above.

During the recent drought, the abundance of shrimp: increased in the South Bay, increased in the Central Bay, decreased in San Pablo Bay and decreased in Suisun Bay. Thus, during the recent drought, the abundance of shrimp increased in some areas. "However, the shrimp biomass index during the drought . . . was 55% less than the index in high outflow years. This is because the species and size groups of shrimp that increased in abundance during the drought were not as large as those that dominated the catch previous to 1987, when *C. franciscorum* was the most abundant species" (CDFG 1992).

2.3.2 Effects of Other Factors

Factors other than flow may affect the abundance of Bay shrimp. As Herbold, et al. (1992) summarize:

> The decreased food abundance in Suisun Bay in recent years may also have played a role in reducing the abundance of *C. franciscorum* since it is the only cranonid to be found in abundance that far upstream. . . .The interaction of direct effects of outflow on shrimp abundance with the indirect effects of outflow on their principal prey and predators could make it difficult to predict their future abundance (Armor and Herrgesell 1985). However, to date, *C. franciscorum* exhibits a straightforward response to outflow alone . . .

2.3.3 Benefits

CDFG (1992) has developed a regression model that explains an abundance index of mature bay shrimp as a function of average March-May monthly net Delta outflow. We use CDFG's model together with flow data from CDWR's DWRSIM hydrology model output supplied by Bruce Herbold of EPA to describe the hydrological/biological processes affecting bay shrimp in the San Francisco Bay-Delta. There are two series of DWRSIM flow data: the first constructed under assumptions consistent with SWRCB's Decision 1485 and 7.1 MAF demand, the second constructed under assumptions consistent with EPA's proposed regulations to maintain the health of the San Francisco Bay-Delta and 7.1 MAF demand

We turn now to biological/economic processes. Currently, these shrimp are not used as food due to the high labor cost of processing (Miller 1986) and because most U.S. citizens prefer eating much larger shrimp (Herbold, et al. 1992). However, a large commercial fishery for Bay shrimp thrived from the late 1800's to the mid-1900's (Table 2.49). During this period, from 200 to 2000 tons of Bay shrimp were dried and exported to China each year, but political upheaval there in the late 1930's led to the abandonment of this fishery. In 1965 a Bay fishery for shrimp was reestablished to provide bait for striped bass and sturgeon fishers (Table 2.50). The bait fishery takes approximately 68 to 91 tons of shrimp each year from the Bay (Siegfried 1989, cited in Herbold, et al., 1992). The NMFS (personal communication, July 1993) provided the recent information on catch and value for the Bay Shrimp fishery. In 1992, the total California catch of 109,806 lbs. of Bay Shrimp was worth $394,124. Of this total, 107,367 lbs. worth $384,124 were landed in the San Francisco Bay area. We assume that these value estimates are based on ex-vessel prices.

Mean monthly net Delta Outflow data (supplied by Bruce Herbold, EPA) for the months relevant to calculating the abundance of bay shrimp are presented in Table 2.51. The bay shrimp abundance index is calculated in Table 2.52 for various representative water year types under each of the rules standards under consideration. Results of a regression of bay shrimp landings on bay shrimp abundance index are presented in Table 2.53, based on data presented in Table 2.54. From the preceding information, estimates of bay shrimp pounds landed for various representative water year types under each of the standards considered in this report are presented in Table 2.55. The available data on average price of commercially-caught bay shrimp is presented in Table 2.56.

We are currently waiting for additional data from CDFG that will aid us in calculating the benefits associated estimated changes in the bay shrimp population. This information will be used in Section 4 of this report, where we will estimate the total benefits of EPA's proposed rules.

Increasing the abundance of Bay shrimp may also indirectly benefit other Bay-Delta fisheries. Herbold, et. al. (1992) cite Ganssle's (1966) finding that "[Bay shrimp] are common food items for many fishes of the Bay and Delta, including: striped bass, American shad, green and white sturgeon, white catfish, and Pacific tomcod."

2.4 Pacific Herring Commercial Fishery

2.4.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions

Most Pacific herring (*Clupea harengeus*) (Figure 2.22) spawning in California occurs in a very restricted area of San Francisco Bay near Tiburon Peninsula and Angel Island (Spratt 1981, cited in Herbold et al. 1992). Pacific herring spend much of the first year of their 10-12-year life cycle in the San Francisco Bay and Delta before migrating to sea. Although the herring population in San Francisco Bay was "thriving" (Herbold et al. 1992) as recently as 1991, CDFG marine biologist Frank Henry estimates that herring spawning biomass has recently declined dramatically, from 46,000 tons during the 1991-92 season to 21,000 tons this season (National Fisherman, August 1993a). Reasons include the effects of El Nino during the past two years and the seven-year California drought which severely affected Delta outflows. "A resulting increase in salinity may have profoundly affected the survival of young herring" (Frank Henry, CDFG, quoted in National Fisherman 1993a). Data on new herring recruits this year suggest that the herring stock could rebound by 1995 (Frank Henry, CDFG, quoted in National Fisherman 1993a).

2.4.2 Effects of Other Factors

See the paragraph above.

2.4.3 Benefits

San Francisco Bay supports 90% of the California fishery for Pacific herring roe (eggs) for export to Japan. Up to 22% of the body weight of a mature female consists of roe (Hay and Fulton 1983, cited in Herbold et al. 1992). Approximately 400 boats fish for herring roe under a limited-entry system established in 1977. Non-Californians hold 26% of the herring gillnet permits. California landings reached a high of 11,000 tons in 1982. "Throughout the '80's, in fact, the fishery's ex-vessel value averaged over $1,000/ton for the product and $10 million a year overall. During a typical spawning season, many boats in the fleet grossed $75,000-$95,000 apiece. . . . buyers searched worldwide to replace Japanese and Russian herring stocks that were declining, if not depleted. . . . but worldwide recession and the availability of herring roe from Alaska and Canada has turned prices upside down" (National Fisherman, 1993a).

As a result of the declines in stock and price, "CDFG has proposed shutting down the 1993-94 San Francisco Bay herring roe fishery as a result of the recent drought and the subsequent loss of fresh water inflows into the bay as part of its recommendation for the upcoming season" (National Fisherman, August 1993b). The price of freely-traded herring fishing permits has fallen from $50,000 to $30,000 in the past couple of years.

We are not aware of any studies that establish a relationship between Delta outflows and the survival of young herring. However, to the extent that the proposed regulations improve conditions for the Pacific herring in San Francisco Bay, as yet unquantified benefits in the form of increased catches in the commercial roe fishery would result. The magnitude of these benefits would depend upon future Japanese demand and competition from Alaskan and Canadian herring roe fisheries. Additional benefits might accrue in the form of the enhanced stability, and thus reduced uncertainty, of the fishery.

3. RECREATIONAL AND NON-USE BENEFITS

3.1 Salmon Recreational Fishery

3.1.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions

See the description of salmon life history, population trends, and the effects of inland water flow in Section 2.1.1 of this report.

3.1.2 Effects of Other Factors

Many of the effects of factors other than water on the salmon population are described in Section 2.1.2 of this report. In addition, the effects of regulations and El Nino events on the recreational fishery are described below.

The salmon recreational fishery consists of two parts, an ocean recreational fishery composed of both charter (for hire) sport fishing boats and private sport fishing boats, and an inland recreational fishery composed both of pier and shore anglers and private sport fishing boats. Regulation of these two recreational fisheries (ocean and inland) will directly affect the salmon population, and thus recreational catches and consumer surplus, but it will also indirectly affect commercial catches when total (recreational plus commercial) catch is constrained by a catch limit or an escapement target.

The ocean recreational fishery is regulated by PFMC and CDFG. A summary of PFMC ocean recreational fishery regulations is presented in Table 3.1. PFMC regulates the ocean recreational fishery by specifying a limited fishing season, setting an overall catch quota, specifying a daily bag (catch) limit, specifying certain gear restrictions (barbless hooks), and setting regulations for geographical areas of special concern. CDFG regulates the ocean recreational fishery within state waters. CDFG regulations generally follow PFMC regulations by specifying fishing seasons, daily bag limits, gear restrictions, and geographic areas of special concern. However, CDFG does not set overall season catch quotas but does set minimum size limits for some species, including a minimum size of 20 inches for salmon. In addition, CDFG requires that anyone 16 years or older must purchase a sport fishing license. Fish caught using this license may not be sold.

The inland recreational fishery is regulated by CDFG (CDFG, 1992-1994 California Sport Fishing Regulations). First, anyone 16 years or older must purchase a valid sport fishing license. Fish caught using this license may not be sold. For each salmon caught, anglers must fill out a "punch card" specifying the month, day, area, and species caught and send the card to CDFG. Inland waters are regulated by geographical area, each area having its own fishing season, time of day for legal fishing, bag limit, and possible gear and bait restrictions. We emphasize that any fishery benefits resulting from EPA's proposed standards will by mediated by any changes that might occur in fishery regulations. If fishing regulations were to be relaxed, then the short-run benefits of any increases in fish populations in terms of increased catches and increased consumer surplus might be larger, but the long-run benefits in terms of a larger, more stable, and genetically secure fish stock might be smaller. On the other hand, if fishing regulations were to be tightened, we might enjoy the smaller short-run benefits but larger long-run benefits.

Korson (1984) documents the effects of El Nino on the California ocean recreational salmon fishery in 1983. Charterboat trips dropped 25% in 1983, an El Nino year, compared to 1982. Such effects exemplify the exogenous, natural shocks that are not included in our

C-110509

model but that would affect the California salmon harvest and would thus modify the benefit estimates derived under our equilibrium assumptions.

3.1.3 Benefits

The recreational fishery for salmon can be divided into the ocean recreational fishery and the inland recreational fishery. We first discuss participation and catch in the ocean recreational fishery. Next, we turn to participation and catch in the inland recreational fishery. Finally, we discuss estimates of the economic values associated with participation and catch in recreational fishing.

Every five years, USFWS conducts a national survey of fishing, hunting and wildlife associated recreation. The survey focuses on recreation by people aged 16 and over. The results for California in 1985 are summarized in Table 3.7. The Mitchell and Wade (1991) estimates are broadly consistent with these data, when one allows for the difference in age coverage and the fact that Mitchell and Wade cover just freshwater recreation. USFWS data show that non-residents account for about 5.3% of the 55.8 million days of fishing that were estimated to occur in California in 1985. Apart from problems with the sample coverage and survey methodology, the main limitation with these federal and state surveys of recreation by Californians is that they don't tell us *where* in the state the recreation took place—this is not included in the surveys. In effect, they give us information by origin but not, simultaneously, by destination. This is unfortunate for two reasons. First, without having origin-destination information, one cannot estimate travel-cost models of recreation demand, which are used to generate estimates of the consumer's surplus per unit of recreation activity. The absence of such data has severely limited the number of activities for which estimates of use values in

California are available. Second, because we don't know where the recreational activities take place, it is harder to trace the links between changes in water quality conditions and changes in human uses of the estuary.

There is a variety of other less complete and more piecemeal information on water- and wildlife-oriented recreation in California, some of which provides information on participation by destination but generally not by origin. The main activities for which data are available are saltwater fishing, recreation at beaches, freshwater reservoirs, and other public facilities where the authorities collect attendance data.

Data on participation in saltwater sportfishing are collected by CDFG for party/charter boat fishing and by NMFS for all fishing modes. NMFS systematically collected data on West Coast fishing by origin (and, to a lesser extent by destination) each year from 1979 to 1990. These surveys were supplemented in 1985-86 in Northern California (and in 1989 in Southern California) by some special surveys aimed at collecting additional economic information. The Northern California Bay Area Sportfish Economic Study (BASES) covered saltwater fishing during July 1985 through June 1986 by anglers residing in nineteen Central and Northern California coastal counties. Unfortunately, the data from these various sources—CDFG, the regular NMFS surveys and the BASES survey—do not match up very well. Because of its relative completeness of coverage, we have chosen to focus on the BASES survey, some of whose results are reproduced in Table 3.8. This shows that anglers from these counties took almost 2.5 million saltwater fishing trips (which represents only a subset of the fishing trips at saltwater sites in Northern California—and none of the freshwater trips). Of these trips, about 919,630 (38%) were for salmon or striped bass, sometimes in combination with other species. The choices of target species suggest that the vast majority of saltwater fishing trips by Northern California anglers take place in Northern California waters—and this is confirmed by the regular NMFS surveys, which show very little fishing in Southern California by Northern Californians, and vice versa.

Table 3.2 presents data on the ocean recreational salmon fishery collected by PFMC (1993). The number of recreational angler trips per year dedicated to salmon fishing fluctuates around 130,000, with annual catch for the fishery averaging 108,000 salmon. There is no apparent trend in fishing success of approximately 0.84 fish caught per angler trip. Since 1987, the number of charter sport fishing boats in Northern California has averaged 130 boats. We are not aware of any data on the number of private sport fishing boats in search of salmon, but this number is surely substantial. The abundance index data will be described later.

We assume that fishery managers give ocean recreational catch priority over ocean commercial catch and that ocean commercial catch is determined residually by:

Ocean Commercial Catch = Total Ocean Catch - Ocean Recreational Catch

This allows us to assume that ocean recreational catch is not constrained by ocean commercial catch.

Focusing on the determinants of ocean recreational catch and angler trips, Andrews and Wilen (1988) examined the responsiveness of these two variables to fishing success. They estimated both an aggregate angler effort (number of anglers fishing) function and a catch (or harvest) function. Aggregate angler effort is hypothesized to be a function of expected success and an exogenous time trend, where expected success is measured as mean catch per angler day. Andrews and Wilen's findings suggest that aggregate angler effort is responsive to recent success. The elasticities for several ports of aggregate angler effort with respect to changes in an index of stock abundance follow:

Port	Elasticity	% Tot. CA Trips
San Francisco	0.50	30.05
Sausalito	0.35	31.69
Emeryville	0.41	9.04
Berkeley	0.12	13.12

Andrews and Wilen further hypothesized that aggregate catch (or harvest) in a given port in a given week is a function of aggregate angler effort and a fish abundance index. Their findings suggest that catch is affected by aggregate angler effort with an elasticity > 1:

Port	Elasticity	% Tot. CA Trips
San Francisco	1.38	30.05
Sausalito	1.50	31.69
Emeryville	1.23	9.04
Berkeley	1.07	13.12

They note that harvest/angler elasticity is higher in the fisheries close to urban areas (e.g., San Francisco, Sausalito, Emeryville, Berkeley) and speculate that "increasing marginal product may be due to searching and information sharing behavior which is more efficient with more numbers." Andrews and Wilen conclude:

> In practice, management agencies allocate marginal increases in abundance proportionately to targeted groups (sport and commercial fishermen). . . .
>
> . . . current management practices . . . estimate the upcoming season's angler trips by 'dividing the number of fish available for harvest by the (previous year's) catch rate' (PFMC 1986:19). This procedure (ignoring the fact that it confuses causality among these relationships) appears to assume that catch per unit effort is a constant and that we may, therefore, use this constant to estimate this year's [effort] if we simply divide it into this year's sportfishing allocation. . . .
>
> . . . this amounts to a belief that effort is proportional to abundance. . . .

> . . . from our results . . . we would predict effort to respond somewhat, but less than proportional, to changes in abundance allocated to sportfishing . . . hence current management procedures overestimate both the economic gains from abundance increases and the economic losses from abundance decreases.

In the spirit of Andrews and Wilen, we run two regressions to determine the responses of ocean recreational catch and trips to an index of salmon abundance:

(1) ln(Trips) = 1.68474 + 0.49363*ln(Abundance Index)
(1.34) (2.51)

N = 22 yearly observations (1970-1992)
R^2adj. = 0.20
probF = 0.02

(2) ln(Catch|Trips) = -2.1884 + 0.94063*ln(Trips) + 0.3602*ln(Abundance Index)
(-2.21) (5.57) (2.11)

N = 22 yearly observations (1970-1992)
R^2adj. = 0.74
probF = 0.000

where

Trips = The annual sum of charter boat and private boat angler trips for San Francisco and Monterey. (units = thousands of trips)

Abundance Index = The annual sum of California Central Valley chinook salmon spawning escapement, the ocean commercial catch of chinook salmon landed at San Francisco, and Monterey, and the ocean recreational catch of chinook salmon landed at San Francisco and Monterey. (units = thousands of fish)

Catch = The annual ocean recreational catch of chinook salmon landed at San Francisco and Monterey. (units = thousands of fish)

We present our estimates of equilibrium ocean recreational salmon fishery catch and trips for each scenario in Table 3.3, along with the equilibrium salmon ocean abundance indices used in their calculation. Note that while Andrews and Wilen analysis uses weekly data and generates short-run, or weekly, elasticities, our analysis uses annual data and generates long-

C-110514

run, or seasonal, elasticities. In contrast to the usual case, where short-run elasticites are smaller than long-run elasticities, here we would expect short-run elasticities to be larger than long-run elasticities. We expect this because the short-run, weekly elasticities would pick up not only changes in season-average effort and catch but also any reallocations of effort and catch within a fishing season. Nevertheless, there is little difference between our estimates and those of Andrew and Wilen.

Inland salmon catch is composed entirely of recreational catch; by law there is no inland commercial catch of salmon. We assume that a river reach-specific fraction of the salmon passing through or spawning in each reach is caught by anglers. We avoid the problem of determining how this fraction would change with escapement or catch by relying on an assumption of constant escapement. Constant escapement follows from our assumptions regarding the management of the ocean fishery.

PFMC (1993) reports 28,200 salmon as the estimated inland recreational salmon catch in the Sacramento River basin for 1992. An estimated 487,500 angler hours were expended in pursuit of these salmon. Using Loomis and Ise's (1992) estimate of 3.5 angler hours per day user fishing trip and assuming that the vast majority of fishing trips are day trips, we calculated the estimated number of fishing trips in 1992 as 487,500/3.5 = 139,286 angler trips. From Table 3.3, we see that the estimate of the equilibrium inland recreational salmon catch from the model of Dumas and Hanemann (assuming a fixed escapement target management strategy for the ocean fisheries, and assuming catch rates in each river reach remain constant at recent, estimated levels given in Dumas and Hanemann) is 21,900 salmon annually, 22.3% less than the estimated catch in 1992. Using an elasticity of inland recreational fishing trips per capita with respect to total catch of 0.328 as per Loomis and Ise (1992), and assuming population remains constant at about the 1992 level, we calculate that the equilibrium number of inland recreational salmon fishing trips is 0.328*22.3% = 7.33% less than the number of trips taken in 1992. Thus, the equilibrium number of inland recreational salmon fishing trips is 139,286*(1-0.0733) = 129,076 annually.

We turn now from data on participation in the recreational fisheries to data on the economic values associated with these activities. In our analysis we choose to focus on the increase in *recreational fishing* value associated with an increase in salmon abundance, because this value is most readily (although not easily) quantified with the available data. Almost certainly, there exist other values associated with the level of the salmon population that would increase with an increase in the population, including existence and bequest values. However, we do not believe that there exist adequate data to reliably quantify such values at this time. For the purpose of measuring the recreational fishing value of a fishing trip or of catch to an angler, a key distinction exists between an angler's expenditure and an angler's consumer surplus. It is the consumers surplus—and not the expenditure—which measures the recreational fishing value of a fishing trip or fish caught to an angler. We will review the available data on both angler expenditure and angler consumer surplus. For the purpose of measuring the overall impact on society's welfare—for producers as well as anglers—it is the change in angler's consumer surplus plus the change in society's personal income that should be measured. Thus, what is relevant from society's point of view is not total expenditure per trip, but rather the personal income component of expenditure. Unfortunately, however, the personal income component of expenditure is not separately identified in the data that are currently available. We will present arguments for why EPA's proposed standards will likely not result in significant changes in society's personal income.

Available expenditure data for a range of recreation activities are summarized in Table 3.4. After adjusting the figures in Table 3.4 for inflation, these expenditures range from an average of around $10/trip for beach use to around $90/trip and more for charter boat fishing and hunting.

The King and Flagg input-output analysis of California fisheries did not consider California's recreational fisheries. Carter and Radtke (1986) compare the relative coastal community value in Oregon of commercially caught salmon to that of recreationally caught salmon.

Tables 3.5 and 3.6 present Carter and Radtke's estimates of ocean charter boat costs per fishing day and angler expenditures per fishing day. Assuming California's recreational fishery is similar, we see that fixed costs for moorage, insurance, booking commission, license, fees, and taxes account for approximately 24% of total costs. This does not include the capital expenditure, interest, and depreciation components of fixed costs, which, unfortunately, are not given. Twenty-one percent of gross revenues remain to cover these missing elements of fixed costs. Crew wages and skipper salary comprise 36% of total costs.

From Table 3.6 we see that daily angler expenditures depend on whether the angler provides his own boat or takes a charter boat trip. An angler taking a charter boat trip spends about 30% more per day. The entire difference in expenditure is estimated to go to the charter boat operator.

Expenditure on goods complementary to a fishing trip is significant; 16-24% of total angler expenditure is made in restaurants, and 15-20% is made for lodging. While these expenditures would probably increase in the Bay-Delta region if additional recreational fishing trips were made, there would probably be little net increase in such expenditures at the state level, because fewer expenditures would be made on alternative recreational activities elsewhere in the state. However, local or regional shifts in expenditure might be significant. Another potential source of such geographic shifts in expenditure is the regulatory allocation of the catch between the inland recreational fishery and the ocean fisheries. With inland sport fishermen taking up to 50% of the immigrating salmon in some river reaches, ocean fishermen complain that too few fish survive to spawn. Inland fishermen say that commercial fishermen get more than their fair share. Shifts in the allocation of the catch between these two user groups would be another source of local or regional shifts in expenditure by fishermen on complementary goods like food and lodging.

With regard to estimates of the consumer's surplus associated with recreational fishing trips, these can be estimated using either the travel cost method or the contingent valuation method.[12] Both methods require the collection of special data and for the most part, unfortunately, such data have not been collected in California. Perhaps the main exception is saltwater sport fishing, where NMFS supplemented its regular surveys with special surveys in 1985 and 1986 in Northern California (and in 1989 in Southern California) aimed at collecting additional economic information. The Northern California survey focused

[12] For discussions of the travel cost method see, for example, Fletcher, et al. (1989), McConnell (1985), and Smith (1989). For discussions of the contingent valuation method see, for example, Carson (1991), Carson and Martin (1991), Mitchell and Carson (1989), and Burness et al. (1991).

specifically on anglers fishing for striped bass and salmon; the data were analyzed by Huppert (1986,1989) and Huppert & Thompson (1987). Using the travel cost method, they estimated the consumer's surplus per boat fishing trip for salmon and striped bass was about $61/trip. These figures are highly consistent with other estimates based on similar data for other years in California and elsewhere along the Pacific coast, which generally fall in the range of $60-90 per trip. Both from the demand model and from a separate contingent valuation question, they estimated how much anglers would be willing to pay to avoid a 50% *reduction* in the catch of salmon and striped bass and, conversely, how much they would be willing to pay to obtain a 100% *increase* in the catch of salmon and striped bass. The current average catch was about 8 fish per year, or 1.35 fish per trip, so that these changes would translate on average into a reduction of 4 fish or gain of 8 fish caught per year. The travel cost estimates were about $100 per angler to avoid the loss and $163 per angler to secure the gain—these translate crudely into a value of $25 per fish lost or $20 per fish gained. The contingent valuation estimates were lower—$32 per angler to avoid the loss ($8/fish) or about $45 per angler to secure the gain ($5/fish). In 1980, CDWR conducted a survey of anglers along the Sacramento River. These data were subsequently analyzed by Loomis and Ise (1992), who obtained an estimated average consumer's surplus of about $17/trip. There are a few scattered data sets from creel surveys conducted in the Sierras by CDFG in the early 1980's; one such data set for the Feather River was analyzed by Cooper and Loomis (1990), who obtained an estimate of average consumer's surplus of about $24/trip. In all of these cases, these data are of limited geographic coverage and poor quality; in particular, they are not capable of providing a reliable accounting of how substitutability among alternative sites

C-110519

might affect consumer's surplus values.

In this report, we value the consumer surplus from ocean recreational fishing trips for salmon at $61/trip and from inland recreational fishing trips for salmon at $20/trip. Benefits associated with estimated changes in the number of recreational fishing trips are presented in Table 4.1 for an Above Normal water year and Table 4.2 for a Critically Dry water year.

3.2 Striped Bass Recreational Fishery

3.2.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions

Callahan, Fisher, and Templeton (1989) conducted a review of striped bass (*Roccus saxatilis*) (Figure 3.1) biology and population trends in California. We present the following excerpts from their much longer work:

> The adult striped bass is a large fish, ranging up to forty or more pounds, with the average catch around six to ten pounds (Albert, 1987). . . . Striped bass are voracious predatory fish that, as Raney (1952) summarizes, will eat 'practically every marine form found in the San Francisco Bay area.' That includes crabs, clams, and every kind of fish of a suitable size. . . . Hedgepeth and Mortensen (1987) mention that the most common prey of adult bass are shad and young striped bass. . . . Males are mature at 2 to 3 years and about 10 inches in length while females mature later at 4 or 5 years and around 16 to 18 inches (Raney, p.34). They grow to be more than 4 feet long and over 40 pounds. The adult bass follow an annual cycle of migration (Chadwick, 1967). They spend the summer feeding in San Francisco Bay and the nearby areas of the Pacific Ocean. Apparently, the cold California current keeps these bass from undertaking the extensive ocean migrations that have been seen in Atlantic Coast striped bass. In the fall they begin to migrate into fresh water, with many of the adults passing through the San Pablo Bay-Carquinez Strait areas and then spending the winter in the Delta (but not all - adult bass do not necessarily spawn every year). In the winter they are present in the Delta (as shown by net surveys) but are relatively inactive, and they are seldom caught by fishermen. In the spring, as water in the inflowing Sacramento and San Joaquin Rivers warms up, the bass swim upstream to spawn. In the Sacramento River the peak of spawning occurs around 100 miles up river. The spawning run up the San Joaquin River is blocked by salinity in the river from agricultural return flows, so the spawning is limited to the lower reaches that receive fresh water due to cross-Delta flows of Sacramento River water drawn

toward the export pumps at Tracy (Radtke and Turner, 1967). Most spawning in the San Joaquin River occurs in the broad channels between Antioch and Venice Island (see Figures 3.2 and 3.3 for a depiction of the Delta and spawning migration). After spawning, the adults return to the salt waters of San Francisco Bay and the ocean.

The fecundity of female striped bass ranges from around 250,000 eggs per newly mature female to over 1 million eggs from an 8-year or older bass (Wang, 1986). Estimated annual production in the San Francisco Bay system is in the order of several hundred billion eggs. The eggs are nonadhesive and slightly more dense than water, so the eggs and newly hatched larvae drift downstream with the bottom currents. Where they reach the entrapment zone, they accumulate. The eggs generally hatch in two days, and the infant bass are about 3 millimeters long. After hatching, the larvae depend on yolk sac absorption until they reach about 6 millimeters in length. They then begin feeding on the smaller zooplankton. Their mobility is limited at this stage, so survival is dependent on the presence of adequate food nearby. Later on, as the larvae grow, they tend to prey on *Neomysis*. But at this early stage, *Neomysis* may prey on the larval bass (Wang). The combination of spawning habits and hydrology leads to two major striped bass nursery areas -- the western Delta and Suisun Bay.

Evidence presented by CDFG (1992a, 1992c, 1992g, 1992h) in testimony before the SWRCB indicates that after nearly a century of population stability at around 3 million adult bass, the striped bass population began to decline 15 to 20 years ago. Mark-recapture estimates of the Sacramento-San Joaquin Estuary adult striped bass population have declined from around 1,600,000 in the first half of the 1970's, to around 1,000,000 from the late 1970's and throughout the 1980's (CDFG 1992a). In 1990, the adult striped bass population fell below 600,000, a level less than one-third the historical average (Figure 3.4) (CDFG 1992c). "Estimates of the abundance of 3-year old fish, which are the youngest and most numerous component of the adult population, have been declining and were at record lows in 1990" (Figure 3.5) (CDFG 1992a). Although striped bass abundance indices seemed to rebound in 1991, "1991 estimates are not as reliable because . . . they are based on an inadequate recapture sample of only two tags . . . a . . . reasonable conclusion is that the 1991 population is at about the same level as the 1990 population" (CDFG 1992a). Three distinct population indices have shown this decline: Petersen mark-recapture indices, catch per effort indices, and the young-of-the-year index.

The extensive data base on the striped bass population indicates that the adult population has declined primarily due to three factors: reduced Delta outflow, increased Delta exports, and fewer eggs available to replenish the population (SWRCB 1993). CDFG (1992a) believes that "there has been an increase in death rate (decrease in the survival rate) predominately during the first year of life and caused mainly by increased losses of fish entrained in water exports by the State and Federal Water Projects . . . The relationship between young striped bass abundance, outflows and water diversion rates from 1959 to 1976 . . . is the basis for the striped bass outflow standards and water export limitations mandated in Decision 1485." However, since 1977, although *survival* between the egg stage and the 38-mm stage has not declined, the 38-mm young striped bass *abundance* index has consistently fallen below expectations. The decreased abundance at the 38-mm stage is thought to be the result of fewer *eggs* entering the system. CDFG contends that there are fewer eggs, because there are fewer adults, and that there are fewer adults, because striped bass survival *has* decreased between the 38-mm stage and the stage at which striped bass recruit to the reproductive population, which occurs at age 3. CDFG further contends that survival has decreased between the 38-mm stage and recruitment at age 3, because a greater proportion of these fish are being entrained in water export pumps in the Delta. CDFG cites as evidence the substantially increased losses of fish that occurred at the pumps when exports increased due to initiation of the State Water Project and the San Luis Project during the 1970's.

The SWRCB (1993) summarized the predicted effects of its (now shelved) Decision 1630 regulations on the striped bass population, as analyzed by CDFG's striped bass population model, as follows:

> CDFG striped bass model predicts that the [SWRCB Decision 1630] standards should stop the decline of striped bass and maintain the wild population at approximately 730,000 adults if transfers do not occur (D-1630-P). The wild population could fall to 710,000 adults if transfers are maximized (D-1630-T). [Although] the CDFG model relationship is based on data from more than twenty years, . . . only a few data points are included which correspond to the levels of exports recently seen, and which are expected to be present in many wetter years in the future. The accuracy of the predictions of the CDFG model at the extreme end of its range is limited. [These model results], like all model results, should be viewed with appropriate caution.
>
> The present adult abundance may continue to decline for the next several years because the effects of the last three years of drought (1990-1992) have not yet been reflected in the adult population statistics. . . . The YOY index, however, should increase in response to the proposed standards [whether or not water transfers occur] because transfers will occur after July and the YOY index is usually set by that time.[13]

CDFG's YOY indices have lost a large degree of explanatory power in the years since the major drought of 1976-77. Several explanations have been offered for the change. The simplest one is that the adult population had declined sufficiently to cause a reduction in the production of eggs. Hanemann and Fisher (1992) use a modified version of the STRIPER simulation model, as developed by Professor Lou Botsford and his associates at the University

[13] The CDFG's young-of-the-year (YOY) index is an annual index of the production of young striped bass. The YOY actually consists of two parts: the Suisun Bay index (SYOY) and the Delta index (DYOY). The CDFG has calculated the YOY indices for 30 years.

of California, Davis, to look at the relationships between water flow parameters and the production of striped bass. Hanemann and Fisher hypothesize that changes in water flows have reduced the adult striped bass population to the point where egg production has declined, and that this explains the changes in the YOY index since 1976-77. Hanemann and Fisher model the SYOY and the DYOY separately. The data support the notion that quite different flow parameters affect these two sub-indices. The SYOY appears to be related to the level of outflow in the spring from the Delta into Suisun Bay, whereas the DYOY appears to be related to the level of water exports from the Delta to the major canal systems. CDFG has tended to favor increased outflow over decreased exports as a means of promoting the production of striped bass, since the production of SYOY has been a more reliable indicator in recent years than has DYOY.

Hanemann and Fisher's simulation results suggest that a reduction in exports will have a greater impact on the overall level of the striped bass population. However, this result is sensitive to the estimated relationship between the YOY indices and the population of adult bass 3 or 4 years later.

3.2.2 Effects of Other Factors

The first possible alternative factor to water flows, diversions, and exports as a cause of the decline in the striped bass population is recreational fishing pressure. The striped bass recreational fishery may be divided into the ocean recreational fishery and the inland recreational fishery. We will focus on the inland recreational fishery, because that is where the large majority of striped bass are taken. There is no commercial fishery for striped bass.

The striped bass recreational fishery catch has ranged from a high of perhaps 800,000 in the early 1960's to between 100,000 to 200,000 since the late 1970's (CDFG 1992a). CDFG angler surveys indicate that about 1.5 million angler days of fishing effort were expended fishing for striped bass in the early 1970's. Such information from CDFG is not available for recent years. Results from the BASES study, conducted from July 1985 through June 1986, indicate that Northern Californians made 456,907 trips to fish for striped bass, either exclusively or in combination with other target species (Thompson and Huppert 1987). Approximately 7% of these trips were made in charter boats, 60% were made in private boats, and the remaining 33% were shore fishing trips. The total number of trips is probably a lower bound, because additional fishing for striped bass occurs in freshwater areas and because fishers from out of state were not included in the survey.

CDFG (1987a, p.12) calculated estimates of striped bass recreational fishery harvest rates derived from tagging studies conducted from 1958 to 1985. The estimated harvest rates fluctuated between 10% and 25% per year, with years of low harvest rates often occurring during years of high estimated natural mortality and vice versa. CDFG reports that recent tagging programs estimate the striped bass recreational fishery harvest rate (adult striped bass caught / total adult striped bass population) at 9-13% (Delisle 1993).

Both the inland and the ocean recreational fishery for striped bass are regulated by CDFG (1993). First, anyone 16 years or older must purchase a sport fishing license. Fish caught using this license may not be sold. Inland waters are regulated by geographical area, each area having its own fishing season, time of day for legal fishing, bag limit, and possible gear and bait restrictions. Currently, there is no season restriction on fishing for striped bass,

C-110525

however, there is a bag limit of 2 per day and a minimum size limit of 18 inches. In addition, in the ocean fishery, striped bass may not be taken with any type of powered fishing gear. We emphasize that any fishery benefits resulting from EPA's proposed standards will be mediated by any changes that might occur in fishery regulations. If fishing regulations were to be relaxed, then the short-run benefits of any increases in fish populations in terms of increased catches and increased consumer surplus might be larger, but the long-run benefits in terms of a larger, more stable, and genetically secure fish stock might be smaller. On the other hand, if fishing regulations were to be tightened, we might enjoy the smaller short-run benefits but larger long-run benefits.

Other alternative factors have been investigated as possible causes of the decline in the striped bass population. The primary candidates are food availability and pollution. With respect to food availability, CDFG (1992a) reports: "We have used several approaches to evaluate whether or not the survival rate has declined [due to a decline in food availability] . . . there has not been a persistent unexplained decline in this rate." Further, "The food explanation for the dependence of YOY on flows is discounted by the lack of starving larvae" (CDFG 1992h). Turning to pollution, CDFG reports (1992a): "Due to restrictions on rice field water management, the amounts of herbicides and insecticides discharged to the Sacramento River have decreased substantially as a result of the Department of Pesticide Regulation Program. . . .One would expect to see a substantial recent rebound in the young striped bass abundance index, particularly in 1992. Yet, the 1991 index of 5.5 was the fourth lowest of record and consistent with expectations based on CDFG's model . . . Evidence in support of the pesticide hypothesis is not compelling . . ." However, CDFG's "findings do not discount toxicity as a potential source of 'background' striped bass mortality." In summary, CDFG (1992a) states: "We do not want to imply that other factors such as toxicity or illegal fishing are not potentially significant . . . The evidence, however, is that effects of these other factors have not changed in the persistent manner required to account for the major downward trend in striped bass abundance."

As a final note, Hanemann and Fisher (1992) note that hatchery production of striped bass is in its early stages. CDFG estimates that currently approximately 13% of the striped bass recreational catch is of hatchery origin (Delisle 1993). However, we are unaware of any studies investigating the potential effects of hatchery production on striped bass population abundance or its interaction with water management activities. Thus, at this time, the potential effects of this factor are unknown and not included in our analysis.

3.2.3 Benefits

We begin with a short excerpt from Callahan, Fisher, and Templeton (1989) on the history of the striped bass fishery in the San Francisco Bay area:

> The striped bass was introduced to the Bay in 1879, and an important commercial fishery developed in a surprisingly short time. From 1890 to 1915, the annual catch was around 1 million pounds. The catch gradually fell off to about half that amount by 1935 when the commercial fishery was ended in order to protect the striped bass for sport fishing (Smith and Kato 1979). By the 1960's, most striped bass fishing had shifted to north San Francisco Bay. Raney (1952) considered that the population had stabilized, at least through the late 1940's. The annual sport catch now ranges from 100,000 to 400,000 bass.

There is currently no commercial fishery for striped bass, and very little information is available about sportfishing for striped bass. Focusing on the recreational fishery for striped bass, in addition to the information presented in Section 3.1.3 that also applies to striped bass, we use the results of sensitivity analyses performed on striped bass population models developed by CDFG (reproduced in Table 3.9) to estimate the population of striped bass adults resulting from estimated changes in Net Delta Outflow for several water year types under the alternative water quality standards (Table 3.10) with exports held constant and an assumed Decision 1485 baseline population of adult striped bass of 1 million. The results are presented in Table 3.11. These results will be used in Section 4 of this report, where we will estimate the total benefits of EPA's proposed standards.

In our analysis we use the results of CDFG's striped bass population model (CDFG 1992c) to estimate the change in the striped bass population associated with the changes in Net Delta Outflows expected to result from EPA's proposed standards. We take 1 million striped bass as our baseline population, because this figure approximates the striped bass population level from the late 1970's through the late 1980's, and because this is one of the baseline figures considered in CDFG study. Although this number is larger than the recent population estimates of around 600,000 , we believe that it more closely matches the long-term "average" striped bass population under average D1485 conditions. We believe that the recent low population estimates are due to the recent extended drought and that when the drought is over the population would return to around 1 million under D1485 conditions.

We take 500,000 as our conservative estimate of the annual number of fishing trips taken for striped bass, either exclusively as a target species or in combination with other target species. We base this estimate on the results of the 1985 BASES survey of saltwater fishing in Northern California analyzed by Thompson and Huppert (1987). We are not aware of any more recent data on this key variable. Thompson and Huppert estimate that fishers made 456,907 saltwater fishing trips for striped bass both exclusively and in combination with other target species in 1985. Adjusting this estimate for population growth and the significant amount of freshwater striped bass fishing that occurs during the striped bass spawning run up the Sacramento River (Stevens 1993), we arrive as 500,000 trips as a reasonable baseline estimate.

The only data supplied to us concerning the differential effects of EPA's proposed standards in contrast with the D1485 standards are changes in water flows. We find that the percent increase in average Net Delta Outflow in April through July associated with EPA's proposed standards would be zero in a Wet water year (using 1963 as a representative Wet water year)[14] and approximately 50% in a Critically Dry water year (using 1976 as a representative Critically Dry water year)[15] (Table3.9). We use the data on changes in average Net Delta Outflow in April through July together with the results of a sensitivity analysis of CDFG's striped bass population model (Table 3.10) to estimate the change in the striped bass population resulting from EPA's proposed standards (Table 3.11). This procedure implicitly holds constant both the level of average Net Delta Outflow in August through December and the level of exports from the Delta. From the background information on striped bass ecology reviewed in Section 3.2 of this report, it seems apparent that changes in Delta exports are an important determinant of striped bass abundance. Unfortunately, we

[14] We use 1963 as our representative wet water year because the DWRSIM flow data supplied by EPA gives flow values under Decision 1485 conditions that closely approximate the wet water year baseline flow used in CDFG's striped bass model sensitivity analysis.

[15] We use 1976 as our representative critically dry water year because the DWRSIM flow data supplied by EPA gives flow values under Decision 1485 conditions that closely approximate the critically dry water year baseline flow used in CDFG's striped bass model sensitivity analysis.

have no data on the differential effects of EPA's proposed standards on Delta exports. If EPA's proposed standards would result in significant changes in Delta exports, then the differential effects on the striped bass population might be significantly different from our estimates.

Turning to economic valuation of the estimated increase in the striped bass population, although some of the information presented in Section 3.1.3 on the salmon recreational fishery also applies to striped bass, in general we find less data available for the striped bass recreational fishery. Most importantly, we do not have the data required to estimate the *response* of striped bass fishing effort (i.e., number of trips) to *changes* in the striped bass population index, as we did for the salmon recreational fishery. Because of this increased uncertainty, we develop two estimates of the value of the estimated increase in the striped bass population, a value at the lower end of the range of reasonable estimates and a value at the upper end.

3.2.3.1 Low Value Scenario

In developing our lower value estimate, we first assume that the estimated marginal change (~10%) in striped bass abundance would have little effect on the number of fishing trips made in the Sacramento-San Joaquin Delta and San Francisco Bay. We next assume that the estimated marginal change in abundance would have little effect on the average "catchability" of striped bass. While it is known that the number of recreational fishing trips varies with "fishing success" (expected number of fish caught), and that fishing success depends upon the level of the striped bass population and its spatial concentration, the point in the spawning cycle, and natural factors such as the turbidity of the water (Stevens 1993), we have no quantitative way to estimate the size of these relationships directly at this time. In addition, there are at least two possible reasons why the *change* in the number of fishing trips might be small with a marginal change in the striped bass population, (1) much of the consumer surplus associated with a fishing trip resides in relaxation and/or socializing and does not depend on small changes in the number of fish actually caught and (2) other fish species would be sought and caught in the absence of striped bass. Instead, given our estimate of the change in striped bass abundance, we estimate the change in striped bass recreational fishing catch as 11% of the change in abundance. The 11% figure is the midpoint of the 9%-13% range of recent CDFG striped bass recreational fishery harvest rate estimates. We specify a constant harvest rate by assuming (1) that the number of trips does not change and (2) that the average "catchability" of a striped bass does not change with a change in the population level (at least over the range of population changes that we are considering here). The estimated small change in striped bass abundance (up to +10.1%, see Table 3.11) and the relatively small harvest rate (11%) result in the small change in recreational fishing *catch* (up to +10.1%) reported in Tables 4.1 and 4.2.

Using both the travel cost method and the contingent valuation method to analyze data collected in the BASES survey, Huppert (1989) and Thompson and Huppert (1987) found that the willingness to pay for an increase in the catch of salmon and/or striped bass ranged from $5/fish (contingent valuation method) to $20/fish (travel cost method). Assuming that a significant portion of each of these value estimates should be allocated to the more highly prized salmon, and wishing to be conservative in our estimation, we choose $5/fish as the increase in consumer surplus associated with catching one more *striped bass* on a fishing trip.

In principle, the increase in economic value associated with recreational fishing trips for striped bass in the presence of an increased striped bass population is the sum of two parts: (1) the increase in society's personal income resulting from the increase in expenditures made on an increased number of striped bass fishing trips and (2) the increase in consumer surplus derived from striped bass fishing trips. Because we have assumed no change in the number of trips in this scenario, there would be no change from the baseline in the *personal income components* of economic value. However, because fishers value fishing trips *more* if they are able to catch more striped bass, there would be an increase above the baseline in the *consumer surplus component* of economic value.

Estimates of striped bass catch and associated consumer surplus value under each of the alternative water year scenarios are presented in Tables 4.1 and 4.2. The estimated small change in striped bass catch together with the relatively small economic value per striped bass and the assumption of no change in the number of trips results in the small economic value attributed to the change in the striped bass abundance associated with EPA's proposed standards under the low value estimate scenario.

Significant differences in Delta exports from those assumed in CDFG striped bass population model baseline scenarios might significantly alter the estimates of the change in the striped bass population and thus alter the estimates of economic value. Significant existence, bequest, or "preemptive delisting" benefits might also significantly alter the economic value estimates.

3.2.3.2 High Value Scenario

In contrast to the Low Value Scenario, we now assume that the number of striped bass fishing trips *is* affected by the estimated change in the striped bass population to result from EPA's proposed standards, and we assume a relatively high value for the consumer surplus associated with a striped bass fishing trip.

Assuming that striped bass fishers respond to changes in the estimated striped bass population when planning sport fishing trips for striped bass in ways similar to those of salmon fishers with respect to the salmon abundance index, we use our estimate of the elasticity of ocean recreational fishing trips for salmon with respect to changes in the salmon abundance index, elasticity = 0.49363, to describe the percent change in striped bass fishing trips due to a one percent change in the estimated striped bass population.

We value the consumer surplus resulting from any change in the number of trips using a figure of $61/trip as estimated by Thompson and Huppert (1987) for Northern California saltwater sport fishing for salmon and striped bass. The true value for fishing exclusively for striped bass is probably lower, because striped bass are less highly valued than salmon and the $61/trip consumer surplus estimate applies to some "average" fishing trip for striped bass and salmon. Furthermore, the $61/trip consumer surplus estimate is for saltwater fishing, whereas fishing for striped bass occurs in both fresh and saltwater. The evidence presented by Loomis and Cooper (1990) and Loomis and Ise (1992) suggests that the consumer surplus per freshwater fishing trip might be somewhat lower, around $20/trip.

Given the estimated percent change in the striped bass population, we use the elasticity estimate of 0.49363 to find the percent change in the number of striped bass fishing trips. Because the estimated percent change in the striped bass population is zero in a Wet water year, we estimate no change in trips during Wet water years. For Critically Dry water years, we estimate a percent change in trips of 0.49363 * 10.1% = 4.985663%. These additional trips are then assigned a consumer surplus value of $61/trip. We then assume that the increase in the personal income components of economic value arising from the increase in the number of striped bass fishing trips is roughly balanced by a decrease in society's personal income resulting from a decrease in expenditure on alternative recreational activities (for example, trout fishing). While regional shifts in expenditure and personal income might occur (for example, shifts from the mountains to the Bay-Delta), we expect little change in net personal income *statewide* as a result in of changes in the number of striped bass fishing trips.

Estimates of striped bass fishing trips and associated consumer surplus value under each of the alternative water year scenarios are presented in Tables 4.1 and 4.2. The estimates of additional trips and consumer surplus for the Critically Dry water year are probably overestimates, because the baseline number of trips would probably be lower than the value used here in a Critically Dry water year.

Significant differences in Delta exports from those assumed in CDFG striped bass population model baseline scenarios might significantly alter the estimates of the change in the striped bass population and thus alter the estimates of economic value. Significant existence, bequest, or "preemptive delisting" benefits might also significantly alter the economic value estimates.

3.3 Sturgeon Recreational Fishery

3.3.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions

Two species of sturgeon are found in the Sacramento-San Joaquin estuary: the White

C-110534

Sturgeon (*Acipenser transmontanus*) and the Green Sturgeon (*Acipenser medirostris*).

White Sturgeon

White sturgeon (Figure 3.6) spend most of their lives in the Sacramento-San Joaquin Estuary. White sturgeon may live more than 100 years and grow as large as 1,300 pounds. White sturgeon spawn in the Sacramento and San Joaquin rivers, and juveniles rear in the rivers and the Delta, being found farther downstream the greater the flow. CDFG (1992j) has found a strong correlation between an index of year class strength and mean April-July Delta outflow (Figure 3.7). The index of year class strength has declined to very low levels in the past five years (Figure 3.8). "High flows may improve young sturgeon survival by transporting larvae to areas of greater food availability, by dispersing larvae over a wide area of the rivers and estuary to take advantage of all available habitat, by quickly moving larvae downstream of any influence of water diversions in the delta, or by enhancing productivity in the nursery area by increasing the nutrient supply. In addition, adults may experience a stronger attraction to upstream spawning areas in high flow years and spawn in greater numbers" (CDFG 1992j).

Green Sturgeon

Green sturgeon are much less abundant than white sturgeon, forty to one-hundred-and-sixty times less abundant according to CDFG tagging studies. Because green sturgeon are less abundant, less is known about this species, but "it is believed to be declining in abundance (P.Foley, UC Davis)" (Herbold, et al. 1992). It is also known that green sturgeon spawn in the Sacramento River and that juveniles rear in the Delta for four to six years CDFG (1992j).

3.3.2 Effects of Other Factors

White Sturgeon

White sturgeon mature relatively late and may spawn rather infrequently. Thus, they are classic case of a species susceptible to overfishing. Fishing regulations have been tightened in a effort to avoid this potential problem.

Green Sturgeon

Unknown.

3.3.3 Benefits

White Sturgeon

White sturgeon is now an important sport fish. The sport fishing harvest increased rapidly in the 1980's as the populations of other sport fish declined and better techniques for taking sturgeon were developed. The sport harvest exceeded 10,000 fish annually in the mid-1980's, but has declined over the past five years (CDFG 1992j). The proposed regulations may increase the consumer surplus benefits derived from the sturgeon sport fishery through increasing the currently depressed stock of white sturgeon. We are unable to quantify such benefits at this time. To the extent that the proposed regulations increase Delta outflow or stabilize it at a sufficient level, special actions to protect white sturgeon in the future may not be necessary, provided that the regulation of fishing effort is effective. Avoiding the need for future special actions to protect white sturgeon may be an additional, though unquantified, benefit of the proposed regulations.

Green Sturgeon

Though only a minor component of the sport fishery, to the extent that the proposed regulations improve Delta conditions for the green sturgeon, they may eliminate the potential future need for special actions to protect green sturgeon, and this may be an additional, though unquantified, benefit of the proposed regulations.

3.4 American Shad Recreational Fishery

3.4.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions

American shad (*Alosa sapidissima*) (Figure 3.9) were introduced to California in 1871. Most American shad spawn in the mainstem channels of the Sacramento River and its tributaries in late May and June. Many, but not all, of the adults die after spawning. Juveniles rapidly migrate downstream to the Delta, where most juvenile mortality occurs. Most juveniles leave the Delta in late summer. Herbold et al. (1992) discuss the relationship of Delta outflows to American shad survival:

> Stevens and Miller (1983) describe the apparent increase in American shad recruitment in wetter years. Recent data confirm the earlier study. Lower catches of American shad have generally occurred during drought periods . . . The mechanism most likely to explain the linkage of American shad abundance with outflow is that temperatures over 20 C are known to produce high mortality in young shad . . . This effect is likely . . . within the Delta or upstream . . . However, increased entrainment during dry years probably also contributed to the decline.

3.4.2 Effects of Other Factors

The effects of factors other than the recreational fishery itself are unknown.

3.4.3 Benefits

A commercial fishery for American shad existed in Suisun Bay and the Delta until

1957 (Miller 1986). American shad supports an important recreational fishery upstream of the Delta. Estimates of fishing effort for American shad in the early 1970's include 38,000 angler days in the Delta, 35,000 angler days in the Feather River, between 65,000 and 80,000 angler days in the American River, and between 10,000 and 20,000 angler days in the Yuba River (Miller 1986). The total of these estimates is probably a lower bound on fishing effort for American shad since it does not include an estimate of fishing effort on the mainstem Sacramento River and because fishing effort in general for most species has increased since then.

To the extent that the proposed regulations improve conditions for American shad juveniles in the Delta, as yet unquantified benefits in the form of increased catches and consumer surplus in the recreational fishery could result.

3.5 White Catfish Recreational Fishery

3.5.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions

White catfish (*Ictalurus catus*) (Figure 3.10) is an introduced species which has become "one of the most commonly caught fish in the Delta" (CDFG 1992i). Mark-recapture studies estimated the abundance of white catfish larger than seven inches at 5.5 million fish around 1980. Since then, data indicate that the abundance of white catfish has declined severely. Because white catfish spawning areas are in the south and east Delta, and because the screening efficiencies for export pumps located in the south Delta are relatively low for white catfish, "it seems reasonable to hypothesize that . . . losses to water exports have caused the decline in white catfish abundance. The [abundance of] catfish is inversely associated with the increasing trend in water exports." (CDFG 1992i).

3.5.2 Effects of Other Factors

Other than the recreational fishery itself, unknown.

3.5.3 Benefits

In 1980, it was estimated that anglers harvested 18% of the white catfish population larger than seven inches, or approximately one million white catfish annually (Schaffter 1987). We are not aware of any other information on the white catfish recreational fishery. To the extent that the proposed regulations decrease water exports or otherwise improve conditions for white catfish in the Delta, increased white catfish populations and the as yet unquantified, associated angler consumer surplus would be counted as additional benefits.

3.6 Starry Flounder Recreational Fishery

3.6.1 Life History, Population Trends, and the Effects of Bay-Delta Conditions

See Section 2.2.1.

3.6.2 Effects of Other Factors

See Section 2.2.2.

3.6.3 Benefits

Reports of starry flounder fishing in San Pablo Bay date back to the 1800's (CDFG 1992e). Starry flounder were one of the fish species most commonly caught from the Berkeley and San Francisco Municipal piers between 1957 and 1961, however, data from Commercial Passenger Fishing Vessel logs over the period 1964 to 1990 reveal that most of the recreational catch occurs in San Pablo and Suisun Bays. Starry flounder were once the most common flatfish species in San Pablo Bay and were very common as recently as the early 1970's. Large incidental catches of starry flounder were made in the late 1960's and early 1970's by recreational fishermen seeking the popular sturgeon. Beginning in 1976, starry flounder catch and catch per angler hour dropped rapidly, while total angler hours remained fairly constant at around 10,000 annually (Figure 3.11). However, according to CDFG data, starry flounder were still the most common flatfish species taken by sportsmen in northern California in 1980. More recently, Herbold et al. (1992) report that "[Starry flounder] adults in the Bay support a popular sport fishery," and CDFG (1992e) notes that starry flounder are "excellent eating."

3.7 Other Use Benefits

At the statewide level, we have only rudimentary information on participation in various wildlife- and water-oriented outdoor recreation activities in California. The two primary sources of data are surveys conducted for the California Department of Parks & Recreation (CDPR) and the National Survey of Fishing, Hunting & Wildlife Associated Recreation conducted for USFWS.

In 1980 and 1987, CDPR arranged for telephone surveys to be conducted on a small, statewide sample of California households. The surveys cover participation in *all* recreational activities, indoor and outdoor, by *all* residents of the California. The two surveys used somewhat different methodologies, and the results are unfortunately not fully comparable. Some data from the 1980 survey are presented in Table 3.12, which shows estimates of current recreation activity in 1980 combined with projections for the year 2000. Fishing,

C-110540

swimming, beach recreation, hunting, boating and nature appreciation accounted for 400.6 million days of recreation in 1980, or about 18.7% of the total recreation activity, and are projected to account for 518.2 million days, or about 18.8% of the total, in 2000. The data show that freshwater sportfishing accounts for more than thrice as many days as saltwater fishing, but the proportions are reversed for freshwater and ocean swimming.

Some of the 1987 survey data dealing with freshwater recreation have recently been analyzed by Mitchell and Wade (1991). For the entire state population, they estimate that, in 1986, there were 216 million days of freshwater-related recreation, including 57 million days of freshwater fishing, 54 million days of powerboating/skiing, 45 million days of freshwater swimming, and 60 million days of picnicking. These figures are generally higher than the CDPR estimates in Table 3.12 — more so than can be accounted for by the increase in population between 1980 and 1986. Mitchell and Wade suggest that the 1980 CDPR survey may be underestimating recreation in Southern California. Table 3.13 presents some data on participation in freshwater recreation at various sites in California in 1985, involving activities such as picnicking, swimming, boating and fishing. In 1985, there were about 11.6 million visiter days at CVP reservoirs in Northern and Central California, and 6.6 million visiter days at SWP reservoirs, mainly in Northern and Central California. There also were 9.4 million visiter days at either federal and local government reservoirs. In addition, there were approximately 7.7 million visiter days of recreation in the Delta (this estimate is derived from a DWR Delta Recreation Survey, adjusted downwards to account for errors in the estimated number of people per car). Mannesto estimates that about 3.9 million of these visits were for sportfishing in the Delta.

Table 3.14 presents similar data on recreational activities along the Sacramento River, upstream of the Delta, in 1980. Overall, it is estimated that there were about 4.8 million hours of recreational activity of which about 1.89 million hours were spent on sport fishing, by boat or from the shore. In terms of visitors-days, the total recreational activity translates into about 1.3 million user days of freshwater recreation along the Sacramento River. In addition, according to the same DWR source, there were about 1.7 million user days of recreation along the lower American River in 1980. Another set of data, this time on rafting on the California rivers in 1983, is shown in Table 3.15. According to this data, the lower American River accounted for almost half of the million visiter days recorded at the Northern location included in the list.

Every five years, USFWS conducts a national survey of fishing, hunting and wildlife associated recreation. The survey focuses on recreation by people aged 16 and over. The results for California in 1985 are summarized in Table 3.7. The Mitchell and Wade (1991) estimates are broadly consistent with these data, when one allows for the difference in age coverage and the fact that Mitchell and Wade cover just freshwater recreation. Table 3.16 shows that Californians engaged in 28.6 million days of nonconsumptive wildlife-related recreation -- i.e., recreation involving a trip of at least one mile from the home for the *primary* purpose of observing, photographing, or feeding fish and wildlife (this excludes participation in such activities around the home or while on trips taken for other purposes, as well as other outdoor activities).

In addition to rivers and lakes, wetland areas in Northern and Central California provide significant opportunities for hunting and non-consumptive wildlife recreation. Total public use of the wetland areas listed in Table 3.17 was estimated to be about 421,000 days per year, of which about 177,000 days were for hunting and the rest for wildlife viewing. Similar, non-consumptive wildlife recreational activities occur at a variety of other locations in the Bay Area. The San Francisco Estuary Project reports that, in 1988, shoreline parks of the East Bay Regional Park District attracted over 160,000 bird watchers and that about 19,200 hours are spent annually on bird watching trips organized by the ten National Audubon Society chapters within the Bay Area. It notes, also, that over 119,000 individuals participated in wildlife observation in 1989-1990 at the San Francisco Bay Wildlife Refuges and nearly 10,000 individuals engaged in sightseeing and native studies at Grizzly Island Wildlife Area in 1989 (San Francisco Estuary Project 1992).

A study on birdwatching was conducted by Cooper and Loomis (1991) in the fall of 1987 based on a mail survey of random sample of California households, members of which were asked whether they had made recreational trips to view birds, the details of the most recent trip, and a contingent valuation question about possible future trips. At the current level of an average of 28 birds viewed per trip, the consumer's surplus was estimated to be about $37 per trip. This increases to $45 per trip when the number of birds viewed rises by 50% to 42 birds. When the number of birds doubles to 56 birds per trip, the consumer's surplus increases to $47 per trip.

For most other recreational activities, however, the data on consumers's surplus per trip is more limited. There are some data covering boating and other water-based recreation at reservoirs and freshwater lakes, which have been analyzed by Wade et al. (1989) and Spectrum Economics (1991); these generate estimates of consumer's surplus per trip of about

$30-40, but there are some severe problems with the data (much of it is made-up by the Department of Parks and Recreation) as well as some questions about the modelling methodology. These estimates of consumer's surplus per trip are summarized in Table 3.18.

3.8 Non-use Benefits

General Non-use Benefits

The Bay-Delta estuary provides habitat for many individual species of fish and wildlife and supports a diverse ecosystem. EPA's proposed water quality regulations may improve the health of this ecosystem. Improved environmental quality may be valued in itself by individuals, apart from any values associated with the use of natural resources. As outlined in the introduction to this report, individuals may have several motivations for the value they place on protecting and improving the quality of environmental resources, including existence value, bequest value and option value.

Unlike the use values discussed in the previous sections of this report, nonuse values cannot be measured by travel cost or similar revealed preference methods -- they can only be measured by the contingent valuation (CV) method. In the last few years two significant CV studies have been conducted on aquatic resources in California. The first is a statewide mail/telephone survey conducted by Jones & Stokes Associates, Inc. for the Interagency San Joaquin Drainage Program in 1989 (Jones & Stokes Associates, Inc., 1990; Hanemann, Loomis and Kanninen, 1991). This survey asked respondents about their willingness to pay (WTP) for five environmental programs in the San Joaquin Valley. The first two programs related to wetlands habitat in the San Joaquin Valley. One program would maintain wetlands

C-110544

habitat at current conditions; without this action, wetlands acreage in the San Joaquin Valley would decrease further. The other program would go beyond maintenance to improve wetlands habitat above current levels. The next two programs relate to the exposure of wildlife to contaminated agricultural drainage waters stored in evaporation ponds at various locations throughout the Valley. The first of these two programs would prevent any increase in the exposure of wildlife to contamination, thus maintaining current conditions, and the second program would improve conditions by reducing wildlife exposure to contaminated waters. The fifth program dealt with restoring water flows in the upper San Joaquin River below Friant Dam; these flows affect salmon and other fish in the river and wildlife and vegetation along the river banks. All of the programs were fully described before respondents were asked their willingness to pay for them individually and in combination.

The format for eliciting the valuation information was a voter referendum, and the payment vehicle was additional taxes. For example, the question pertaining to the wetlands maintenance program read as follows: "If the wetlands habitat and wildlife maintenance program were the only program you had an opportunity to vote on, and this maintenance program cost every household in California $\$x$ each year in additional taxes, would you vote for it?" The interviewer then followed up with "What if the cost were $\$y$?" A similar wording sequence was used with the other programs. The survey was administered to 803 households in California and 201 households in the adjacent states of Oregon and Washington. The overall response rate was 60%, with most of the nonresponses occurring before subjects knew about the subject matter of the survey. The results, based on a statistical analysis of the responses, are shown in Table 3.19. This presents point estimates of median annual WTP for a household with typical demographic variables in California and out of state, together with a 90% confidence interval for the California household. It should be noted that these values are *not* directly additive across programs: WTP for combinations of programs is typically smaller than the sum of the WTPs for the individual programs considered separately (Hoehn and Loomis 1993).

The second CV study was also performed by Jones and Stokes, this time as part of the environmental impact report (EIR) for the SWRCB decision on Los Angeles' water rights in the Mono Lake Basin (Jones & Stokes Associates 1993a). This was a mail/telephone survey in which respondents were told that the state of California was considering ways to balance the water inflow needs of the Mono Lake ecosystem with the needs of water users in other areas of the state that currently receive water diverted from the Mono Lake watershed. Limiting the amount of water being diverted would cause less water to be available for those water users in other areas of the state. The state is considering alternative water sources to replace any reductions in water currently diverted from Mono Lake. Water from alternative sources would cost additional money, and the SWRCB would like to know if citizens are willing to pay it. Respondents were told that, if no action is taken now, the lake level will drop by three feet over the next 10 years. Three possible programs were then described. Program A would maintain the lake at its current level. Program B would raise the lake by 15 feet over what it is now, by limiting the amount of water diverted from tributary streams. It would take about 25 years for this higher lake level to be reached, and the results would be to increase the size of the lake by 30%, restore historic nesting sites for gulls, moderately increase habitat for ducks and geese, moderately reduce dust storms, but also adversely affect scenic tufa towers, submerging the smaller tufa towers and causing between 5 and 20% of the larger towers to fall. Program C would put even greater limitations on water being diverted from the tributary streams, and would raise the level of the lake by 35 feet above current levels. It would take about 75 years for the lake to reach this level; when it did, the lake's size would increase by 45%. In addition to restoring some historic nesting sites for gulls, this would greatly increase habitat for ducks and geese. However, it would greatly reduce nesting habitat for snowy plovers, a bird that is a candidate for the threatened or endangered species list, and it would put most of the tufa towers under water.

After the three programs had been described, respondents were asked a referendum type question on whether they would vote for a program given the estimate of its cost in higher annual taxes, similar to the WTP question used in the San Joaquin Valley Drainage Program study. The survey was administered to a random sample of 600 households statewide, with an overall response rate of 72%. Most of the nonresponses occurred before the subject matter of the survey had been revealed. The results are shown in Table 3.20. Many respondents were opposed to Program C, because they felt that the higher lake level had more adverse effects than beneficial ones, but they were generally highly supportive of Programs A and B. The statewide aggregate value is based on the estimate of population median WTP applied to the approximately 9.28 million English-speaking households in California. At this time, confidence intervals have not been computed for the point estimates of median WTP because of the complexity of the statistical calculation, but the difference between the values associated with Programs A and B has been shown to be statistically significant.

The results in Table 3.20 were used in the Mono Lake EIR to identify the recommended program alternative. In addition to these nonuse values, there also were some recreational benefits associated with raising the level of Mono Lake which were included in the analysis. On the cost side, higher lake levels meant increased costs for water supply and lost hydropower revenues. The EIR analysis is reproduced in Figure 3.20. Lake level 6,372' corresponds to the long-run outcome if there is no reduction in diversions from tributary streams; lake level 6,377' corresponds to Program A; lake level 6,390' corresponds to Program B; and lake level 6,410' corresponds to Program C. The benefits for lake level 6,383.5' are based on a linear extrapolation of nonuse values between Programs A and B. On the basis of these estimates, the EIR recommends lake level 6,390' as the preferred program alternative. [Los Angeles Department of Water & Power has challenged this conclusion, rejecting not the CV estimates *per se*, but rather the linear extrapolation between Programs A and B; LADWP prefers a nonlinear extrapolation. LADWP also argues that the water supply and hydropower costs are higher than estimated in the EIR, and that net benefits are maximized at lake levels 6,377' or 6,383.5'. The SWRCB is expected to announce its decision in April 1994.]

De-listing Benefits

"De-listing" benefits describe the increased management flexibility and decreased management costs associated with either removing a species from a list of officially designated threatened or endangered species, or preventing its listing. Listing of a species associated with a river, stream, or estuary may severely restrict water management and adjacent agricultural activities. De-listing benefits have not been quantified but are surely significant, as evidenced by the considerable sums certain interest groups have expended in recent years to weaken the provisions of existing endangered species legislation. The proposed regulations could be seen as a relatively low-cost, preemptive strike to prevent the listing of several California Central Valley and Delta species as threatened or endangered and thus avoid the associated management inflexibility and cost.

According to Moyle (1992a) there is only one formally listed endangered species that uses the estuary: winter run chinook salmon. Other fishes that are being considered for formal listing or that may qualify for it soon are: spring-run chinook salmon, delta smelt, longfin smelt, splittail, and green sturgeon. The green sturgeon was discussed earlier under recreational fisheries. The remaining species on Moyle's list, and the late-fall-run Chinook salmon, will be briefly described here. The proposed regulations may potentially produce "de-listing" benefits with respect to these species.

Sacramento Winter-Run Chinook Salmon

The construction of Shasta Dam has increased the numbers of winter run chinook (Moyle 1976). Controlled releases allow adequate flows at low enough temperatures for eggs to survive during the summer months. The winter run begins to travel upstream during the winter months and spawns in mid-April through July. The eggs then hatch in late August. Dick Daniel of CDFG commented on the unique characteristics of the winter run in a recent issue of Northwest Energy News (1993):

> If you've ever seen a fall-run salmon after its spawning run, it's all beat up. But not the winter run. Somehow they've adapted to the rigors of migrating upstream and return in excellent physical condition. It's important to the long-term survival of chinook to keep the winter run around. . . . The main problem we're seeing with the winter run salmon is high water temperatures in the summer and early fall. That's a function of Shasta Dam and how it's operated.

Dave Vogel, formerly with USFWS, commented in the same newsletter that twenty years ago the average winter run was approximately 80,000 fish. In 1969, a record high 117,808 winter chinook salmon were counted in the Sacramento River. However, in 1990 fewer than 500 winter-run salmon returned to spawn. In 1991, the count was 191, a decline of more than 99 percent in the twenty-two years since the high in 1969 (see Table 3.21). Spawning escapement of Sacramento winter chinook salmon in 1992 was estimated at 1100 adults, well above the 1991 escapement, but less than 5 percent of the 1971-1975 average of 22,500 fish (PFMC 1993).

In November 1985, California and Nevada chapters of the American Fisheries Society petitioned NMFS to declare the winter run a threatened species. State and federal fish and water agencies developed the "Ten-Point Recovery Plan," but implementation was slow. The winter run was declared an endangered species by the state of California in May 1989 (Western Water 1990). NMFS announced its intention to list the fish as threatened in August 1989 and did so in November 1990. Listing the winter run as a threatened species led to the creation of a NMFS team to develop an alternative recovery plan. By Fall 1992, the NMFS team had met only once. A draft plan is expected by July 1993.

Sacramento Spring-Run Chinook Salmon

The spring run has greatly decreased in abundance since the water projects were built in California (National Council on Gene Resources 1982). Dams which check the natural water flows have increased the water temperature in the San Joaquin River, where spring-run chinook were formerly abundant, and have created a barrier to fish trying to reach the cooler headwaters. The spring run enters freshwater in the spring when melted snow swells the rivers; there they remain for 3 to 6 months until they spawn in the fall. Dave Vogel, formerly with USFWS, commented in a recent issue of Northwest Energy News (1993) that the spring run numbered in the hundreds as of 1990. We present an excerpt from Moyle

(1992a):

> The distinctive [spring] run of [chinook] salmon was once the most abundant salmon in California. They were nearly eliminated from the state by the construction of Shasta, Friant, and other dams which denied them access to upstream holding and spawning areas. Less than 1,000 wild spring-run chinook remain -- primarily in Deer and Mill Creeks, Tehama County. Conditions in the estuary -- a relatively small cause of the total decline of this run compared to upstream effects -- may be major factors contributing to their continuing decline. One of the most vulnerable stages of their life history is when the smolts are passing through the estuary in December through May. Adults move through the estuary mainly in March through July although the wild fish are probably moving through mainly in April. Because of their continuing decline (present wild populations are less than 0.5% of the historic runs), spring-run chinook should be listed as an endangered species in California. A key factor in their recovery will be to have adequate delta outflows during the smolt outmigration period, to reduce their vulnerability to entrainment and to Delta predators.

Sacramento Late Fall-Run Chinook Salmon

The late fall run is a small run limited to the Sacramento River and a few of its tributaries. Migration upstream begins in November, spawning occurs from January through April, and the fry move downstream during the late spring and summer months (National Council on Gene Resources 1982).

Delta Smelt

The Delta Smelt (Figure 3.12) (*Hypomesus transpacificus*) is listed by USFWS as a federal threatened species and by CDFG as a state endangered species. Delta smelt are small (up to 5 inches in length), fast-growing, short-lived fish found only in the Sacramento-San Joaquin Estuary. Most adults die in the early spring after spawning. Spawning occurs from late winter to early summer of the first year. Sometime after hatching larvae begin to float and drift with water currents, becoming concentrated in the beneficial entrapment zone. The position and extent of this entrapment zone is affected by water flow and diversions in the Delta.

CDFG (1992d) estimates that there has been a dramatic decline of the delta smelt population and low population levels since 1983 (Figure 3.13). CDFG has identified several factors potentially responsible for the delta smelt decline:

A. Decline in zooplankton food supply.
B. Low spawning stock levels.
C. Entrainment in water diversions.
D. Non-optimal water flows.
E. Toxic substances.
F. Genetic dilution.
G. Competition and predation.

A comprehensive study begun in January 1992 will attempt to determine the relationship and significance of each of these factors to the delta smelt population. To the extent that the proposed regulations improve conditions for the Delta smelt, as yet unquantified benefits in the form of "de-listing" a threatened/endangered species would result. Additional benefits might accrue in the form of increased water management flexibility associated with de-listing.

Longfin Smelt

Longfin smelt (Figure 3.14) (*Spirinchus thaleichthys*) are found from San Francisco Bay to Prince William Sound, Alaska, with the largest California population found in San Francisco Bay. In most years longfin smelt spend their entire lives in the Bay (Figure 3.15). Longfin smelt are harvested commercially in and around San Francisco Bay as part of the smelt bait fishery. Total catch of all smelt species in this bait fishery ranged between 20,000 and 40,000 pounds annually (CDFG Division of Marine Resources, unpublished data).

CDFG's (1992e) annual abundance index of longfin smelt has varied widely over the past 25 years, but very low index values have persisted over the past five years (Figure 3.16). "Although longfin smelt populations were known to be affected by freshwater inflow to the estuary (Stevens and Miller 1983), there has been little concern for their persistence in the estuary as they have been regarded as abundant and widely distributed, with additional populations in other California estuaries (Moyle 1976; Monaco et al. 1990)" (Herbold et al. 1992). CDFG has found significant positive relationships between $\log_{10}$ average February through May monthly Delta outflow and $\log_{10}$ Fall MWT Survey Longfin Smelt Abundance Index (Figure 3.17). CDFG (1992e) believes that increased outflows result in beneficial increased larval dispersal and nursery habitat volume. Herbold et al. (1992) note that, although there are some differences in the life histories and strategies of Delta smelt and Longfin smelt, "both spawn in river channels at the eastern-most end of the San Francisco Bay complex. . . .If changes in flow in the spawning ground are the mechanism by which the Delta smelt populations have suffered decimation, then the same pattern can be expected in longfin smelt populations."

To the extent that the proposed regulations improve conditions for the Longfin smelt, as yet unquantified small benefits in the form of increased catches in the commercial bait fisheries would result. Additional non-use benefits might accrue in the form of enhanced biological population stability.

Splittail

The splittail (Figure 3.18) (*Pogonichthys macrolepidotus*) is a large minnow reaching over 14 inches in length that historically was found in the California Central Valley, from

C-110554

Redding to Fresno. Today, the distribution of the splittail is limited to the lower reaches of the Sacramento and San Joaquin rivers and the S.F. Bay-Delta, and the abundance is much lower than in the past. CDFG (1992f) considers the splittail a species of special concern and Moyle et al. (1989) find that management may be required to prevent its eventual extinction.

CDFG (1992f) presents the results of a regression of a splittail abundance index on Delta outflow during March through May, the primary spawning months for splittail (Figure 3.19). The regression indicates that the index of splittail abundance increases with Delta outflow. To the extent that the proposed regulations increase Delta outflow or stabilize it at a sufficient level, special actions to protect splittail may not be necessary. Avoiding the need for special actions to protect splittail may be an additional, though unquantified, benefit of the proposed regulations.

4.0 SUMMARY AND CONCLUSIONS

The San Francisco Bay and Delta is a hydrological, biological and economic crossroads of the state of California. Many interest groups are affected by the health of the Bay-Delta and the ways in which it is managed. This report highlights those groups who might benefit from EPA's proposed regulations to improve the quality of this valuable natural resource, including those who make their living in the region's fisheries and the many residents who enjoy recreational activities associated with the Bay-Delta. We also consider those who may not directly interact with the estuary, but who might nonetheless value improvements in its health. Of course, ethical or moral arguments might support additional value to being placed on maintaining a healthy Bay-Delta, but this is beyond the scope of this work.

We estimate the benefits of EPA's proposed regulations under two hydrological scenarios, an Above Normal water year and a Critically Dry water year. Because relatively more information is available on values associated with commercial and recreational fishing, much of our analysis centers on fishing values. Over 200 species of fish, shrimp and crabs are known to inhabit the San Francisco Bay-Delta. We have chosen to focus on a few fish species that are important either for the commercial or recreational benefits they convey or for the potential management costs they might impose as threatened or endangered species. We have presented evidence that many of these Bay-Delta fish populations are seriously depressed. We use changes in the populations of these Bay-Delta fish species as indices of Bay-Delta environmental improvement. Many factors have contributed to the declines of

Bay-Delta fish populations, including mining gravel wastes, habitat lost behind dams, over-fishing, pollution, introduced species, declining water quality, water diversions for agriculture and urban use, El Nino events, and droughts. While hatcheries may have helped stabilize some fish populations, we now realize that they may pose long-run risks to the genetic integrity of some fish stocks. It is certainly difficult to sort out the individual effects of these many, interrelated factors, yet much research has been done, and the weight of the evidence now points to water flow, water quality, and water exports from the Bay-Delta as major determinants of the health of the ecosystem. We consider two policy control variables, (1) salmon smolt survival in the Bay-Delta and (2) Net Delta Outflow. We assume that EPA's proposed regulations will result in changes in the levels of the two control variables. Our analysis relates estimated changes in the control variables to changes in species populations. We then estimate the value of these changes in species populations to commercial and recreational fisherpeople. Although changes in non-use values associated with Bay-Delta improvements may be significant, we believe that sufficient data do not currently exist to quantify these changes. The estimated quantifiable benefits under each hydrological scenario are gathered from the preceding sections of this report and presented together for ease of comparison in Tables 4.1 and 4.2. Our estimates of the quantifiable benefits of EPA's proposed standards are on the order of $10 million under each of the hydrological scenarios. The proposed standards appear to benefit commercial fisheries more in Above Normal water years than in Critically Dry water years, because a given increase in salmon smolt survival results in a larger increase in benefits with a larger baseline salmon population. The proposed standards appear to benefit recreational fisheries more in Critically Dry years than in Above

Normal or Wet years, because the striped bass population is assumed to depend in part on Net Delta Outflow, and Net Delta Outflow is estimated to increase by about 50% in Critically Dry years while changing only imperceptibly in Above Normal or Wet years.

Throughout this report we have tried to be conservative in our estimates of the benefits of EPA's proposed regulations, and we believe that the benefits estimates given are toward the low end of the range of reasonable values. In evaluating the quantitative benefits estimates given in Tables 4.1 and 4.2, two points should be kept in mind. First, the values reflect the increase in benefits due to EPA's proposed standards *in comparison with the baseline scenarios.* Our baseline scenarios are very conservative in the sense that we assume that many of the recent declines in species populations are due to the recent drought, and that these declines would reverse themselves at the end of the drought without EPA's proposed regulations. If in fact this were not the case, we would be grossly underestimating the benefits of the proposed standards. Second, we have used conservative assumptions in our economic analyses. For example, we have assumed (1) a relatively small set of affected species, (2) the ready availability of substitute products and recreational opportunities, and (3) valuations of recreational fishing trips and catch near the low end of estimates reported in the economics literature.

Given the conservative baseline scenarios and the conservative assumptions used in our analyses, we estimate that EPA's proposed standards would result in a moderate increase in quantifiable benefits over the baseline level of quantifiable benefits under each hydrological scenario. However, this conclusion must be qualified by the fact that adequate data do not exist to quantify some categories of probable benefits. Indeed, several benefit categories in

Tables 4.1 and 4.2 are listed simply as "positive but unquantifiable." Thus, the benefit estimates given in this report are most likely near the low end of the range of reasonable benefit estimates; the true benefits are likely higher than the estimates reported here. While significant uncertainty surrounds much of the information used in this study, we believe that the analysis is successful in establishing benefits estimates that would be useful in the public policy arena.

C-110559

5.0 REFERENCES

Abrahams, M.V. and M.C. Healey. 1990. Variation in the Competitive Abilities of Fishermen and its Influence on the Spatial Distribution of the British Columbia Salmon Troll Fleet. Can. J. Fish. Aquat. Sci. 47:1116-1121.

Abramson, N.J. 1962. Estimating the Number of Angling License Purchasers. California Fish and Game. 48(4):253-255.

Adasiak, A. 1977. Limited Entry in Alaska. In: Pacific Salmon: Management for People. D.V. Ellis, Ed. Western Geographical Series, Vol. 13, Department of Geography, University of Victoria, Victoria, British Columbia, Canada.

Albert, K. 1987. Fishing in Northern California. Marketscope Books. Aptos, CA.

Anderson, J.L. and S.U. Bettencourt. 1993. A Conjoint Approach to Model Product Preferences: The New England Market for Fresh and Frozen Salmon. Marine Resource Economics. 8:31-49.

Andersen, P. and J.G. Sutinen. 1984. Stochastic Bioeconomics: A Review of Basic Methods and Results. Marine Resource Economics. 1(2):117-136.

Anderson, E.E. 1986. Taxes vs. Quotas for Regulating Fisheries Under Uncertainty: A Hybrid Discrete-Time Continuous-Time Model. Marine Resource Economics. 3(3):183-207.

Andrews, E. and J. Wilen. 1988. Angler Response to Success in the California Salmon Sportfishery: Evidence and Management Implications. Marine Resource Economics. 5:125-138.

Armor, C. and P.L. Herrgesell. 1985. Distribution and abundance of fishes in the San Francisco Bay estuary between 1980 and 1982. Hydrobiologia 129: 211-227.

Bell, F.W. 1989. Main Quarry Hypothesis and Salmon Angling. Marine Resource Economics. 6:71-82.

Bell, M.C. 1980. Fisheries Handbook of Engineering Requirements and Biological Criteria. Fisheries-Engineering Research Program. Corp of Engineers, North Pacific Division, Portland, Oregon. Contract No. DACW57-68-C-0086. (Revised Edition).

Bergh, M.O. 1991. Population and Harvesting Theory for Nonlinear Sex and Age-Structured Resources. Natural Resource Modeling. 5(1):91-134.

Bevan, D.E. 1988. Problems of Managing Mixed-Stock Salmon Fisheries. In: Salmon Production, Management, and Allocation: Biological, Economic, and Policy Issues. W.J. McNeil, Ed. Oregon State University Press. Corvallis, O.R.

BioSystems Analysis, Inc. 1989. Chinook Salmon Population Model for the Sacramento River Basin, Version CPOP-2. For CDFG, Sacramento, CA. pp. 200+.

Bird. P.J.W.N. 1986. Econometric Estimation of World Salmon Demand. Marine Resource Economics. 3(2):169-

Bjorndal, T., K.G. Salvanes and J.H. Andreassen. 1992. The Demand for Salmon in France: the Effects of Marketing and Structural Change. Applied Economics. 24:1027-1034.

Blumm, M.C. and A. Simrin. 1991. The Northwest Power Act: Point & Counterpoint - The Unraveling of the Parity Promise: Hydropower, Salmon, and Endangered Species in the Columbia Basin. Environmental Law. 21:657-805.

Bonneville Power Administration. 1992. Yakima Fisheries Project: Can It Help Save Our Salmon? Issue Alert.

Boyce, J.R. 1990. Information and Uncertainty in a Fishery: The British Columbia Salmon Fishery. PhD. Dissertation. Dept. Agri. Economics, U.C. Davis. Davis, CA.

Brown, W.G. 1990. Estimation of Net Economic Values for Oregon Sport-Caught Salmon and Steelhead. Working Paper ?. Oregon State University. Corvallis, OR.

Brown, W.G., D.M. Larson, R.S. Johnston, R.J. Wahle. 1976. Improved Economic Evaluation of Commercially and Sport-Caught Salmon and Steelhead on the Columbia River. Oregon State University, Agricultural Experiment Station, Special Report 463.

Brown, W.G., C. Sorhus, and K.C. Gibbs. ?. Estimated Expenditures By Sport Anglers and Net Economic Values of Salmon and Steelhead for Specified Fisheries in the Pacific Northwest. Oregon State University, Department of Agricultural and Resource Economics, Corvallis, OR.

Burness, H.S., R.G. Cummings, P.T. Ganderton and G.W. Harrison. 1991. Valuing Environmental Goods: A Critical Appraisal of the State of the Art. In: The Economics and Management of Water and Drainage in Agriculture. A. Dinar and D. Zilberman, Editors. Kluwer Academic Publishers. Norwell, Mass.

Calkins, R. 1990. Iron Gate Salmon and Steelhead Hatchery. Outdoor California. Jul.-Aug. Issue.

Callahan, J., A. Fisher, S. Templeton. 1989. The San Francisco Bay/Delta Striped Bass Fishery: Anatomy of a Decline. U.C. Berkeley. Dept. of Agri. and Resource Econ. Giannini Foundation Working Paper No. 499.

Carson, R.T. 1991. Constructed Markets. In: Measuring the Demand for Environmental Quality. Braden, J.B. and C.D. Kolstad, Editors. Elsevier Science Publishers B.V. (North-Holland).

Carson, R.T and K.M. Martin. 1991. Measuring the Benefits of Freshwater Quality Changes: Techniques and Empirical Findings. In: The Economics and Management of Water and Drainage in Agriculture. A. Dinar and D. Zilberman, Editors. Kluwer Academic Publishers. Norwell, Mass.

Carson, R.T., W.W. Wade and T. Graham-Tomasi. 1987. Rebuttal to Philip Meyer Testimony Bay Institute Exhibits 40 and 41. Testimony before the State Water Resources Control Board Bay/Delta Hearings. September 1987. SWRCB. Sacramento, CA.

Carter, C.N. and H.D. Radtke. 1986. Coastal Community Impacts of the Recreational/Commercial Allocation of Salmon in the Ocean Fisheries. Oregon Department of Fish and Wildlife Staff Report. Portland, Oregon.

California Department of Finance. 1992. California Statistical Abstract - 1992. Sacramento, CA.

CDFG. 1973. Author-Title Index to Inland Fisheries Administrative Reports 1932-1972. Inland Fisheries Admin. Rep. No. 73-2. 40 pp.

CDFG. 1977. California's River Salmon Sport Fishery. Unpublished report. Inland Fisheries Division, Rancho Cordova, CA. pp 5.

CDFG. 1985. The Economic Value of Striped Bass, Morone saxatilis, Chinook Salmon, Oncorhynchus tshawytscha, and Steelhead Trout, Salmo gairdneri, of the Sacramento and San Joaquin River Systems. (By Meyer Resources, Inc.) CDFG Anadromous Fisheries Branch Admin. Rep. No. 85-03. pp. 44.

CDFG. 1987a. Factors Affecting Striped Bass Abundance in the Sacramento-San Joaquin River System. Sacramento, CA.

CDFG. 1987b. Chadwick, H.K.: Conclusions and Recommendations -- Summary of Testimony to the State Water Resources Control Board. CDFG. Sacramento, CA.

CDFG. 1987c. The Status of San Joaquin Drainage chinook salmon stocks, habitat conditions, and natural production factors. CDFG testimony before the 1987 State Water Resources Control Board Bay/Delta Hearings. Exhibit 15. Sacramento, CA.

CDFG. 1987d. Delta Outflow Effects on the Abundance and Distribution of San Francisco Bay Fish and Invertebrates. Exhibit No. 60, State Water Resources Control Board, 1987 Water Quality / Water Rights Proceeding on the San Francisco Bay / Sacramento-San Joaquin Delta. Sacramento, CA. 345 pp.

CDFG. 1988a. Funding Commercial Seafood Harvesting Programs. California Department of Fish and Game. Sacramento, CA.

CDFG. 1988b. Annual Report: Chinook Salmon Spawning Stocks in California Central Valley - 1987. Author: Reavis, R. Inland Fisheries Division.

CDFG. 1989. Description of Winter Chinook Ocean Harvest Model, Ocean Salmon Project. Anadromous Fisheries Branch, Rancho Cordova, C.A. pp. 27.

CDFG. 1991. Lower Yuba River Fisheries Management Plan. Final Report. CDFG Stream Evaluation Report No. 91-1. Sacramento, C.A.
pp. 197.

CDFG. 1992a. A Re-examination of Factors Affecting Striped Bass Abundance in the Sacramento-San Joaquin Estuary. SWRCB 1992 Water Right Hearings Exhibit WRINT-CDFG-2. Sacramento, CA.

CDFG. 1992b. Revised and Updated Estimates of Fish Entrainment Losses Associated with the State Water Project and Federal Central Valley Project Facilities in the South Delta. State Water Resources Control Board 1992 Bay-Delta Estuary Proceedings. WRINT-DFG-1.

CDFG. 1992c. A Model for Evaluating the Impacts of Freshwater Outflow and Export on Striped Bass in the Sacramento-San Joaquin Estuary. State Water Resources Control Board 1992 Bay-Delta Estuary Proceedings. WRINT-DFG-3.

CDFG. 1992d. Delta Smelt. SWRCB 1992 Hearings. Exh. No. WRINT-DFG-9. Sacramento, CA.

CDFG. 1992e. Estuary Dependent Species. State Water Resources Control Board 1992 Water Quality / Water Rights Proceedings on the San Francisco Bay / Sacramento - San Joaquin Delta. WRINT-DFG-6.

CDFG. 1992f. Impact of Water Management on Splittail in the Sacramento-San Joaquin Estuary. SWRCB 1992 Hearings. Exh. No. WRINT-DFG-5. Sacramento, CA.

CDFG. 1992g. Paul Smith Testimony on Causes of the Decline in Striped Bass. State Water Resources Control

C-110562

Board 1992 Bay-Delta Estuary Proceedings. WRINT-DFG-12.

CDFG. 1992h. Louis Botsford Testimony on Causes of the Decline in Striped Bass. State Water Resources Control Board 1992 Bay-Delta Estuary Proceedings. WRINT-DFG-13.

CDFG. 1992i. Status of White Catfish in the Sacramento-San Joaquin Delta. SWRCB 1992 Hearings. Exh. No. WRINT-DFG-4. Sacramento, CA.

CDFG. 1992j. Sturgeon in Relation to Water Development in the Sacramento-San Joaquin Estuary. SWRCB 1992 Hearings. Exh. No. WRINT-DFG-28. Sacramento, CA.

CDFG. 1992k. Summary and Recommendations for the Department of Fish and Game's Testimony on the Tributaries to the Sacramento-San Joaquin Estuary. State Water Resources Control Board 1992 Water Quality / Water Rights Proceedings on the San Francisco Bay / Sacramento - San Joaquin Delta. WRINT-DFG-30.

CDFG. 1993. California Sport Fishing Regulations: 1992-1994. Sacramento, CA.

CDWR. 1980. Upper Sacramento River Spawning Gravel Study. Northern District Report.

CDWR. 1982. Sacramento River Recreation Survey - 1980. Red Bluff, CA.

CDWR. 1984a. Middle Sacramento River Spawning Gravel Study. Northern District Report.

CDWR. 1985. Sacramento River Spawning Gravel Studies. Northern District, Executive Summary.

CDWR. 1986. Clear Creek Fishery Study. Red Bluff, CA. pp. 70.

CDWR. 1986. Dayflow Program Documentation and Dayflow Data Summary User's Guide. Central District Office, Sacramento, CA. pp. 66.

CDWR. 1988. Water Temperature Effects on Chinook Salmon (Oncorhynchus tshawytscha): With Emphasis on the Sacramento River - A Literature Review. G.L. Boles. Red Bluff, CA. pp. 42.

CDWR. 1992. An Evaluation of Existing Data in the Entrapment Zone of the San Francisco Bay Estuary. W. Kimmerer. Technical Report 33, Interagency Ecological Studies Program for the Sacramento - San Joaquin Estuary. pp. 49.

CDWR. 1992. General Update of Evidence, Overview, and Recommendations. State Water Resources Control Board 1992 Water Quality / Water Rights Proceedings on the San Francisco Bay / Sacramento - San Joaquin Delta. WRINT-DWR-1.

CDWR. 1992. South Delta Water Management Program. State Water Resources Control Board 1992 Bay-Delta Estuary Proceedings. WRINT-DWR-21.

CDWR. 1993. Draft Program Environmental Impact Report for the State Drought Water Bank. Sacramento, CA.

Chadwick, H.K. 1967. Recent Migrations of the Sacramento-San Joaquin River Striped Bass Population. Transactions of the American Fisheries Society. 96:327-342.

Chambers, R.G. and I.E. Strand, Jr. 1986. Estimating Parameters of a Renewable Resource Model Without Population Data. Marine Resource Economics. 2(3):263-274.

Charles, A.T. and G.R. Munro. 1985. Irreversible Investment and Optimal Fisheries Management: A Stochastic Analysis. Marine Resource Economics. 1(3):247-264.

Clark, G.H. 1929. Sacramento River Salmon Fishery. Calif. Fish and Game. 15(1): 1-10.

Clark, C.W. and G.R. Munro. 1975. The economics of fishing and modern capital theory: a simplified approach. J. Environ. Econ. Manag. 2:92-106.

Clark, C.W. and G.P. Kirkwood. 1979. Bioeconomic model of the Gulf of Carpentaria prawn fishery. J. Fish. Res. Board Can. 36: 1304-1312.

Clarke, W.C., R.E. Withler and J.E. Shelbourn. 1992. Genetic Control of Juvenile Life History Pattern in Chinook Salmon (Oncorhynchus tshawytscha). Can. J. Fish. Aquat. Sci. 49:2300-2306.

Clepper, H. 1980. Marine Recreational Fisheries. Proc. 5th Annual Marine Recreational Fisheries Symposium. Sport Fishing Institute. Washington, DC.

Collins, B. 1992. Survey of Salmon Stocks Looks Grim. National Fisherman. December issue.

Commodity Research Bureau. 1992. 1992 CRB Commodity Year Book. Knight-Ridder Financial Publishing. New York, N.Y.

Connelly, N.A. and T.L. Brown. 1991. Net Economic Value of the Freshwater Recreational Fisheries of New York. Trans. Amer. Fish. Soc. 120:770-775.

Cooley, R.A. 1963. Politics and Conservation: The Decline of the Alaska Salmon. Harper & Row. New York. 231 pp.

Coon, J. 1993. PFMC salmon specialist. Personal communication, December 1993.

Cooper, J. 1990. Demand for and Net Economic Value of Waterfowl Hunting in California's Sacramento and San Joaquin Valley Refuges. U.S. Bureau of Reclamation. Sacramento, CA.

Cooper, J. and J. Loomis. 1991. Economic Value of Wildlife Resources in the San Joaquin Valley: Hunting and Viewing Values. In: The Economics and Management of Water and Drainage in Agriculture. A. Dinar and D. Zilberman, Editors. Kluwer Academic Publishers. Norwell, Mass.

Cope, O.B. and D.W. Slater. 1957. Role of Coleman Hatchery in maintaining a king salmon run. U.S.F.W.S. Wildlife Service Report. 47. 22 pp.

Cramer, Steven P. 1990. Contribution of Sacramento Basin Hatcheries to Ocean Catch and River Escapement of Fall Chinook Salmon. Prepared by S.P. Cramer & Associates, Corvallis, OR for CDWR. pp. 113+Appendices.

Creel, M.D. and J.B. Loomis. 1992. Modeling Hunting Demand in the Presence of a Bag Limit, with Tests of Alternative Specifications. JEEM 22:99-113.

Criddle. K.R. and A.M. Havenner. 1991. An Encompassing Approach to Modeling Fishery Dynamics: Modeling Dynamic Nonlinear Systems. Natural Resource Modeling. 5(1):55-89.

Crutchfield, J.A. 1977. The Fishery: Economic Maximization. In: Pacific Salmon: Management for People. D.V. Ellis, Ed. Western Geographical Series, Vol. 13, Department of Geography, University of Victoria, Victoria, British Columbia, Canada.

Crutchfield, J.A. and K. Schelle. 1979. An Economic Analysis of Washington Ocean Recreational Salmon Fishing with Particular Emphasis on the Role Played by the Charter Vessel Industry. University of Washington. Seattle, Washington. For the Pacific Fishery Management Council.

Dauble, D.D., T.L. Page, and R.W. Hanf, Jr. 1989. Spatial Distribution of Juvenile Salmonids in the Hanford Reach, Columbia River. U.S. Fishery Bulletin. 87:775-790.

Davis, J.A., A.J. Gunther, B.J. Richardson, J.M. O'Conner, R.B. Spies, E. Wyatt, E. Larson and E.C. Meiorin. 1991. Status and Trends Report on Pollutants in the San Francisco Estuary. San Francisco Estuary Project. U.S. EPA San Francisco, CA.

Delisle, G. August 1993. Personal Communication. CDFG Inland Fisheries. Sacramento, CA.

Delta Salmon Team, Five Agency Salmon Management Group. 1991. Alternative Measures for the Protection of Chinook Salmon in the Sacramento-San Joaquin River Delta. Second Draft. pp. 36.

Dettman, D.H. and D.W. Kelley. 1987a. The Roles of Feather and Nimbus Salmon and Steelhead Hatcheries and Natural Reproduction in Supporting Fall Run Chinook Salmon Populations in the Sacramento River Basin. Prepared by D.W. Kelley & Associates for CDWR. DWR 559. pp. 106.

Dettman, D.H., D.W. Kelley and W.T. Mitchell. 1987b. The Influence of Flow on Central Valley Salmon. Prepared by D.W. Kelley & Associates for CDWR. DWR 561. pp.66.

DeVoretz, D. 1982. An Econometric Demand Model for Canadian Salmon. Canadian J. of Agri. Econ. 30:49-59.

DeVoretz. D. and R. Schwindt. 1985. Harvesting Canadian Fish and Rents: A Partial Review of the Report of the Commission on Canadian Pacific Fisheries Policy. Marine Resource Economics. 1(4):347-

DeVoretz. D. and K. G. Salvanes. 1993. Market Structure for Farmed Salmon. AJAE. 75(1):227-233.

Dewees, C.M., E.M. Strange and G. Guagnano. 1990. Competing for the Recreational Dollar: An Analysis of the California Commercial Passenger-Carrying Fishing Vessel Industry. Marine Fisheries Review. 52(1):1-6.

Dewees, C.M. and E. Ueber., Eds. 1990. Effects of Different Fishery Management Schemes on Bycatch, Joint Catch, and Discards. California Sea Grant. Rep. No. T-CSGCP-019.

Dick, D. 1992. Captive Breeding for Endangered Salmon. Outdoor California. Nov.-Dec.:12-13.

Diringer, Elliot. U.S. Agencies Square Off Over Water for Salmon. San Francisco Chronicle. February 11, 1992.

Dixon, R. 1993. Personal Communication regarding salmon ocean recreational fishing effort. CDFG.

Dornbusch, D.M. & Company. 1987. Impacts of Outer Continental Shelf (OCS) Development on Recreation and Tourism. Volume 3: Detailed Methodology. U.S. Department of the Interior, Minerals Management Service. Los Angeles, CA.

Dumas, C.F. and W.M. Hanemann. 1992. A Simulation Model of the Sacramento River Fall Run Chinook Salmon. Department of Agricultural & Resource Economics, University of California, Berkeley.

Dupont, D.P. 1990. Rent Dissipation in Restricted Access Fisheries. Journal of Environmental Economics and Management. 19(1):26-44.

Dupont, D.P. 1991. Testing for Input Substitution in a Regulated Fishery. Amer. J. Agr. Econ. Febr.:155-164.

Dupont., D.P. and S.A. Phipps. 1991. Distributional Consequences of Fisheries Regulations. Can. J. Econ. 24(1):206-220.

EA Engineering. Cheslak, E.F. 1987?. Chinook Salmon Population Model -- San Joaquin Tributary System. Testimony for San Francisco - San Joaquin Bay-Delta Hearings Phase 1. Lafayette, C.A.

EA Engineering. 1991a. DRAFT San Joaquin River System Chinook Salmon Population Model Documentation. Lafayette, CA. pp. 65.

EA Engineering. 1991. DRAFT Stock-Recruitment Analysis of the Population Dynamics of San-Joaquin River System Chinook Salmon. Lafayette, CA. pp. 54.

EA Engineering. 1991. DRAFT Addendum to San Joaquin River System Chinook Salmon Population Model Documentation: Validation of the Model. Lafayette, CA. pp. 21.

EA Engineering. 1991d. DRAFT Comments on "Estimating the Effect of Changing Delta Conditions on Sacramento Basin Fall Run Chinook Salmon Stock." Lafayette, CA. pp. 17.

EA Engineering. 1992. Modeling the Population Dynamics of Chinook Salmon: A Way of Evaluating Water Resource Management Strategies. Features.

Earle, C.J. and H.C. Fritts. 1986. Reconstructing Riverflow in the Sacramento Basin Since 1560. Laboratory of Tree-RIng Research, Univ. Arizona, Tucson, Arizona. (for CDWR)

Ellis, D.V., Ed. 1977. Pacific Salmon: Management for People. D.V. Ellis, Ed. Western Geographical Series, Vol. 13, Department of Geography, University of Victoria, Victoria, British Columbia, Canada.

English, K.K, R.C. Bocking and J.R. Irvine. 1992. A Robust Procedure for Estimating Salmon Escapement Based on the Area-Under-the-Curve Method. Can. J. Fish. Aquat. Sci. 49:1982-1989.

Feinberg, L. and T. Morgan. 1980. California's Salmon Resource: It's Biology, Use, and Management. Sea Grant Report Series No. 3, California Sea Grant College Program, CSGCP No. 72. La Jolla, C.A.

Fisher, A.C., W.M. Hanemann and A.G. Keeler. 1990. Integrating Fishery and Water Resource Management: A Biological Model of a California Salmon Fishery. Working Paper 532, Department of Agricultural and Resource Economics, University of California, Berkeley, CA. pp. 49.

Fisher, A.C., W.M. Hanemann and A.G. Keeler. 1991. Integrating Fishery and Water Resource Management: A Biological Model of a California Salmon Fishery. JEEM. 20:234-261.

Fisher, J.P. and W.C. Pearcy. 1987. Movements of Coho, Oncorhynchus kisutch, and Chinook, O. tshawytscha, Salmon Tagged at Sea Off Oregon, Washington, and Vancouver Island During the Summers 1982-1985. Fishery Bulletin. 85(4):819-826.

Fisher, J.P. and W.C. Pearcy. 1989. Distribution and Residence Times of Juvenile Fall and Spring Chinook Salmon in Coos Bay, Oregon. U.S. Fishery Bulletin. 88:51-58.

Fletcher, J.J., W.L. Adamowicz and T. Graham-Tomasi. 1989. Overview of Travel Cost Models: Problems and Potential Improvements. Unpublished manuscript.

Fletcher, J.J., R.E. Howitt and W.E. Johnston. 1988. Management of Multipurpose Heterogeneous Fishing Fleets Under Uncertainty. Marine Resource Economics. 4:249-270.

Fletcher, J.J. and W.E. Johnston. 1984. An Economic Analysis of Eureka Crabber-Troller Vessels. Giannini Foundation Information Series No. 84-2, Department of Agricultural Economics, University of California, Davis.

Frey, H.W., ed. 1971. California's Living Marine Resources and Their Utilization. CDFG. Sacramento, CA. 148 pp.

Fry, D.H., Jr. 1952. Cleaning Losses in King and Silver Salmon. California Fish and Game. 38(3):425-426.

Fry, D.H., Jr. 1962. Potential Profits in the California Salmon Fishery. Calif. Fish and Game, Fish Bull. 48(4): 256-267.

Fry, D.H., Jr. 1979. Anadromous Fishes of California. CDFG. pp. 112.

Gangmark, H.A. and R.D. Broad. 1955. Further Observations on Stream Survival of King Salmon Spawn. California Fish and Game. ?.

Ganssle, D. 1966. Fishes and decapods of San Pablo and Suisun Bays. In: Ecological Studies of the Sacramento-San Joaquin Estuary, Part 1. D.W. Kelley, (ed.). CDFG Fish Bull. No. 133. pp.64-94.

Getz, W.M. 1991. A Unified Approach to Multispecies Modeling. Natural Resource Modeling. 5(4):393-421.

? Goodman. 1989 Envir. Law. 20(1):111-

Gordon, H.S. 1954. The economic theory of a common property resource: the fishery. J. Polit. Econ. 62:124-142.

Grader, Zeke. 1992. Pacific Coast Federation of Fishermen's Associations. Personal Communication, December 1992.

Greenberg, J.A., S.C. Matulich, and R.C. Mittelhammer. 1991. A System-of-Equations Approach to Modeling Age-Structured Fish Populations: The Case of Alaskan Red King Crab, Paralithodes camtschaticus. Can. J. Fish. Aquat. Sci. 48:1613-1622.

Groot, C. and T.P. Quinn. 1987. Homing Migration of Sockeye Salmon, Oncorhynchus nerka, to the Fraser River. U.S. Fishery Bulletin. 85(3):455-469.

Gruen Gruen & Associates. 1972. A Socio-economic Analysis of California's Sport and Commercial Fishing Industries. For CDFG, Sacramento, CA.

Hallock, R.J. and D.H. Fry, Jr. 1967. Five Species of Salmon, Oncorhynchus, in the Sacramento River, California. Calif. Fish and Game. 53(1):5-22.

Hanemann, W.M. 1986. Economic Valuation of Changes in the Catch of Sacramento River Chinook Salmon. Department of Agricultural and Resource Economics, University of California, Berkeley. pp. 58 + Attachment.

C-110567

Hanemann, W.M. 1992. Economic Impact on Ocean Fishing. In: Integrated Modeling of Drought and Global Warming: Impacts on Selected California Resources. National Institute for Global Environmental Change, University of California, Davis.

Hanemann, W.M. and C.F. Dumas. 1992. Simulating Inpacts on the Sacramento River Fall Run Chinook Salmon Population. In: Integrated Modeling of Drought and Global Warming: Impacts on Selected California Resources. National Institute for Global Environmental Change, University of California, Davis.

Hanemann, W.M. and A.C. Fisher. 1992. Economic Values of San Francisco Bay Fisheries and Water-Quality Management. Department of Agricultural and Resource Economics, University of California, Berkeley. Berkeley, CA.

Hanemann, W.M., J.B. Loomis and B Kanninen. 1991. Statistical Efficiency of Double-Bounded Dichotomous Choice Contingent Valuation. American Journal of Agricultural Economics. 73(4): 1255-1263.

Hankin, D.G. and R. McKelvey. 1985. Comment on Fecundity of Chinook Salmon and its Relevance to Life History Theory. Can. J. Fish. Aquat. Sci. 42:393-394.

Harris, C.K. 1988. Recent Changes in the Pattern of Catch of North American Salmonids by the Japanese High Seas Salmon Fisheries. In: Salmon Production, Management, and Allocation: Biological, Economic, and Policy Issues. W.J. McNeil, Ed. Oregon State University Press. Corvallis, O.R.

Hashagen, K. 1988. California's Hatchery System. Outdoor California. Mar.-Apr. volume.

Healey, M.C. 1982. Juvenile Pacific Salmon in Estuaries: The Life Support System. In: Estuarine Comparisons. Ed.: V.S. Kennedy. Academic Press. New York.

Hedgepeth, J.W. and W.E. Mortensen. 1987. San Francisco Bay Estuarine Circulation and Productivity of the Estuary for Striped Bass and Other Species. Bay Institute of San Francisco. Sausalito, CA.

Heimlich, S. 1991. Fish Springs Hatchery. Outdoor California. Sept.-Oct. Issue.

Herbold, B., A.D. Jassby, and P.B. Moyle. 1992. Status and Trends Report on Aquatic Resources in the San Francisco Estuary. San Francisco Estuary Project. Oakland, C.A.

Herrgesell, P.L. (compiler). 1990. 1989 Annual Report Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary. CDWR, Sacramento, CA. 112 pp.

Hershberger, W.K. 1988. Directed and "Inadvertent" Genetic Selection in Salmonid Culture: Results and Implications for the Resource, and Regulatory Approaches. In: Salmon Production, Management, and Allocation: Biological, Economic, and Policy Issues. W.J. McNeil, Ed. Oregon State University Press. Corvallis. O.R.

Hershey, M.C. 1973. The Silver Salmon of Muir Woods. Muir Woods -Point Rayes Natural History Asso. Muir Woods National Monument, CA.

Hilborn, R. 1992. Hatcheries and the Future of Salmon in the Northwest. Fisheries. 17(1):5-8.

Hinrichsen, R., T. Frever, J. Anderson, G. Swartzman, B. Sherer. 1992. Columbia River Salmon Passage (CRiSP) Model: Documentation for CRiSP.0. Bonneville Power Administration, Portland, O.R.

Hoehn, J.P. and J.B. Loomis. 1993. Substitution Effects in the Valuation of Multiple Environmental Programs.

Journal of Environmental Economics and Management. 25(1): 56-75.

Holtby, L.B., R.K. Kadowaki and K.S. Simpson. 1992. Factors Affecting the Vulnerability of Juvenile Coho (Oncorhynchus kisutch) and Chinook Salmon (O. tshawytscha) in a Saltwater Sport Fishery. Can. J. Fish. Aquat. Sci. 49: 2164-2178.

Huppert, D.D. 1983. NMFS Guidelines on Economic Valuation of Marine Recreational Fishing. NOAA Tech. Memo. NMFS-SWFC-32. La Jolla, CA.

Huppert, D.D. 1986. A Primer on Limited Access Alternatives for the Pacific Coast Groundfish Fishery. NOAA-NMFS, La Jolla, CA. Distributed by: Pacific Marine Fisheries Commission.

Huppert, D.D. 1987. Limited Access Alternatives for the Pacific Groundfish Fishery. NOAA Tech. Rep. NMFS-52.

Huppert, D.D. 1989. Measuring the Value of Fish to Anglers: Application to Central California Anadromous Species. Marine Resource Economics. 6:89-107.

Johnston, R.S. 1988. The Market for Salmon. In: Salmon Production, Management, and Allocation: Biological, Economic, and Policy Issues. W.J. McNeil, Ed. Oregon State University Press. Corvallis, O.R.

Jones & Stokes Associates, Inc. 1990. Environmental Benefits Study of San Joaquin Valley's Fish and Wildlife Resources. Chapter 5 - Scenario for San Joaquin River Restoration. (JSA Report No. 87-150). Sacramento, CA. Prepared by J.B. Loomis, W.M. Hanemann, and T.C. Wegge.

Jones & Stokes Associates, Inc. 1993a. Environmental Impact Report for the Review of Mono Basin Water Rights of the City of Los Angeles. Draft. May. (JSA 90-171.) Sacramento, CA. Prepared for California State Water Resources Control Board, Division of Water Rights, Sacramento, CA.

Jones & Stokes Associates, Inc. 1993b. Regulatory Impact Analysis of the Proposed Water Quality Standards for the San Francisco Bay/Delta and Listing of the Delta Smelt. Administrative Draft. September 14, 1993. (JSA 93-147.) Sacramento, CA. Prepared for U.S. Environmental Protection Agency, San Francisco, CA.

Judge, E.E., and Sons, Inc. 1988. The Directory of the Canning, Freezing, Preserving Industries. Edward E. Judge & Sons, Inc., Westminster, MD.

Kagan, R.A. 1991. The Dredging Dilemma: Economic Development and Environmental Protection in Oakland Harbor. Coastal Management. 19(3):313-341.

Keeler, A.G., A.C. Fisher, and W.M. Hanemann. 1989. The San Francisco Bay/Delta Chinook Salmon Fishery: A Review and Analysis of Recent Trends. Working Paper 501, Department of Agricultural and Resource Economics, University of California, Berkeley, CA. pp. 33.

Kelley, D.W., Sheila Greene, and W.T. Mitchell. 1990. DRAFT: Estimating the Effect of Changing Delta Environmental Conditions on Sacramento Basin Fall Run Chinook Salmon Stock. Prepared for Five Agency Salmon Management Group Delta Salmon Team by D.W. Kelley & Associates, Newcastle, CA. pp. 147.

Kennedy, V.S., Ed. 1982. Estuarine Comparisons. Academic Press, New York, New York.

King, D.M. and H.A. Bateman. 1985. The Economic Impact of Recent Changes in the U.S. Tuna Industry. California Sea Grant College Program Working Paper No. P-T-47.

King, D.M. and V.G. Flagg. 1984. The Economic Structure of California's Commercial Fisheries - 1982. California Sea Grant College Program Working Paper No. P-T-32.

King, D.M. and K.L. Shellhammer. 1981. The California Interindustry Fisheries (CIF) Model: An Input-Output Analysis of California Fisheries and Seafood Industries. San Diego State Unversity, Center for Marine Studies, Working Paper PT-5.

King, D.M., K.L. Shellhammer, J.P. Reid, and D.D. Selover. 1981. The California Interindustry Fisheries (CIF) Model: An Economic Impact Calculator for California Fisheries. California Sea Grant College Program Working Paper No. P-T-5.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life History of Fall-Run Juvenile Chinook Salmon, Oncorhynchus tshawtyscha, in the Sacramento-San Joaquin Estuary, California. In: Estuarine Comparisons. Ed.: V.S. Kennedy. Academic Press. New York.

Kjelson, M.A., Sheila Greene and Pat Brandes. 1989. A Model for Estimating Mortality and Survival of Fall-Run Chinook Salmon Smolts in the Sacramento River Delta Between Sacramento and Chipps Island. U.S. Fish and Wildlife Service, Stockton, CA. WQCP-USFWS-1. pp. 50.

Kjelson, M.A. and P.L. Brandes. 1991. DRAFT: Benefit/Cost Evaluations of Alternative Salmon Protective Measures in the Sacramento-San Joaquin Delta. Prepared for Five Agency Salmon Management Group Delta Salmon Team. U.S. Fish and Wildlife Service, Stockton, CA. pp. 101.

Klamath River Technical Advisory Team. 1990. Progress Report: Cohort Analysis of Klamath River Basin Fall Chinook Salmon of the 1979 Through 1984 Broods. CDFG, Rancho Cordova.

Knutson, C. 1991. California's Federal Aid in Sport Fish Restoration Program. Outdoor California. Sept.-Oct. Issue.

Kope, R.G. 1987. Separable virtual population analysis of Pacific salmon with application to marked chinook salmon, Oncorhynchus tshawytscha, from California's Central Valley. Can. J. Fish. Aquat. Sci. 44:1213-1220.

Kohlhorst, D.W. December 1993. Personal Communication. CDFG Bay-Delta Division. Stockton, CA.

Kope, R.G. and L.W. Botsford. 1990. Determination of Factors Affecting Recruitment of Chinook Salmon Oncorhynchus tshawytscha in Central California. U.S. Fishery Bulletin. 88:257-269.

Korson, C.S. 1984. Economic Status of the California Salmon Fishery in 1983. NOAA-TM-NMFS-SWR-005.

Lee, D.C. and J.B. Hyman. 1992. The Stochastic Life-Cycle Model (SLCM): A Tool for Simulating the Population Dynamics of Anadromous Salmonids. May 15, 1992 Draft.

Leidy, G.R., T.H. Richardson, and G.C. Adams. 1984. Evaluation of the Potential Impacts of the Proposed Lake Red Bluff Water Power Project on the Fishery Resources of the Sacramento River. Joint Report by USFWS and USBR. USBR, Sacramento.

Lin, Biing-Hwan, M. Herrman, T-Y Lin, R.C. Mittelhammer. 1989. Forecasting the Price of Farmed Atlantic Salmon: An Integrated Econometric and Time Series Approach. Agribusimess: An International Journal. ?:?

Lin, Biing-Hwan, M. Herrman, T-Y Lin, R.C. Mittelhammer. 1989. Future Price of Farmed Atlantic Salmon. DRAFT.

Lin, Biing-Hwan, M. Herrmann, T. Lin, and R.C. Mittelhammer. 1989. Future Price of Farmed Atlantic Salmon. Amer. Agri. Econ. Asso. annual meeting selected paper AAEA-89-049.

Lin, Biing-Hwan and N.A. Williams. 1988. Specifying a Functional Form for the Influence of Hatchery Smolt Release on Adult Salmon Production. U.S. Fishery Bulletin. 86(4):655-662.

Logan, D.T. 1985. Environmental Variation and Striped Bass Population Dynamics: A Size-Dependent Mortality Model. Estuaries. 8(1):28-38.

Loomis, J.B. 1987. An Economic Evaluation of the Public Trust Resources of Mono Lake. Universtiy of California, Davis. Institute of Ecology Series No. 30. Davis, CA.

Loomis, J.B. 1988. The Bioeconomic Effects of Timber Harvesting on Recreational and Commercial Salmon and Steelhead Fishing: A Case Study of the Siuslaw National Forest. Marine Resource Economics. 15:43-60.

Loomis, J.B. 1989. Estimation of and Variation in Site Specific Marginal Values for Recreational Fisheries. J. Envir. Management. 29(1):183-191.

Loomis, J.B. and J. Cooper. 1990. Economic Benefits of Instream Flow to Fisheries: A Case Study of California's Feather River. Rivers. 1(1):23-30.

Loomis, J.B. 1991. Conceptual and Empirical Classification of Wildlife Benefits and Beneficiaries - Implications for Funding Wildlife Conservation. Policy Studies J. 19(3-4):560-568.

Loomis, J.B., M. Hanemann, B. Kanninen, and T. Wegge. 1991. Willingness to Pay to Protect Wetlands and Reduce Wildlife Contamination From Agricultural Drainage. In: The Economics and Management of Water and Drainage in Agriculture. A. Dinar and D. Zilberman, Editors. Kluwer Academic Publishers. Norwell, Mass.

Loomis, J.B. and M. Creel. 1992. Recreation Benefits of Increased Flows in California's San Joaquin and Stanislaus Rivers. Rivers 3(1):1-13.

Loomis, J.B. and S. Ise. 1992. Net Economic Value of Recreational Fishing on the Sacramento River in 1980. In: Integrated Modeling of Drought and Global Warming: Impacts on Selected California Resources. National Institute for Global Environmental Change, University of California, Davis.

Ludwig, D., R. Hilborn and C. Walters. 1993. Uncertainty, Resource Exploitation, and Conservation: Lessons from History. Science. 260: pp. 17 and 36.

Lufkin, A. ed. 1991. California's Salmon and Steelhead: The Struggle to Restore an Imperiled Resource. University of California Press. Berkeley, C.A. pp. 305.

Mangel, M. and R.E. Plant. 1985. Regulatory Mechanisms and Information Processing in Uncertain Fisheries. Marine Resource Economics. 1(4):389-418.

Mannesto, G. 1989. Comparative Evaluation of Respondent Behavior in Mail and In-person Contingent Valuation Methodology Surveys. Ph.D. dissertation. University of California, Davis. Davis, CA.

Mannesto, G. and J.B. Loomis. 1991. Evaluation of Mail and In-person Contingent Valuation Surveys - Results of a Study of Recreational Boaters. J. Envir. Management. 32(2):177-190.

Matson, B. 1991. The Commercial Troller. In Salmon and Steelhead: The Struggle to Restore an Imperiled

Resource. Alan Lufkin, ed. Univ. California Press. Berkeley, CA.

Mayer, J. Judge Says Salmon Safety Comes Before Farmer's Rights. The Sacramento Bee. December 14, 1991.

Mayer, J. Ancient Idea Offered as Savior for Salmon. The Sacramento Bee. January 27, 1992.

McCann, R. 1992. Economic Impacts on the Northern California Hydropower System. DRAFT Report for NIGEC.

McConnell, K.E. 1985. The Economics of Outdoor Recreation. In: Handbook of Natural Resource and Energy Economics, vol. II, Chapter 15. A.V. Kneese and J.L. Sweeney, Editors. Elsevier Science Publishers B.V.

McCully, H. 1956. An Undescribed Type of Migration in King Salmon, Oncorhynchus tshawytscha (Walbaum). California Fish and Game. 42(3):189.

McEvoy, A.F. 1979. Economy, Law, and Ecology in the California Fisheries to 1925. PhD. Dissert, Department of History, University of California, San Diego.

McKervill, H.W. 1967. The Salmon People. Gray's Publ. Ltd. Sidney, B.C. Canada. 198 pp.

McNeil, W.J., Ed. 1988. Salmon Production, Management, and Allocation: Biological, Economic, and Policy Issues. Oregon State University Press. Corvallis, O.R.

Melvin, E.F., B.B. Wyatt and R.J. Price. 1983. Recommended Procedures for Handling Troll-Caught Salmon. California Sea Grant.

Merkel, T.J. 1957. Food Habits of the King Salmon, Oncorhynchus tshawytscha (Walbaum), in the Vicinity of San Francisco, California. California Fish and Game. 43(4):249-.

Meyer, P.A. 1977. New Approaches to Canadian Recreational Fisheries. In: Pacific Salmon: Management for People. D.V. Ellis, Ed. Western Geographical Series, Vol. 13, Department of Geography, University of Victoria, Victoria, British Columbia, Canada.

Meyer, P.A. 1985. The Economic Value of Striped Bass, Chinook Salmon, and Steelhead Trout of the Sacramento and San Joaquin River Systems. Admin. Report 85-93, California Department of Fish & Game.

Meyer, P.A. 1987. A Review of "Results of the Bay Area Sportfish Economic Study (BASES)". Bay Institute of San Francisco Exhibit No. 47A. State Water Resources Control Board Bay-Delta Hearings, 1987. Sacramento, CA.

Meyer, P.A. 1987. The Value of King Salmon, Harbor Seals and Wetlands of San Francisco Bay. The Bay Institute of San Francisco. Sausalito, CA.

Meyer, P.A. 1987. Summary of Testimony. Bay Institute of San Francisco Exhibit No. 39, State Water Resources Control Board, 1987 Bay-Delta Hearings. Sacramento, CA.

Meyer, P.A. 1987. Value Associated With King Salmon of the Sacramento/San Joaquin/San Francisco Bay System. Bay Institute of San Francisco Exhibit No. 40, State Water Resources Control Board, 1987 Bay-Delta Hearings. Sacramento, CA.

Meyer, P.A. 1991. What's a Salmon Worth? In Salmon and Steelhead: The Struggle to Restore an Imperiled

Resource. Alan Lufkin, ed. Univ. California Press. Berkeley, CA.

Meyer Resources, Inc. 1985. The Economic Value of Striped Bass, Chinook Salmon, and Steelhead Trout of the Sacramento and San Joaquin River Systems. Admin. Report 85-93, California Department of Fish & Game.

Miller, W.J. 1986. The State of San Francisco Bay: A Report for the Bay Area Dischargers Association.

Mills, T.J. 1988. Klamath Basin: A Glimpse of Salmon Biology. Outdoor California. Sept-Oct Issue.

Mitchell, R.C. and R.T. Carson. 1989. *Using Surveys to Value Public Goods: The Contingent Valuation Method.* Resources for the Future. Washington, D.C.

Monaco, M.E., R.L. Emmett, S.A. Hinton, and D.M. Nelson. 1990. Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries, Volume 1: Data Summaries. ELMR Rep. No. 4. Strategic Assessment Branch, NOS/NOAA, Rockville, MD. 240 pp.

Morey, E.R., W.D. Shaw and R.D. Rowe. 1991. A Discrete-Choice Model of Recreational Participation, Site Choice, and Activity Valuation When Complete Trip Data Are Not Available. JEEM 20:181-201.

Moyle, P.B. 1976. Inland Fishes of California. University of California Press. Berkeley, CA. 405 pp.

Moyle, P.B., R.A. Daniels, B. Herbold and D.M. Baltz. 1986. Patterns in Distribution and Abundance of a Noncoevolved Assemblage of Estuarine Fishes in California. Fishery Bulletin. 84(1):105-117.

Moyle, P.B, J.E. Williams and E.D. Wikramanayake. 1989. Fish Spcies of Special Concern of California. Report for CDFG, Inland Fisheries Division, Rancho Cordova, C.A.

Moyle, P.B. 1992a. Causes of Decline in Estuarine Fish Species. Representing The Natural Heritage Institute, et. al., testimony before the SWRCB, Exhibit WRINT-NHI-9.

Moyle, P.B. 1992b. Artificial Propagation of Declining Fish Species in the Estuary Does Not Substitue for the Habitat Restoration Measures Required for Natural Production. Representing The Natural Heritage Institute, et. al., testimony before the SWRCB, Exhibit WRINT-NHI-19.

Myers, K.W. and H.F. Horton. 1982. Temporal Use of an Oregon Estuary By Hatchery and Wild Juvenile Salmon. In: Estuarine Comparisons. Ed.: V.S. Kennedy. Academic Press. New York.

National Council on Gene Resources. 1982. Anadromous Salmonid Genetic Resources: An Assessment and Plan for California. California Gene Resources Program. Berkeley, CA.

National Fisherman. 1992. Captive Broodstock Program May Help Jump-Start the Recovery of an Endangered Salmon Run. Kris Freeman. October Issue.

National Fisherman. 1992. Endangered California Salmon Face Threats from Lethal Rivers. Brooks Mencher. December Issue.

National Fisherman. 1993a. California Herring - An Uncertain Future. August issue.

National Fisherman. 1993b. San Francisco Herring Under Fire. August issue.

Neilson, J.D. and G.H. Geen. 1985. Effects of Feeding Regimes and Diel Temperature Cycles on Otolith

Increment Formation in Juvenile Chinook Salmon, Oncorhynchus tshawytscha. U.S. Fishery Bulletin. 83(1)91-101.

Neilson, J.D., G.H. Geen, and B. Chan. 1985. Variability in Dimensions of Salmonid Otolith Nuclei: Implications for Stock Identification and Microstructure Interpretation. U.S. Fishery Bulletin. 83(1):81-89.

Neuman, T. 1936. Method Used in Compiling the Full Natural Runoffs of Streams In California Stream Basins. Calif. Dept. Public Works, Div. Water Resources. 16 pp.

Newell, D. ed. 1990. The Development of the Pacific Salmon-Canning Industry: A Grown Man's Game. McGill-Queen's University Press. Toronto, Canada. pp. xix + 303.

NMFS. 1990. Southwest Region Seafood Dealers Guide - 1990 Edition. NOAA-NMFS-Admin.Rep.-SWR-90-02. NMFS Southwest Region. Terminal Island, CA.

NMFS. Huppert, D.D. 1987. Limited Access Alternatives for the Pacific Groundfish Fishery. NOAA-NMFS-Tech.Rep.-52.

NOAA. Huppert, D.D. 1987. Limited Access Alternatives for the Pacific Groundfish Fishery. NOAA Tech. Rep. NMFS 52.

Nolte, C. 1993. Fish Businesses Can't Catch a Break. San Francisco Chronicle, April 8, 1993.

Northwest Energy News. 1993 Jan.-Febr Issue. Sacramento Basin Blues: A Sad Old Saga In Search of a New Refrain.

Olsen, D., J. Richards and R.D. Scott. 1991. Existence and Sport Values for Doubling the Size of Columbia River Basin Salmon and Steelhead Runs. Rivers. 2(1):44-56.

Orlob, G.T. 1990. San Joaquin Salt Balance Future Prospects and Possible Solutions. Civil Engin. Dept., U.C. Davis.

Painter, R.E., L.H. Wixom, and S.N. Taylor. 1977. An Evaluation of Fish Populations and Fisheries in the Post-Oroville Project, Feather River. CDFG, Rancho Cordova, CA. pp. 56.

Petry, G.H. 1979. Pacific Northwest Salmon and Steelhead Fishery Report (Volume 1): The Economic Status of the Oregon and Washington Non-Indian Salmon Gillnet and Troll Fishery. College of Business and Economics, Washington State University.

Petry, G.H., L.L. Blakeslee, W.R. Butcher, R.J. Fuller, and S.K. Staitieh. 1979. Pacific Northwest Salmon and Steelhead Fishery Report (Volume 2): The Economic and Employment Impacts of Commercial and Sport Fishing for Salmon and Steelhead in the Pacific Northwest. College of Business and Economics, Washington State University.

Pinkas, L., M.S. Oliphant and C.W. Haugen. 1968. Southern California Marine Sportfishing Survey: Private Boats, 1964; Shoreline, 1965-66. CDFG Fish Bulletin 143. Sacramento, CA.

Pool, R.L. 1991. American River Trout Hatchery. Outdoor California. Jul.-Aug. Issue.

PFMC. 1979. Freshwater Habitat, Salmon Produced, and Escapements for Natural Spawning along the Pacific Coast of the U.S. Pacific Fisheries Management Council. Portland, OR.

PFMC. 1986. Review of 1985 Ocean Salmon Fisheries. Pacific Fisheries Management Council. Portland, OR.

PFMC. 1986. Preseason Report III: Analysis of Council Adpoted Management Measures for 1986 Ocean Salmon Fisheries. Portland, O.R.

PFMC. 1986. Review of 1985 Ocean Salmon Fisheries. Pacific Fisheries Management Council. Portland, OR.

PFMC. 1988. Draft Ninth Amendment to the Fishery Management Plan for Commercial and Recreational Salmon Fisheries off the Coasts of Washington, Oregon, and California Commencing in 1978. Portland, O.R.

PFMC. 1992. Review of 1991 Ocean Salmon Fisheries. Pacific Fisheries Management Council. Portland, O.R.

PFMC. 1993. Review of 1992 Ocean Salmon Fisheries. Pacific Fisheries Management Council. Portland, OR.

PSMFC. 1991. User's Guide for On-Line Retrieval of CWT Data. Pacific States Marine Fisheries Commission, Regional Mark Processing Center. Portland, OR.

Radtke, H. and W. Jensen. 1985. Fisheries Economic Assessment Model. West Coast Fisheries Development Foundation. Portland, O.R. 76 pp.

Radtke, L.D. and J.L. Turner. 1967. High Concentrations of Total Dissolved Solids Block Spawning Migration of Striped Bass, Roccus saxatilis, in the San Joaquin River, California. Trans. Amer. Fish. Soc. 96:405-407.

Randall, R.G., M.C. Healey, J.B. Dempson. 1987. Variability in Length of Freshwater Residence of Salmon, Trout, and Char. Amer. Fish. Soc. Symp. 1:27-41.

Raney, E.C. 1952. The Life History of the Striped Bass, Roccus saxatilis (Walbaum). Yale University, Peabody Museum of Natural History, Bulletin of the Bingham Oceanographic Collection, 14:5-97. New Haven, Connecticut.

Reisenbichler, R.R. and S.R. Phelps. 1987. Genetic Variation in Chinook, Oncorhynchus tshawytscha, and Coho, O. kisutch, Salmon From the North Coast of Washington. Fishery Bulletin. 85(4):681-701.

Richards, J. 1986. Economic Information for Habitat Management Decisions. ?.

Richards, J. 1986. Technical Appendix to Economic Information for Habitat Management Decisions. ?.

Reynolds, F.L., R.L. Reavis, J. Schuler. 1990. Central Valley Salmon and Steelhead Restoration and Enhancement Plan. CDFG, Inland Fisheries Division.

Robertson, O.H. 1957. Survival of Precociously Mature King Salmon Male Parr (Oncorhynchus tshawytscha juv.) After Spawning. California Fish and Game. 43(2):119-.

Rogness, R.V. and Biing-Hwan Lin. 1986. The Marketing Relationship Between Pacific and Pen-Raised Salmon: A Survey of U.S. Seafood Wholesalers. University of Alaska. Alaska Sea Grant Report 86-3.

Rosenman, R. 1991. Impacts of Recreational Fishing on the Commercial Sector: An Empirical Analysis of Atlantic Mackerel. Natural Resource Modeling. 5(2):239-257.

Rowell, J.H. 1990. USBR Monthly Temperature Model - Sacramento River Basin. Draft Report. USBR Mid-Pacific Region, Sacramento, C.A. pp. 26 +Appendices.

Saiki, M.K., M.R. Jennings and S.J. Hamilton. 1991. Preliminary Assessment of the Effects of Selenium in Agricultural Drainage on the Fish in the San Joaquin Valley. In: The Economics and Management of Water and Drainage in Agriculture. A. Dinar and D. Zilberman, Editors. Kluwer Academic Publishers. Norwell, Mass.

Saiki, M.K., M.R. Jennings and R.H. Wiedmeyer. 1992. Toxicity of Agricultural Subsurface Drainwater from the San Joaquin Valley, California, to Juvenile Chinook Salmon and Striped Bass. Trans. Am. Fish. Soc. 121:78-93.

San Francisco Estuary Project. 1992. Status and Trends Report on Aquatic Resources in the San Francisco Estuary. San Francisco Estuary Project. San Francisco, CA.

San Francisco Estuary Project. 1992. State of the Estuary: A Report on Conditions and Problems in the San Francisco Bay / Sacramento-San Joaquin Delta Fishery. San Francisco Estuary Project. San Francisco, CA.

San Francisco Estuary Project. 1993. Managing Freshwater Discharge to the San Francisco Bay / Sacramento-San Joaquin Delta Estuary: The Scientific Basis for an Estuarine Standard. San Francisco Estuary Project. San Francisco, CA.

Sanders, L.D., R.G. Walsh, and J.B. Loomis. 1990. Toward Empirical Estimation of the Total Value of Protecting Rivers. Water Resources Research. 26(7):1345-1357.

Schaffter, R.G. 1987. Job Final Report - White Catfish Population Dynamics and Life History Studies. CDFG, Bay-Delta Division, Project F-9-R-33.

Scofield, N.B. 1929. The Status of Salmon in California. California Fish and Game. 15(1):13-18.

Seger, J. 1993. PFMC salmon fisheries specialist. Personal communication, December 1993.

Shaw, S. and J.F. Muir. 1987. Salmon: Economics and Marketing. Timber Press. Portland, OR.

Shebley, W.H. 1927. History of Fish Planting in California. California Fish and Game. 13(3):163-180.

Siegfried, C.A. 1982. Trophic relations of Crangon franciscorum and Palaemon macrodactylus Rathbun; predation on the opossum shrimp, Neomysis mercedis Holmes. Hydrobiologia 89:129-139.

Siegfried, C.A. 1989. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific southwest) -- Crangonid Shrimp. USFWS Biol. Rep. No. 82(11.125) U.S. Army Corps of Engineers, TR EL-82-4. 18 pp.

Slater, D.W. 1963. Winter-Run Chinood Salmon in the Sacramento River, California, With Notes on Water Temperature Requirements At Spawning. USFWS Special Scientific Report -- Fisheries No. 461.

Smith, J.B. 1986. Stochastic Steady-State Replenishable Resource Management Policies. Marine Resource Economics. 3(2):155-168.

Smith, R.T, R. Vaughan. 1989. A Statistical Analysis of the Effect of Project Exports on Striped Bass Fisheries. Water Strategist. Jan. 1989. Stratecon, Inc. Claremont, C.A.

Smith, S.E. and S. Kato. 1979. The Fisheries of San Francisco Bay: Past, Present and Future. National Marine Fisheries Service. Tiburon, CA.

Smith, S.H. 1950?. Upper Sacramento River Sport Fishery. USFWS Special Scientific Report - Fisheries No. 34..

Smith, V.K. 1989. Taking Stock of Progress with Travel Cost Recreation Demand Methods: Theory and Implementation. Marine Resource Economices. 6:279-?

Smith, V.L. 1969. On models of commercial fishing. J. Polit. Econ. 77:181-198.

Snyder, J.O. 1931. Salmon of the Klamath River California. CDFG Fish Bulletin No. 34. Sacramento, C.A.

Somach, S.L. 1990. The American River Decision: Balancing Instream Protection with Other Competing Beneficial Uses. Rivers. 1(4):251-263.

Spectrum Economics, Inc. 1991. Recreation Forecasts and Benefit Estimates for California Reservoirs: Recalibrating the California Travel Cost Model. Report to Joint Agency Recreation Committee. Sacramento, CA.

Spencer, J. 1936. Prevention of Fish Loss in Water Diversions. California Fish and Game. 22(4):301-309.

Spies, R.B., D.W. Rice and J. Felton. 1988. Effects of organic contaminants on reproduction of the starry flounder in San Francisco Bay. I. Hepatic contamination and mixed function oxidase activity (MFO) during the reproductive season. Mar. Biol. 98:181-189.

Spies, R.B., J. Stegeman, D.W. Rice, B. Woodin, P. Thomas, J.E. Hose, J. Cross and M. Prieto. 1990. Sublethal responses of *Platichthys stellatus* to organic contamination in San Francisco Bay with emphasis on reproduction. In: Biological Markers of Environmental Contamination. Lewis Publishers, Chelasea, MI.

Socioeconomics of the Idaho, Washington, Oregon, and California Coho and Chinook Salmon Industry, 2 volumes. 1978. Oregon State University, Dept. of Agri. and Resource Economics. Corvallis, OR.

Spulber, D.F. 1985. The Multicohort Fishery Under Uncertainty. Marine Resource Economics. 1(3):265-282.

Stevens, D.E. December 1993. Personal Communication. CDFG Bay-Delta Division. Stockton, CA.

Stevens, D.E. and H.K. Chadwick. 1979. Sacramento-San Joaquin Estuary: Biology and Hydrology. Fisheries. 4(4):2-6.

Stevens, D.E. and L.W. Miller. 1983. Effects of River Flow on Abundance of Young Chinook Salmon, American Shad, Longfin Smelt, and Delta Smelt in the Sacramento-San Joaquin River System. North American Journal of Fisheries Management. 3:425-437.

Stevens, D.E., D.W. Kohlhorst, L.W. Miller, and D.W. Kelley. 1985. The Decline of Striped Bass in the Sacramento-San Joaquin Estuary, California. Trans. Amer. Fish. Soc. 114:12-30.

Swartzman, G.L. 1991. Equilibrium Abundance of Salmon Stocks in a Life Cycle Model with Interacting Hatchery and Natural Substocks. Natural Resource Modeling. 5(1):1-18.

SWRCB. 1978. Water Right Decision 1485. State Water Resources Control Board. Sacramento, C.A.

SWRCB. 1990. Water Quality Control Plan for Salinity: San Francisco Bay / Sacramento - San Joaquin Delta Estuary. Revised Draft. Report No. 91-16WR. State Water Resources Control Board. Sacramento, C.A.

SWRCB. 1991. Technical Appendix - Water Quality Control Plan for Salinity: San Francisco Bay / Sacramento - San Joaquin Delta Estuary. State Water Resources Control Board. Sacramento, C.A.

C-110577

SWRCB. 1992. Draft Water Right Decision 1630. State Water Resources Control Board. Sacramento, CA.

SWRCB. 1993. Draft Water Reight Decision 1630. State Water Resources Control Board. Sacramento, CA. pp.155+appendices.

Sykes, S.D. and L.W. Botsford. 1986. Chinook Salmon, Oncorhynchus tshawytscha, Spawning Escapement Based on Multiple Mark-Recapture of Carcasses. Fishery Bulletin. 84(2):261-270.

Taylor, S.N. and R.J. Hallock. 1972. King (Chinook) Salmon Spawning Stocks in California's Central Valley - 1971. CDFG Anadromous Fisheries Branch Admin. Rep. No. 73-2.

Thabault, M.G. 1990. Southwest Region Seafood Dealers Guide -1990 Edition. NOAA-NMFS-AR-SWR-90-02. Terminal Island, CA.

Thompson, C.J. and D. Huppert. 1987. Results of the Bay Area Sportfish Economic Study. (NOAA-TM-NMFS-SWFC-78) August. National Marine Fisheries Service, Southwest Fisheries Center. LaJolla, CA.

Ueber, E. 1993. Personal Communication. Sanctuary Manager for the Gulf of the Farallons National Marine Sanctuary, CA. (Formerly with NMFS, Tiburon, CA).

US Army Corps of Engineers. 1992. Public Notice No. 9200600. Regarding a tempory barrier across Georgianna Slough. Sacramento, CA. Issued 8/27/1992.

USBR. 1983. Central Valley Fish and Wildlife Management Study: Predation of Anadromous Fish in the Sacramento River, California. Special Report. Mid-Pacific Region. Sacramento, C.A. pp. 77 + Appendix.

USBR. 1991. Executive Summary: 1990 Striped Bass Egg and Larvae Management Studies - San Francisco Bay-Delta Estuary. SWRCB 1992 Hearings Exhibit No. WRINT-USBR-2. Sacramento, CA.

USBR. 1992. Testimony of the USBR, Mid-Pacific Region, for the Water Right Phase of the Bay-Delta Estuary Proceedings Before the SWRCB. SWRCB 1992 Hearings Exhibit No. WRINT-USBR-10. Sacramento, CA.

USDA. 1993. Agricultural Statistics - 1992. U.S. Department of Agriculture. U.S. Government Printing Office. Washington, DC.

USDC. 1992. Fisheries of the United States -1991. USDC-NOAA-NMFS-Current Fishery Statistics No. 9100. U.S. Gov't Printing Office, Washington, DC.

USDC. 1993. Statistical Abstract of the United States - 1992. U.S. Dept. Commerce. U.S. Government Printing Office. Washington, DC.

USFWS. 1950?. Smith, S.H. Upper Sacramento River Sport Fishery. USFWS Special Scientific Report - Fisheries No. 34. pp. 26 + Appendices.

USFWS. 1978. Hydraulic Simulation In Instream Flow Studies: Theory and Techniques. Instream Flow Information Paper No. 5. Env. Protec. Agency, Heritage Cons. and Rec. Service, Bur. of Rec.

USFWS. 1985. Flow Needs of Chinook Salmon in the Lower American River: Final Report of the 1981 Lower American River Flow Study. Prepared by the USFWS for the U.S. Bureau of Reclamation, Mid-Pacific Region, Sacramento, CA. pp. 21.

C-110578

USFWS. 1987. Water Quality and Water Quantity Needs for Chinook Salmon Production in the Upper Sacramento River. Exhibit 29 for the State Water Resources Control Board 1987 Water Quality/Water Rights Proceeding on the San Francisco Bay/Sacramento - San Joaquin Delta. Stockton, C.A.

USFWS. 1987. The Needs of Chinook Salmon, Oncorhynchus tshawytscha, in the Sacramento - San Joaquin Estuary. Exhibit 31 for the State Water Resources Control Board 1987 Water Quality/Water Rights Proceeding on the San Francisco Bay/Sacramento - San Joaquin Delta. Stockton, C.A.

USFWS. 1988. 1985 National Survey of Fishing, Hunting & Wildlife-Associated Recreation.

USFWS. 1992. Expert Testimony of USFWS on Recommendations for Interim Protection and Response to Hearing Notice Key Issues. SWRCB 1992 Hearings Exhibit No. WRINT-USFWS-8. Sacramento, CA.

USFWS. 1992. Interagency Statement of Principles - USFWS, NMFS, EPA. SWRCB 1992 Hearings Exhibit No. WRINT-USFWS-10. Sacramento, CA.

Utter, F., D. Teel, G. Milner and D. McIsaac. 1985. Genetic Estimates of Stock Compositions of 1983 Chinook Salmon, Oncorhynchus tshawytscha, Harvests Off the Washington Coast and the Colombia River. Fishery Bulletin. 85(1):13-23.

Utter, F., G. Milner, G. Stahl and D. Teel. 1989. Genetic Population Structure of Chinook Salmon, Oncorhynchus tshawytscha, in the Pacific Northwest. Fishery Bulletin. 87:239-264.

Vogel, D.A. 1982. Preferred Spawning Velocities, Depths, and Substrates for Fall Chinook Salmon in Battle Creek, California. USFWS. Red Bluff, C.A.

Wade, W.W. 1990. Estimating California Freshwater Recreation Visitation and Benefits with the California Travel Cost Model. Spectrum Ecomonics, Inc. San Francisco, CA.

Waldvogel, J. 1992. Klamath Management Zone Ocean Salmon Sport Fishery Survey. California Sea Grant. UCSGEP 92-3.

Walters, C.J. 1977. Management Under Uncertainty. In: Pacific Salmon: Management for People. D.V. Ellis, Ed. Western Geographical Series, Vol. 13, Department of Geography, University of Victoria, Victoria, British Columbia, Canada.

Walters, C.J. 1988. Mixed-Stock Fisheries and the Sustainability of Enhancement Production for Chinook and Coho Salmon. In: Salmon Production, Management, and Allocation: Biological, Economic, and Policy Issues. W.J. McNeil, Ed. Oregon State University Press. Corvallis, O.R.

Wang, J.C.S. 1986. Fishes of the Sacramento-San Joaquin Estuary and Adjacent Waters, California: A Guide to the Early Life Histories. CDWR, Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary, Technical Report. Sacramento, CA.

Warner, G.H., D.H. Fry, Jr. and A.N. Culver. 1961. History of Yearling King Salmon Marked and Released At Nimbus Hatchery. California Fish and Game. ?.

Wertheimer, A., A. Celewycz, H. Jaenicke, D. Mortensen, and J. Orsi. 1989. Size-related Hooking Mortality of Incidentally Caught Chinook Salmon, Oncorhynchus tshawytscha. Marine Fisheries Review. 51(2):28-35.

Wessells, C.R. 1990. An Economic Analysis of the Japanese Salmon Market. PhD. Dissertation. Dept. Agri.

Economics, U.C. Davis. Davis, CA.

Wessells, C.R. and J.E. Wilen. 1993. Inventory Dissipation in the Japanese Wholesale Salmon Market. Marine Resource Economics. 8:1-16.

Western Water. 1990. Sacramento River Fisheries: Restoring a Declining Resource. Water Education Foundation. Sacramento, CA. Jul.-Aug. Issue.

Western Water. 1992. California's Chinook Salmon: Upstream Battle to Restore the Resource. Water Education Foundation. Sacramento, CA. Nov.-Dec. Issue.

Western Water. 1993. Changes in the Central Valley Project. Water Education Foundation. Sacramento, CA. Jan.-Febr. Issue.

Western Water. 1993. The Delta Dilemma Continues. Water Education Foundation. Sacramento, CA. Mar.-Apr. Issue.

Wheaton, F.W. and T.B. Lawson. 1985. Processing Aquatic Food Products. Wiley-Interscience. New York, New York.

Wilen, J.E. 1985. Towards a Theory of the Regulated Fishery. Marine Resource Economics. 1(4):369-388.

C-110580

6.0 APPENDICES

APPENDIX A - THE DUMAS AND HANEMANN (1992) SALMON POPULATION MODEL

Our model is a spatially and temporally explicit deterministic system of difference equations. The model discriminates spatially between specific portions, or "reaches," of the Sacramento River system, the San Francisco Bay and Delta, and the ocean. The San Joaquin River and its tributaries are not considered. Temporal effects are captured by using a weekly time step. We choose a weekly time step for two reasons. First, because it is a compromise between (1) the need for a small time step to capture the density-dependent spawning mechanism and (2) the convenience of a large time step for running simulations. Second, a weekly time step is compatible with EA Engineering's (1991) San Joaquin salmon model. Any given simulation scenario may consist of many years, each year consisting of 52 weeks.

The model is a compartment-type model consisting of stock variables, flow variables, and linear and non-linear difference equations defining the relationships between the variables over time. Stock variables describe a quantity of interest. The principal stock variables in our model are the numbers of salmon by age in the ocean and the numbers of eggs by river reach inland. Because our model uses long-term average streamflow data, our stocks should be interpreted as expected, or average, quantities, and so results denominated in fractions of fish, for example, are reasonable. Flow variables describe changes in stock variables. Flow variables include the various rates of growth, mortality, escapement, fecundity, etc. that affect fish and egg stocks, as well as variables such as streamflows, gravel quality, and hatchery operations that affect those rates. Other factors that may affect flow variables are not explicitly included in the model, yet many of these factors are correlated with streamflow. By emphasizing the effects of streamflow in our model structure, we hope to partially account for the effects of any correlated factors.

The model is deterministic, because it contains no random variables. All parameters are assumed constant except streamflows and functions of streamflows, where streamflows are given information. We use difference equations instead of differential equations in our model, because many of the mechanisms we consider involve discrete quantities (i.e., numbers of fish or eggs) and discontinuous processes (i.e., the trucking of hatchery smolts to San Francisco Bay for release). In addition, STELLA II® easily handles a difference equation framework. Future research may focus on the random, or stochastic, nature of some of these parameters.

Another aspect of model structure is the linearity or non-linearity of the equations that relate the stock and flow variables together. Non-linearity can lead to classic density-dependent biological relationships. For example, in this model it is hypothesized that the process of "superimposition" leads to density-dependent salmon spawning. Other non-linear relationships exist in the inland module of the model. However, since we are not aware of any verified density-dependent mechanisms at work on chinook salmon in the ocean, our ocean module is described entirely by linear relationships.

The concerted action of many mechanisms determines the net behavior of the salmon population. In keeping with our objective of focusing on the effects of changing flow regimes, we would like our model to have a high level of resolution with respect to those aspects of the salmon life cycle most influenced by changing streamflows. However, other aspects of the salmon life history can be modeled with less resolution, using coarser relationships and average or equilibrium values for key variables. We strive for an intermediate level of model complexity, somewhere between the precedent models of Biosystems Analysis (1989) and Kelley, Greene, and Mitchell (1990). The Biosystems model addresses a multitude of mechanisms, being very generalized yet cumbersome. The Kelley, Greene, and Mitchell (1990) model uses a coarse stock-recruitment mechanism to model spawning, possessing less resolution in this critical flow-dependent life history phase than we would prefer given our modeling objectives. See the full Dumas and Hanemann (1992) report for further description of this model.

APPENDIX B - ECONOMIC INEFFICIENCY IN THE CALIFORNIA SALMON FISHERY

Problems with overfishing and low profitability have plagued the California salmon industry throughout its history, resulting in a extended series of regulatory actions. Indeed, the first season closure occurred in 1880, when commercial fishing in the Sacramento River and San Francisco Bay was prohibited in August and on Saturdays (Clark 1929). Seine-net fishing was prohibited in 1924 (Clark 1929), and gillnet fishing was finally outlawed in 1956. But before these relatively efficient harvesting methods were banned, Crutchfield (1977) noted that many of the purse seine and gill net fishermen were forced by competition and limited regulation to operate much farther from the river mouths than they would have under sole ownership of the resource, leading to profit dissipation. Because the various stocks of salmon are more mixed farther out to sea, this also made biological management of the fish more difficult. This problem was institutionalized in 1957, when, in an attempt to reduce overfishing, all commercial fishing by boat inside San Francisco Bay was eliminated by legislation. Since 1957, the commercial salmon industry has been supported by the ocean troll fishery (Feinberg and Morgan 1980).

These regulations sought to reduce overfishing by reducing the efficiency of the harvest. Crutchfield (1977) commented that because regulatory agencies had lacked the authority to control entry to the fishery, they were forced to manage stocks through directly or indirectly reducing gear efficiency, leading to lower fishing profits. Further, as overfishing depletes the fish stock, individual vessel effort must increase to maintain catch. But because marginal costs generally increase with individual vessel effort in this industry, profits decline even as effort increases (Feinberg and Morgan 1980).

Most fishery managers and many salmon fishermen see the need to limit fishing effort and generally support such programs. CDFG estimates that aggregate fishing effort for salmon in California almost tripled between 1965 and 1980 (Feinberg and Morgan 1980). In 1976, a first step toward limiting entry was taken when the Fishery Conservation and Management Act (FCMA) banned foreign factory ships from the 200-mile Exclusive Economic Zone (Matson 1988) off the California coast. The Act also established the Pacific Fishery Management Council (PFMC) to recommend fishery management plans for commercial fisheries, in cooperation with CDFG, to the U.S. Secretary of Commerce for approval. The plans may recommend limited fishing seasons, gear restrictions, area closures, and entry limits. However, the plan must consider how restrictions would affect the social and economic well-being of those who use the fishery. In addition, commercial fishing licenses are required by CDFG (Feinberg and Morgan 1980).

The sport fishery is currently regulated by both federal and state agencies (Feinberg and Morgan 1980). In addition to respecting any federal regulations resulting from the FCMA, sport fishermen must obtain a license from CDFG. Recreational fishing is permitted on most inland rivers and is regulated in most cases by specifying restricted fishing seasons and a maximum allowable catch per day (creel limit).

Commercial and sport fishing have been limited as one part of an overall strategy to increase salmon stocks, especially federally and state-listed threatened or endangered sub-stocks. Changes in the timing of water releases from dams necessary for the recovery of threatened or endangered sub-stocks may be harming the larger fall-run sub-stocks on which fishermen depend (Western Water 1992).

Based on the King and Flagg economic analysis of the industry and an assumed industry objective of profit maximization, King at first recommended that California's commercial fishery be composed entirely of a smaller number of large vessels. Alternatively, more efficient trap and net-based fishing methods are available, and studies have documented their potential profitability,[16] but squabbles between interest groups concerning the

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[16] Crutchfield and Pontecorvo (1969), present descriptions of alternative salmon fishing technologies (Figure 3.). These are summarized below, along with references to their potential comparative efficiencies.

Trapping - Fish traps placed in rivers to catch salmon migrating upstream are the most efficient harvest method (Figure 4.). Though initial capital costs would be high, average costs would be the lowest. However, fishermen have successfully lobbied to have traps banned. Crutchfield (1977) notes, "Although fish traps are in many areas the most efficient method of harvesting salmon, their use is so politically unacceptable . . . [I will] confine discussion to other gear."

distribution of the potential gains from using alternative fishing techniques have prevented their adoption. The fishermen responded to King's recommendation of fewer, larger vessels by arguing that using more, smaller vessels reduced fishing efficiency and in effect allowed greater sustainable fishing employment. Apparently, the fishermen made their point well; King reversed his recommendation. However, the fishermen again objected, saying that there was a place for some large vessel, low cost harvesting in the industry, but that maximizing profits was not the sole industry objective (Grader, 1992). Apparently, fishing as "a way of life" conveys valuable non-market benefits to commercial fishermen, and commercial fishing trade associations weigh these non-market benefits against overall industry profitability when formulating policy recommendations. Indeed, commercial troller Matson (1988) gives arguments based on equity and a conservation ethic in support of the *in*efficiency of trolling technology:

> Large, powerful boats with nets are capable of quickly cleaning out the fish resources of the Pacific Ocean's narrow continental shelf. Salmon are especially vulnerable to overfishing because of the ease with which nets can harvest them . . . [the troll industry believes] trolling to be the best method of harvesting salmon. Here's why: (i) trolling is inefficient - the chances of overfishing with troll gear are slim [because of the technological inefficiency of using] hook and line, and small boats, (ii) ocean harvested fish are of higher quality than river harvested fish and (iii) harvest opportunity is spread over dozens of communities along the coast and thousands of fishermen.

Purse Seining - Relatively large seagoing fishing boats surround schooling fish with a net that is drawn together at the bottom and then hauled aboard the ship.

Gill Netting - Medium-sized boats place a large drifting net across the path of migrating fish, entangle the fish by the gills, and then retrieve the net and fish. Fry (1962) estimated the potential profit an efficient limited entry gill net fishery of 50 two-man boats operating in the lower Sacramento River straits. Fry found that by avoiding overcapitalization, geographic races by trollers, crowding over the fishing areas, and the mortality of immature fish associated with trolling, the same average catch could be achieved with an economic profit an order of magnitude larger than total costs! (However, these nets are notorious for killing non-target species.)

APPENDIX C - REVIEW OF ANALYSES OF THE WORLD MARKET FOR SALMON

Bird (1986) estimated an dynamic model of aggregate world Pacific salmon demand at dockside over the period 1958 -1982. In Bird's model, the equilibrium world price of salmon depends upon world salmon landings, OECD consumer expenditures, and the price of a substitute. In Bird's paper, the U.S. ex-vessel price of Pacific salmon is taken as the representative market price.

> The ex-vessel market for Pacific salmon can be viewed, subject to two reservations, as a market in competitive equilibrium. The first reservation is that on occasion price reacts slowly to excess supply and demand; this is allowed for by incorporating lags in the model. In the world market, with its long marketing and distribution channels, lags in the transmission of both supply and demand influences should be expected. Second, there was a potential market disequilibrium in the latter half of the 1970's due to the extension of fishing limits to 200 miles. This had its major effect on Japanese fishing efforts in Alaskan waters. Data problems preclude this from being considered in the current paper. . . .
>
> A number of econometric studies of salmon demand equations have been reported in the literature. These have differed according to salmon species, product form, geographical market, level in the marketing chain (wholesale/retail), specification of the model, and period of estimation. . . . Little consensus emerges from this literature. . . . One common conclusion in the literature is that price-dependent demand models perform substantially better than quantity-dependent models. Bird estimates a single price-dependent demand equation. It is explicitly assumed that landings of salmon are exogenous, and determined principally by biological and oceanographic factors. . . .
>
> The market price is competitively determined, adjusting to equate quantity demanded with the actual quantity landed. Bird investigated several candidate substitute prices: the U.S. ex-vessel price of albacore tuna, and composite indices for the U.S. real price of meat, poultry, and fish. The best fit was obtained with tuna as the substitute. . . .
>
> A dynamic model was specified as first differences in the variables. The static model is the special case where the short-run flexibilities are constrained to equal their long-run values. Ultimately, the price of salmon and of substitutes are determined together in a larger simultaneous model. Estimating a single price equation for salmon, with substitutes included as an explanatory variable, thus implies some endogeneity bias. Given the small size of the salmon market relative to that for other foodstuffs, such bias is unlikely to affect seriously the current results.
>
> Implied Lower-Bound Elasticities
>
> | | | |
> |---|---|---|
> | Short Run | | |
> | Own Price | -2.15 | (s.e. = 1.02) |
> | Substitute Price | 0.22 | (s.e. = 0.57) |
> | Income | 10.29 | (s.e. = 9.18) |
> | Long Run | | |
> | Own Price | -0.88 | (s.e. = 0.27) |
> | Substitute Price | 0.81 | (s.e. = 0.37) |
> | Income | 0.33 | (s.e. = 0.20) |
>
> . . . For both income and own price, the main feature is the difference between the very elastic short-run responses (10.29 and -2.15, respectively) and the less elastic long-run responses (0.33 and -0.88). Short-run income elasticity (10.29) appears high, but the estimate has a large standard error. three of the four elasticity estimates reported by Devoretz (who did

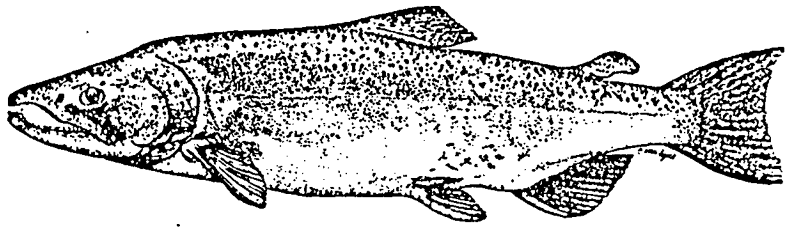
not distinguish short- and long-run responses) lie between the short and long-run estimates reported here. The large short-run elasticities are broadly consistent with salmon's status as a luxury commodity. The less elastic long-run response appears to confirm the importance of habit as a determinant of food consumption patterns over the longer period. The surprisingly high long-run cross-elasticity with respect to the substitute (0.81) should also be noted. This possibly reflects the extent to which salmon competes with tuna in the canned fish sector for lower-income groups. It could also simply reflect the fact that fish prices have moved together under some other influence during the sample period. . . . Atlantic salmon are excluded from the empirical analysis in the absence of reliable price data. However, in recent years quantities of farmed Atlantic salmon have increased substantially. Consequently, if it were desired to use the model to forecast salmon prices into the future, the output of Atlantic salmon would have to be taken into account.

DeVoretz and Salvanes (1993) investigated market structure in the rapidly expanding market for farmed Atlantic salmon, which by 1988 made up 20% of the world total salmon market by weight. While Norway holds a large share (50%+) of this sub-market, Scotland, Chile, Ireland, Japan, and Canada have entered the industry. DeVoretz and Salvanes find that fresh and frozen Coho and Chinook salmon compete directly with Atlantic farmed salmon and that Canada and The United States supply the dominant shares of Coho and Chinook salmon. However, a quantity-dependent model seems to describe the production of the farmed Atlantic salmon market segment better than the price-dependent model that has been found to describe the supply of wild-caught Coho and Chinook salmon. The reason seems to be that salmon farmers time their harvests to coincide with the seasonal drop in wild-caught Pacific salmon supply. Thus, price discrimination by season may occur. But seasonal price discrimination does not occur when Pacific salmon is available; i.e., own price elasticities were higher when wild caught U.S. and Canadian salmon were available. In any event, Devoretz and Salvanes conclude that world price appears to be predetermined. This is supported by the relatively high own-price elasticities estimated by Devoretz and Salvanes using both ordinary least squares (OLS) and two-stage least squares (2SLS) presented below:

Mode Specification	Own-Price Elasticity	Cross-Price Elasticity	Income Elasticity
OLS	-2.38	0.95	2.11
2SLS	-2.47	1.12	2.14

C-110585

Figure 2.1



Chinook salmon, adults typically 75 cm (from Moyle 1976)

C-110586

Source: SWRCB. 1991. Rep. No. 91-16WR.

Timing of life history stages for the four races of Chinook salmon in the Sacramento River Basin
(After USFWS, 29, 5, Figure 2)

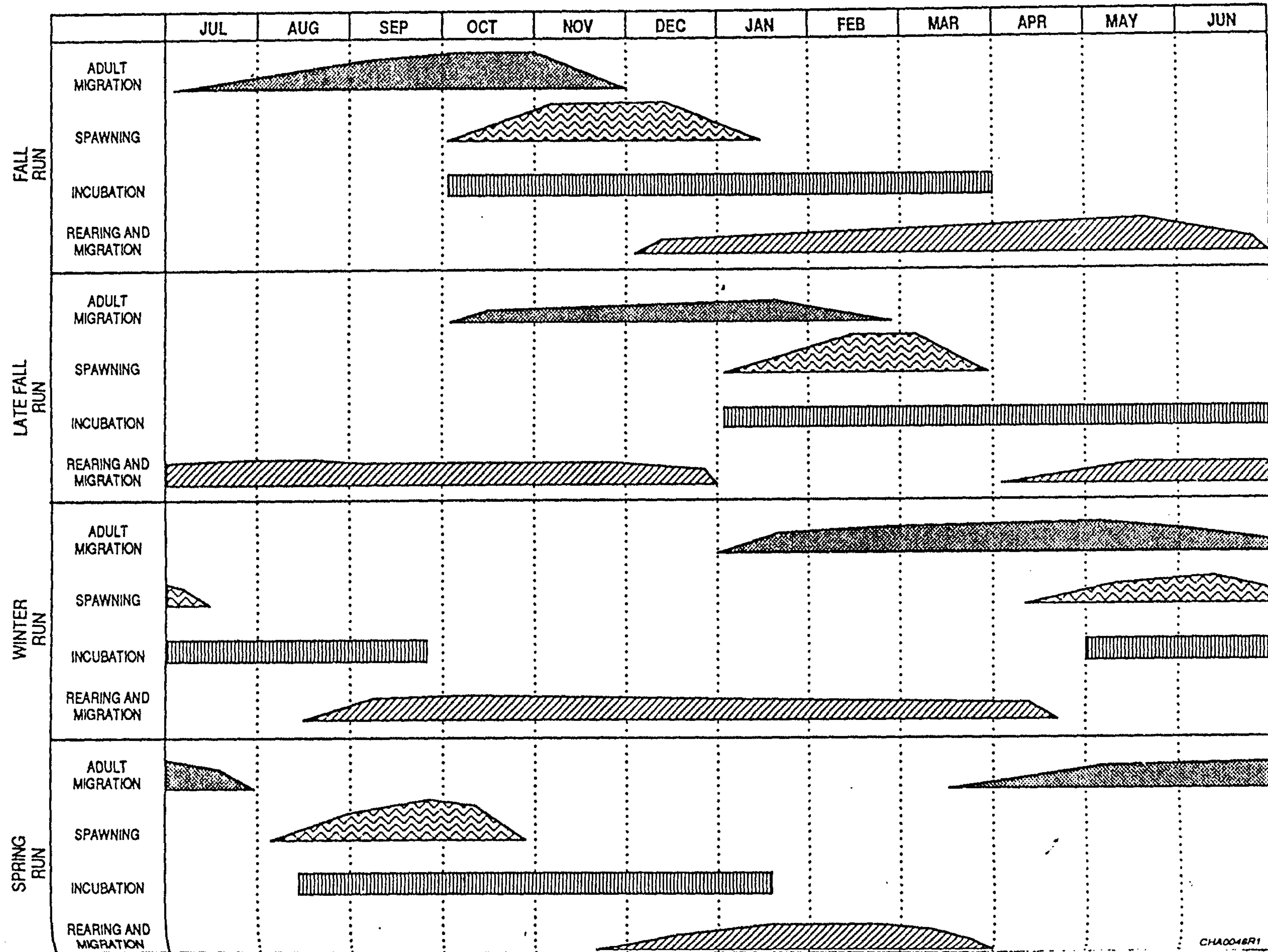


Figure 2.2

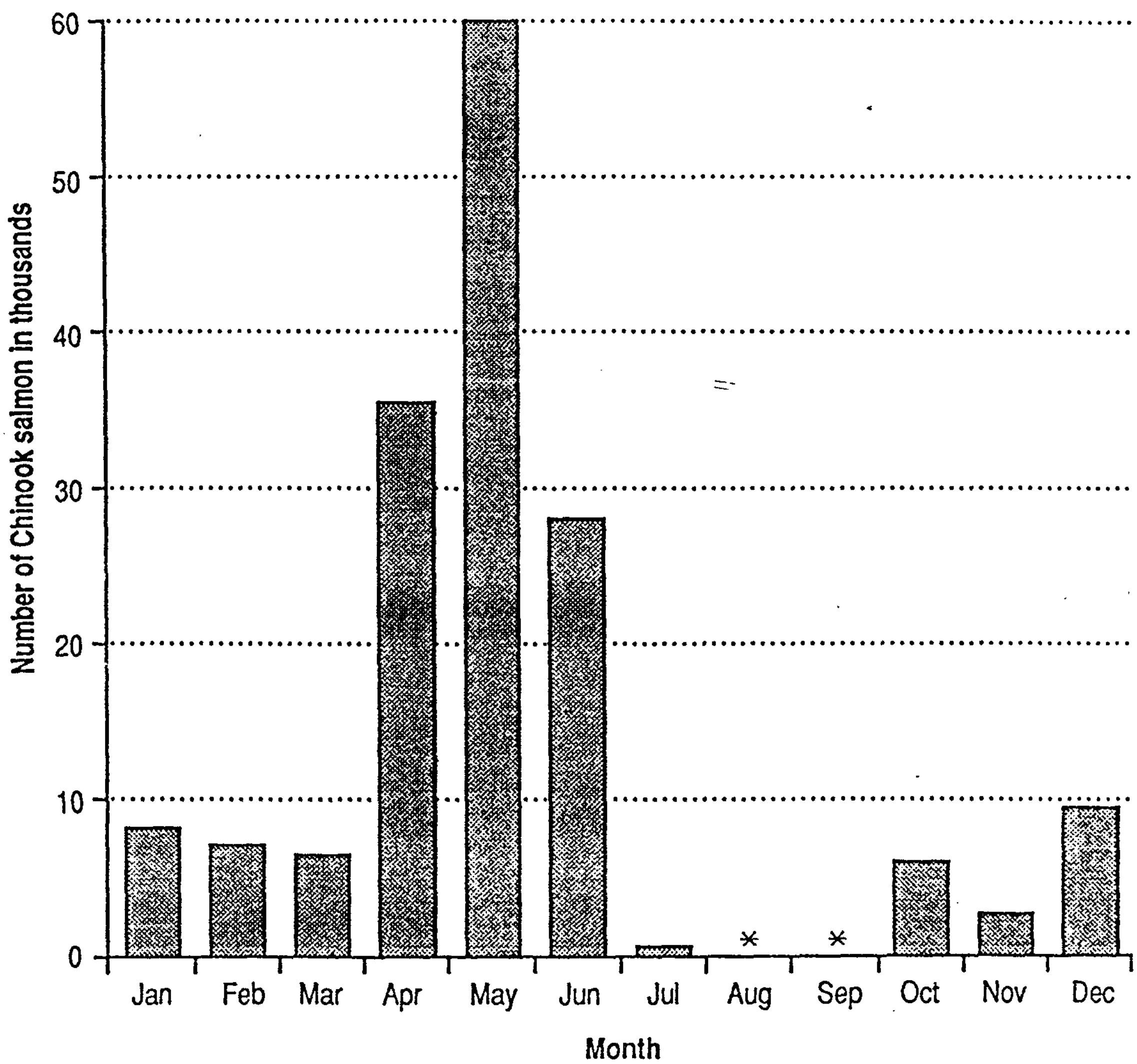
C-110587

C-110587

Figure 2.3

Source: SWRCB. 1991. Rep. No. 91-16WR.

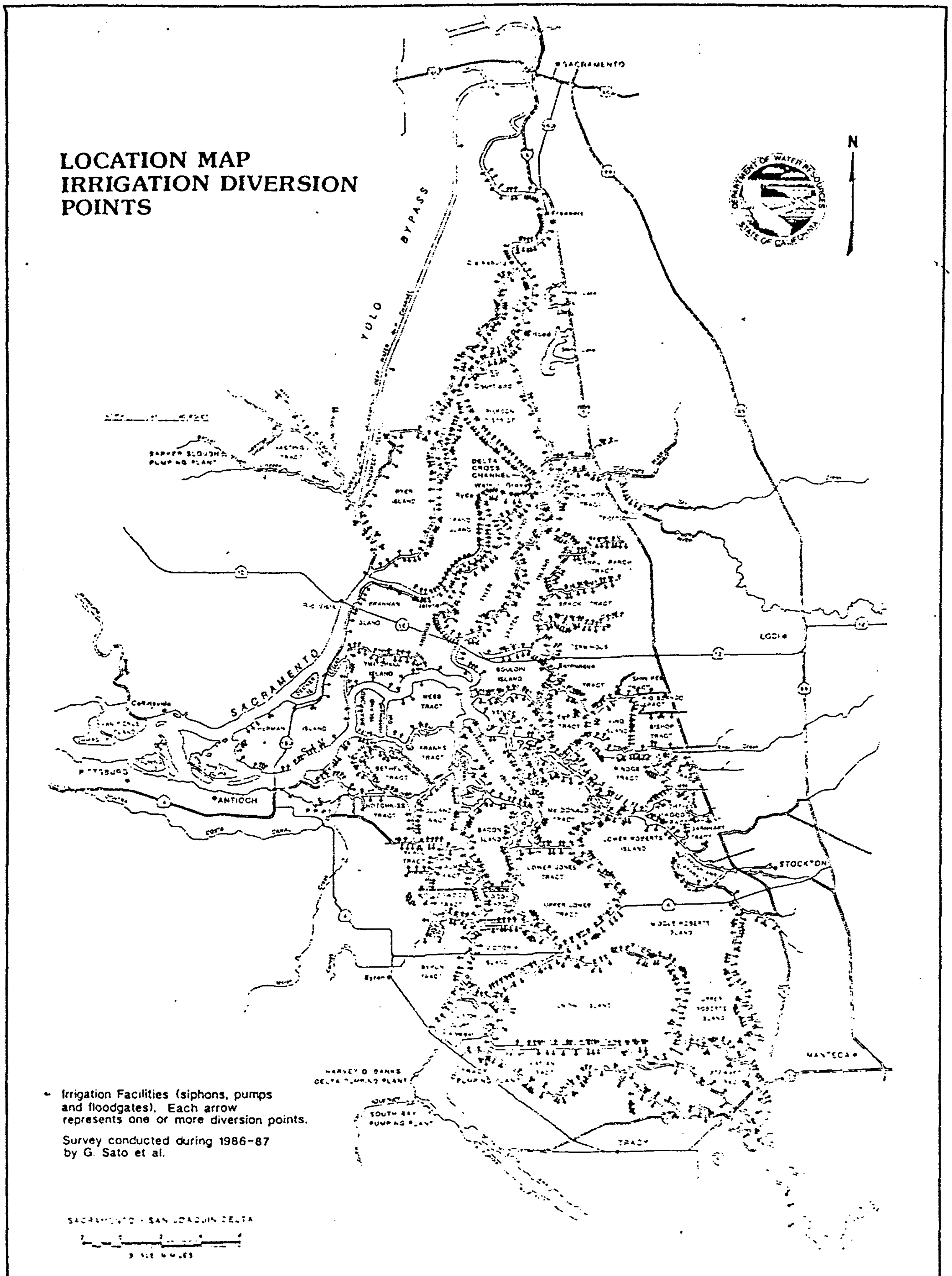
Mean monthly salvage of Chinook salmon at the State Water Project fish protective facility, 1968 - 1986 (From DFG, 17, Appendix , Table 4)



* about 100 fish

Figure 2.4

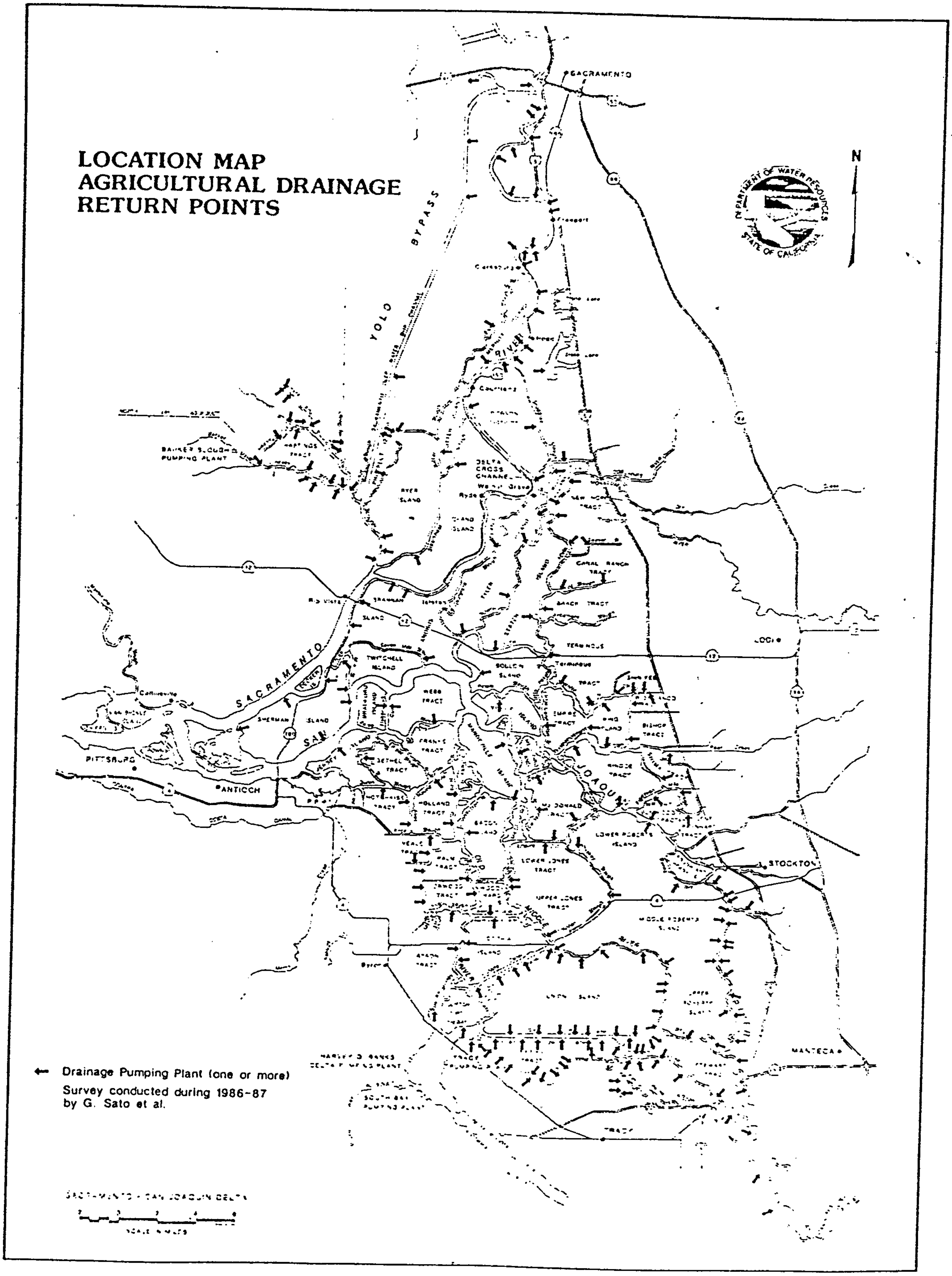
Source: SWRCB. 1991. Rep. No. 91-16WR.



C-110589

Figure 2.5

Source: SWRCB. 1991. Rep. No. 91-16WR.



C-110590

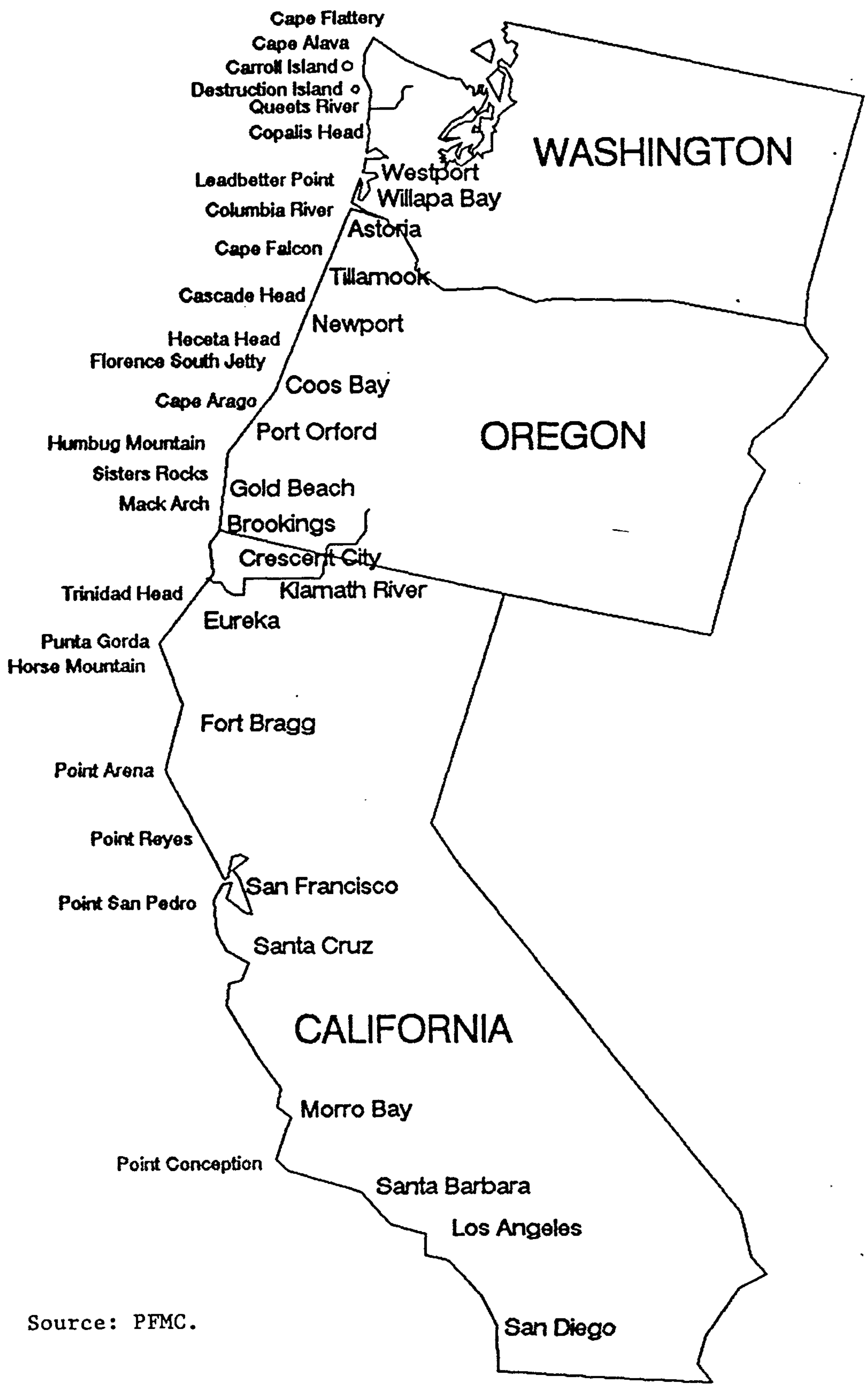
Figure 2.6

MODEL TIMELINE

Week	Month	Event
1	Jan	
2	Jan	
3	Jan	
4	Jan	Mean time of hatching.
5	Jan	
6	Feb	
7	Feb	Mean time of alevin emergence.
8	Feb	
9	Feb	
10	Mar	
11	Mar	Mean time fry/smolts begin downmigration.
12	Mar	
13	Mar	
14	Apr	
15	Apr	
16	Apr	
17	Apr	
18	Apr	Fish "Birthday" at sea.
19	May	Ocean fishing begins.
20	May	
21	May	
22	May	Mean time smolts pass out to sea.
23	Jun	
24	Jun	
25	Jun	
26	Jun	
27	Jul	
28	Jul	
29	Jul	
30	Jul	
31	Jul	
32	Aug	
33	Aug	
34	Aug	
35	Aug	
36	Sep	
37	Sep	
38	Sep	
39	Sep	
40	Oct	
41	Oct	
42	Oct	Mean time of escapement.
43	Oct	
44	Oct	Ocean fishing ends.
45	Nov	
46	Nov	
47	Nov	Mean time of spawning.
48	Nov	Mean time egg incubation begins.
49	Dec	
50	Dec	
51	Dec	
52	Dec	

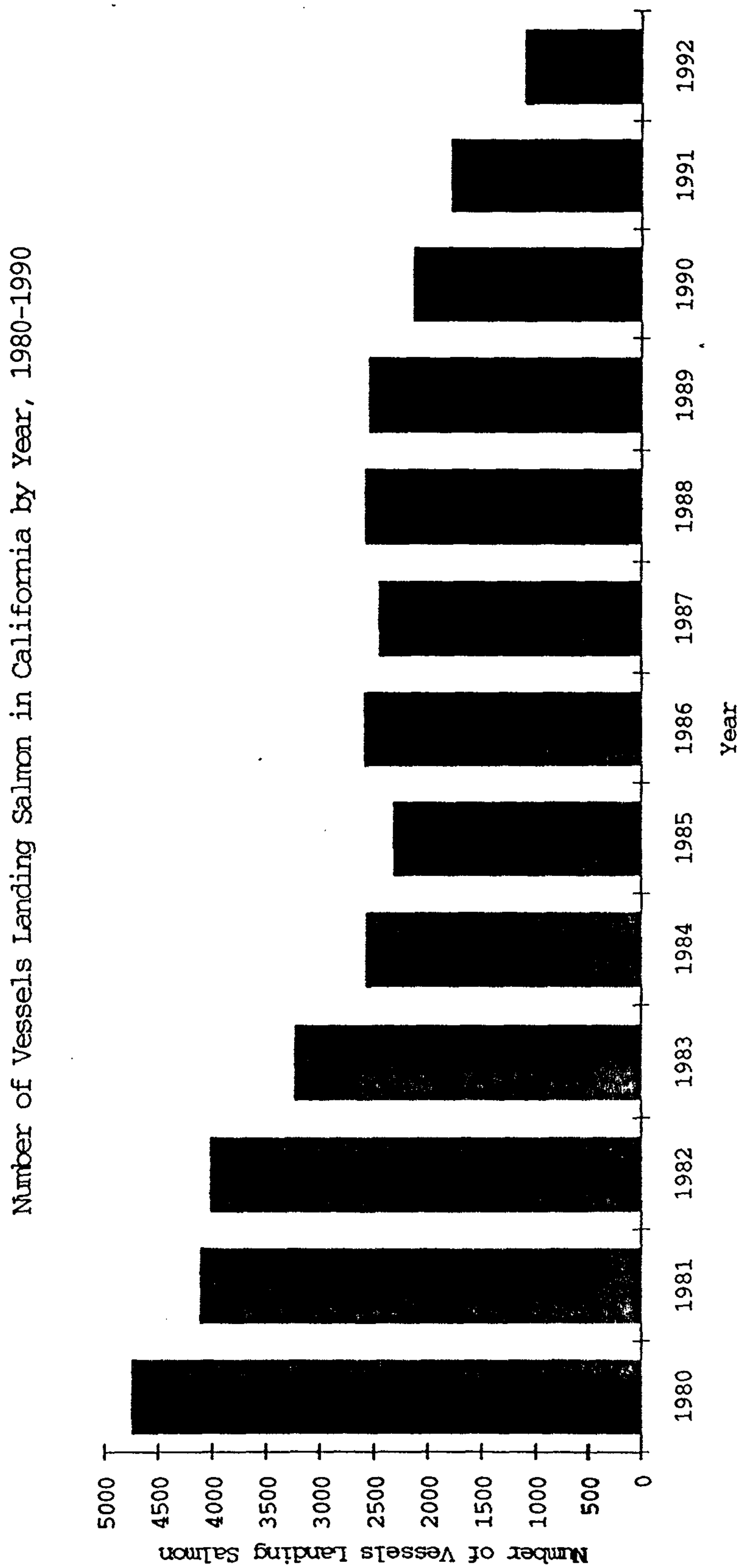
Figure 2.7

Significant features of the western coast of the United States.



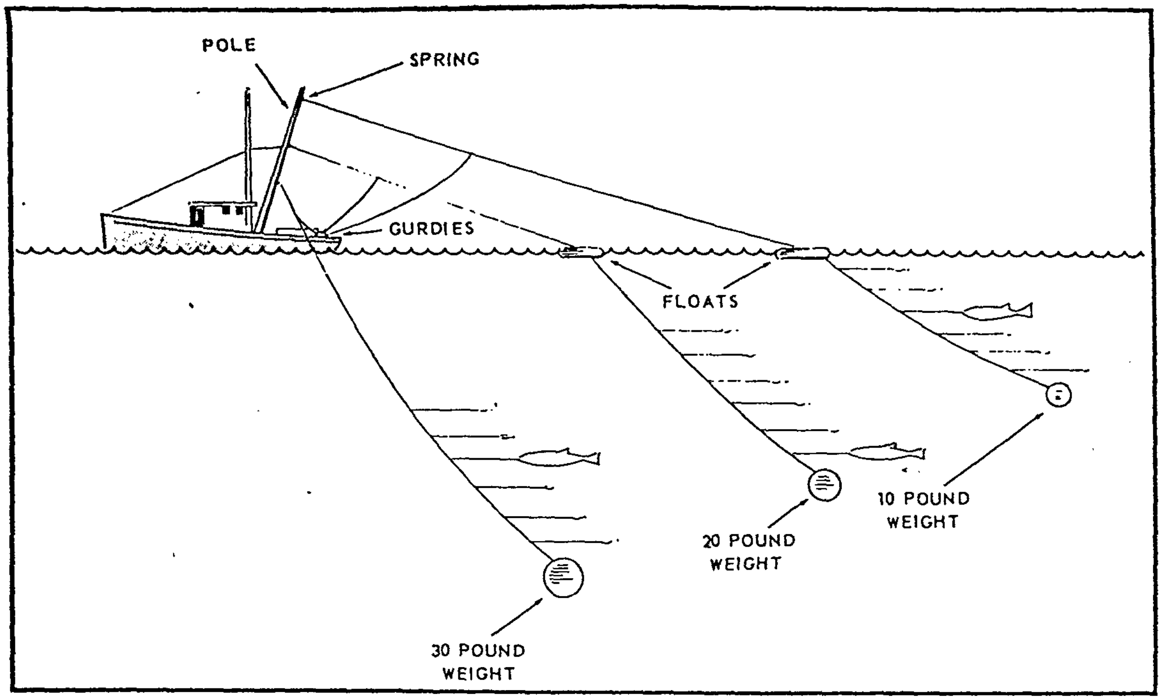
Source: PFMC.

Figure 2.8



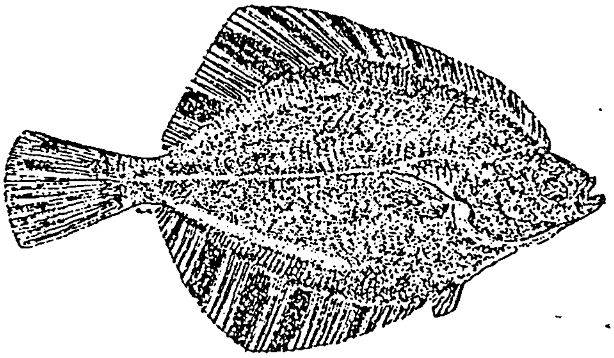
Source: PFMC. 1993.

Figure 2.9



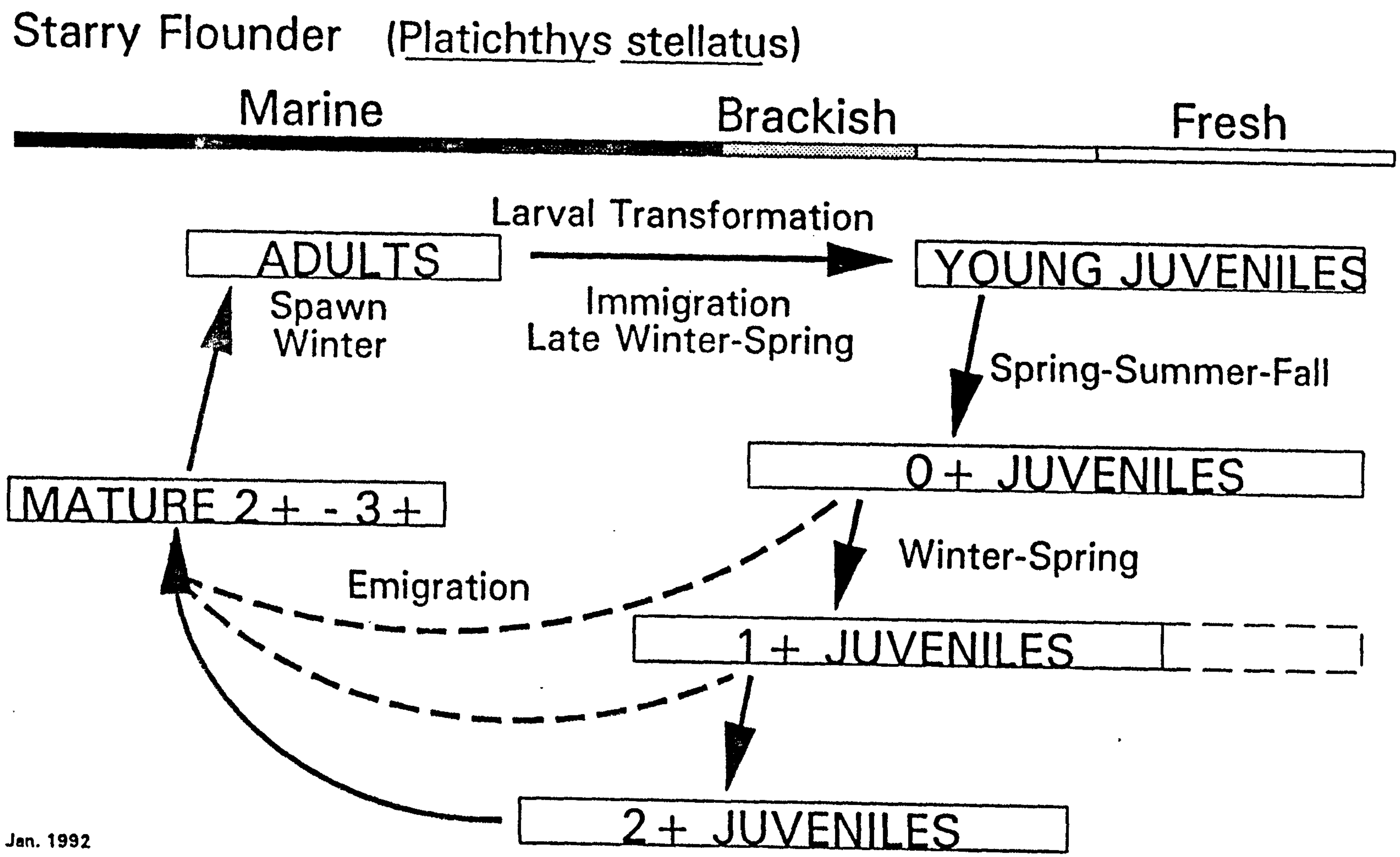
All commercial salmon catches in California are from trollers moving at a speed of about two knots. Four to six lines, each with about six or more hooks, are hung at different depths and held in place by sinkers. The heavier sinkers, on the front lines, pull the lines down as deep as 350 feet and help keep the lines untangled. (Illustration from Major Commercial Fisheries of California, *California Sea Grant Marine Advisory Program.)*

Figure 2.10



Starry flounder, juveniles usually less than 12 cm, adults to 90 cm (from Eschmeyer et al. 1983).

Source: CDFG. 1992e.



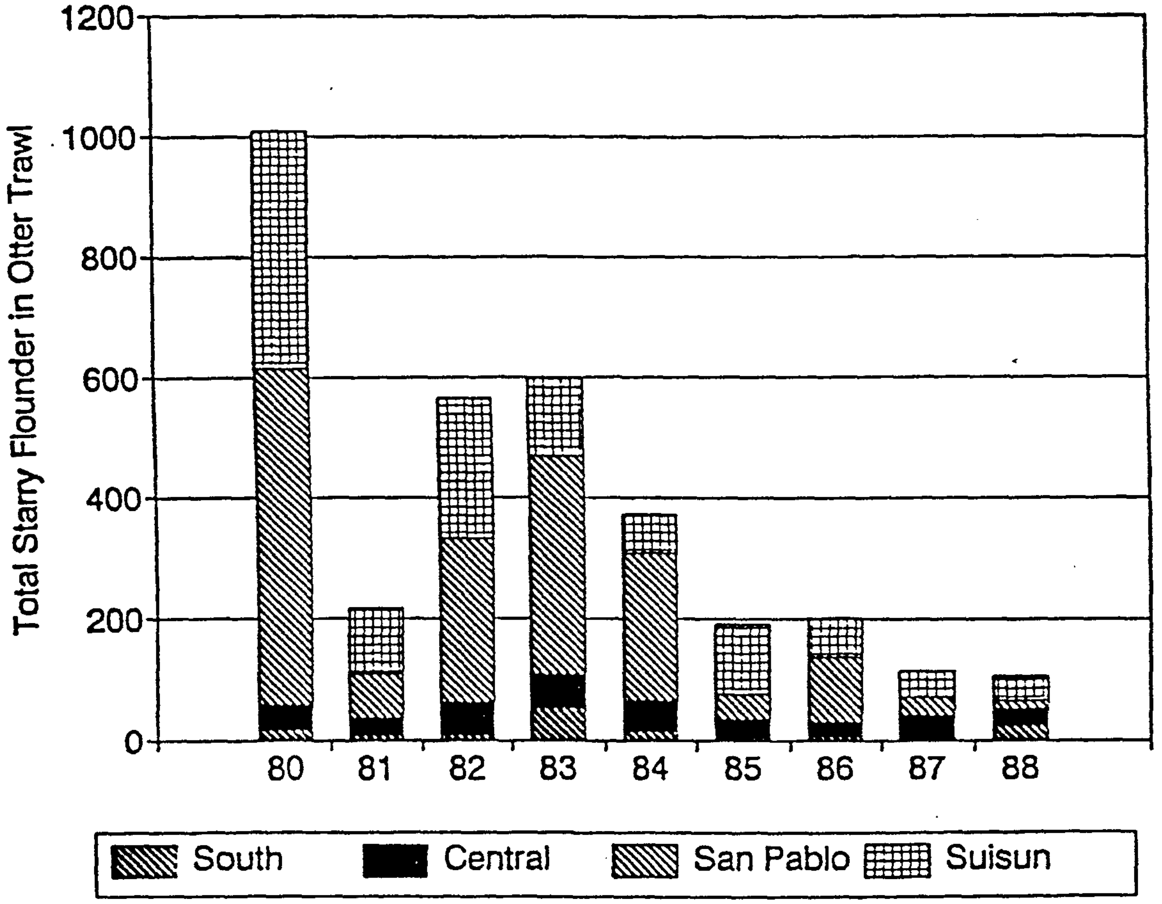
Starry flounder life cycle.

Figure 2.11

C-110596

C-110596

Figure 2.12



Catch of starry flounder through time, 1980-1988 (data from otter trawls of the Bay study)

Source: Herbold, et al. 1992.

Source: CDFG. 1992e.

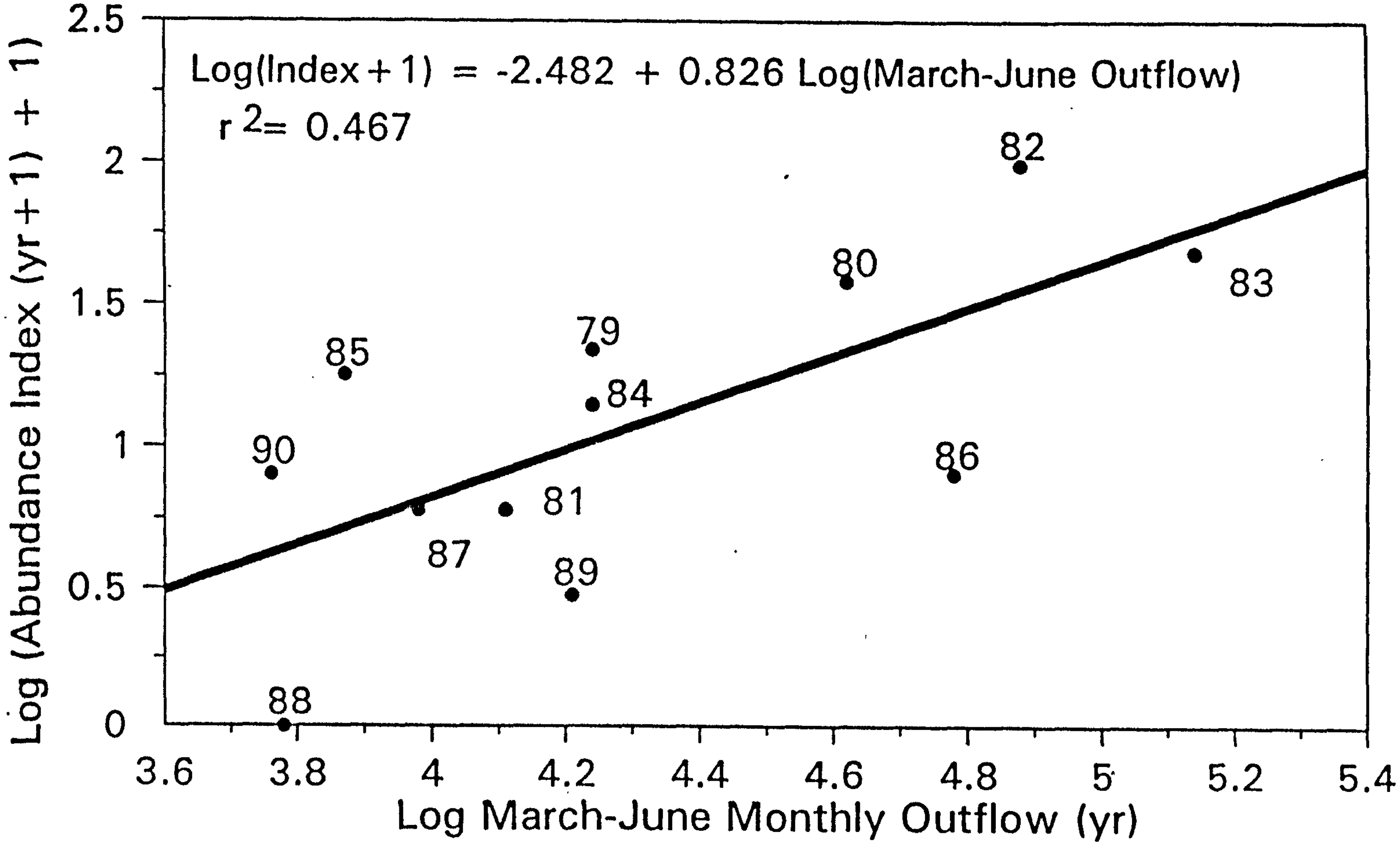
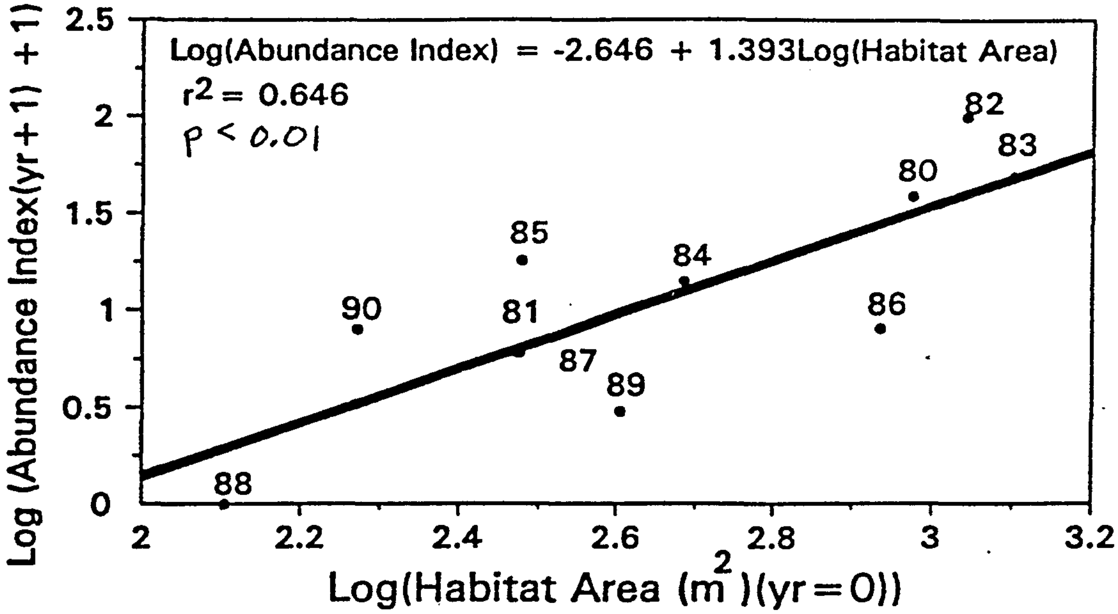


Figure 2.13

Relationship between $\log_{10}$ average March through June monthly outflow at Chipps Island in year=0 (i.e. when they recruited to the estuary) and $\log_{10}$ average February through May abundance of one-year-old starry flounder collected in year+1.

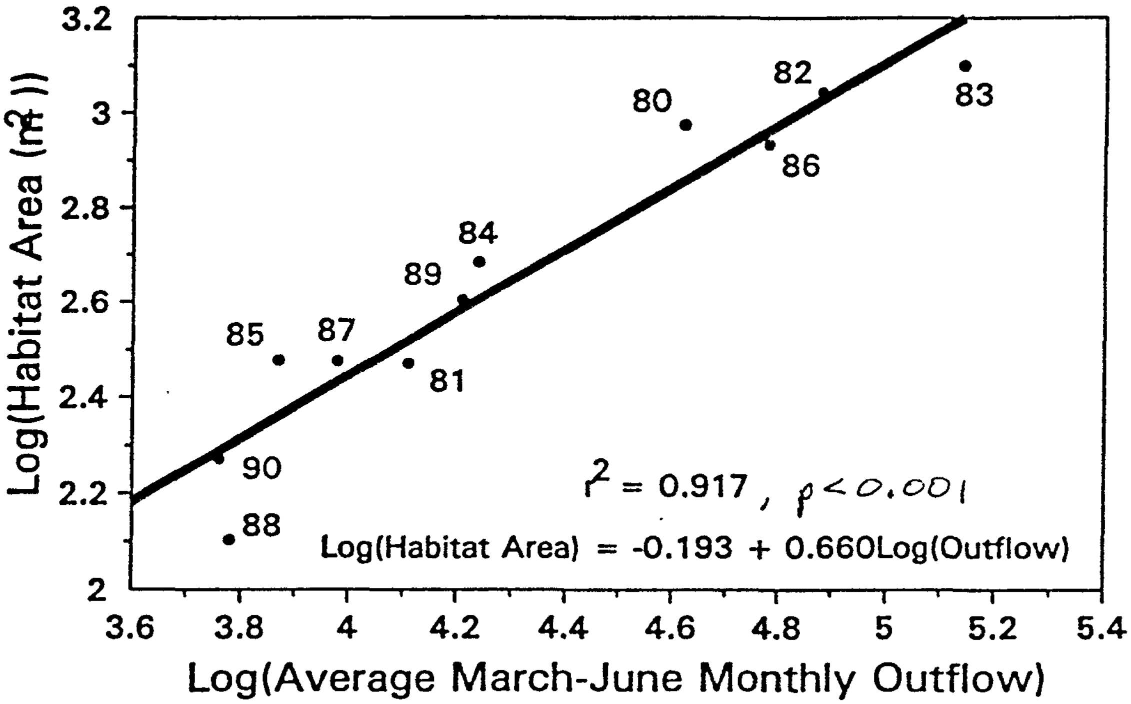
Figure 2.14

a



b

Figure 2.15

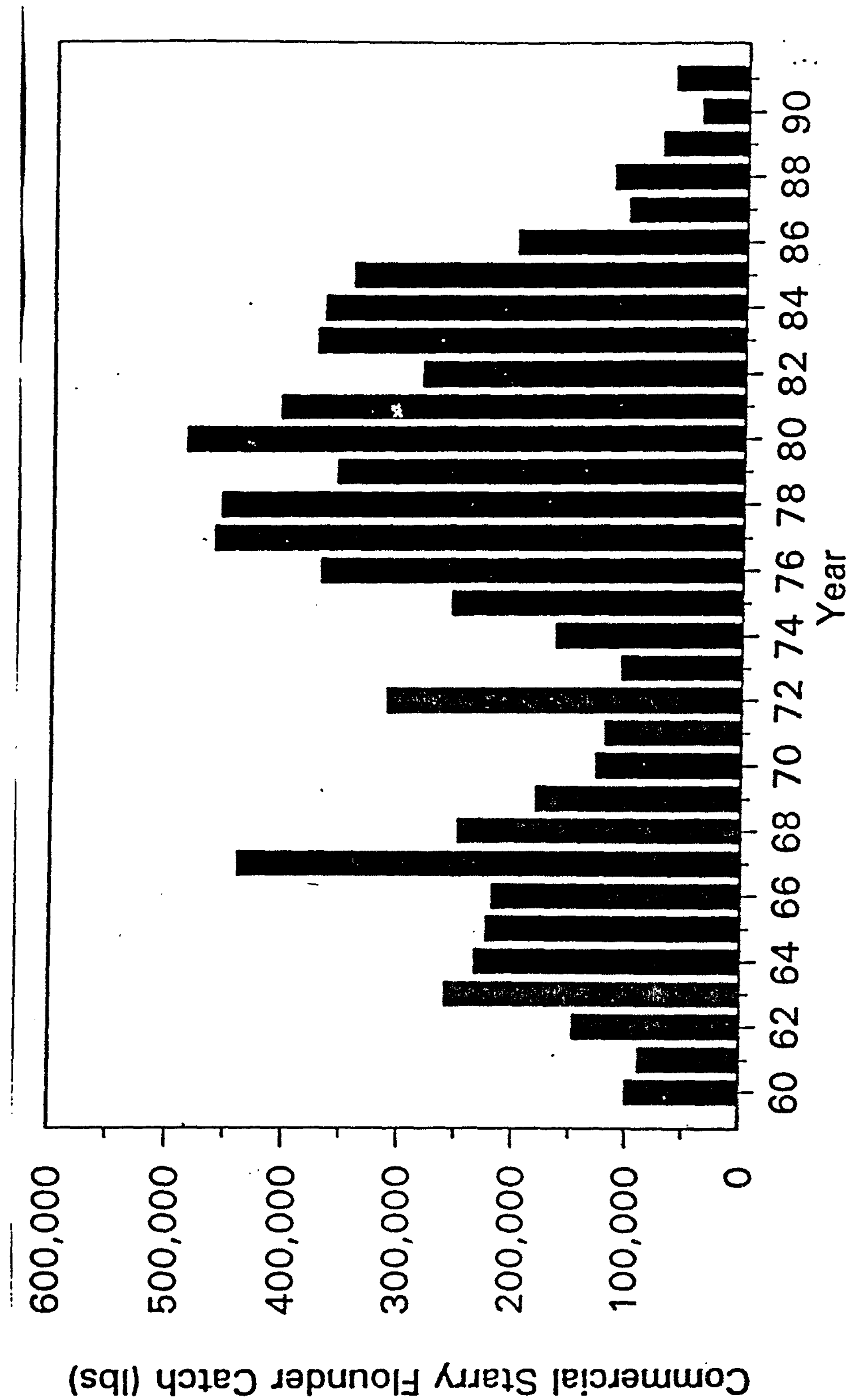


a. Relationship between habitat area (m^2, depth < 7 m, bottom salinities < 22 ppt between April and July) for YOY starry flounder, and the February through May abundance of ONEPLUS starry flounder the next year. b. Relationship between average March through May monthly outflow at Chipps Island, and habitat area for YOY starry flounder.

Source: CDFG. 1992e.

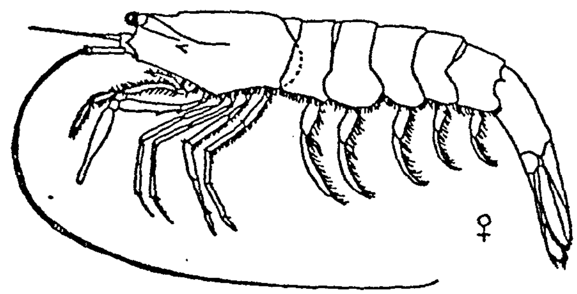
Figure 2.16

Annual Total Commercial Landings of Starry Flounder
in the San Francisco Bay Area



Source: CDFG. 1992e.

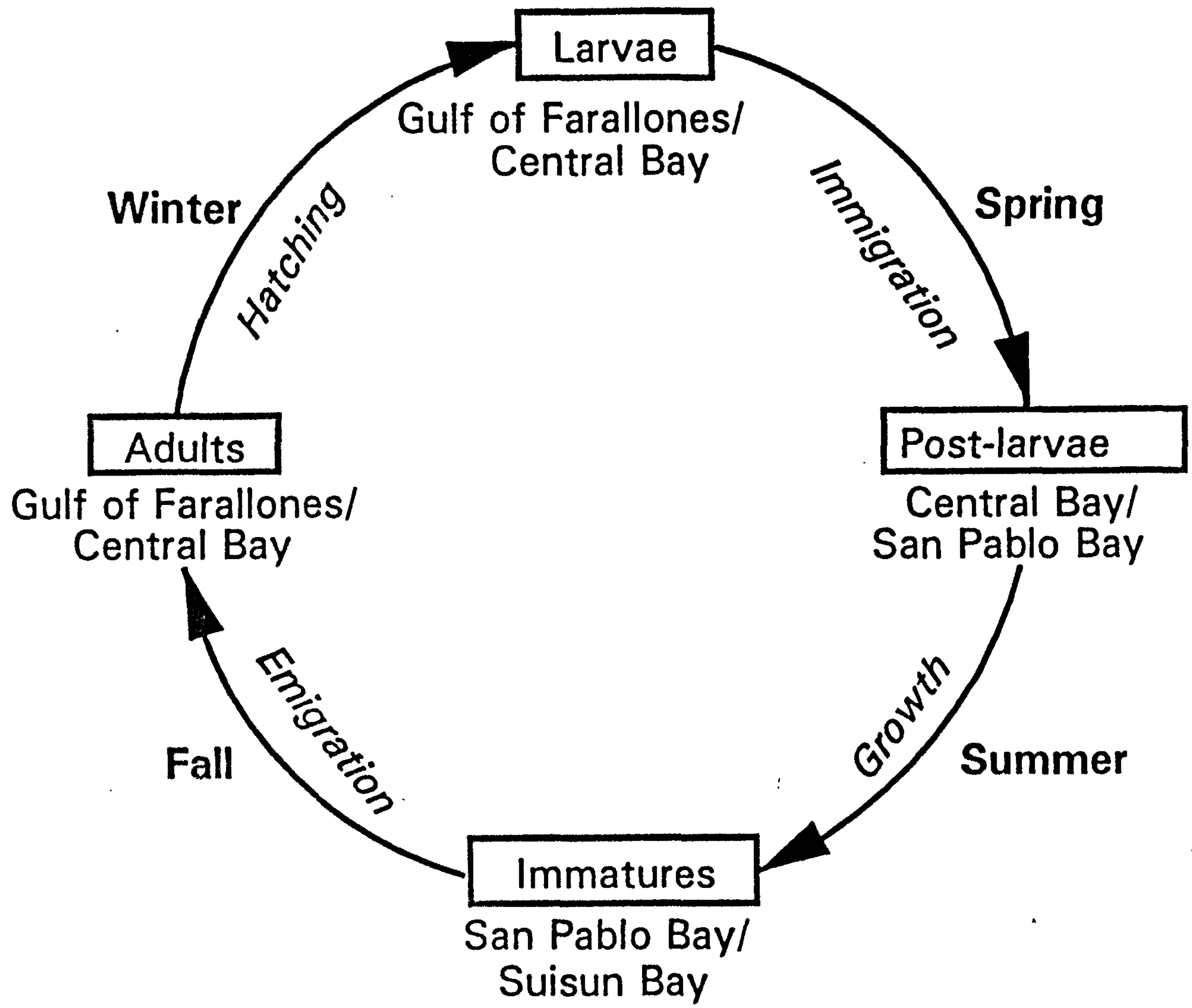
Figure 2.17



Crangon franciscorum (from Smith and Carlton 1975)

C-110601

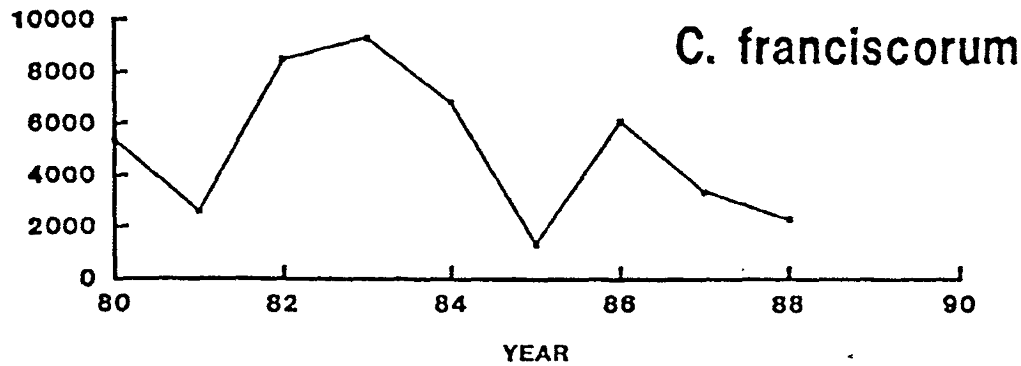
Figure 2.18



Life cycle of Crangon franciscorum in the San Francisco Bay-Estuary.

Source: CDFG. 1992e.

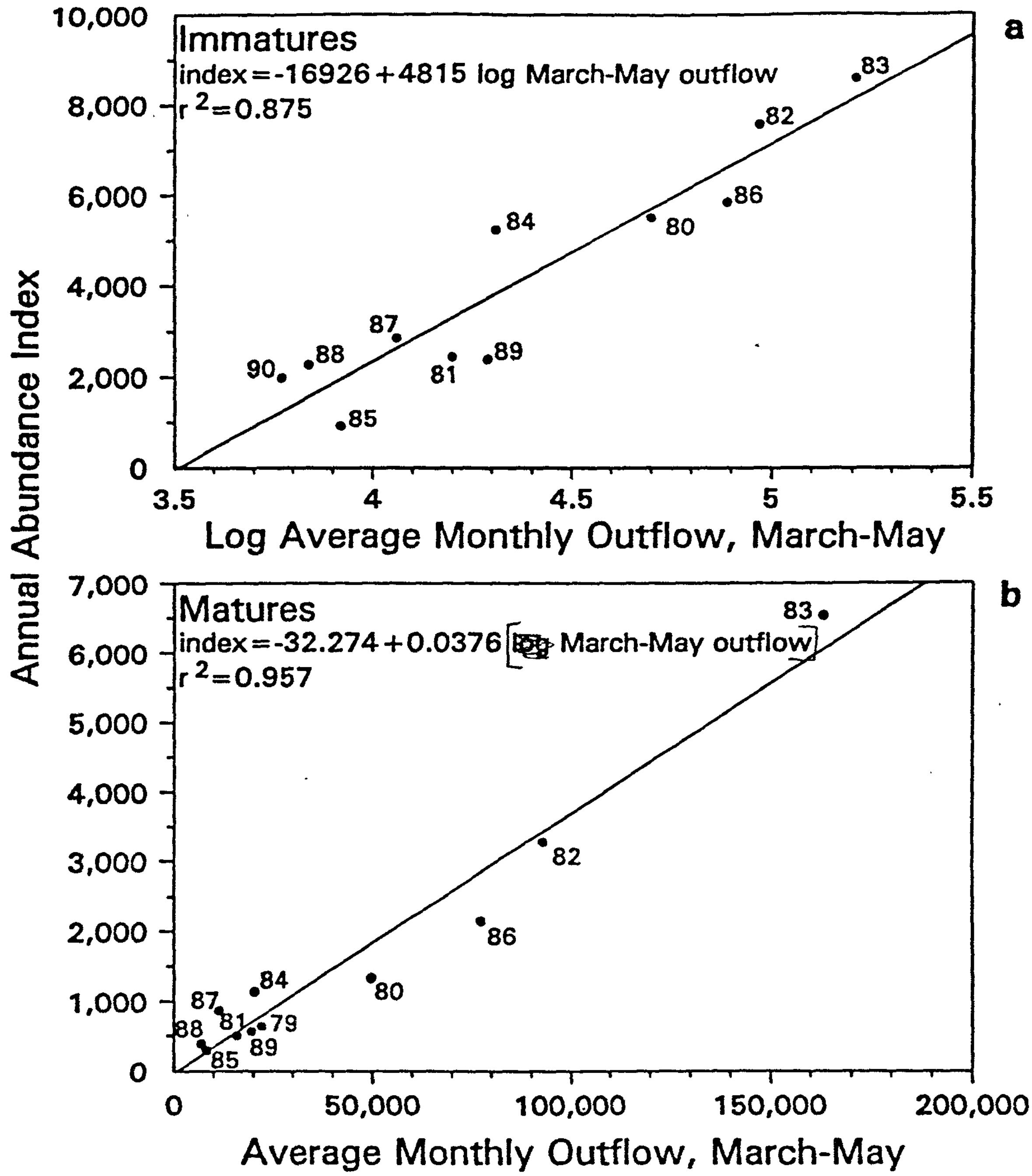
Figure 2.19



Abundance indices of 5 species of shrimp in otter trawls of the Bay Study 1980-1989 (data from Herrgesell 1990).

Source: Herbold, et al. 1992.

Figure 2.20



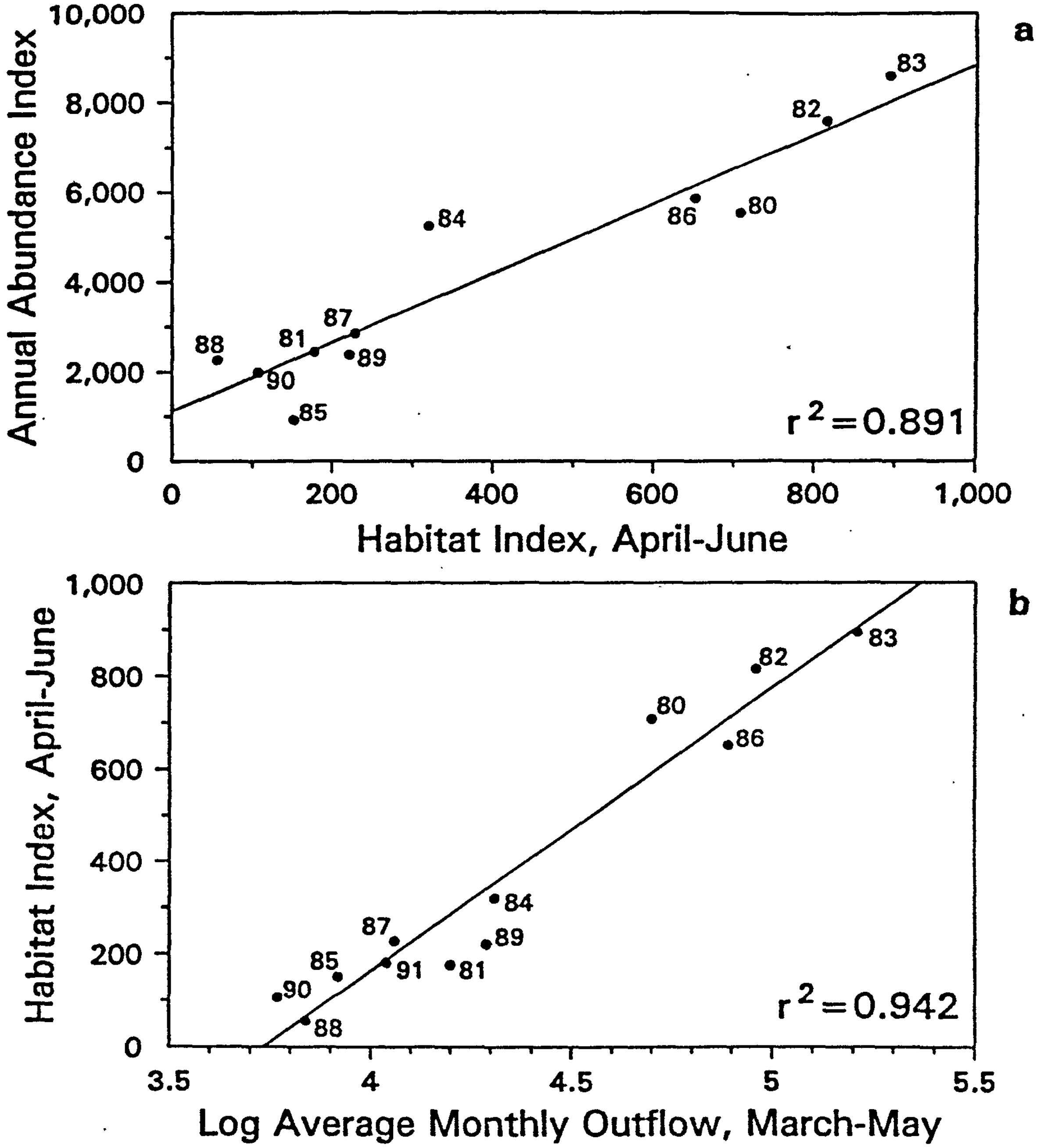
Source: CDFG. 1992e.

a. Relationship between the annual abundance index of immature Crangon franciscorum (May-October) and $\log_{10}$ average monthly outflow at Chipps Island, March-May. 1980-1990.

b. Relationship between the annual abundance index of mature Crangon franciscorum (January-April) and ~~log~~ average monthly outflow at Chipps Island, March-May the previous year. 1979-1989.

C-110604

Figure 2.21

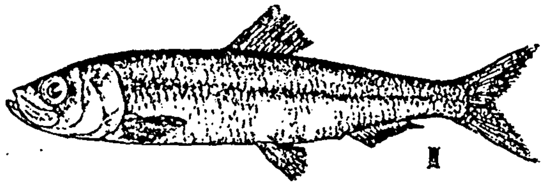


Source: CDFG. 1992e.

a. Relationship between the annual abundance index of immature Crangon franciscorum (May-October) and the annual habitat index (April-June, 3.0-18.1 ppt, shoals only). 1980-1990.

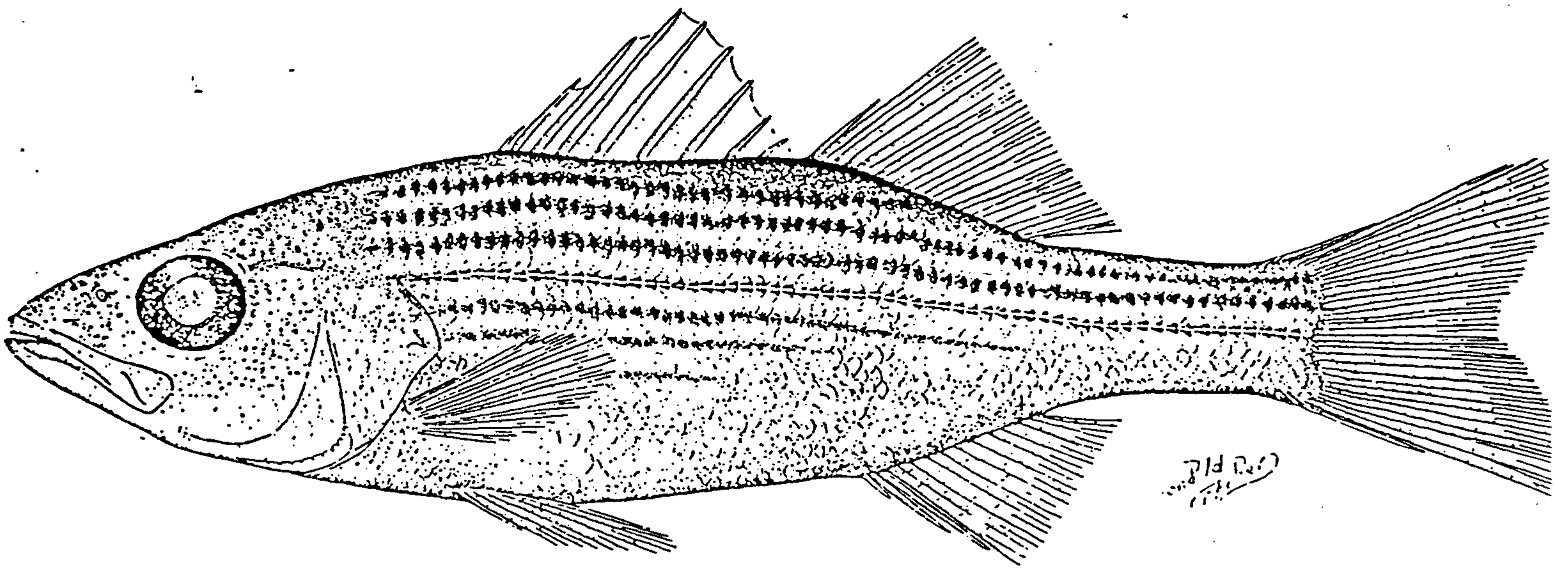
b. Relationship between the annual habitat index for Crangon franciscorum (April-June, 3.0-18.1 ppt, shoals only) and the average monthly outflow at Chipps Island, March-May. 1980-1991.

Figure 2.22



Pacific herring, usually 20-30 mm. (from Moyle 1976)

Figure 3.1

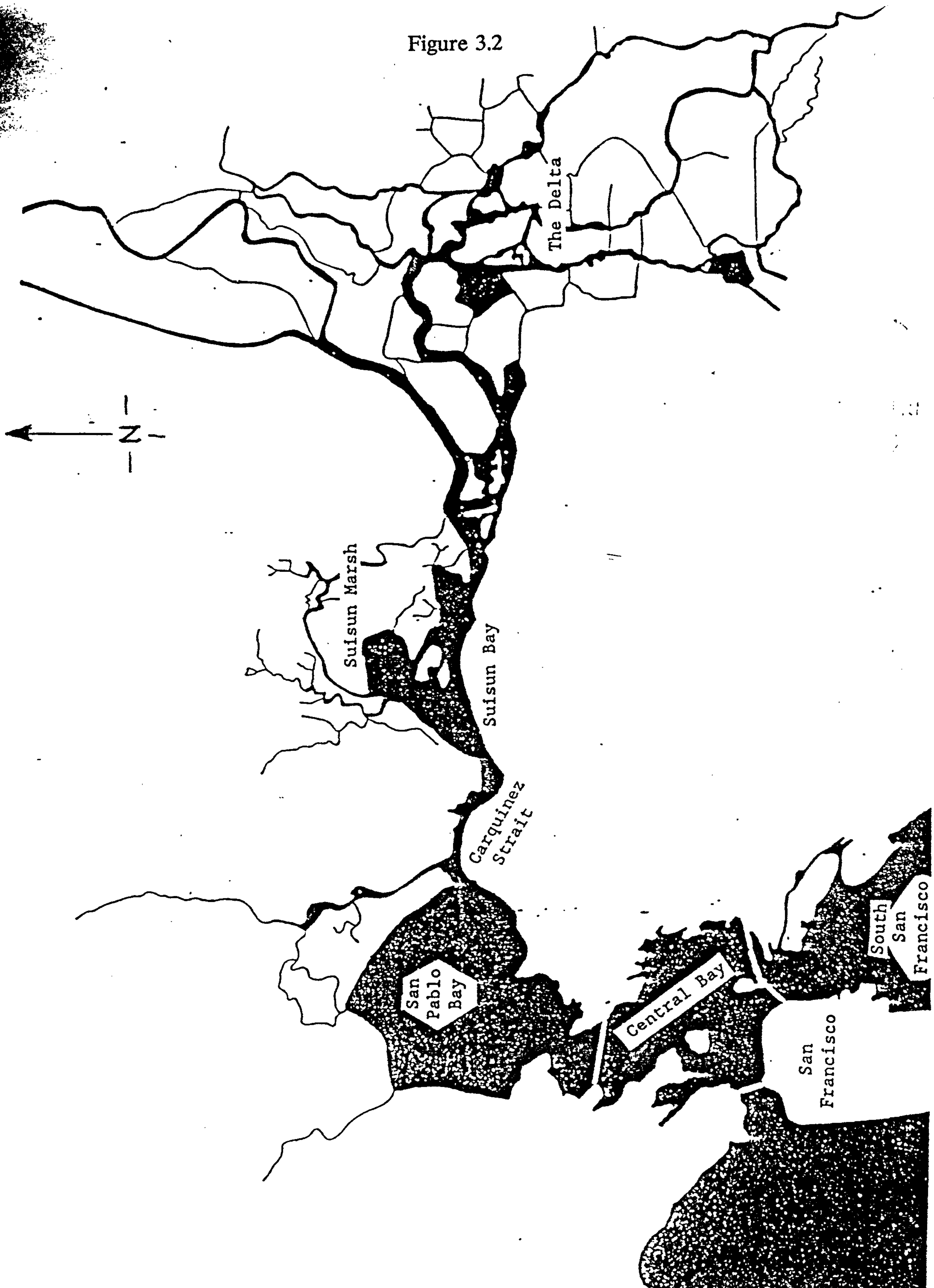


Striped bass, drawn from a specimen 4 inches in standard length.

From "Studies on the Striped Bass (*Roccus saxatilis*) of the Atlantic Coast," a dissertation presented to Yale University in candidacy for the degree of Doctor of Philosophy by Daniel Merriman, June 1938.

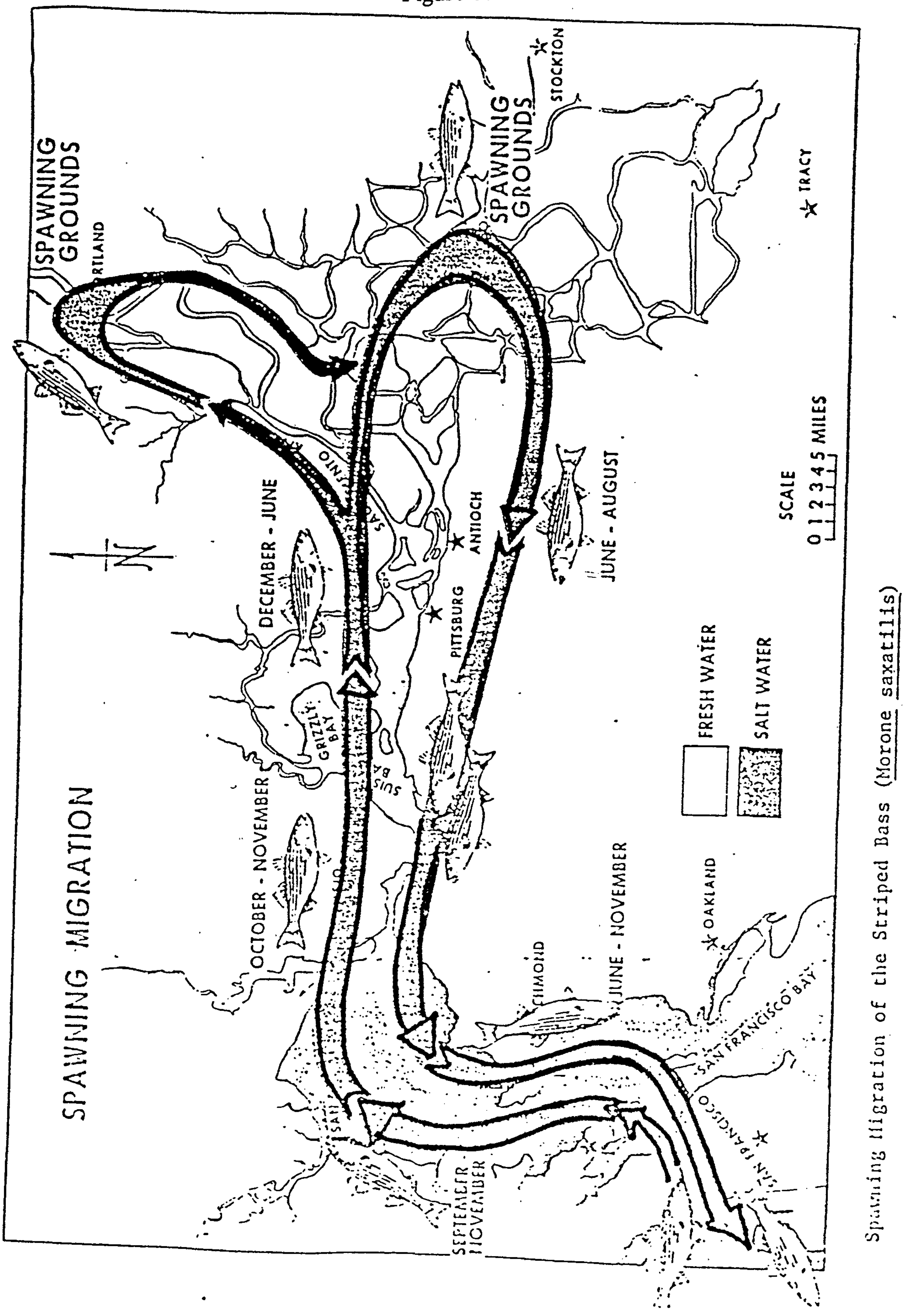
The striped bass, as shown in Raney (1952), p. 5. The striped bass is a large fish, ranging up to forty or more pounds, with the average catch around six to ten pounds (Albert, 1987).

Figure 3.2



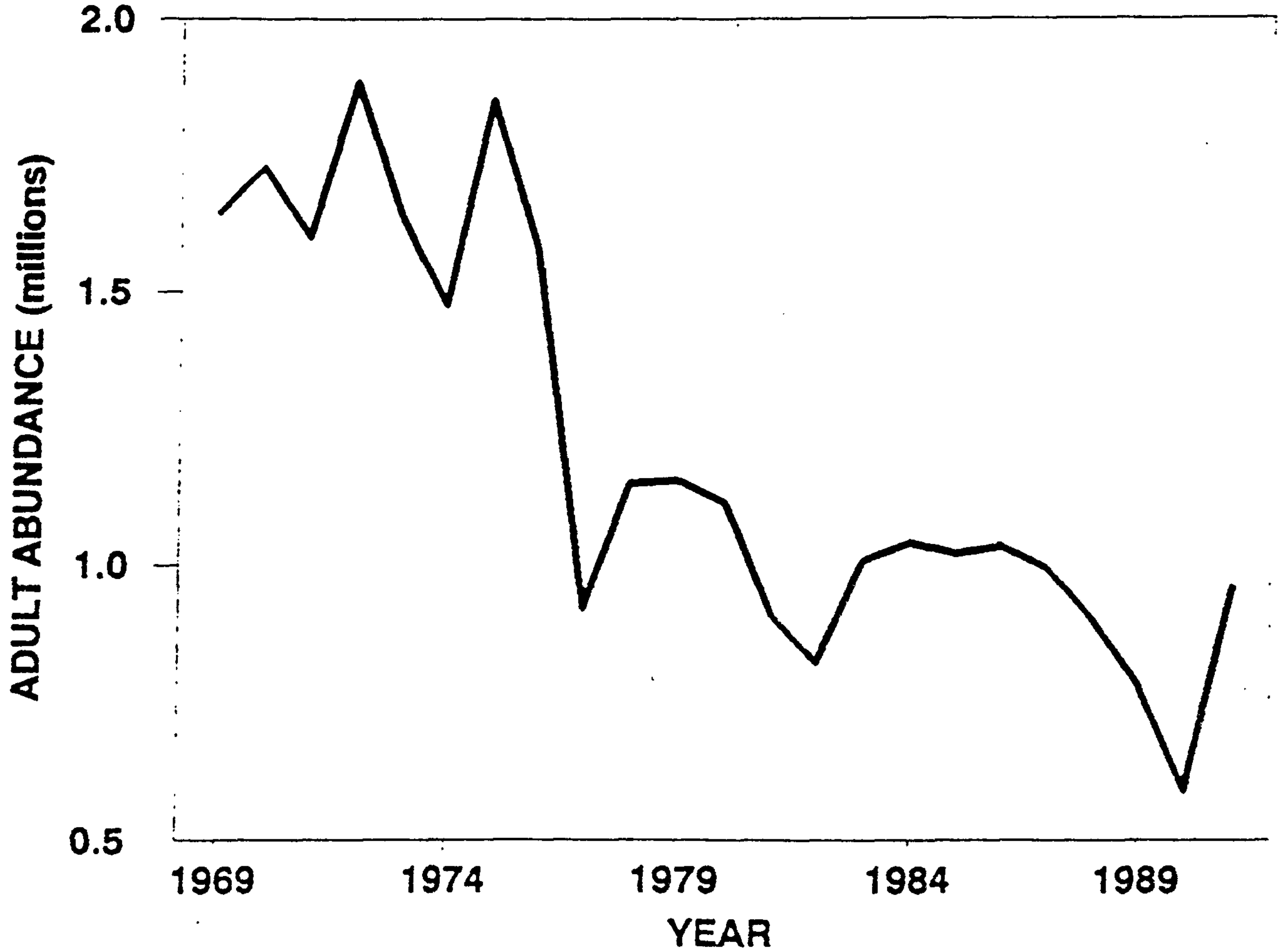
The San Francisco Bay/Delta Estuary.

Figure 3.5



Striped bass spawning migration. National Marine Fisheries Service figure, taken from Hedgepth and Mortensen (1987), p. 30.

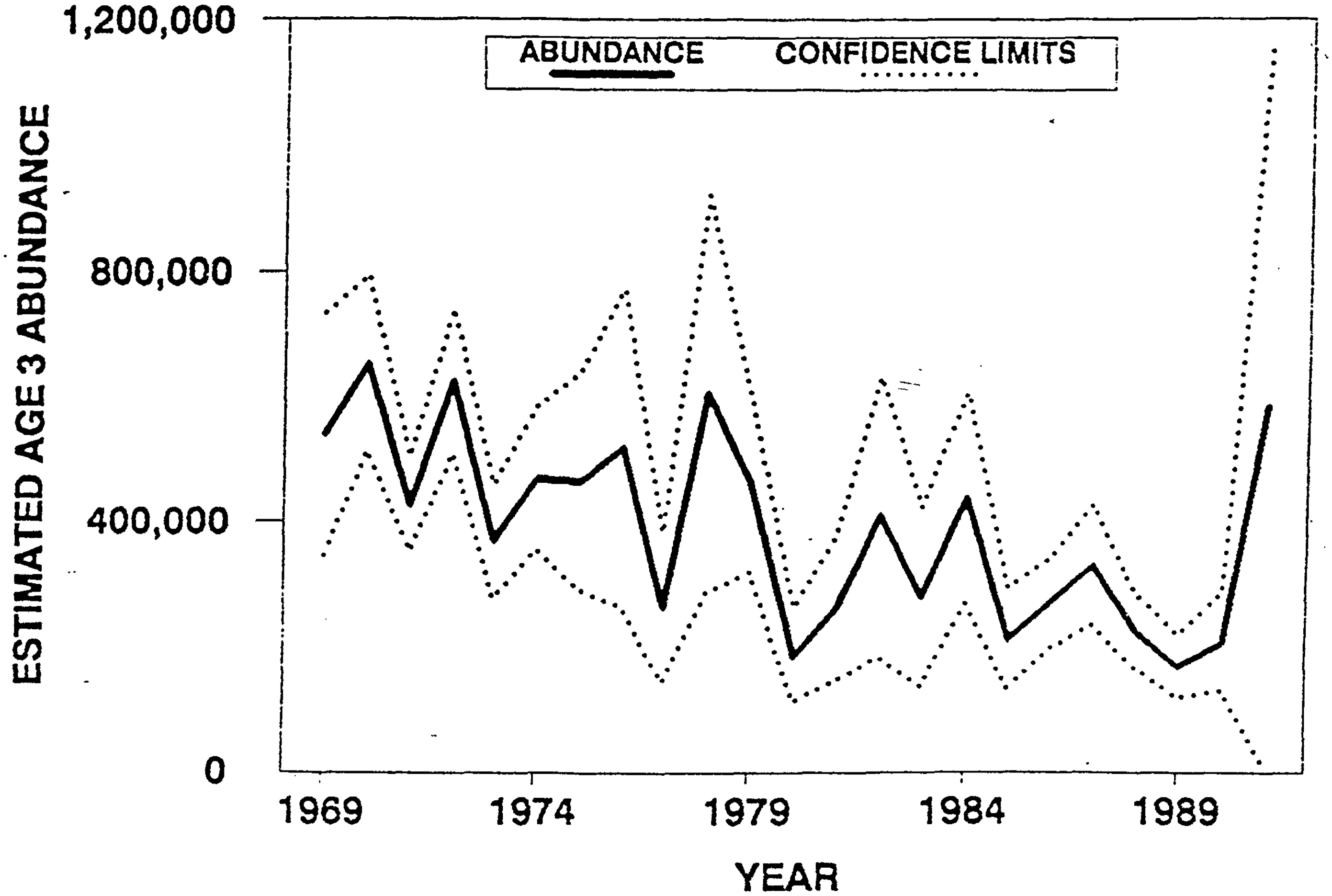
Figure 3.4



Trend in legal-sized striped bass abundance in the Sacramento-San Joaquin Estuary, 1969-1991.

Source: CDFG. 1992c.

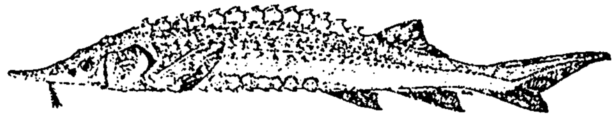
Figure 3.5



Trend in mark-recapture estimates of age 3 striped bass abundance in the Sacramento-San Joaquin Estuary, 1969-1991.

Source: CDFG. 1992a.

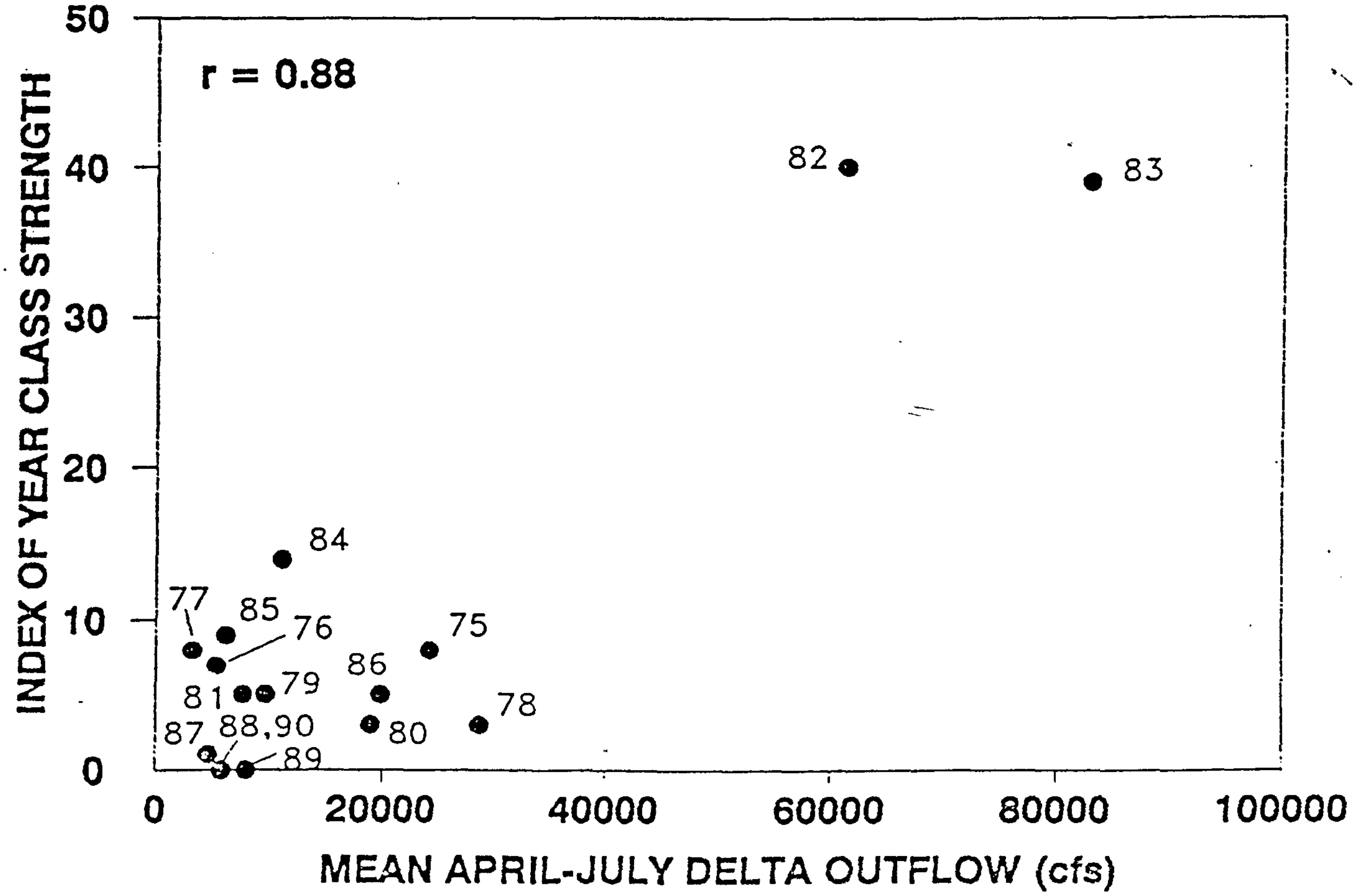
Figure 3.6



White sturgeon, maximum length today about 3m (from Moyle 1976).

C –1 1 0 6 1 2

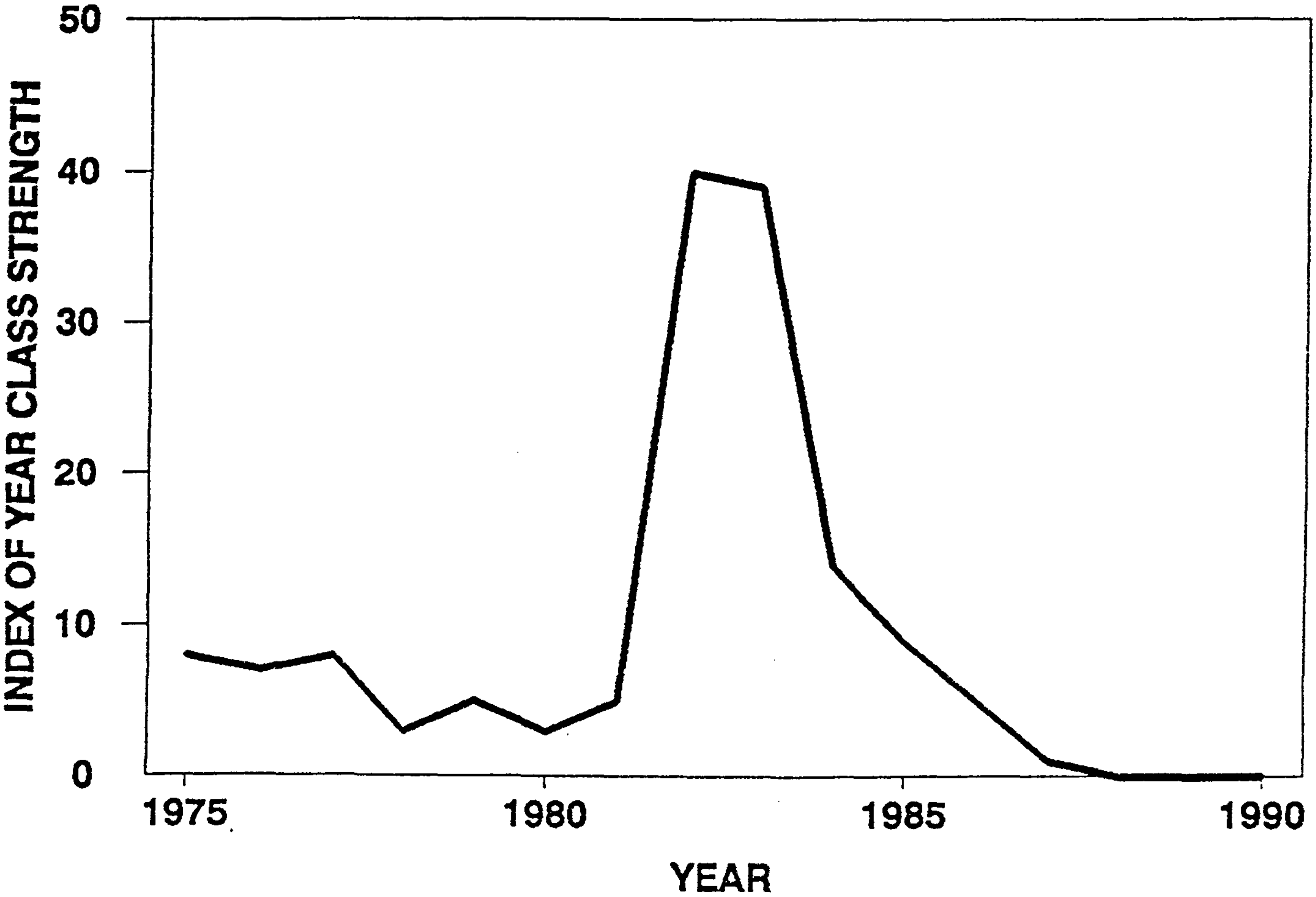
Figure 3.7



Scatterplot of white sturgeon year class index from trawl catches versus mean daily outflow for April to July in the Sacramento-San Joaquin Estuary. Numbers adjacent to points designate year classes.

Source: CDFG. 1992j.

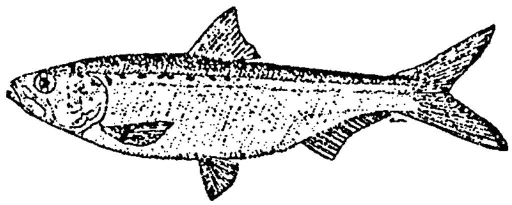
Figure 3.8



Trend in white sturgeon year class indices for the Sacramento-San Joaquin Estuary developed from trawl catches by the San Francisco Bay Outflow Study.

Source: CDFG. 1992j.

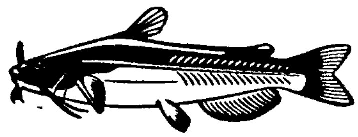
Figure 3.9



American shad, adults to 70 cm, juveniles in the Delta are less than 20 cm (from Moyle 1976).

C-110615

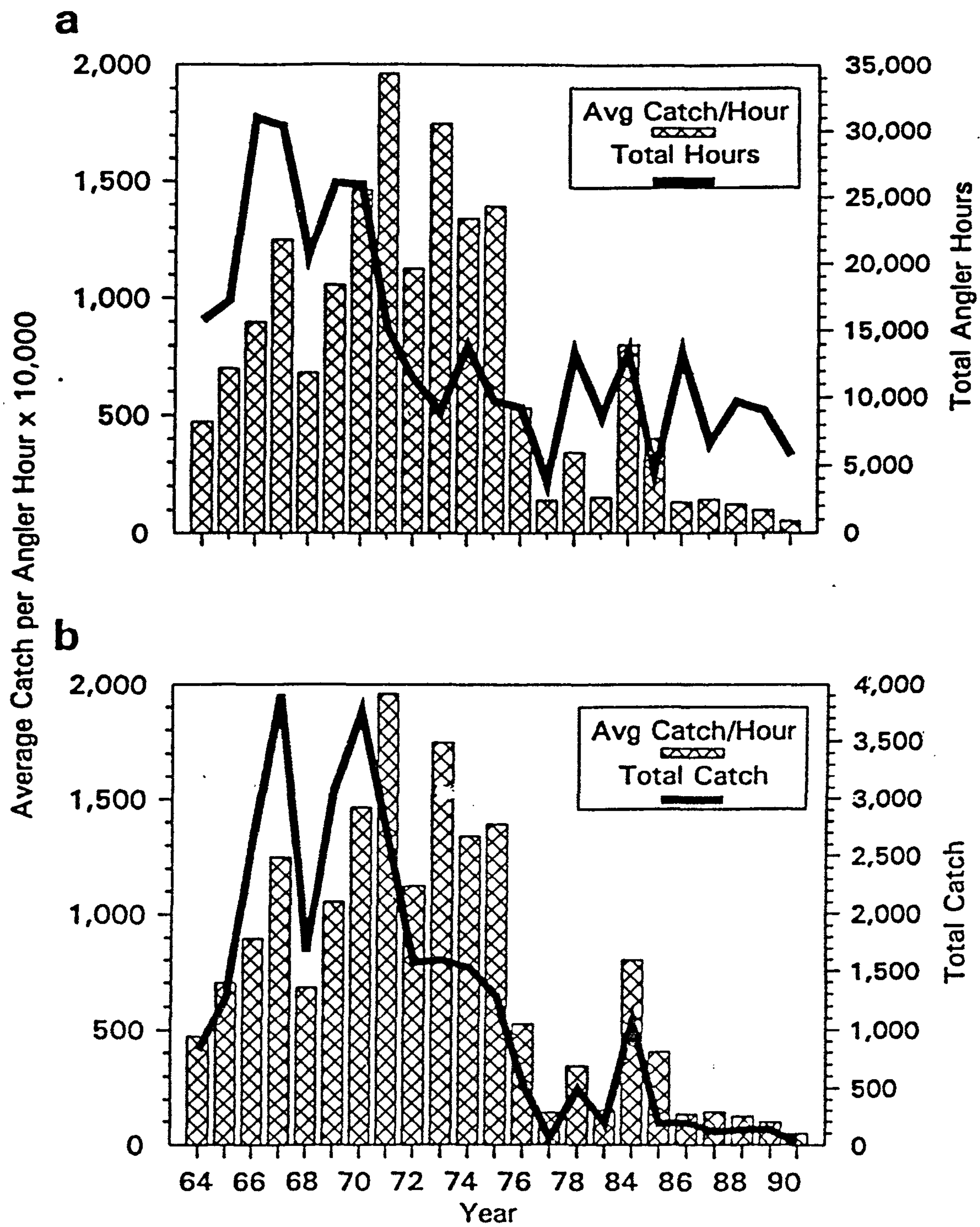
Figure 3.10



White catfish: *With the most bullhead-like body shape of any California catfish, it's the most important sports catch in the upper reaches of the estuary.*

Source: San Francisco Examiner. 1993.
Special Reprint, Bay in Peril.

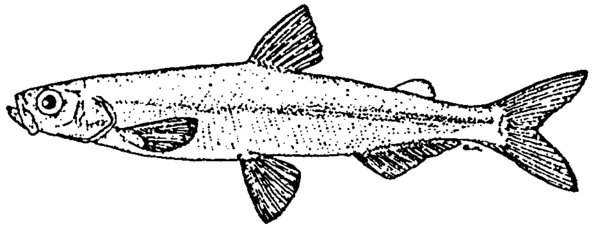
Figure 3.11



Source: CDFG. 1992e.

Starry flounder catch and fishing effort in San Pablo Bay based on Commercial Passenger Fishing Vessel log data from 1964-1990. A January through May period was use to calculate annual data. Data for the years 1979, and 1981-1983 were not available during analyses, nor were they plotted.

Figure 3.12



Delta smelt, adults usually 7-8 cm.
(from Moyle 1976)

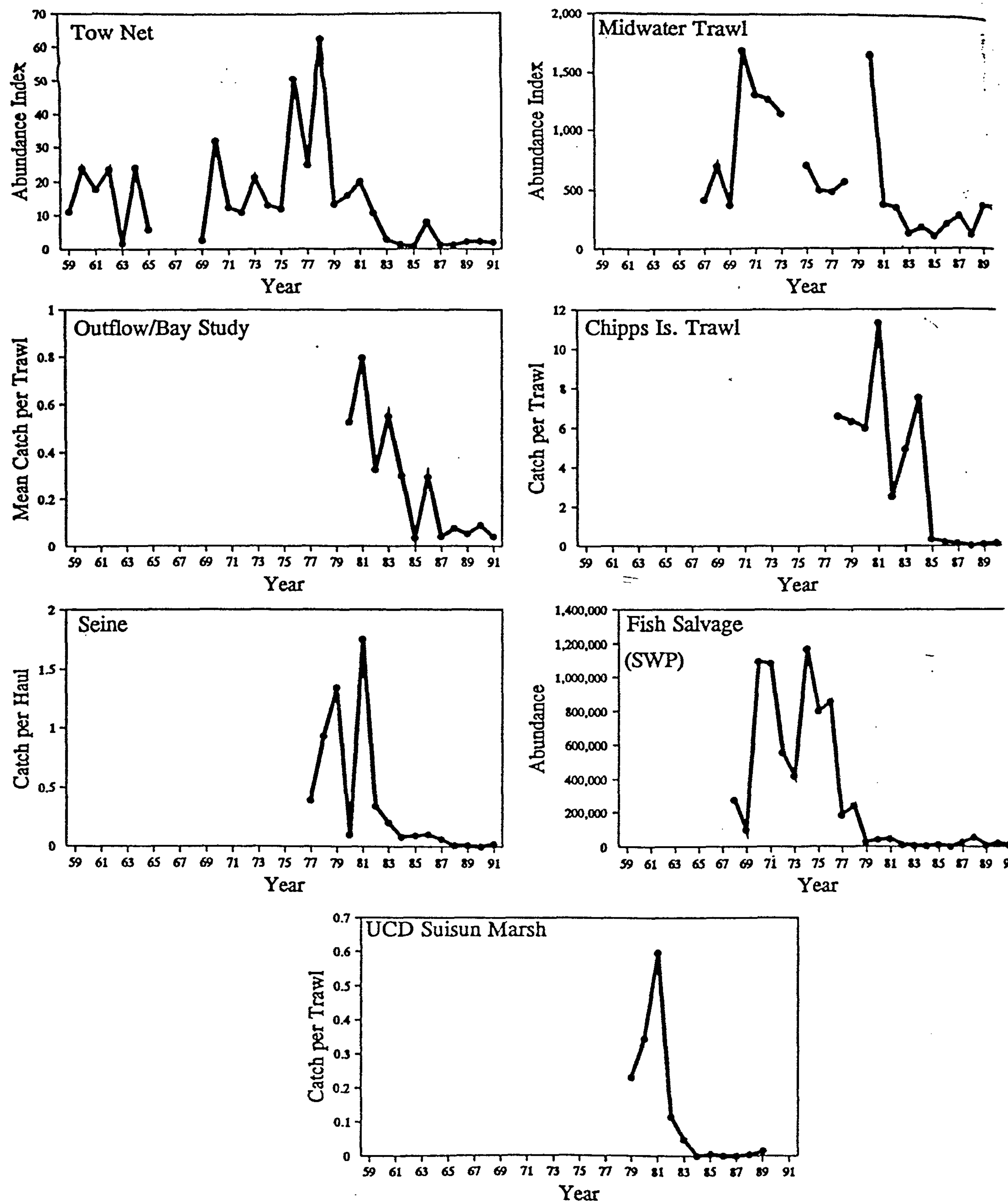
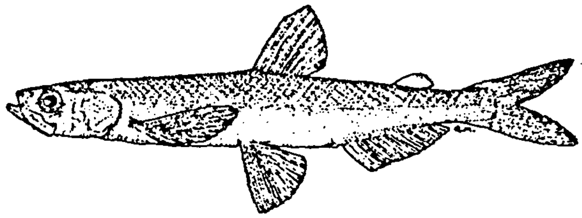


Figure 3.13 Trends in delta smelt as indexed by seven independent surveys (updated from Stevens, et.al., 1990, Figure 4).

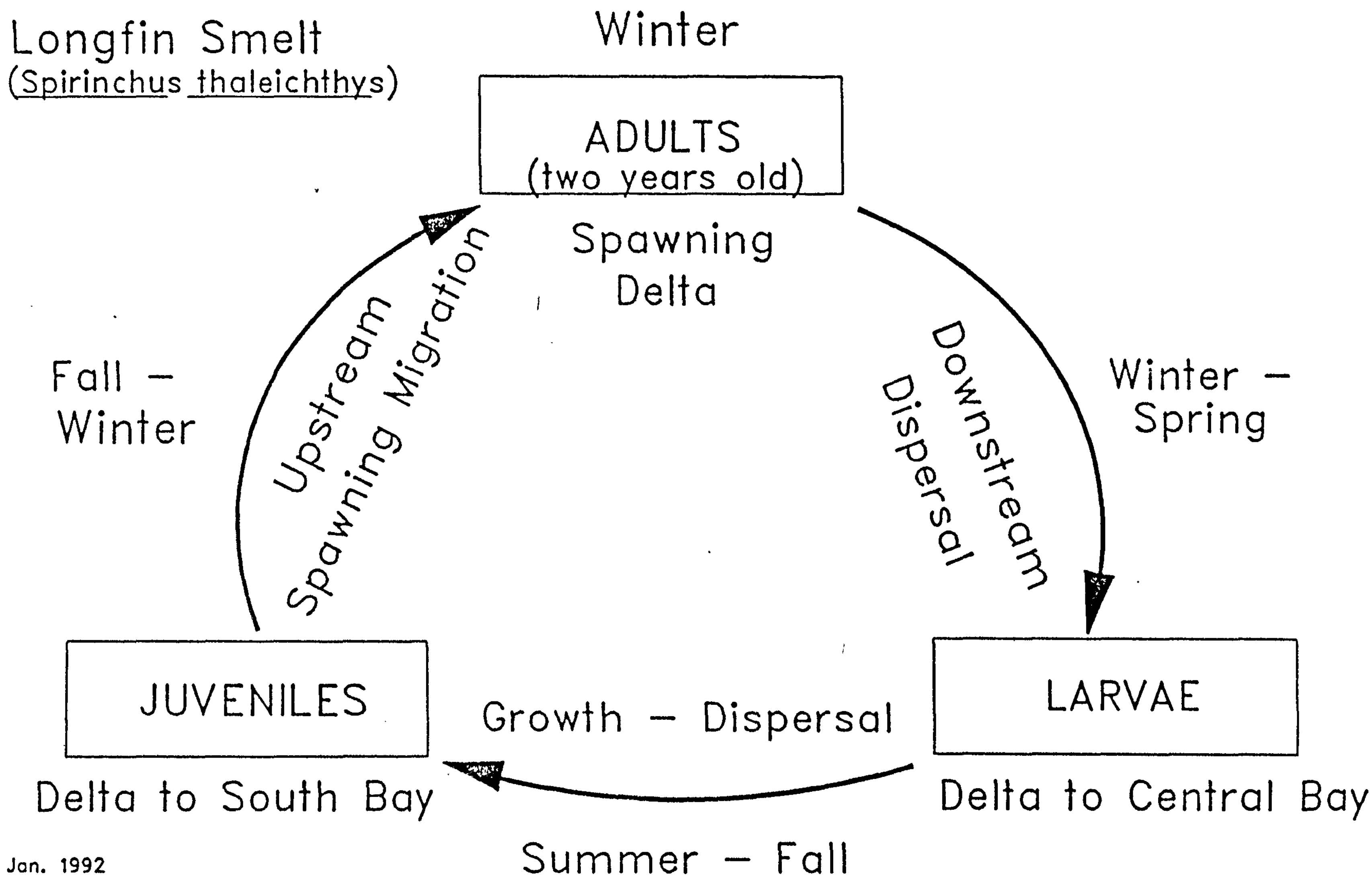
Source: CDFG. 1992d.

Figure 3.14



Longfin smelt, adults usually 9-10 cm. (from Moyle 1976)

Figure 3.15



<u>Longfin Smelt</u> Life Cycle.

Source: CDFG. 1992e.

C-110622

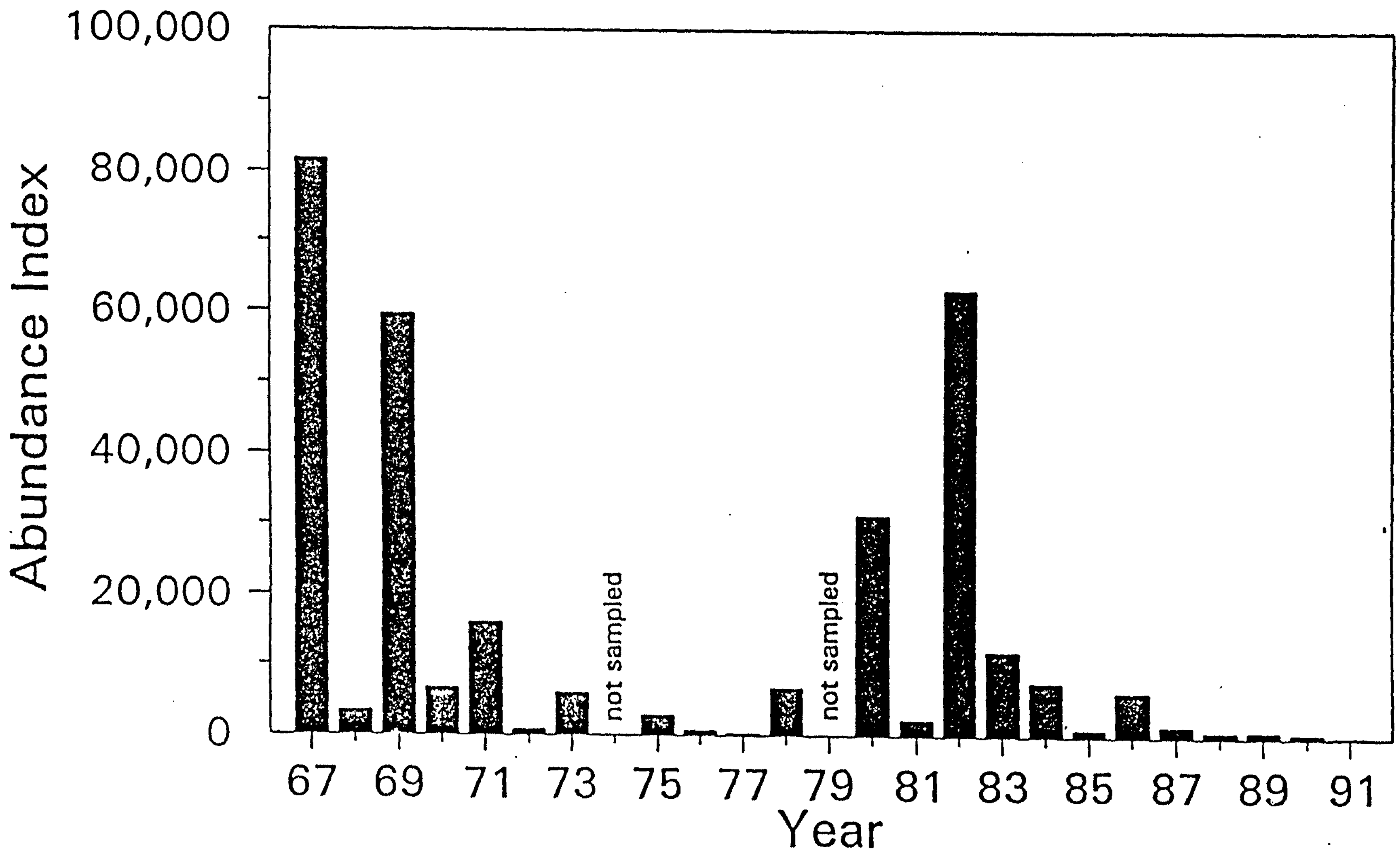


Figure 3.16

Longfin smelt annual abundance in CDFG Striped Bass Fall Midwater Trawl Survey sampling from 1967 to 1991. No sampling was done during 1974 or 1979.

Source: *CDFG. 1992e.*

C-110622

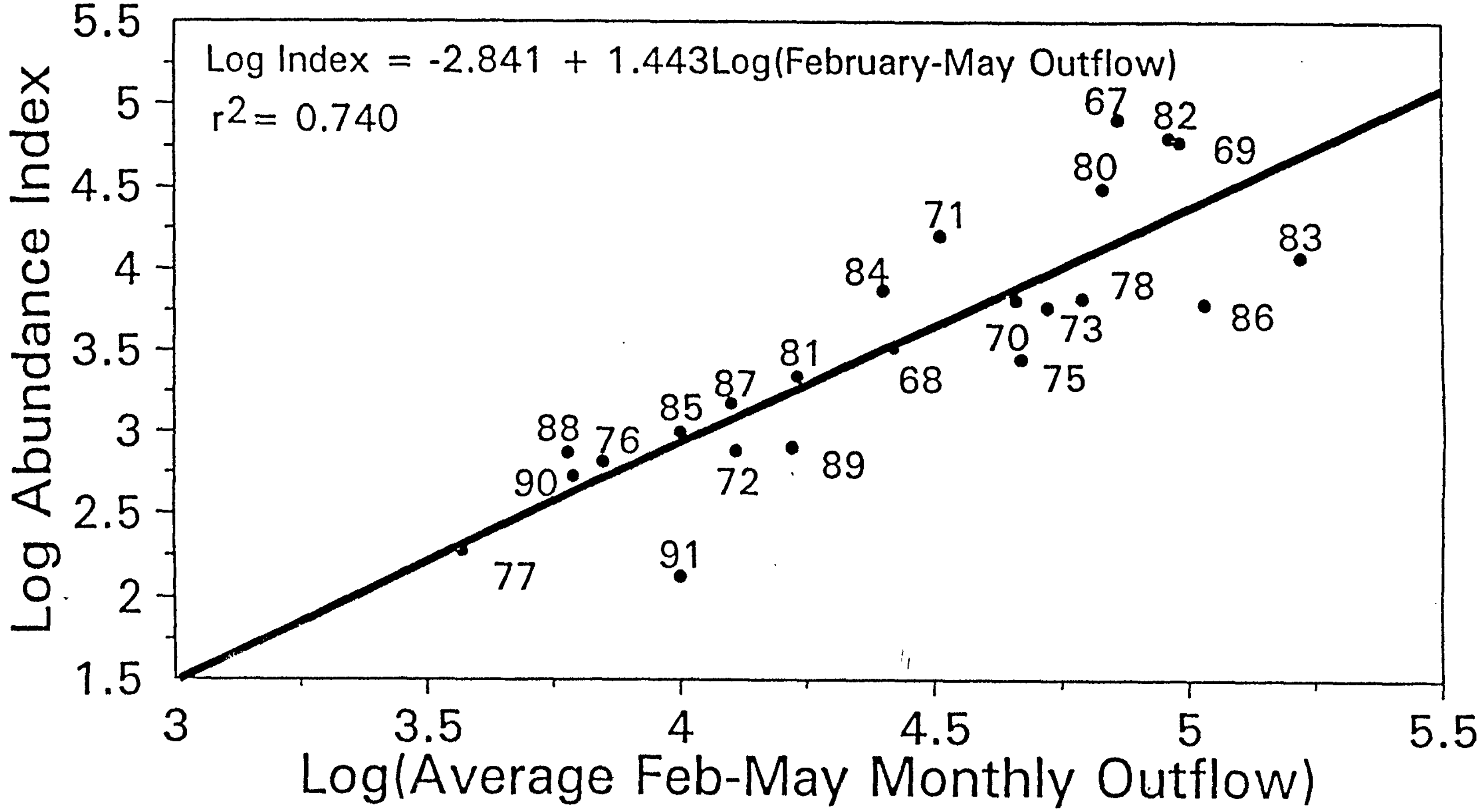


Figure 3.17

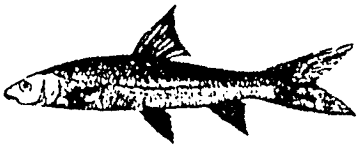
Relationship between the $\log_{10}$ of the average February through May outflow at Chipps Island in cubic feet per second and the $\log_{10}$ of the CDFG Striped Bass Fall Midwater Trawl longfin smelt abundance index.

Source: CDFG. 1992e.

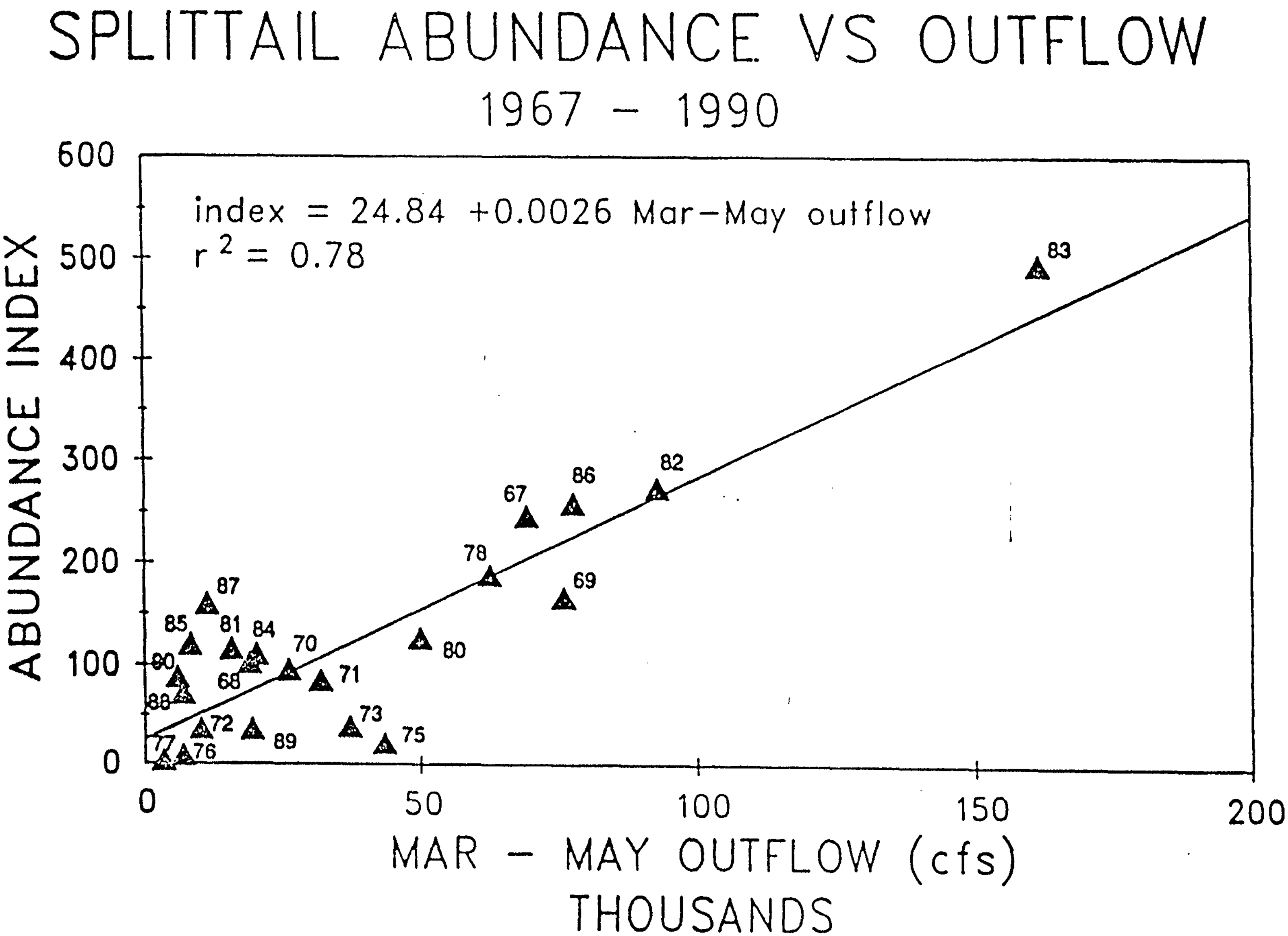
C-110623

C-110623

Figure 3.18



Splittail (Pogonichthys macrolepidotus)
Adults to 14 inches.
Source: Audubon Society (1983).



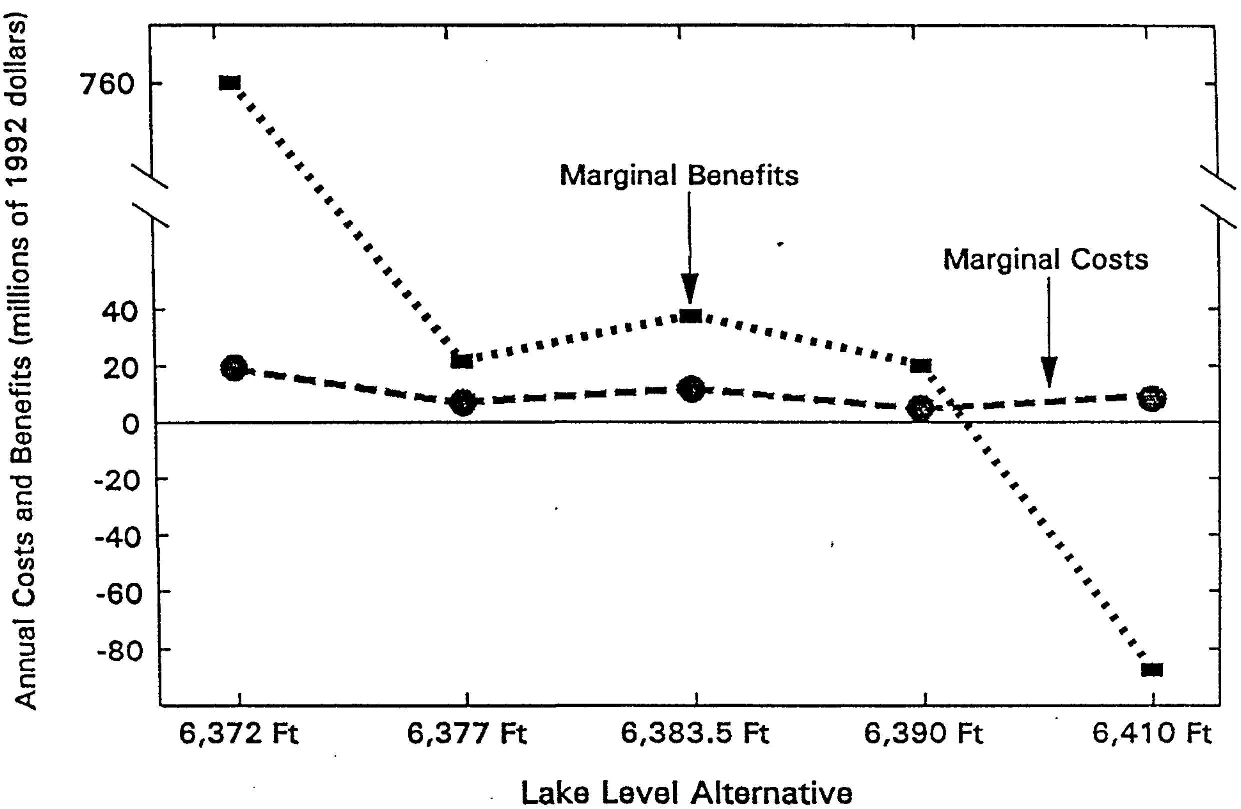
Association between splittail abundance and Delta outflow during the primary spawning months. Numbers next to data points indicate years.

Source: CDFG. 1992f.

Figure 3.19

Figure 3.20

Marginal Economic Costs and Benefits of the Alternatives



Marginal Economic Costs and Benefits of the Alternatives

Lake Level Alternative	Marginal Benefits[a]	Marginal Costs[b]	Ratio of Benefits to Costs
No Restriction[c]	--	--	--
6,372 Ft	659.8	19.1	34.5
6,377 Ft	22.0	6.5	3.4
6,383.5 Ft	37.7	11.4	3.3
6,390 Ft	20.4	4.8	4.3
6,410 Ft	−87.4	9.2	N/A

[a] Includes recreation benefits and Mono Lake preservation values.
[b] Includes LADWP water supply and power generation costs.
[c] Used as reference for calculating marginal costs and benefits for the 6,372-ft Alternative.
N/A = Not applicable.

Source: Jones & Stokes Associates. 1993. Environmental impact report for the review of Mono Basin water rights of the City of Los Angeles. Draft. (JSA 90-171.) Sacramento, CA. Prepared for California State Water Resources Control Board, Division of Water Rights. Sacramento, CA.

Table 2.1

DISTRIBUTION OF 1992 CALIFORNIA CHINOOK SALMON SPAWNING RUN
(PFMC 1993, Tables B-1,B-2,B-3,B-6,B-7)

Fall Run	
Klamath River Basin	18,884
Sacramento River	82,800
San Joaquin River	1,500
Late Fall Run	
Sacramento River	9,400
Winter Run	
Sacramento River	1,100
Spring Run	
Sacramento River	2,300

Table 2.2

Annual estimates of adult chinook spawning escapement in the San Joaquin River and in the Central Valley from 1957 to 1986.1/

Year	San Joaquin	Central Valley
1957	8.5	88.4
1958	39.6	234.7
1959	28.3	369.4
1960	53.1	416.6
1961	2.0	229.4
1962	1.7	189.2
1963	1.3	262.3
1964	7.8	266.9
1965	6.7	169.8
1966	6.4	184.4
1967	20.9	131.2
1968	7.0	173.4
1969	50.7	311.8
1970	30	177.0
1971	40	177.9
1972	12	91.0
1973	6.5	205.5
1974	3.7	191.7
1975	5.8	145.8
1976	3.5	157.8
1977	.6	134.6
1978	2.3	125.3
1979	4.0	152.0
1980	5.0	130.0
1981	14.0	156.0
1982	14.0	141.0
1983	11.6	101.7
1984	41.1	163.1
1985	60.9	273.0
1986	16.1	214.2

1/ Source for adult escapement estimates between 1957 to 1969 was from Dave Dettman per. comm., Don Kelley and Associates, estimates between 1970 to 1984 were from PFMC, 1986, estimates of 1984 and 1985 from Bob Reavis, CDFG per. comm.

Source: SWRCB. 1991. Rep. No. 91-16WR.

Table 2.3

Chinook Salmon Environmental Requirements and Life History Stages

Life Stage	Location	Duration (race)	Flow	Water Quality	Other
Adult Migration	Pacific Ocean Bay-Delta to upstream	July-Dec (fall) Oct-Mar (Late-Fall) Jan-June (winter) mid Mar-Aug (spring)	Adequate flow of home stream water to locate spawning grounds and cover redds	Temperature Chinook Migration Range Optimum: 49-57.5°F Dissolved Oxygen ≥6 mg/l	
Spawning	Upper reaches of all major rivers and streams in Sacramento-San Joaquin River Basins below dams	Oct-mid Jan (fall) Jan-Apr (late fall) Apr-mid July (winter) Aug-Nov (spring)	Stable flow without extreme fluctuation sufficient to cover and aerate redds	Temperature Chinook Gen'l Spawning Range Lower Threshold: 42°F Upper Threshold: 58°F Dissolved Oxygen ≥7 mg/l	Clean gravel substrate with good circulation through redd
Incubation (Egg-Alevin)	Spawning grounds (see above)	Oct-Apr (fall) Jan-Jul (late fall) May-Oct (winter) mid Aug-mid Jan (spring)	same as above	same as above	same as above
Rearing (Fry-Junvenile)	Upstream, Delta, and upper estuary	Dec-Mar (fall) Apr-Aug (late fall) mid Aug-Nov (winter) late Nov-Jan (spring)	Stable flow to prevent stranding Can tolerate greater flows and velocities as they mature and move into deeper water	Temperature Chinook Optimum Range Lower Lethal: 32°F Upper Lethal: 79°F Preferred Range: 45-58°F Dissolved Oxygen ≥6 mg/l	Diet of aquatic and terrestrial insects, crustaceans
Smolt Migration	Downstream to Bay-Delta Estuary to Pacific Ocean	Apr-June (fall) Aug-Jan (late fall) Nov-late Apr (winter) Feb-Apr (spring)	Tolerate higher flows typical of spring snow melt or rainy season. Helps move smolts downstream	same as above (Water Quality data from Bell 1973)	Diet of Neomysis Crangon, Corophium, and aquatic and terrestrial insects (SWRCB,433,133)

C-110629

C-110629

Table 2.4

Annual adult natural fall-run chinook salmon spawning escapements.
SWRCB. 1987. Exhibit USWFS-31. Appendix 25. p.160.
Annual adult natural fall-run chinook salmon spawning escapements.
PFMC. 1993. Review of 1992 Ocean Salmon Fisheries. Table B-1. p. B-1.

(in thousands of fish)

Year	Year	Sacramento	San Joaquin	Central Valley
1965	1965	163.1	6.7	169.8
1966	1966	178.0	6.4	184.4
1967	1967	110.3	20.9	131.2
1968	1968	166.4	7.0	173.4
1969	1969	261.1	50.7	311.8
1970	1970	147.0	30.0	177.0
1971	1971	137.9	40.0	177.9
1972	1972	79.0	12.0	91.0
1973	1973	199.0	6.5	205.5
1974	1974	188.0	3.7	191.7
1975	1975	140.0	5.8	145.8
1976	1976	154.3	3.5	157.8
1977	1977	129.8	0.6	130.4
1978	1978	123.0	2.3	125.3
1979	1979	148.0	4.0	152.0
1980	1980	125.0	5.0	130.0
1981	1981	142.0	15.9	157.9
1982	1982	130.5	14.0	144.5
1983	1983	90.1	11.1	101.2
1984	1984	117.2	40.8	158.0
1985	1985	209.0	72.6	281.6
1986	1986	212.4	23.2	235.6
1987	1987	150.4	15.8	166.2
1988	1988	197.0	20.7	217.7
1989	1989	120.4	3.2	123.6
1990	1990	84.9	0.9	85.8
1991	1991	86.7	0.6	87.3
1992	1992	61.4	1.1	62.5

Table 2.5

Annual adult hatchery fall-run chinook salmon spawning escapements.

PFMC. 1993. Review of 1992 Ocean Salmon Fisheries.
Table B-2. p. B-2.
(Table B-2 also has break-down by hatchery and numbers of jacks)
Values for Total from 1965-1969 from Dettman and Kelley, 1987, p.34.

(in thousands of fish)

Year	Sacramento	San Joaquin	Central Valley
1965			
1966			
1967			
1968			
1969			
1970	13.2	0.3	13.5
1971	11.7	1.0	12.7
1972	8.4	0.2	8.6
1973	21.0	0.6	21.6
1974	12.9	1.0	13.9
1975	12.6	0.8	13.4
1976	10.4	0.6	11.0
1977	17.9	0.4	18.3
1978	11.1	0.5	11.6
1979	15.3	0.6	15.9
1980	25.3	0.6	25.9
1981	30.8	0.6	31.4
1982	30.7	2.0	32.7
1983	17.9	1.9	19.8
1984	37.8	1.7	39.5
1985	26.0	1.3	27.3
1986	22.6	0.8	23.4
1987	21.2	0.6	21.8
1988	26.7	0.4	27.1
1989	25.9	0.1	26.0
1990	22.4	0.1	22.5
1991	24.7	0.3	25.0
1992	21.4	0.4	21.8

Table 2.6

Distribution (percent) of total midwater trawl catch of chinook smolts by month at Chipps Island from 1978 to 1991.

Year	April	May	June
1978	27	40	33
1979	19	52	29
1980	14	34	52
1981	34	50	16
1982	18	49	33
1983	19	49	32
1984	11	66	23
1985	26	63	11
1986	37	55	8
1987	44	54	2
1988	27	70	3
1989	29	62	9
1990	31	56	12
1991	14	72	12
$\bar{x}$ (1978-1991)	26	54	20

Source: USFWS. 1992. SWRCB Ex. No. WRINT-USFWS-9.

Table 2.7

Source: PFMC 1993

Summary of troll salmon fishing regulations for 1992

	Season		Quota	
Management Area	Dates	Species	Chinook	Coho
Pt. Arena to	8/1-8/7	All	e	d
Pt. Reyes	8/8-9/30	Not Coho	e	NA
Pt. Reyes to	5/1-5/10	Not Coho	10,000	NA
Pt. San Pedro	8/8-9/30	Not Coho	10,000	NA
	8/1-8/7	All	e	d

Other Restrictions:

1) No more than 6 lines per boat.

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d/ For the entire area south of Cape Falcon, the preseason impact quota (catch plus hook-and-release mortality) was 60,000 coho. The catch quota for this impact was 57,000 coho. A 70% subarea impact ceiling within the overall impact allowed a catch on no more than 40,000 coho south of Cascade Head. A 17% subarea impact ceiling allowed a harvest of no more than 10,000 coho south of Pt. Arena.

e/ The Secretary of Commerce established an 8,000 chinook quota for the Aug. portion of the fishery between Pt. Arena and Pt. San Pedro. The unharvested portion of the chinook quota for the May fishery between Pt. Raeyes and Pt. San Pedro was transferred to the August fisheries to provide an overall quota of 21,500 chinook in August.

Table 2.8

AVERAGE DAYS AT SEA BY VESSEL SIZE AND EXPECTED CATCH
(Fletcher and Johnston, 1984)

	EXPECTED CATCH		
VESSEL SIZE	Poor	Average	Good
Sm.(35-ft.) Vessel	25	45	60
Md.(45-ft.) Vessel	25	50	75
Lg.(55-ft.) Vessel	0	40	75

Table 2.9

COMMERCIAL TROLLING INDUSTRY (PFMC 1992)

YEAR	AVE.REAL VALUE PER VESSEL
1977	6477
1978	4252
1979	7534
1980	4425
1981	5346
1982	6846
1983	1893
1984	3908
1985	6133
1986	6772
1987	12182
1988	18258
1989	5744
1990	5908
1991	5096

Table 2.10

SECTORS OF THE 1982 CALIFORNIA INTERINDUSTRY FISHERIES MODEL

(Source: King and Flagg. 1984)

Fish Harvesting Sectors (1-20)

Sector Number	Title	Sector Number	Title
1	Groundfish Trawlers, North	11	Salmon-Albacore
2	Groundfish Trawlers, South	12	Long-Liners
3	Shrimp Trawlers	13	Hook & Line
4	Tuna Purse-Seiners	14	Black Cod Pots
5	Wetfish Seiners	15	Crab/Lobster, North
6	Herring Gillnetters	16	Crab/Lobster, South
7	Other Gillnetters	17	Baitboats
8	Small Salmon Trollers	18	Jigboats
9	Large Salmon Trollers	19	Diveboats
10	Salmon-Crabbers	20	Harpoon Billfish

Fish Processing Sectors (21-29)

Sector Number	Title	Sector Number	Title
21	Fish Whsl., Proc., Dist., Small	26	Seafood Restaurants
22	Fish Whsl., Proc., Dist., Medium	27	Other Eat & Drink
23	Fish Whsl., Proc., Dist., Large	28	Seafood Markets
24	Fish Import/Export Brokers	29	Other Food & Kindred Products
25	Tuna Canners		

Non-Fishery Sectors (30-64)

Sector Number	Title	Sector Number	Title
30	Forestry & Other Fishing	48	Textiles
31	Forestry/Fish Services	49	Apparel
32	Petfood	50	Paper
33	Animal & Marine Fats	51	Printing
34	Ship & Boat	52	Chemical
35	Motor Freight	53	Petroleum
36	Agricultural	54	Rubber & Plastics
37	Mining	55	Leather
38	Construction	56	Telephone & Public Utilities
39	Lumber	57	Wholesale Traders
40	Furniture	58	Retail Traders
41	Glass, Stone, Clay	59	Insurance
42	Metal	60	Finance
43	Non-Electric Machines	61	Services
44	Electric Equipment	62	Federal Government
45	Transportation Equipment	63	State & Local Governments
46	Instruments	64	Scrap Industries
47	Miscellaneous Mfg. Goods		

Primary Sectors (65-66)

Sector Number	Title
65	California Households
66	Imports/Exports

Table 2.11

SMALL SALMON TROLLERS
(n = 72)

I. DESCRIPTION OF THE FLEET

Primary gear: Troll and a few pole and line
Secondary gear: Not pots and traps
Vessel length: Less than or equal to 32 feet
Value of catch: Salmon greater than zero; greater than any other species

II. SUMMARY OF VESSEL REVENUES

Species	1 # Vessels Reporting Catch > 0	2 Sample Revenues	3 % Revenues by Vessels Reporting Catch > 0	4 Average Revenues based on: All Vessels	5 Average Revenues based on: Vessels Reporting	6 Standard Deviation of Vessel Revenues: All Vessels	7 Standard Deviation of Vessel Revenues: Vessels Harvesting	8 Minimum % of Total Revenues	9 Maximum % of Total Revenues
Crustaceans	2	2162	0.40	30	1081	178	39	34.78	46.05
Flatfish	4	980	0.18	14	245	68	164	2.90	37.63
Wetfish	1	215	0.04	3	215	25	0	33.86	33.86
Sable/Rock	11	7826	1.44	109	711	648	1523	0.13	47.49
Sharks/Rays/Skates	1	440	0.08	6	440	51	0	27.59	27.59
Salmon	72	516551	94.81	7174	7174	17390	17390	30.11	100.00
Tuna	5	12880	2.36	179	2576	848	2043	1.39	21.05
Cod	8	3801	0.70	53	475	199	394	0.91	55.94
TOTAL	72	544855	100.00	7567	7567	17727	17727	100.00	100.00

III. SUMMARY OF VESSEL COSTS

Cost Category	10 # Vessels Reporting Cost > 0	11 Total Expenses by Vessels Reporting	12 % of Total Expenses	13 Average Vessel Cost based on: All Vessels	14 Average Vessel Cost based on: Vessels Reporting	15 Standard Deviation of Vessel Costs: All Vessels	16 Standard Deviation of Vessel Costs: Vessels Reporting	17 Minimum % of Total Costs	18 Maximum % of Total Costs
Dockage	58	70222	11.91	1018	1211	3898	4224	0.98	72.09
Interest	11	8234	1.40	119	749	318	403	1.71	24.04
Depreciation	28	87332	14.81	1266	3119	2466	3034	7.97	58.68
Capital Expenditure	34	99241	16.83	1438	2919	2579	3030	5.06	80.32
Insurance	19	15853	2.69	230	834	519	688	1.34	90.00
Taxes	32	20421	3.46	296	638	1252	1778	0.07	25.26
Other Fixed (gear,etc)	13	11298	1.92	164	869	508	669	4.13	30.77
Total Fixed	66	312599	53.00	4530	4736	6179	6240	0.29	94.86
Fuel	67	75494	12.80	1094	1127	1699	1714	1.35	62.62
Repairs & Maintenance	61	103119	17.48	1494	1690	2016	2065	1.50	81.93
Crewshares & Wages	18	37148	6.30	538	2064	1715	2850	1.58	57.11
Other Variable (ice,bait,etc)	37	61461	10.42	891	1661	1731	2075	1.00	100.00
Total Variable	69	277222	47.00	4018	4018	3994	3994	5.14	100.00
TOTAL	69	589820	100.00	8548	8548	8587	8587	100.00	100.00

Source: 1980 CIF Survey; Sector 8
California vessels only; updated to 1982 using input and product price adjustments.

Table 2.12

LARGE SALMON TROLLERS
(n = 124)

I. DESCRIPTION OF THE FLEET

Primary gear: Troll and a few pole and line
Secondary gear: Not pots and traps
Vessel length: Greater than 32 feet
Value of catch: Salmon greater than zero; greater than any other species

II. SUMMARY OF VESSEL REVENUES

Species	1 # Vessels Reporting Catch > 0	2 Sample Revenues	3 % Revenues by Vessels Reporting Catch > 0	4 Average Revenues based on: All Vessels	5 Average Revenues based on: Vessels Reporting	6 Standard Deviation of Vessel Revenues: All Vessels	7 Standard Deviation of Vessel Revenues: Vessels Harvesting	8 Minimum % of Total Revenues	9 Maximum % of Total Revenues
Crustaceans	2	4480	0.21	36	2240	316	1120	7.67	21.05
Flatfish	5	2555	0.12	21	511	140	488	0.57	20.00
Wetfish	12	77437	3.62	624	6453	2395	4656	0.03	41.67
Sable/Rock	36	79068	3.70	638	2196	1980	3176	1.10	74.07
Sharks/Rays/Skates	3	352	0.02	3	117	24	104	1.85	9.48
Salmon	124	1692248	79.14	13647	13647	48037	48037	25.30	100.00
Billfish	2	26650	1.25	215	13325	2326	12675	1.76	40.45
Tuna	43	240140	11.23	1937	5585	3845	4719	1.06	48.98
Cod	8	4217	0.20	34	527	207	633	0.06	15.46
Other	1	11200	0.52	90	11200	1002	0	25.48	25.48
TOTAL	124	2138347	100.00	17245	17245	48766	48766	100.00	100.00

III. SUMMARY OF VESSEL COSTS

Cost Category	10 # Vessels Reporting Cost > 0	11 Total Expenses by Vessels Reporting	12 % of Total Expenses	13 Average Vessel Cost based on: All Vessels	14 Average Vessel Cost based on: Vessels Reporting	15 Standard Deviation of Vessel Costs: All Vessels	16 Standard Deviation of Vessel Costs: Vessels Reporting	17 Minimum % of Total Costs	18 Maximum % of Total Costs
Dockage	99	80990	3.71	669	818	502	432	0.44	61.20
Interest	34	184425	8.44	1524	5424	4567	7285	1.43	51.30
Depreciation	50	217952	9.98	1801	4359	3275	3849	3.12	76.95
Capital Expenditure	67	450650	20.63	3724	6726	10278	13061	0.83	81.94
Insurance	49	130557	5.98	1079	2664	2047	2474	1.32	37.90
Taxes	66	55154	2.52	456	836	1158	1463	0.10	65.77
Other Fixed (gear,etc)	32	47385	2.17	392	1481	1178	1906	1.41	27.71
Total Fixed	119	1167261	53.44	9647	9809	14364	14429	0.82	95.32
Fuel	121	252360	11.55	2086	2086	2459	2459	0.70	100.00
Repairs & Maintenance	113	313657	14.36	2592	2776	3688	3749	1.04	91.99
Crewshares & Wages	48	219001	10.03	1810	4563	4583	6355	0.71	68.50
Other Variable (ice,bait,etc)	77	232080	10.62	1918	3014	4999	5998	1.00	91.44
Total Variable	121	1017095	46.56	8406	8406	11366	11366	4.68	100.00
TOTAL	121	2184355	100.00	18053	18053	22010	22010	100.00	100.00

Source: 1980 CIF Survey; Sector 9
California vessels only; updated to 1982 using input and product price adjustments.

Table 2.13

CRAB - LOBSTER, NORTH
(n = 35)

I. DESCRIPTION OF THE FLEET

Primary or secondary gear:	Pots and traps
Primary gear:	Not gillnet
Home port:	From Santa Barbara - north
Value of catch:	Crustaceans greater than any other species

II. SUMMARY OF VESSEL REVENUES

Species	1 # Vessels Reporting Catch > 0	2 Sample Revenues	3 % Revenues by Vessels Reporting Catch > 0	4 Average Revenues based on: All Vessels	5 Average Revenues based on: Vessels Reporting	6 Standard Deviation of Vessel Revenues: All Vessels	7 Standard Deviation of Vessel Revenues: Vessels Harvesting	8 Minimum % of Total Revenues	9 Maximum % of Total Revenues
Crustaceans	34	1610558	74.19	47369	47369	49400	49400	31.25	100.00
Mollusks	1	18	0.00	1	18	3	0	0.04	0.04
Flatfish	3	68968	3.18	2028	22989	8137	16386	0.28	21.50
Wetfish	1	10800	0.50	318	10800	1825	0	22.32	22.32
Sable/Rock	7	4276	0.20	126	611	510	984	0.05	2.05
Sharks/Rays/Skates	1	5009	0.23	147	5009	846	0	7.32	7.32
Salmon	29	368297	16.97	10832	12700	10503	10277	0.02	49.37
Tuna	10	100878	4.65	2967	10088	5670	6123	3.67	26.70
Cod	1	2000	0.09	59	2000	338	0	12.35	12.35
TOTAL	34	2170804	100.00	63847	63847	54084	54084	100.00	100.00

III. SUMMARY OF VESSEL COSTS

Cost Category	10 # Vessels Reporting Cost > 0	11 Total Expenses by Vessels Reporting	12 % of Total Expenses	13 Average Vessel Cost based on: All Vessels	14 Average Vessel Cost based on: Vessels Reporting	15 Standard Deviation of Vessel Costs: All Vessels	16 Standard Deviation of Vessel Costs: Vessels Reporting	17 Minimum % of Total Costs	18 Maximum % of Total Costs
Dockage	27	18586	1.91	547	688	466	420	0.40	100.00
Interest	11	56970	5.86	1676	5179	3527	4507	0.65	31.25
Depreciation	13	71940	7.40	2116	5534	3183	2754	7.83	47.85
Capital Expenditure	14	101564	10.44	2987	7255	6544	8547	4.66	40.77
Insurance	21	77699	7.99	2285	3700	2620	2424	3.17	24.07
Taxes	19	39565	4.07	1164	2082	1746	1882	0.23	29.60
Other Fixed (gear,etc)	12	32652	3.36	960	2721	1818	2138	1.94	47.05
Total Fixed	33	398975	41.02	11735	12090	11154	11130	3.45	100.00
Fuel	32	116021	11.93	3412	3626	3770	3785	1.70	96.55
Repairs & Maintenance	31	139203	14.31	4094	4490	5817	5944	2.12	100.00
Crewshares & Wages	24	251599	25.87	7400	10483	12672	13970	3.98	72.87
Other Variable (ice,bait,etc)	21	66783	6.87	1964	3180	2319	2201	2.60	30.91
Total Variable	33	573605	58.98	16871	17382	18856	18906	23.96	100.00
TOTAL	34	972580	100.00	28605	28605	25385	25385	100.00	100.00

Source: 1980 CIF Survey; Sector 15
California vessels only; updated to 1982 using input and product price adjustments.

Table 2.14

SALMON - ALBACORE
(n = 30)

I. DESCRIPTION OF THE FLEET

Primary gear: Troll
Secondary gear: Not pots and traps
Value of catch: a) Salmon greater than zero
b) Tuna greater than zero and greater than any other species except salmon

II. SUMMARY OF VESSEL REVENUES

Species	1 # Vessels Reporting Catch > 0	2 Sample Revenues	3 % Revenues by Vessels Reporting Catch > 0	4 Average Revenues based on: All Vessels	5 Average Revenues based on: Vessels Reporting	6 Standard Deviation of Vessel Revenues: All Vessels	7 Standard Deviation of Vessel Revenues: Vessels Harvesting	8 Minimum % of Total Revenues	9 Maximum % of Total Revenues
Crustaceans	3	1604	0.14	53	535	181	267	0.91	4.74
Flatfish	1	8	0.00	0	8	1	0	0.03	0.03
Wetfish	2	43800	3.89	1460	21900	5967	9300	25.91	29.65
Sable/Rock	4	10390	0.92	346	2598	1518	3382	0.94	17.34
Salmon	30	332190	29.48	11073	11073	7983	7983	3.65	55.56
Tuna	30	738802	65.57	24627	24627	16461	16461	29.72	95.41
TOTAL	30	1126794	100.00	37560	37560	24403	24403	100.00	100.00

III. SUMMARY OF VESSEL COSTS

Cost Category	10 # Vessels Reporting Cost > 0	11 Total Expenses by Vessels Reporting	12 % of Total Expenses	13 Average Vessel Cost based on: All Vessels	14 Average Vessel Cost based on: Vessels Reporting	15 Standard Deviation of Vessel Costs: All Vessels	16 Standard Deviation of Vessel Costs: Vessels Reporting	17 Minimum % of Total Costs	18 Maximum % of Total Costs
Dockage	26	29699	3.27	1024	1142	1051	1047	0.33	16.34
Interest	14	53765	5.92	1854	3840	3527	4260	0.42	29.45
Depreciation	18	109784	12.08	3786	6099	3460	2276	5.33	64.10
Capital Expenditure	18	98685	10.86	3403	5483	7105	8362	2.49	70.21
Insurance	21	80687	8.88	2782	3842	2246	1702	3.81	36.86
Taxes	18	33609	3.70	1159	1867	2222	2575	0.08	11.61
Other Fixed (gear,etc)	10	15447	1.70	533	1545	820	622	1.80	8.59
Total Fixed	29	421680	46.40	14541	14541	9504	9504	26.00	85.24
Fuel	29	169347	18.64	5840	5840	2775	2775	7.14	42.72
Repairs & Maintenance	28	120364	13.25	4150	4299	3320	3283	1.65	43.08
Crewshares & Wages	15	123603	13.60	4262	8240	8202	9864	1.90	43.03
Other Variable (ice,bait,etc)	18	73755	8.12	2543	4098	2402	1710	2.70	22.52
Total Variable	29	487066	53.60	16795	16795	12919	12919	14.76	74.00
TOTAL	29	908746	100.00	31336	31336	19429	19429	100.00	100.00

Source: 1980 CIF Survey; Sector 11
California vessels only; updated to 1982 using input and product price adjustments.

Table 2.15

HERRING GILLNETTERS
(n = 24)

I. DESCRIPTION OF THE FLEET

Primary gear: Gillnet
Home port: From Monterey - north
Value of catch: Herring (wetfish) greater than any other species

II. SUMMARY OF VESSEL REVENUES

Species	1 # Vessels Reporting Catch > 0	2 Sample Revenues	3 % Revenues by Vessels Reporting Catch > 0	4 Average Revenues based on: All Vessels	5 Vessels Reporting	6 Standard Deviation of Vessel Revenues: All Vessels	7 Vessels Harvesting	8 Minimum % of Total Revenues	9 Maximum % of Total Revenues
Crustaceans	7	49568	4.47	2065	7081	6955	11416	0.14	32.94
Mollusks	1	70400	6.35	2933	70400	14068	0	24.24	24.24
Flatfish	1	3500	0.32	146	3500	699	0	3.27	3.27
Wetfish	24	591960	53.38	24665	24665	22335	22335	31.37	100.00
Sable/Rock	5	477	0.04	20	95	51	74	0.13	1.29
Sharks/Rays/Skates	1	13200	1.19	550	13200	2638	0	12.32	12.32
Salmon	22	222848	20.10	9285	10129	6761	6428	3.14	46.67
Tuna	11	56459	5.09	2352	5133	3509	3550	0.07	27.85
Cod	2	100500	9.06	4188	50250	19979	49750	4.14	34.44
TOTAL	24	1108912	100.00	46205	46205	55372	55372	100.00	100.00

III. SUMMARY OF VESSEL COSTS

Cost Category	10 # Vessels Reporting Cost > 0	11 Total Expenses by Vessels Reporting	12 % of Total Expenses	13 Average Vessel Cost based on: All Vessels	14 Vessels Reporting	15 Standard Deviation of Vessel Costs: All Vessels	16 Vessels Reporting	17 Minimum % of Total Costs	18 Maximum % of Total Costs
Dockage	17	16616	1.07	722	977	868	878	0.43	18.87
Interest	10	58058	3.73	2524	5806	4705	5645	2.31	24.60
Depreciation	13	75954	4.88	3302	5843	3860	3393	1.01	29.60
Capital Expenditure	14	140388	9.02	6104	10028	12452	14676	2.75	63.04
Insurance	12	38156	2.45	1659	3180	2075	1849	0.70	19.37
Taxes	18	40278	2.59	1751	2238	2348	2441	0.04	22.63
Other Fixed (gear,etc)	9	23414	1.50	1018	2602	1453	1129	2.16	37.74
Total Fixed	22	392864	25.23	17081	17857	17876	17895	7.80	84.91
Fuel	23	124343	7.99	5406	5406	13695	13695	0.83	100.00
Repairs & Maintenance	22	150457	9.66	6542	6839	12358	12555	2.25	50.63
Crewshares & Wages	20	833937	53.55	36258	41697	122433	130429	0.54	75.99
Other Variable (ice,bait,etc)	15	55584	3.57	2417	3706	3699	4026	1.08	33.56
Total Variable	23	1164317	74.77	50622	50622	147170	147170	15.09	100.00
TOTAL	23	1557181	100.00	67704	67704	157641	157641	100.00	100.00

Source: 1980 CIF Survey; Sector 6
California vessels only; updated to 1982 using input and product price adjustments.

Table 2.16

DIVEBOATS
(n = 33)

I. DESCRIPTION OF THE FLEET

Primary gear: Scuba or hooka

II. SUMMARY OF VESSEL REVENUES

Species	1 # Vessels Reporting Catch > 0	2 Sample Revenues	3 % Revenues by Vessels Reporting Catch > 0	4 Average Revenues based on: All Vessels	5 Vessels Reporting	6 Standard Deviation of Vessel Revenues: All Vessels	7 Vessels Harvesting	8 Minimum % of Total Revenues	9 Maximum % of Total Revenues
Crustaceans	1	3360	0.25	102	3360	576	0	17.63	17.63
Mollusks	31	289528	21.68	8774	9340	10677	10773	2.33	100.00
Flatfish	3	7105	0.53	215	2368	835	1600	4.37	36.80
Sharks/Rays/Skates	2	6600	0.49	200	3300	833	1100	23.08	23.13
Salmon	4	421050	31.53	12759	105263	71991	181714	0.44	97.67
Billfish	2	53632	4.02	1625	26816	6417	1960	43.03	73.12
Tuna	3	14800	1.11	448	4933	1623	2620	8.39	44.44
Other	15	539489	40.39	16348	35966	33901	42695	11.54	100.00
TOTAL	33	1335564	100.00	40472	40472	76360	76360	100.00	100.00

III. SUMMARY OF VESSEL COSTS

Cost Category	10 # Vessels Reporting Cost > 0	11 Total Expenses by Vessels Reporting	12 % of Total Expenses	13 Average Vessel Cost based on: All Vessels	14 Vessels Reporting	15 Standard Deviation of Vessel Costs: All Vessels	16 Vessels Reporting	17 Minimum % of Total Costs	18 Maximum % of Total Costs
Dockage	24	32351	4.02	1011	1348	2049	2268	1.04	37.85
Interest	13	36560	4.54	1143	2812	1695	1541	1.72	22.31
Depreciation	17	63204	7.85	1975	3718	2624	2546	2.07	42.28
Capital Expenditure	15	83518	10.37	2610	5568	5684	7242	3.47	75.00
Insurance	15	20216	2.51	632	1348	986	1054	0.92	9.65
Taxes	17	14799	1.84	462	871	750	839	0.09	10.81
Other Fixed (gear,etc)	6	8346	1.04	261	1391	783	1302	0.45	26.87
Total Fixed	32	258993	32.15	8094	8094	7822	7822	2.50	79.62
Fuel	32	155834	19.35	4870	4870	3736	3736	7.36	90.91
Repairs & Maintenance	30	95387	11.84	2981	3180	3647	3682	1.61	67.44
Crewshares & Wages	21	226869	28.17	7090	10803	11703	12984	5.24	66.91
Other Variable (ice,bait,etc)	21	68412	8.49	2138	3258	2696	2725	0.87	54.37
Total Variable	32	546502	67.85	17078	17078	14210	14210	20.38	97.50
TOTAL	32	805495	100.00	25172	25172	18415	18415	100.00	100.00

Source: 1980 CIF Survey; Sector 19
California vessels only; updated to 1982 using input and product price adjustments.

Table 2.17

Budget for Salmon Troller.

Type of Vessel: 42 foot troller
Market value $24,000[a]
1 crew and skipper[b]
Gross revenue $35,000
12% loan or investment return

	Net Cash Flow $	Percentage of Total Revenues
Revenue	$35,000	
Less Expenses:		
Variable Expenses:		
Repair work	1,440	0.0410
Gear replacement	2,400	0.0684
Fuel and lubricants	3,590	0.1026
Food and supplies	1,795	0.0513
Ice and bait	360	0.0103
Dues and fees	240	0.0068
Transportation	880	0.0252
Miscellaneous	880	0.2520
Crew shares (39% of gross)[b]	13,650	0.3900
Total Variable Costs	25,235	0.7208
Contribution Margin		
Fixed Expenses:		
Insurance	480	0.0137
Moorage	720	0.0205
Interest expensea	2,875	0.0821
Depreciationa		
Licenses	360	0.0103
Miscellaneous	25	0.0007
Total Fixed Expenses	4,460	0.1273
Net Return	5,305	0.1519

a It is assumed that the total amount of the purchase price of the boat is borrowed; if the boat owner's money is used, this is considered a return on his or her investment. Depreciation is frequently viewed as the value of principal payments; depreciation of boat and equipment is taken over a 10-year period. Market value of the boat may also include market value of boat license or fishing contract.

b Crew share formula and the number of crew will vary from boat to boat and from fishery to fishery; the shares vary from a percentage of gross revenues to formulas that may include deductions for food, fuel, employment tax, etc. The payment to the skipper is part of crew shares; the skipper may also be the boat owner.

Source: Carter and Radkte. 1986.

Table 2.18

Salmon Commercial Fishing Permit Utilization
Source: PFMC, 1993, Table D-4.

Year	Vessels With Permits	Vessels Landing Salmon	Percent Vessels Landing Salmon
1982	5964	4013	67
1983	4617	3223	70
1984	4180	2569	61
1985	3869	2308	60
1986	3753	2582	69
1987	3533	2442	69
1988	3493	2571	74
1989	3464	2534	73
1990	3372	2115	63
1991	3242	1769	55
1992	2970	1083	36

Table 2.19

Estimated Ownership and Operating Costs for Representative Eureka Crabber-Troller Vessels in the Crab, Salmon, and Albacore Fisheries[a]

	35 foot[b]	45 foot[b]	55 foot[b]
Market value:			
Vessel and attached gear	$75,000	$140,000	$180,000
Crab pots @ $80/pot	12,000	20,000	32,000
Total Value	$87,000	$160,000	$212,000
Fixed costs[c]			
Insurance liability[d]	$ 4,550	$ 4,800	$ 5,800
Depreciation (20 years—not including crab pots)[e]	3,750	7,000	9,000
Property tax	250	400	500
Moorage	500	600	900
Annual maintenance costs[f]	3,000	4,300	5,000
Annual gear cost[g]	2,000	3,000	4,000
Transportation	3,000	3,000	3,000
Misc. (utilities, legal, accounting, storage, etc.)	1,500	2,000	2,000
	$18,550	$ 25,100	$ 30,200
Variable costs (per day)			
Crab fishing			
Vessel repair	$ 15	$ 18	$ 20
Gear repair	60	80	100
Fuel (@ 1.10/gal)	27	55	88
Galley	5	10	10
Bait[h]	50	75	100
	$ 157	$ 238	318
Salmon			
Vessel repair	$ 15	$ 18	$ 20
Gear repair	5	5	5
Fuel (@ 1.10/gal)	33	44	55
Galley	15	25	25
Bait and ice	35	55	75
	103	147	180
Albacore			
Vessel repair	$ 15	$ 18	$ 20
Gear repair	2	2	2
Fuel (@ 1.10/gal)	66	88	110
Galley	15	25	25
Bait and ice	25	10	10
	123	143	167

[a]Based on interviews conducted with operators in the Eureka fisheries during the summer and fall of 1980.

[b]For a description of each representative size configuration see the footnotes in Table 2.

[c]Fixed costs are incurred by remaining in business regardless of actual number of days fished or total landings.

[d]Actual insurance cost is highly dependent on vessel construction. A steel hull vessel may run 2-1/2 to 3-1/2 percent of the insured value while a similarly equipped vessel with a wooden hull may cost 5 to 6 percent of value.

[e]The actual cost incurred by the operator depends on the market for used fishing vessels and must also be adjusted for the effects of inflation. The 20-year figure used here is an estimate of the useful life and is not determined by tax considerations.

[f]Maintenance cost is usually considered a variable cost, but many of the major expense items such as hull maintenance, painting, etc., are incurred regardless of actual fishing time. Due to the format of this report, these maintenance costs are included under fixed costs.

[g]Much gear is replaced or repaired annually. Eighty-five percent of this cost is in replacing crab pots and other crab gear. Ten percent and 5 percent, respectively, are allocated to salmon and albacore gear.

[h]Crab bait costs vary greatly over the season and among vessels depending on the bait used.

Source: Fletcher and Johnston. 1984.

Table 2.20

HARVESTING SECTOR SALES ($ millions, 1982)
King and Flagg (1984)

BUYER	SMALL SALMON TROLLERS	LARGE SALMON TROLLERS
Sm. Fish Proc.,Whsl.,Dist.	0.06	0.20
Md. Fish Proc.,Whsl.,Dist.	0.54	1.72
Lg. Fish Proc.,Whsl.,Dist.	1.13	3.62
Import/Export Brokers	0.00	0.02
Tuna Canners	0.02	0.71
Direct Export	0.00	0.01
TOTALS	1.75	6.28

Table 2.21

HARVESTING SECTOR INPUT PURCHASES ($ millions, 1982)
King and Flagg (1984)

SUPPLIER	SMALL SALMON TROLLERS	LARGE SALMON TROLLERS
Ship and Boat	0.27	0.74
Metal	0.10	0.24
Non-electric Machines	0.03	0.07
Electric Equipment	0.00	0.01
Instruments	0.01	0.02
Misc. Mfg. Goods	0.01	0.02
Petroleum	0.06	0.21
Public Utilities	0.06	0.10
Wholesale Goods	0.08	0.23
Retail Goods	0.11	0.32
Finance	0.03	0.32
Households	0.61	3.32
Imports	0.22	0.63
TOTALS	1.60	6.24

Table 2.22

Standard	Water Year	Ocean Commercial Catch
1485	Above Normal	289312
1630	Above Normal	359677
EPA	Above Normal	410113
1485	Critically Dry	207369
1630	Critically Dry	276614
EPA	Critically Dry	306398

Table 2.23

California monthly troll chinook and coho average dressed weights (pounds) by area of landing.

Year	Apr.	May	June	July	Aug.	Sept.	Season[a/]	May	June	July	Aug.	Sept.	Season[a/]
				CHINOOK						COHO			
San Francisco													
1971-1975	8.7	9.7	11.4	11.9	11.1	11.3	10.7	5.2	6.5	8.7	8.9	8.9	7.4
1976-1980	8.5	8.8	9.9	10.8	11.4	11.6	9.9	4.2	5.0	6.8	6.8	7.7	5.2
1981	-	8.6	9.8	11.3	11.3	9.9	10.4	4.0	6.7	7.0	5.6	10.2	6.4
1982	7.5	9.0	10.1	10.4	11.0	11.2	9.9	4.4	5.6	6.6	7.2	7.9	6.2
1983	6.1	6.3	6.9	7.5	8.5	8.3	7.1	5.5	3.8	4.6	5.1	4.3	4.6
1984	-	8.0	8.5	9.2	8.8	8.6	8.9	-	6.9	7.9	7.6	8.7	7.6
1985	-	11.0	12.8	14.2	13.0	12.0	12.4	-	6.9	7.8	9.0	8.0	7.2
1986	-	8.3	8.8	9.4	11.0	13.6	9.1	-	5.4	6.2	6.6	5.5	6.0
1987	-	10.1	11.4	11.3	12.3	11.5	10.9	-	5.7	5.9	-	-	5.8
1988	-	9.5	11.9	11.7	13.5	12.5	11.2	-	6.4	7.2	7.6	7.1	6.9
1989	-	9.1	10.0	11.7	11.9	11.2	10.0	-	5.7	5.9	6.1	5.8	5.8
1990	-	9.1	9.1	10.5	13.5	11.9	9.5	-	5.0	5.4	6.4	6.5	5.2
1991	-	9.2	10.4	10.8	11.8	10.8	10.4	-	5.3	5.9	6.4	-	5.5
1992 b/	-	8.2	8.7	9.1	11.0	12.3	10.6	-	4.2	5.1	4.9	-	4.6
Monterey													
1971-1975	9.2	10.5	11.2	11.2	12.7	10.9	11.0	4.8	6.7	8.5	10.1	13.3	6.0
1976-1980	8.5	9.2	9.3	10.9	13.2	10.0	9.9	4.4	4.9	6.7	7.2	5.6	5.1
1981	-	7.2	9.3	8.5	11.8	8.7	8.0	5.0	4.0	6.9	5.5	10.0	5.7
1982	8.3	9.1	10.1	10.8	10.8	11.9	9.7	6.7	5.5	5.8	8.7	10.4	6.9
1983	6.3	6.4	7.0	7.9	8.4	9.5	7.1	4.4	3.9	5.0	5.9	5.3	4.2
1984	-	7.8	8.3	9.8	9.5	8.6	8.4	-	6.7	7.9	10.7	-	7.0
1985	-	12.5	13.2	14.9	16.1	12.0	13.1	3.2	6.4	5.2	9.0	8.0	5.4
1986	-	8.8	9.7	10.1	11.5	11.0	9.4	-	5.0	7.4	6.8	8.0	6.3
1987	-	11.6	12.3	12.3	11.1	11.4	11.9	-	5.6	5.6	-	5.2	5.6
1988	-	10.1	12.5	15.0	16.6	12.5	12.3	-	5.8	5.1	6.1	-	5.8
1989	-	11.1	11.9	12.4	12.4	12.1	11.7	-	6.1	5.8	6.7	6.2	6.1
1990	-	9.8	10.2	11.3	9.7	11.8	10.3	-	5.3	6.4	6.3	6.3	5.6
1991	-	9.7	14.2	13.0	12.1	13.0	12.6	-	5.2	6.0	6.6	-	5.4
1992b/	-	8.9	9.6	9.6	12.4	10.1	9.4	-	4.7	4.0	4.5	-	4.6
Total Statewide													
1971-1975	8.8	9.2	10.7	10.4	11.3	11.1	10.2	4.5	5.7	7.3	8.8	8.1	6.1
1976-1980	8.4	8.5	9.2	10.3	10.7	10.5	9.5	3.5	4.5	6.5	7.0	7.1	4.9
1981	-	8.0	10.1	10.3	10.0	9.7	9.4	3.8	4.6	6.0	6.7	7.1	5.7
1982	7.9	8.8	10.0	10.2	10.7	10.4	9.7	4.9	5.4	6.0	6.6	6.8	6.0
1983	6.2	6.5	7.4	7.7	8.3	8.4	7.3	5.0	4.3	4.4	5.0	4.8	4.4
1984	-	7.5	8.5	9.1	8.8	9.3	8.7	-	6.8	7.7	7.2	8.6	7.4
1985	-	11.6	13.0	12.5	13.0	12.2	12.4	3.2	7.9	7.3	7.9	8.0	7.5
1986	-	8.6	8.8	8.9	10.3	11.6	9.0	-	5.0	6.0	6.4	6.1	5.5
1987	-	10.1	10.4	10.3	10.7	10.5	10.3	-	5.4	5.8	-	6.4	5.6
1988	-	9.7	11.3	11.3	12.9	11.0	11.0	-	5.8	6.6	7.4	6.2	6.3
1989	-	9.7	10.7	10.7	10.4	10.9	10.3	-	5.1	5.7	5.9	5.9	5.5
1990	-	9.4	9.5	10.4	11.3	10.1	9.7	-	4.9	5.4	6.2	5.6	5.1
1991	-	9.5	11.9	11.6	11.2	10.4	11.0	-	5.3	5.9	6.4	6.2	5.6
1992b/	-	8.7	9.4	9.4	11.1	12.1	10.1	-	4.3	5.1	4.8	-	4.6

a/ Season average includes minor catches for Oct. where appropriate.
b/ Preliminary.

Source: PFMC. 1993.

Table 2.24

	California		California
	Chinook	Price	Chinook
	Nominal $	Index	Real $
Year	(Per Dressed Pound)	(1990=100)	(Per Dressed Pound)
1980	2.27	63.5	3.57
1981	2.25	69.8	3.22
1982	2.55	74.2	3.44
1983	2.09	77.3	2.70
1984	2.67	80.6	3.31
1985	2.56	83.6	3.06
1986	2.01	85.8	2.34
1987	2.78	88.6	3.14
1988	2.86	91.6	3.12
1989	2.39	96	2.49
1990	2.77	100	2.77
1991	2.58	104.3	2.47
1992	2.73	107.8	2.53
			Ave. 1988-1992: 2.68
Price Index based on GDP Price Deflator, as per PFMC (1993).			

Table 2.25

PRICE INDICES

YEAR	PFMC 1993 PRICE INDEX (1992 = 100)	PRICE INDEX (1990 = 100)
1971	30.4	32.8
1972	31.9	34.4
1973	33.9	36.5
1974	36.9	39.8
1975	40.4	43.5
1976	43	46.3
1977	45.9	49.5
1978	49.5	53.3
1979	53.8	58.0
1980	58.9	63.5
1981	64.8	69.8
1982	68.9	74.2
1983	71.7	77.3
1984	74.8	80.6
1985	77.6	83.6
1986	79.6	85.8
1987	82.2	88.6
1988	85	91.6
1989	89.1	96.0
1990	92.8	100.0
1991	96.8	104.3
1992	100	107.8

Based on Gross Domestic Product Price Deflator.

Source: PFMC. 1993. Table D-22.

Table 2.26

U.S. Salmon cold storage holdings (round, dressed) in 1981 through 1983 (thousands of pounds)

Month	1981	1982	1983
January	24,242	17,819	40,953
February	18,240	12,396	32,881
March	12,585	9,676	26,959
April	9,361	6,409	20,324
May	7,893	6,072	12,968
June	7,762	7,493	10,265
July	15,784	32,236	23,007
August	36,604	62,131	49,663
September	38,156	68,368	50,754
October	33,962	63,019	45,369
November	29,657	58,515	46,048
December	22,314	48,943	38,362

Source: Department of Commerce, NOAA, National Marine Fisheries Service, Survey of cold storage holdings, National Fishery Statistics Program in 1981, 1982, and 1983.

Table 2.27

DOLLAR VALUE OF 1982 FISH PURCHASES BY CALIFORNIA FISH PROCESSORS
CIF SPECIES "USE" TABLE

Species	21 Fish,Whsl Proc,Dist Small	22 Fish,Whsl Proc,Dist Medium	23 Fish,Whsl Proc,Dist Large	24 Fish Imp/Exp Brokers	25 Tuna Canners	26-29 Other Fish Buyers	Total
Crustaceans	476,600	4,190,600	8,833,500	0	0	0	13,500,700
Mollusks	257,400	2,263,200	4,770,400	83,300	0	0	7,374,300
Flatfish	348,200	3,061,400	6,453,100	0	0	0	9,862,700
Wetfish	0	0	0	11,425,900	12,786,700	0	24,212,600
Sable/Rock	553,700	4,869,300	10,268,500	1,292,500	0	0	16,984,000
Sharks/Rays/Skates	102,200	898,500	1,893,900	0	0	0	2,894,600
Salmon	704,800	6,197,500	13,063,800	0	0	0	19,966,100
Billfish	179,200	1,575,800	3,321,600	0	0	0	5,076,600
Tuna	0	549,800	378,700	0	121,245,700	0	122,174,200
Cod	26,500	232,700	490,500	0	0	0	749,700
Bass	4,700	42,000	88,700	0	0	0	135,400
Perch	7,200	62,900	132,600	0	0	0	202,600
Other	211,000	1,935,800	4,041,800	0	0	0	6,188,700
TOTAL	2,871,300	25,879,300	53,737,200	12,801,700	134,032,400	0	229,322,100

This table shows the 1982 dollar value of California fish purchases by various types of fish buyers. Reading down a column shows the dollar value of purchases of each species group by a given type of fish buyer. Reading across a row shows the dollar value of a given species group purchased by each type of fish buyer.

Source: King and Flagg. 1984.

Table 2.28

CALIFORNIA SALMON DEALERS -- 1990

(Source: Southwest Region Seafood Dealers Guide -- 1990 Edition. 1990. NMFS-Admin.Rep.-SWR-90-02. 93pp.)

Note: A "1" in a column indicates that the dealer is involved in transactions described by the column heading.

	SALMON DEALER	CITY	WHOL SALER	PRO- CESSO	IM- PORTE	EX- PORTE	BROKE
1	ANDERSON SEAFOODS INC.	ANAHEIM	1	1			
2	NATIONAL BROKERAGE OF C.A. INC	ANAHEIM					1
3	SEAFOOD CORNER	APPLE VALLEY	1				
4	FISH BROTHERS	ARCATA		1			
5	BERKELEY BOWL SEAFOOD	BERKELEY	1				
6	MONTEREY FISH MARKET	MONTEREY PARK	1				
7	SEABREEZE (ENTERPRISES) MARKET	BERKELEY	1				
8	PHIL YUDOVIN & SONS INC.	BEVERLY HILLS	1				
9	BUGATTO ENTERPRISES INC.	BODEGA BAY	1				
10	MASONS MARINA INC.	BODEGA BAY	1				
11	WILSON'S CRAB SHACK	BODEGA BAY		1			
12	EDWARD A ANDO	BUELLTON	1	1			
13	DAY-LEE FOODS INC.	CAMPBELL	1				
14	ATLANTIC FISH CO.	CASTRO VALLEY	1				
15	PENNON SEAFOODS OF C.A. INC.	CITY OF INDUSTRY					1
16	MILLIE'S CRAB SHACK	CLEARLAKE OAKS	1				
17	INGARDIA BROS. PRODUCE INC.	COSTA MESA	1				
18	UNDERSEAS SEAFOOD CO. INC.	COSTA MESA	1				
19	MODESTO FOOD DISTRIBUTORS INC.	DALY CITY	1				
20	JON'S FISH MARKET	DANA POINT	1	1			
21	LAS OLAS FISH MARKET & CAFE	DEL MAR	1	1			
22	PEMBERTON FISH	EL GRANADA	1	1		1	
23	PILLAR POINT FISHERMANS ASSOC	EL GRANADA	1				
24	PRINCETON SEAFOOD CO.	EL GRANADA	1				
25	THREE CAPTAINS SEA PRODUCTS	EL GRANADA	1				
26	FORTUNE FOODS	ESCONDIDO	1				
27	FERNBRIDGE COLD STORAGE	FERNBRIDGE	1				
28	EUREKA FISHERIES INC.	FIELDS LANDING	1	1			
29	BRADLEY FISH CO.	FORT BRAGG	1				
30	CAITO FISHERIES INC.	FORT BRAGG		1		1	
31	J & S DISTRIBUTING, QUAL. MEAT	FORT BRAGG	1				
32	OCEAN FRESH SEA FOOD PRODUCTS	FORT BRAGG		1		1	1

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33	SEA PAL	FORT BRAGG	1				
34	DEEP WATER DELIVERIES	LAGUNA BEACH					1
35	MIKE SILVER BROKERS	LOMITA	1				
36	KANSAS PACKING CO. INC.	LONG BEACH	1				
37	LONG BEACH SEAFOOD CO.	LONG BEACH		1			
38	SMOKEY BBQ FISH CO.	LONG BEACH		1			
39	CAVIAR AND FINE FOODS INC.	LOS ANGELES	1		1	1	
40	EY SEAFOOD CO.	LOS ANGELES	1				
41	FISH WAREHOUSE CORP.	LOS ANGELES	1	1			
42	FRESH ENDEAVORS	LOS ANGELES	1				
43	HOLLY SEAFOOD CO.	]	1				
44	HOMARUS INC.	LOS ANGELES	1	1	1	1	
45	INT'L MARINE PRODUCTS INC.	LOS ANGELES	1	1	1	1	
46	INT'L SEAFOOD VENTURES	LOS ANGELES			1	1	1
47	LOS ANGELES SMOKING & CURING CO	LOS ANGELES	1	1	1	1	
48	MARUGEN SEA FOOD CO.	LOS ANGELES	1				
49	MONARCH SEAFOOD, INC.	LOS ANGELES	1				
50	MORINAGA & CO.	LOS ANGELES	1		1	1	1
51	PACIFIC CAL. FISH CO. INC.	LOS ANGELES	1				
52	PACIFIC SEA PRODUCTS INC.	LOS ANGELES	1	1	1		
53	PRIVATE SECTOR FOODS INC.	LOS ANGELES	1				
54	REEL SEAFOOD CO. INC.	LOS ANGELES	1	1			
55	SEA & FARM FOODS INC.	LOS ANGELES	1				
56	SHELTER ISLAND SEAFOOD INC.	LOS ANGELES	1				
57	SHOWA MARINE INC.	LOS ANGELES	1				
58	SUNSET SHRIMP INC.	LOS ANGELES	1				1
59	U.S. NIPPON MEATS INC.	LOS ANGELES	1		1	1	
60	PROVIDENCE SEAFOOD	MARSHALL	1				
61	ANGEL DELIGHTS	MARTINEZ	1	1		1	1
62	ABALONETTI INC.	MONTEREY	1				
63	CONSOLIDATED FACTORS	MONTEREY	1	1	1	1	
64	SEA HARVEST	MONTEREY	1	1			
65	JOHN B. DOUGHERTY	MORRO BAY	1				1
66	MORRO BAY SEAFOODS	MORRO BAY	1	1			
67	MOSS LANDING OYSTER BAY INC.	MOSS LANDING	1				
68	OMEGA THREE SEAFOODS INC.	NAPA	1				
69	NALBANDIAN & SONS INC.	NORTH HOLLYWO	1				
70	CHARLES P. KEARNEY & CO.	OAKLAND					1
71	GREAT ATLANTIC LOBSTER, CO.	OAKLAND	1		1	1	
72	PRODUCERS SEAFOOD	OAKLAND	1	1		1	
73	VER BRUGGE FOODS INC.	OAKLAND	1				
74	VIKING FOODS CO. INC.	OAKLAND	1				

75	RAMBOW WORMS	ORANGEVALE	1	1			
76	RICHARD W. DEIBERT & ASSO. INC	ORINDA					1
77	BLAGGS INC.	OROVILLE	1				
78	TIDAL WAVE SEAFOOD	OXNARD	1				1
79	CACTUS COVE SEAFOODS INC.	PALM DESERT	1				
80	MARK'S FISH CO.	PETALUMA		1			
81	BUZ'S CRAB INC.	REDDING	1				
82	JOHN TEIXERIA FISH CO.	REDWOOD CITY	1				
83	SEA FARMER	REDWOOD CITY	1	1			
84	CHESAPEAKE FISH CO.	SAN DIEGO	1	1			
85	GHIO SEAFOOD PRODUCTS	SAN DIEGO	1	1	1		
86	MAR CAL SEAFOOD INC.	SAN DIEGO	1		1	1	
87	A. PALADINI SEAFOOD CO.	SAN FRANCISCO	1	1			
88	ALIOTO FISH CO. INC.	SAN FRANCISCO	1	1			
89	ALL SEAS WHOLESALE INC.	SAN FRANCISCO	1				
90	ANCHOR SHELLFISH	SAN FRANCISCO					1
91	CAL-NESIA TRADING CO.	SAN FRANCISCO			1	1	1
92	GULFSPRAY SEAFOOD	SAN FRANCISCO	1	1			1
93	H U G CO., GOURMET FOODS INC.	SAN FRANCISCO	1				
94	L. FRISCIA FISH CO. INC.	SAN FRANCISCO	1				
95	MORGAN FISH	SAN FRANCISCO	1				
96	PACIFIC FISH & POULTRY CORP.	SAN FRANCISCO	1	1			
97	PARAMOUNT OCEAN PRODUCTS INC.	SAN FRANCISCO	1		1		
98	TEMA INC.	SAN FRANCISCO	1		1	1	1
99	TOSHOKU LOS ANGELES INC.	SAN FRANCISCO			1	1	
100	WATAHAN NOHARA INT'L INC.	SAN FRANCISCO	1		1	1	1
101	WEST COAST SEAFOOD CO.	SAN FRANCISCO	1				
102	LUCAS MEAT CO. INC.	SAN JOSE	1				
103	DUPONT MARKET INC.	SAN LEANDRO	1			1	
104	PACIFICA INT'L EXPORT CO. INC.	SAN LEANDRO	1			1	
105	KIKU ENTERPRISES INC	SAN MATEO	1	1	1		
106	MONTEREY SEAFOODS	SAN PEDRO	1				
107	STANDARD SEAFOOD	SAN PEDRO	1				
108	DOMENICO INGRADE	SAN RAFAEL	1				
109	NORWEGIAN SEAFOOD INC.	SAN RAFAEL			1		1
110	KANALOA INPORTS	SANTA BARBARA	1	1			
111	SOVEREIGN SEAFOODS INC.	SANTA BARBARA	1	1			
112	T.J. HINES & CO. LTD.	SANTA BARBARA	1		1	1	1
113	BOB MORRELL ENTERPRISES	SANTA CRUZ	1	1			
114	DOMINICK FISH & POULTRY	SANTA CRUZ	1				
115	ACME FOOD SPECIALTIES INC.	SANTA FE SPRING	1		1		1
116	LONG BEACH ENTERPRISES INC.	SANTA FE SPRING	1	1	1		

117	THE EDWARD FINEMAN CO. INC.	SANTA FE SPRING	1				
118	SPECIAL FOODS INT'L. INC.	SANTA MONICA	1		1	1	
119	ATLANTIC TRADING CO. INC.	SAUSALITO			1		1
120	JERRY'S YACHT SERVICE	SAUSALITO	1				
121	V.W.H. COMPANY LTD.	SOUTH EL MONTE			1	1	1
122	BARKLEY MEAT CO.	SOUTH LAKE TAH	1		1		
123	MARINE FISHERIES	STOCKTON	1				
124	RANUIOS ENTREE PRODUCTS CO.	TWAIN HARTE	1				
125	CAL PACIFICA	VENTURA	1				
126	KAL KAN FOODS INC.	VERNON		1			
127	NIKABAR INC.	VERNON	1				
128	PURCELL INT'L	WALNUT CREEK		1	1		
129	PELICANS LANDING RESTAURANT	WHITETHORN	1				
130	SEACLIFF SEAFOODS INC.	WILMINGTON	1				
131	SHAMROCK SEAFOODS INC.	WILMINGTON	1	1			
132	MAGNISEA FISHERIES INC.	WOODLAND HILLS	1		1	1	

Table 2.29

Representative Budget for Fish Processor.

	Taxable Income	Net Cash Flow
Revenue:	$10,061,077	$10,061,077
Less Expenses:		
Variable Expenses		
Raw Product Cost (a)	$6,961,057	$6,961,057
Processing Labor	$1,493,677	$1,493,677
Packaging & Gen. Costs (b)	$288,633	$288,633
Other Variable Expenses	$0	$0
Bad Debt Expense	$50,305	$50,305
Total Variable Expenses	$8,793,672	$8,793,672
Contribution Margin	$1,267,405	$1,267,405
Fixed Expenses		
Administrative Salaries (c)	$330,000	$330,000
Maintenance and Repair	$75,000	$75,000
Utilities	$45,000	$45,000
Telephone	$40,000	$40,000
Insurance	$25,000	$25,000
Taxes	$25,000	$25,000
Supplies	$30,000	$30,000
Miscellaneous	$30,000	$30,000
Depreciation	$350,000	$0
Interest Expense (d)	$420,000	$420,000
Total Fixed Expenses	$1,370,000	$1,020,000
Operating Income	($102,595)	$247,405

Note: Business is assumed to be mixed, large-size fish processor, with 120-200 employees and a market value of $3,500,000.

(a) Includes fish tax.

(b) Includes general costs of processing, such as equipment rentals, can costs, and chemical additives. Costs of packaging are normally borne by the buyer.

(c) Total personnel = 11.

(d) Assume 12 percent interest and 10 year depreciation -- actual may be more or less.

Source: Carter and Radtke. 1986.

Table 2.30

Price and Cost Structure for West Coast Salmon Processor.

Species	Fishery	Landed Price of Raw Product ($)	Yield of Processed Product %	Raw Product Cost ($)	Processing Labor Cost ($)	Other Processing Costs ($)	Bad Debt Expense ($)	Variable Cost of Processed Product ($)	Sales Price of Processed Product ($)	Contribution Margin of Processed Product ($)
Coho	troll	1.51	97.2	1.54872	0.15	0.02	0.01180	1.7305	2.36	0.6295
Chinook	troll	2.48	97.5	2.54359	0.15	0.02	0.01780	2.7314	3.56	0.8286
Pink	troll	0.65	97.5	0.66667	0.15	0.02	0.00625	0.8429	1.25	0.4071
Coho	gillnet	0.83	80.0	1.03750	0.25	0.02	0.01075	1.3183	2.15	0.8318
Chinook	gillnet	1.04	80.0	1.30000	0.25	0.02	0.01450	1.5845	2.90	1.3155
Tule Chinook	gillnet	0.31	80.0	0.38750	0.25	0.02	0.00450	0.6620	0.90	0.2380
Spring Chinook	gillnet	3.00	80.0	3.75000	0.25	0.02	0.02375	4.0438	4.75	0.7063
Pink	gillnet	0.45	80.0	0.56250	0.25	0.02	0.00500	0.8375	0.10	0.1625
Sockeye	gillnet	1.14	80.0	1.42500	0.25	0.02	0.01150	1.7065	2.30	0.5935

Source: Carter and Radtke. 1986.

Table 2.31

Dumas (1993)

Best Estimate of Annual Household Income Impact per Fish Increase in Annual Commercial Catch of Central Valley Chinook Salmon Marketed Directly Through Farmers' Markets and to Consumers.

Type of Impact	Description	Inside California	Outside California	Total
A	Direct Impact - Harvesting Sector	$57.32	$0.00	$57.32
B	Indirect Impact - Processing Sector	$0.00	$0.00	$0.00
C	Indirect Impact - Retail Sector	$0.00	$0.00	$0.00
D	Indirect Impact - Sectors Other Than Processing and Retail	$4.36	$0.44	$4.80
E	Induced Impact - All Sectors	$24.25	$2.43	$26.68
Total		$85.93	$2.87	$88.80

Assumes an Ex-vessel Price of $2.68/lb. and an Average Dressed Fish Weight of 10 lbs.
Prices in 1990 dollars.

Table 2.32

Dumas (1993)

Best Estimate of Annual Household Income Impact per Fish Increase in Annual Commercial Catch of Central Valley Chinook Salmon Marketed Through Processors

Type of Impact	Description	Inside California	Outside California	Total
A	Direct Impact - Harvesting Sector	$24.12	$0.00	$24.12
B	Indirect Impact - Processing Sector	$12.52	$0.00	$12.52
C	Indirect Impact - Retail Sector	$11.29	$0.00	$11.29
D	Indirect Impact - Sectors Other Than Processing and Retail	$4.36	$0.44	$4.80
E	Induced Impact - All Sectors	$20.56	$2.06	$22.62
Total		$72.85	$2.50	$75.35

Assumes an Ex-vessel Price of $2.68/lb. and an Average Dressed Fish Weight of 10 lbs.
Prices in 1990 dollars.

Table 2.33

Hanemann (1986)

Conservative Estimate of the Increase in Household Income Associated With a One Fish Increase in the Commercial Catch of Sacramento River Chinook

Type of Impact	Description	Inside California	Outside California	Total
A	Direct Impact - Harvesting Sector	$24.11	$0.00	$24.11
B	Indirect Impact - Processing Sector	$12.55	$0.00	$12.55
C	Indirect Impact - Retail Sector	$0.00	$0.00	$0.00
D	Indirect Impact - Sectors Other Than Processing and Retail	$3.76	$0.00	$3.76
E	Induced Impact - All Sectors	$15.86	$0.00	$15.86
Total		$56.28	$0.00	$56.28

Compared with Table 2.34, Table 2.33 assumes zero retail sector impacts, zero indirect and induced impacts outside California, and reduced indirect and induced impacts inside California.
Assumes an Ex-vessel Price of $2.68/lb. and an Average Dressed Fish Weight of 10 lbs.
Prices in 1990 dollars.

Table 2.34

Hanemann (1986)

Average Estimate of the Increase in Household Income Associated With a One Fish Increase in the Commercial Catch of Sacramento River Chinook

Type of Impact	Description	Inside California	Outside California	Total
A	Direct Impact - Harvesting Sector	$24.11	$0.00	$24.11
B	Indirect Impact - Processing Sector	$12.55	$0.00	$12.55
C	Indirect Impact - Retail Sector	$11.29	$0.00	$11.29
D	Indirect Impact - Sectors Other Than Processing and Retail	$4.37	$0.45	$4.82
E	Induced Impact - All Sectors	$20.56	$2.06	$22.62
Total		$72.88	$2.51	$75.39

Assumes an Ex-vessel Price of $2.68/lb. and an Average Dressed Fish Weight of 10 lbs.
Prices in 1990 dollars.

C-110662

C-110663

Table 2.35

Leidy et al. (1984)

Estimate of the Economic Gain Associated With a One Fish Increase
in the Commercial Catch of Sacramento River Chinook

Type of Impact	Description	Inside California	Outside California	Total
A	Direct Impact - Harvesting Sector	$24.39	$0.00	$24.39
B	Indirect Impact - Processing Sector	$8.25	$0.00	$8.25
		$0.00	$0.00	$0.00
	"Net Community Value"	$44.19	$0.00	$44.19
		$0.00	$0.00	$0.00
Total		$76.83	$0.00	$76.83

Assumes an Ex-vessel Price of $2.68/lb.
Prices in 1990 dollars.

C-110663

Table 2.36

King and Flagg (1984)

Estimate of the Increase in California Household Income Associated With a One Fish Increase in the Commercial Catch of Sacramento River Chinook

Type of Impact	Description	Inside California	Outside California	Total
A	Direct Impact - Harvesting Sector	$13.45	$0.00	$13.45
B, C, D	Combined Indirect Impacts - Processing, Retail, and Other	$4.92	$0.00	$4.92
E	Induced Impact - All Sectors	$7.22	$0.00	$7.22
Total		$25.59	$0.00	$25.59

Assumes an Ex-vessel Price of $2.68/lb. and an Average Dressed Fish Weight of 10 lbs.
Prices in 1990 dollars.

Table 2.37

Meyer (1985)

Estimate of the Economic Gain Associated With a One Fish Increase in the Commercial Catch of Sacramento River Chinook

Type of Impact	Description	Inside California	Outside California	Total
A	Direct Impact - Harvesting Sector	$24.11	$0.00	$24.11
B	Indirect Impact - Processing Sector	$12.55	$0.00	$12.55
C	Indirect Impact - Retail Sector	$11.29	$0.00	$11.29
	"State Income Impact"	$53.60	$0.00	$53.60
Total		$101.55	$0.00	$101.55

Assumes an Ex-vessel Price of $2.68/lb. and an Average Dressed Fish Weight of 10 lbs.
Prices in 1990 dollars.

C-110665

Table 2.38

Water Year Type	Example Year	Mar	Apr	May	June	Jul	Aug
		1485 Standard Mean Monthly Net Delta Outflow (cfs)					
Wet	(1975)	86927	15670	29406	21048	8488	
Above Norm.	(1978)	64064	38117	20477	13999	10002	
Critically Dry	(1976)	6063	5348	4505	3877	6023	

Table 2.39

Water Year Type	Example Year	Mar	Apr	May	June	Jul	Aug
		1630 Standard Mean Monthly Net Delta Outflow (cfs)					
Wet	(1975)	86745	23365	31021	21293	10002	
Above Norm.	(1978)	61653	43007	22880	12303	7693	
Critically Dry	(1976)	10821	8987	9116	4918	4622	

Table 2.40

Water Year Type	Example Year	Mar	Apr	May	June	Jul	Aug
		EPA Standard Mean Monthly Net Delta Outflow (cfs)					
Wet	(1975)	86927	17700	29406	21048	8488	
Above Norm.	(1978)	64064	38117	21300	13999	10002	
Critically Dry	(1976)	13300	12200	4900	6600	6023	

Table 2.41

Log10[Mean(Mar-Jun monthly Delta Outflow)]

Water Year Type	Example Year	Standard 1485	Standard 1630	Standard EPA
Wet	(1975)	4.582776	4.60859	4.588499
Above Norm.	(1978)	4.533572	4.543581	4.53618
Critically Dry	(1976)	3.694452	3.927396	3.966142

Table 2.42

Starry Flounder LOG10(Abundance Index)

Water Year Type	Example Year	Standard 1485	Standard 1630	Standard EPA
Wet	(1975)	1.303	1.325	1.308
Above Norm.	(1978)	1.263	1.271	1.265
Critically Dry	(1976)	0.570	0.762	0.794

Table 2.43

Regression of Starry Flounder Pounds Landed on LOG10(Abundance Index)

Regression Statistics

Multiple R	0.768463
R Square	0.590536
Adjusted R Sq	0.549589
Standard Error	104857.6
Observations	12

Analysis of Variance

	df	of Squares	an Square	F	nificance F
Regression	1	1.59E+11	1.59E+11	14.42216	0.003499
Residual	10	1.1E+11	1.1E+10		
Total	11	2.69E+11			

	Coefficients	ndard Error	t Statistic	P-value	Lower 95%	Upper 95%
Intercept	4469.428	68604.34	0.065148	0.949225	-148391	157329.4
Abund.Index	218581.8	57557.11	3.797651	0.002955	90336.57	346827.1

Table 2.44

Starry Flounder

water year	LOG10 abundance index year+1	pounds year+1
1979	1.342	486048
1980	1.580	405494
1981	0.778	282529
1982	1.991	374128
1983	1.681	368223
1984	1.146	342992
1985	1.255	201509
1986	0.903	103522
1987	0.778	116678
1988	0.000	74367
1989	0.477	40336
1990	0.903	63453
1991		

Table 2.45

Starry Flounder Estimated Pounds Landed

Water Year Type	Example Year	Standard 1485	1630	EPA
Wet	(1975)	289363	294024	290396
Above Norm.	(1978)	280479	282286	280950
Critically Dry	(1976)	128977	171035	178031

Table 2.46

Starry Flounder

year	pounds	total dollars	nominal dollars per lb.	price index 1990=100	real dollars per lb.
1982	1500	799	0.532667	74.2	0.395239
1983	62850	19411	0.308846	77.3	0.238738
1984	337239	104373	0.309493	80.6	0.249451
1985	241173	82684	0.342841	83.6	0.286615
1986	161738	60702	0.375311	85.8	0.322017
1992	44251	19544	0.441662	107.8	0.476112
				ave.=	0.328029

STARRY FLOUNDER

CDFG. Fish Bulletin. 1970.
The California Marine Catch for 1968
and Historical Review 1916-1968.
Table 15. Yearly Landings in Pounds - Flatfish.
Data for Starry Flounder.

Date	Pounds	Date	Pounds
1916	453916	1942	370125
1917	1151876	1943	505399
1918	818835	1944	366520
1919	435731	1945	337543
1920	481587	1946	509448
1921	293656	1947	527072
1922	539220	1948	405251
1923	508961	1949	356374
1924	379770	1950	913765
1925	594420	1951	1128892
1926	667711	1952	597477
1927	590064	1953	502526
1928	399880	1954	500550
1929	580752	1955	650180
1930	391096	1956	375400
1931	169806	1957	504461
1932	543806	1958	471202
1933	457998	1959	1046926
1934	537164	1960	259038
1935	656113	1961	315337
1936	621186	1962	338192
1937	974770	1963	521310
1938	542812	1964	420986
1939	739311	1965	378389
1940	804089	1966	380628
1941	601577	1967	870707
		1968	856157

STARRY FLOUNDER

CDFG. Fish Bulletins. Table 15.

Year	Pounds	Value	Notes
1960	100190	4999	gen. flounder
1961	88538	4595	gen. flounder
1962	147652	7811	gen. flounder
1963	259178	14514	gen. flounder
1964	NA	NA	
1965	223533	11985	gen. flounder
1966	218828	15144	gen. flounder
1967	440328	30299	gen. flounder
1968	248693	16725	gen. flounder
1969	181276	11871	gen. flounder
1970	128048	8948	gen. flounder
1971	120308	8542	gen. flounder
1972	311238	23092	gen. flounder
1973	105972	9093	gen. flounder
1974	NA	NA	
1975	254657	28717	gen. flounder
1976	369680	45273	gen. flounder
1977	461288	70478	misc. flounder
1978	455917	84322	misc. flounder
1979	355623	88397	misc. flounder
1980	486048	123447	misc. flounder
1981	405494	114829	misc. flounder
1982	1500	799	starry flounder
1983	62850	19411	starry flounder
1984	337239	104373	starry flounder
1985	241173	82684	starry flounder
1986	161738	60702	starry flounder

BAY SHRIMP

CDFG. Fish Bulletins. Table 15. and
CDFG. Fish Bulletin. 1970.
The California Marine Catch for 1968
and Historical Review 1916-1968.
Table 19. Yearly Landings in Pounds - Crustaceans.
Data for Bay Shrimp.

Date	Pounds	Value	Date	Pounds	Value
1916	411847	NA	1952	913908	NA
1917	605004	NA	1953	732308	51774
1918	722178	NA	1954	744768	52804
1919	747023	NA	1955	682731	NA
1920	817091	NA	1956	718968	NA
1921	907467	NA	1957	192814	20651
1922	990349	NA	1958	45955	6089
1923	1113358	NA	1959	35011	5455
1924	1551086	NA	1960	1580	205
1925	1460234	NA	1961	2050	267
1926	1431511	NA	1962	1075	140
1927	1697365	NA	1963	1225	368
1928	2280871	NA	1964	NA	NA
1929	3054748	NA	1965	10765	2153
1930	2687831	NA	1966	4165	856
1931	1684763	NA	1967	19771	4296
1932	2681807	NA	1968	10465	2491
1933	2087952	NA	1969	8041	1633
1934	1783663	NA	1970	2276	1084
1935	3445091	NA	1971	1899	966
1936	2240849	NA	1972	NL	NL
1937	1108761	NA	1973	NL	NL
1938	1847926	NA	1974	NA	NA
1939	1175979	NA	1975	3637	2833
1940	1080190	NA	1976	NL	NL
1941	952152	NA	1977	NL	NL
1942	800958	NA	1978	NL	NL
1943	253215	NA	1979	NL	NL
1944	291974	NA	1980	NL	NL
1945	382147	NA	1981	NL	NL
1946	432145	NA	1982	NL	NL
1947	841086	50381	1983	NL	NL
1948	926707	NA	1984	NL	NL
1949	800441	NA	1985	NL	NL
1950	913181	NA	1986	NL	NL
1951	931323	NA			

NA = Data Not Available for this date.
NL = Species Not Listed in this Bulletin.

BAY SHRIMP

CDFG. Fish Bulletins.
Table 23.
Inshore Bait Landings by Area Pounds and Value
Sacramento, San Francisco, Monterey
Data for Bay Shrimp.

Date	Pounds	Value
1963	NA	NA
1964	NA	NA
1965	6695	5862
1966	26119	25331
1967	37586	42669
1968	47201	47146
1969	61040	73559
1970	63485	73778
1971	57822	81861
1972	73067	115856
1973	62308	115543
1974	NA	NA
1975	96071	180070
1976	98789	184061

Note: Inshore bait fishery statistics began in 1963.

C-110672

Table 2.51

Mean(Mar-May monthly Delta Outflow)]				
Water	Example	Standard		
Year Type	Year	1485	1630	EPA
Wet	(1975)	44001	47044	44678
Above Norm.	(1978)	40836	42513	41160
Critically Dry	(1976)	5305	9641	10133

Table 2.52

Bay Shrimp Abundance Index				
Water	Example	Standard		
Year Type	Year	1485	1630	EPA
Wet	(1975)	1622	1737	1648
Above Norm.	(1978)	1505	1566	1515
Critically Dry	(1976)	167	330	349

Table 2.53

Data for this table has not arrived.

C-110674

Table 2.54

Bay Shrimp water year	abundance index year +1	pounds year +1
1979	649	
1980	1399	
1981	519	
1982	3291	
1983	6550	
1984	1147	
1985	311	
1986	2150	
1987	876	
1988	401	
1989	574	
1990		
1991		

Table 2.55

Data for this table has not arrived.

C-110676

Table 2.56

Data for this table has not arrived.

Table 3.1

Summary of recreational salmon fishing regulations for 1992:
Source: PFMC (1993).

	Season		Quota	
Management Area	Dates	Species	Chinook	Coho
Pt. Arena to Pt. San Pedro	2/29-11/1	All	39,400	c

Other Restrictions:
1) Daily limit of 2 salmon.
2) Barbless hooks required north of Pt. Conception.
3) Conservation Zone 3 (near mouth of San Francisco Bay) closed Febr. 29 - Apr. 3 and open June 1-29.

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c/ Overall recreational catch between Cape Falcon and the U.S.-Mexican border limited by a preseason catch quota of 172,000 coho. Only the area north of Humbug Mt. closes upon projected attainment of the quota. An emergency rule decreased the recreational quota by a preseason transfer of 5,000 coho to the commercial fishery.

Table 3.2

Data on Ocean Recreational Chinook Salmon Fishery.

Year	Trips (thousands)	Catch (thousands)	Catch per Trip	Abundance Index (thousands)	Charter Boats
1970	138.9	111.1	0.80	528.4	NA
1971	195.5	166.3	0.85	507.6	NA
1972	167.8	187.6	1.12	517.0	NA
1973	183.7	180.9	0.98	830.5	NA
1974	168.2	141.6	0.84	629.9	NA
1975	121.3	92.7	0.76	486.3	NA
1976	110.9	68.6	0.62	475.3	NA
1977	116.1	76.6	0.66	489.1	NA
1978	102.7	65.9	0.64	493.8	NA
1979	114.1	108.5	0.95	510.5	NA
1980	95.7	77.1	0.81	527.3	NA
1981	83.5	73.8	0.88	553.0	NA
1982	113	122.5	1.08	718.1	NA
1983	69.8	53	0.76	352.2	NA
1984	78.3	78.7	1.01	497.9	NA
1985	111.1	121.8	1.10	643.0	NA
1986	137.9	114.8	0.83	876.3	NA
1987	156.1	152.8	0.98	787.6	123
1988	148	130.4	0.88	1205.7	114
1989	150.7	130.9	0.87	644.3	135
1990	156.1	112.6	0.72	557.1	125
1991	121	62.1	0.51	429.0	160
1992	96.7	65.2	0.67	308.4	121
Average	127.70	108.50	0.84	589.93	129.67

Trips = The sum of charter boat and private skiff salmon fishing angler trips originating in San Francisco and Monterey.

Catch = Ocean recreational catch of chinook salmon landed at San Francisco and Monterey.

Catch per Trip = Catch / Trips

Abundance Index = The sum of California Central Valley chinook salmon spawning escapement, ocean commercial catch of chinook salmon landed at San Francisco and Monterey, and ocean recreational catch of chinook salmon landed at San Francisco and Monterey.

Charter Boats = Number of California charter boats participating in the ocean recreational fishery originating in San Francisco and Monterey.

Sources: PFMC. 1993. and CDFG unpublished data.

C-110680

Table 3.3

SALMON ESCAPEMENT, COMMERCIAL AND RECREATIONAL CATCHES, AND OCEAN AND INLAND ANGLER TRIPS										
Standard	Water Year	Escapement	Ocean Commercial Catch	Ocean Recreational Catch	Ocean Total Catch	Inland Recreational Catch	Abundance Index	Ocean Recreational Trips	Inland Recreational Trips
1485	Above Normal	150000	289312	97400	386712	21900	536712	119993	129076
1630	Above Normal	150000	359677	109596	469273	21900	619273	128775	129076
EPA	Above Normal	150000	410113	118132	528245	21900	678245	134689	129076
1485	Critically Dry	150000	207369	82691	290060	21900	440060	108790	129076
1630	Critically Dry	150000	276614	95159	371773	21900	521773	118332	129076
EPA	Critically Dry	150000	306398	100395	406793	21900	556793	122188	129076

C-110680

Table 3.4

Expenditure per Trip for Various Recreational Activities in California		
Activity	Nominal Expenditure Per Trip	Year of Study
1. Northern California Party/Charter Boat Fishery	$72	1986
Northern California Private/Rental Boat Fishery	$48	1986
Northern California Shoreline Fishery	$26	1986
2. Picnicking	$13	1984
Nature Appreciation	$13	1984
Ocean/Beach Use	$8	1984
Boating	$34	1984
3. Fishing, Freshwater/Saltwater	$32	1980
Hunting	$65	1980
4. Deer Hunting	$30	1987

Sources:
1. Thompson and Huppert (1987)
2. California Department of Parks and Recreation (1984)
3. USFWS (1980)
4. Loomis er al. (1981)

Table 3.5

Charter Boat Operator Expenses per Passenger Day		
Expenditure Category	1985 $'s Per Passenger Day	Percent of Total
Crew Wages	$1.56	5.0%
Imputed Skipper Salary	$9.78	31.3%
Fuel	$2.94	9.4%
Moorage	$0.44	1.4%
Maintenance and Repair	$2.28	7.3%
Insurance	$1.28	4.1%
Booking Commission and Fees	$3.41	10.9%
Other	$0.53	1.7%
Taxes, Fees, License, Etc.	$2.35	7.5%
Residual Gross (Profit and/or Interest Payments)	$6.69	21.4%
Total	$31.26	100.0%

Source: Based on Crutchfield and Schelle (1979).
Note: Data adjusted to 1985 $'s using GNP price deflator.

Table 3.6

Destination Expendenditures of Ocean Recreational Salmon Fisher.

	Charter boat Angler	Private boat Angler
Restaurants	10.83	10.83
Groceries	5.26	5.26
Camping,etc.	3.02	3.02
Lodging	5.94	5.94
Boat/motor rental fees	NA	0.22
Boat landing fees	NA	1.87
Gas for boat	NA	14.48
Charter boat fees	31.26	NA
Miscellaneous	4.30	4.30
Total	60.61	45.92

Source: Based on Crutchfield and Schelle (1979).
Note: Data are adjusted to 1985 dollars using the GNP price deflator.

PARTICIPATION BY U.S. POPULATION 16 YRS & OLDER IN FISHING AND HUNTING IN CALIFORNIA, 1985

(Number in thousands; dollars in millions)

	CALIFORNIA RESIDENTS	NON-RESIDENTS
	NUMBER OF PERSONS PARTICIPATING	
FISHING	3,531	219
HUNTING	603	29
	PERCENTAGE OF ADULT POPULATION PARTICIPATING	
FISHING	17.5%	
HUNTING	3.0%	
	DAYS OF PARTICIPATION IN ACTIVITY	
FISHING	55,534	3,114
HUNTING	9,211	1,636
	TRIP-RELATED EXPENDITURES	
FISHING	$1,164.3	$70.8
HUNTING	$229.3	$9.5
	EQUIPMENT AND OTHER NON-TRIP EXPENDITURES	
FISHING	$1,056.6	
HUNTING	$524.0	

SOURCE: USFWS, 1985 NATIONAL SURVEY OF FISHING, HUNTING & WILDLIFE-ASSOCIATED RECREATION, November 1988.

Table 3.8

SALTWATER RECREATIONAL FISHING BY BAY AREA ANGLERS 1985-1986

(Number of trips)

	FISHING MODE			
TARGET SPECIES	SHORE MODES	PARTY BOAT	PRIVATE BOAT	TOTAL
Salmon	11,967	134,518	316,291	462,776
Striped bass	95,289	10,645	127,710	233,644
Striped bass/other	54,688	21,303	147,272	223,263
Rockfish	104,926	160,603	130,352	395,881
Rockfish/other	28,363	1,889	0	30,252
Other	214,827	56,718	344,308	615,853
No target	355,706	32,603	120,906	489,215
TOTAL	845,766	418,279	1,186,839	2,450,884

SOURCE: C.J. Thompson and D. Huppert, Results of the Bay Area Sportfish Economic Study NOAA-TM-NMFS-SWFC-78, August 1987.

Table 3.9

		Mean of Average April-July Net Delta Outflows (cfs) Under Various Hydrological Conditions			
Water Year Type	Example Year	CDFG Striped Bass Model Baseline Flow	DWRSIM Decision 1485 Flow	DWRSIM EPA Standards Flow	Percent Increase of EPA Standards Flow above Decision 1485 Flow
Wet	1963	34,700	33,499	33,499	0%
Critically Dry	1976	4,700	4,938	7,431	+50.5%

Sources: CDFG baseline flow data provided by David Kohlhorst of CDFG.
DWRSIM flow data provided by Bruce Herbold of EPA.

C-110686

Table 3.10

Results of sensitivity of output variable (sustained adults) to proportional changes in values of each input variable while the other input variables are held constant. Values in the table are percentage change in sustained adults.

Condition	Input Variable		Change in the Input Variable +10%	-10%	+20%	-20%	+50%	-50%
1 million adults Critical year	Initial Adults		2.4	-2.4	4.9	-4.8	11.9	-11.0
	Outflow:	Apr-Jul	2.5	-2.9	4.8	-6.3	10.1	-21.1
		Aug-Dec	0.3	-0.3	0.5	-0.5	1.4	-1.4
	Export:	Apr-Jul	-0.9	0.9	-1.8	1.8	-4.4	4.4
		Aug-Mar	-2.2	2.2	-4.3	4.3	-10.8	10.8
1 million adults Wet year	Initial Adults		2.5	-2.4	4.9	-4.8	11.9	-11.1
	Outflow:	Apr-Jul	0.7	-0.8	1.2	-1.9	2.2	-7.5
		Aug-Dec	1.5	-1.5	3.0	-3.0	7.5	-7.5
	Export:	Apr-Jul	-3.4	3.4	-6.8	6.8	-17.1	17.1
		Aug-Mar	-4.3	4.3	-8.6	8.6	-21.6	21.6
1.7 million adults Dry year	Initial Adults		2.2	-2.4	4.3	-5.1	9.3	-13.4
	Outflow:	Apr-Jul	1.4	-1.7	2.7	-3.6	5.7	-12.4
		Aug-Dec	0.6	-0.6	1.1	-1.1	2.9	-2.9
	Export:	Apr-Jul	-0.3	0.3	-0.7	0.7	-1.7	1.7
		Aug-Mar	-0.7	0.7	-1.5	1.5	-3.7	3.7
1.7 million adults Wet year	Initial Adults		2.2	-2.4	4.3	-5.1	9.3	-13.4
	Outflow:	Apr-Jul	0.4	-0.6	0.8	-1.3	1.5	-5.1
		Aug-Dec	1.0	-1.0	2.0	-2.0	5.1	-5.1
	Export:	Apr-Jul	-1.3	1.3	-2.6	2.6	-6.6	6.6
		Aug-Mar	-1.8	1.8	-3.6	3.6	-9.1	9.1

Source: CDFG. 1992c.

Table 3.11

Estimated Effect of EPA Standards on Adult Striped Bass Population Under Two Water Year Types Using Results from CDFG's Striped Bass Population Model				
Water Year Type	Example Year	Decision 1485 Standards	EPA Standards	Percent Change
Wet	1963	1 million	1 million	0.0%
Critically Dry	1976	1 million	1.101 million	10.1%

Source: CDFG. 1992.
SWRCB Hearings Exh. No. WRINT-CDFG-3. Table 16.

Table 3.12

RECREATION ACTIVITY IN CALIFORNIA 1980 & 2000, BY REGION OF ORIGIN (Thousands of days)

ACTIVITY	SAN JOAQUIN VALLEY SMSAs		MONTEREY, SANTA CRUZ SMSAs		SAN FRANCISCO BAY AREA		SACRAMENTO SMSA		NORTHERN NON-METRO COUNTIES		SOUTHERN CALIFORNIA		STATE TOTAL	
	1980	2000	1980	2000	1980	2000	1980	2000	1980	2000	1980	2000	1980	2000
FISHING														
Lake/stream	3,445	4,729	1,162	1,942	13,347	17,012	2,544	3,948	1,874	2,480	15,787	20,429	38,159	50,540
Saltwater	749	1,059	249	402	2,903	3,433	510	799	394	503	6,783	8,980	11,588	15,176
Other	270	346	83	129	903	1,060	185	269	147	178	2,427	2,943	4,015	4,925
SWIMMING/BEACH														
Freshwater swimming	2,315	5,427	798	1,292	8,923	11,759	1,536	2,450	1,136	1,482	12,219	14,109	26,927	36,519
Ocean swimming,surfing	1,837	2,368	619	898	6,577	7,587	1,230	1,728	918	1,072	76,178	95,698	87,359	109,351
Beach	4,781	6,818	1,645	2,556	18,220	22,980	3,205	5,017	2,477	3,167	76,428	94,864	106,756	135,402
HUNTING														
Big game	154	229	38	89	584	771	151	169	79	104	354	412	1,360	1,774
Small game	581	641	196	249	1,915	1,894	401	449	305	293	1,833	1,824	5,231	5,350
Waterfowl	239	306	88	119	840	890	160	219	118	141	257	281	1,702	1,956
BOATING	3,470	5,426	1,255	2,027	13,284	17,285	2,281	3,793	1,674	2,328	25,118	34,012	47,082	64,871
NATURE APPRECIATION	5,330	7,832	1,860	2,947	21,527	28,101	3,748	6,030	2,946	3,856	35,049	43,478	70,460	92,244
ALL OTHER ACTIVITIES	118,429	162,319	37,107	60,050	407,777	499,228	76,949	114,929	59,432	72,496	1,043,967	1,330,170	1,743,661	2,239,192
TOTAL--ALL ACTIVITIES	141,600	197,500	45,100	72,700	496,8000	612,000	92,900	139,800	71,500	88,100	1,296,400	1,647,200	2,144,300	2,757,300

SOURCE: Center for Continuing Study of the California Economy, Recreation Activity in California, Volume 1, Appendix E, Palo Alto CA, June 1982

Table 3.13

Freshwater Recreation at Selected Sites in California, 1985	
	Thousand of Visits
US Army Corps of Engineers Lakes	3,912
BOR Central Valley Project Lakes	11,590
State Water Project Lakes	6,585
Other Government Agency Lakes	6,492
Delta (estimated)	7,746
Total	36,325
Source: Wade et al., Recreation Benefits for California Reservoirs, Spectrum Economics, April 1989	

Table 3.14

ESTIMATED TOTAL HOURS OF RECREATIONAL ACTIVITY ON THE SACRAMENTO RIVER, 1980

REACH	WATER SKIING	PLEASURE BOATING	RAFTING BUGING	CANOEING	CAMPING	RELAXING	SWIMMING/ BEACH USE	PICNICK-ING	BOAT FISHING	SHORE FISHING	OTHER AC-TIVITIES	TOTAL ALL ACTIVITIES
Keswick Dam to North Street Bridge		2,000	42,000	16,000	5,000	150,000	31,000	25,000	23,000	36,000	117,000	405,000
N. Street Bridge to Jellys Ferry Bridge		2,000	4,500	23,500	34,500	59,000	10,000	53,000	62,000	49,000	30,000	323,000
Jellys Ferry Brdige to Red Bluff Diversion Dam	4,000	33,000	17,500	12,500	21,000	95,000	19,500	33,000	34,000	25,000	71,000	348,000
RBDD to Woodson Bridge		3,000	3,500	10,500	46,500	60,000	27,000	42,000	85,000	47,000	26,000	347,000
Woodson Bridge to Hamilton City Bridge		300	1,000	2,500	100	500	1,200		15,000	2,000	1,400	23,000
Hamilton City Bridge to Sidds Landing	100	3,000	94,600	3,000	3,000	26,000	10,000	8,000	22,000	42,000	105,900	223,000
Sidds Landing to Hamilton Bend	100	700	3,000	9,000	600	1,400	5,300		43,000	15,000	5,900	81,000
Hamilton Bend to Meridian Bridge	2,500	11,000	3,000	2,500	54,000	29,000	31,000	11,000	145,000	34,000	15,000	335,000
Meridian Bridge to Eldorado Bend	6,000	20,000	1,300	1,000	9,000	6,000	30,000		80,000	46,000	7,000	205,000
Eldorado Bend to Mouth fo Feather River	14,000	59,000	600	3,500	40,000	32,000	74,500	500	60,000	130,000	16,500	430,000
Feather R to Discovery Park	20,000	90,000	200	500	11,000	30,000	45,000	12,000	135,000	45,000	11,500	400,000
Discovery Park to Miller Park	7,000	118,000	2,000	300	7,000	280,000	112,000	103,000	122,000	105,000	85,700	940,000
Miller Park to Paintersville Bridge, below Courtland	13,000	132,000	800	200	17,000	32,000	40,000	1,000	289,000	199,000	16,800	740,000
TOTAL	66,700	474,000	174,000	85,000	248,700	800,900	436,500	288,500	1,115,000	775,000	509,700	4,800,000

Source: DWR Sacramento RIver Recreation Survery- 1980, Sacramento, August 1982

Table 3.15

RAFTING ON SOME POPULAR CALIFORNIA RIVERS, 1983

(Visitor Days)

RIVER	ANNUAL RAFTING USE
So Fork American River	100,000
Lower American River	460,000
East Fork Carson River	7,000
Kern River	20,000
Kings River	18,000
Klamath River	15,000
Merced River	14,000
Russian River	100,000
Sacramento River	125,000
Smith River	7,000
Trinity River	33,000
Truckee River	106,000
Tuolumne River	6,000
TOTAL	1,011,000

Source: Planning & Conservation League, cited DWR 160-93

Table 3.16

PARTICIPATION BY CALIFORNIANS 16 YRS & OLDER IN NONCONSUMPTIVE WILDLIFE-RELATED RECREATION, 1985

(Numbers in thousands; dollars in millions)

NUMBER OF ADULT CALIFORNIANS PARTICIPATING'	13,090
PERCENT OF ADULT CALIFORNIANS PARTICIPATING	64.9%
DAYS OF PARTICIPATION IN ACTIVITY	28,647
TRIP-RELATED EXPENDITURES	$544.6
EQUIPMENT AND OTHER NON-TRIP EXPENDITURES	$1,230.5

SOURCE: USFWS, 1985 NATIONAL SURVEY OF FISHING, HUNTING & WILDLIFE-ASSOCIATED RECREATION, November 1988.

Table 3.17

Annual Visitation at Wetland Refuges in California		
Facility	Area (acres)	Current Average Public Use (days)
Sacramento River Basin		
Modoc NWR	6,203	14,300
Sacramento NWR	10,776	39,900
Gray Lodge WMA	8,400	141,250
Delvan NWR	5,583	8,800
Sutter NWR	2,394	3,600
Colusa NWR	4,042	7,200
San Joaquin River Basin		
_________ NWR	4,620	3,000
San Luis NWR	7,430	38,000
Merced WMA	2,562	2,250
Grassland RCD	52,000	95,000
Volta WMA	3,000	5,500
Los Banos WMA	3,208	23,500
Mendota WMA	10,740	34,380
Tulare Lake Basin		
Pixley NWR	4,350	50
Kern NWR	10,628	4,400

Source: US Department of Interior, Bureau of Reclamation, Mid-Pacific Region Draft Report on Refuge Water Supply Investigation Volume 1, August 1987.

Table 3.18

Estimated Consumer Surplus per Trip for Various California Recreational Activities		
Activity	Nominal Consumer Surplus Per Trip	Dollars Measured in Year
1. Beach Recreation	$12	1992
2. Boating at Lakes	$30-35	1990
3. Delta Boating	$32	1987
4. Waterfowl Hunting	$23	1989
5. Fishing on Sacramento River	$17	1980
6. Fishing on Feather River	$24	1982
7. Birdwatching	$37	1987
8. Charter Boat Fishing for Salmon	$61	1987

Sources:
1. Dornbusch (1985).
2. Spectrum Economics (1991).
3. Mannesto (1989).
4. Cooper (1990).
5. Loomis and Ise (1993).
6. Cooper and Loomis (1990).
7. Cooper and Loomis (1991).
8. Huppert (1989).

Table 3.19

Annual WTP for Individual Programs in San Joaquin Valley Drainage Program Study

Program/Subgroup	Median Value Per Household	90% Confidence Interval	Aggregate Value[a] (millions of dollars)
Wetland Maintenance			
California households	$153	123-188	$1,506
Non-California households	92	na	246
Wetland Improvement			
California households	$250	235-268	$2,460
Non-California households	158	na	422
Contamination Maintenance			
California households	$187	177-199	$1,839
Non-California households	92	na	246
Contamination Improvement			
California households	$306	289-331	$3,013
Non-California households	128	na	342
Salmon Improvement			
California households	$182	171-193	$1,788
Outside California	102	na	272

[a]Aggregate value estimates based on median WTP and 9,842,000 households in California and 2,669,000 households in Oregon, Washington, and Nevada

Source: Jones and Stokes (1990).

Table 3.20

Annual Willingness to Pay to Protect Mono Lake			
	Sample Median WTP/h'hold ($/yr)	Population Median WTP/household ($/yr)	Aggregate Statewide Value ($M/yr)
Program A	$96	82	$759.7
Program B	$111	91	$845.6
Program C	$26	0	0

Source: Jones and Stokes, 1993a.

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Table 3.21

Estimated Winter Run Chinook Salmon Past Red Bluff Diversion Dam
(Source: CDFG)

1967	57306
1968	84414
1969	117808
1970	40409
1971	53089
1972	37133
1973	24079
1974	21897
1975	23430
1976	35096
1977	17214
1978	24862
1979	2364
1980	1156
1981	20041
1982	1242
1983	1831
1984	2663
1985	3962
1986	2422
1987	1997
1988	2094
1989	533
1990	441
1991	191
1992	1180

Table 4.1

Above Normal Water Year / Wet Water Year Estimated Annual Catches and Benefits 1990 $'s				
Type of Benefit	Decision 1485 Standard	Proposed EPA Standard	Difference	Units
COMMERCIAL FISHERIES				
Salmon - Ocean Commercial Catch	289,312	410,113	120,801	Fish
Salmon - Value Ocean Commercial Catch	$23,743,836	$33,657,974	$9,914,138	Personal Income
Starry Flounder - Ocean Commercial Catch	280,479	280,950	471	Pounds
Starry Flounder - Value Ocean Commercial Catch	$80,778	$80,914	$136	Personal Income
Bay Shrimp	N/A	N/A	+	
Pacific Herring	N/A	N/A	+	
RECREATIONAL FISHERIES				
Salmon - Ocean Recreational Trips	119,993	134,689	14,696	Angler Trips
Salmon - Value Ocean Recreational Trips	$7,319,573	$8,216,029	$896,456	Consumer Surplus
Salmon - Inland Recreational Trips	129,076	129,076	0	Angler Trips
Salmon - Value Inland Recreational Trips	$2,581,520	$2,581,520	$0	Consumer Surplus
Striped Bass - Low Value Scenario				
Striped Bass - Inland Recreational Catch	110,000	110,000	0	Fish
Striped Bass - Value Inland Recreational Catch	$550,000	$550,000	$0	Consumer Surplus
Striped Bass - High Value Scenario				
Striped Bass - Inland Recreational Trips	500,000	500,000	0	Angler Trips
Striped Bass - Value Inland Recreational Trips	$30,500,000	$30,500,000	$0	Consumer Surplus
Sturgeon	N/A	N/A	+	
American Shad	N/A	N/A	+	
White Catfish	N/A	N/A	+	
OTHER RECREATIONAL USE VALUES (a)	N/A	N/A	+	
NON-USE VALUES (b)	N/A	N/A	+	
Totals (with Low Value Striped Bass Scenario)	$34,275,707	$45,086,437	$10,810,730	Personal Income
Totals (with High Value Striped Bass Scenario)	$64,225,707	$75,036,437	$10,810,730	plus Consumer Surplus

N/A = Information not available in appropriate form.
+ = Positive but not quantifiable.
a = Including wildlife viewing, hunting, and other water-enhanced activities.
b = Including existence, bequest, and option values.

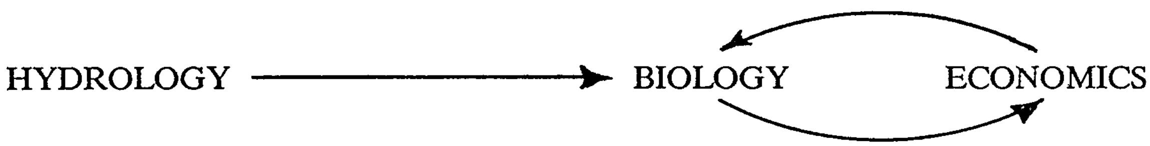
Table 4.2

Critically Dry Water Year
Estimated Annual Catches and Benefits
1990 $'s

Type of Benefit	Decision 1485 Standard	Proposed EPA Standard	Difference	Units
COMMERCIAL FISHERIES				
Salmon - Ocean Commercial Catch	207,369	306,398	99,029	Fish
Salmon - Value Ocean Commercial Catch	$17,018,774	$25,146,084	$8,127,310	Personal Income
Starry Flounder - Ocean Commercial Catch	128,977	178,031	49,054	Pounds
Starry Flounder - Value Ocean Commercial Catch	$37,145	$51,273	$14,128	Personal Income
Bay Shrimp	N/A	N/A	+	
Pacific Herring	N/A	N/A	+	
RECREATIONAL FISHERIES				
Salmon - Ocean Recreational Trips	108,790	122,188	13,398	Angler Trips
Salmon - Value Ocean Recreational Trips	$6,636,190	$7,453,468	$817,278	Consumer Surplus
Salmon - Inland Recreational Trips	129,076	129,076	0	Angler Trips
Salmon - Value Inland Recreational Trips	$2,581,520	$2,581,520	$0	Consumer Surplus
Striped Bass - Low Value Scenario				
Striped Bass - Inland Recreational Catch	110,000	121,110	11,110	Fish
Striped Bass - Value Inland Recreational Catch	$550,000	$605,550	$55,550	Consumer Surplus
Striped Bass - High Value Scenario				
Striped Bass - Inland Recreational Trips	500,000	524,928	24,928	Angler Trips
Striped Bass - Value Inland Recreational Trips	$30,500,000	$32,020,608	$1,520,608	Consumer Surplus
Sturgeon	N/A	N/A	+	
American Shad	N/A	N/A	+	
White Catfish	N/A	N/A	+	
OTHER RECREATIONAL USE VALUES (a)	N/A	N/A	+	
NON-USE VALUES (b)	N/A	N/A	+	
Totals (with Low Value Striped Bass Scenario)	$26,823,629	$35,837,895	$9,014,266	Personal Income
Totals (with High Value Striped Bass Scenario)	$56,773,629	$67,252,953	$10,479,324	plus Consumer Surplus

N/A = Information not available in appropriate form.
+ = Positive but not quantifiable.
a = Including wildlife viewing, hunting, and other water-enhanced activities.
b = Including existence, bequest, and option values.

Figure 1.1



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