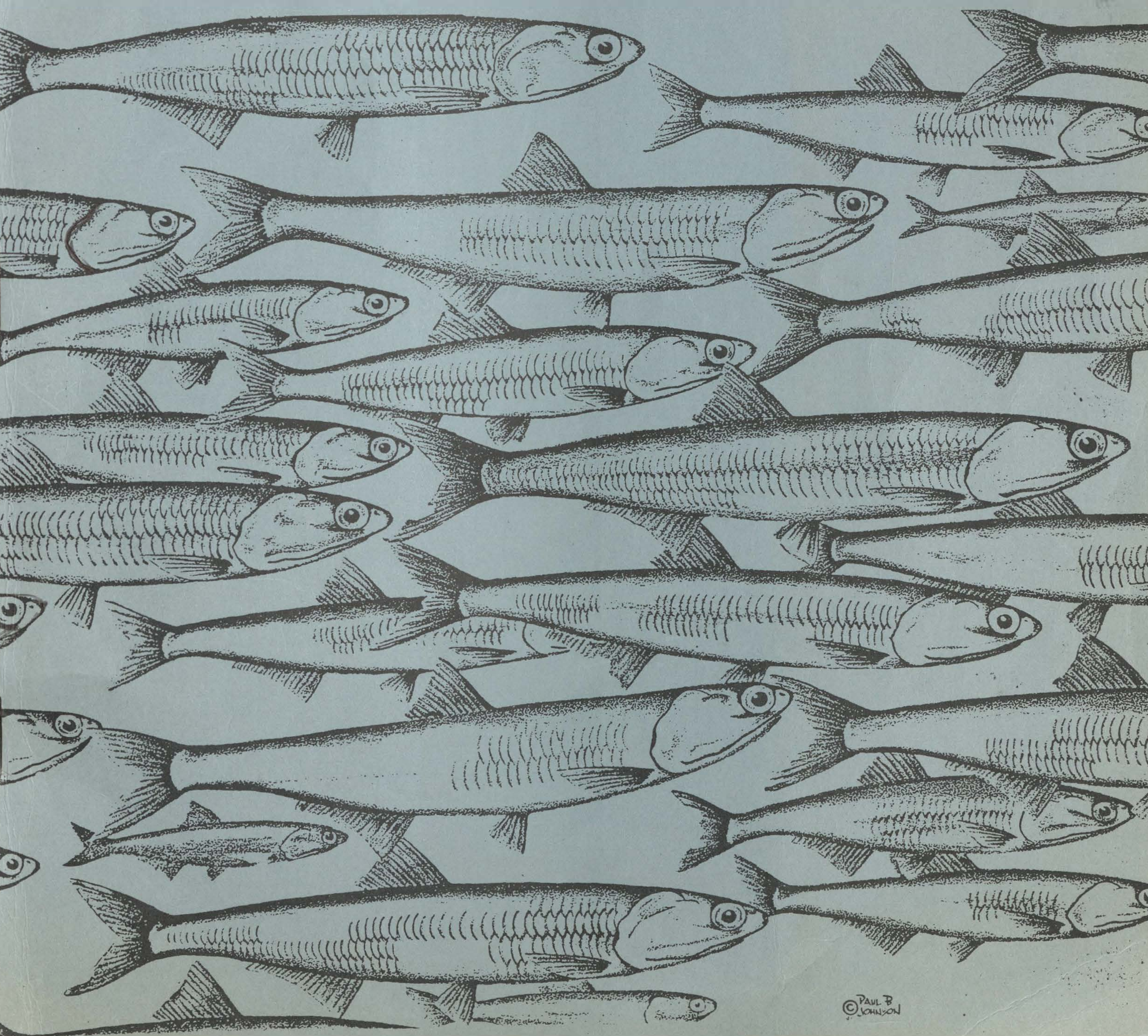
NORTHERN ANCHOVY

FISHERY MANAGEMENT PLAN

INCORPORATING THE FINAL SUPPLEMENTARY

EIS/DRIR/IRFA

October 24, 1983



This revision (Amendment No. 5) of the Northern Anchovy Fishery Management Plan has been prepared by the Anchovy Plan Development Team of the Pacific Fishery Management Council for consideration by the Secretary of Commerce.

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October 24, 1983

NORTHERN ANCHOVY

Fishery Management Plan

(FMP Amendment #5)

Final Supplementary Environmental Impact Statement

and

Draft Regulatory Impact Review/Initial Regulatory Flexibility Analysis

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Name of Action: Administrative

ABSTRACT

The Anchovy FMP/EIS was first approved and implemented in 1978. Due to new scientific information, the 1978 Fishery Management Plan for the northern anchovy (Engraulis mordax) central subpopulation is revised. The anchovy resource benefits a domestic reduction fishery, an unregulated Mexican reduction fishery, and a domestic recreational fishery which relies on anchovy as live bait. In addition, anchovy provides forage for valuable gamefishes, marine mammals and seabirds, including endangered species such as the brown pelican. This revised FMP reviews biological, ecological, social and economic aspects of the anchovy and establishes a revised optimum yield (OY) formula, whereby U.S. OY is calculated each year based on an annual estimate of stock abundance. The new formula reflects a new, more cost-effective "egg production method" of estimating stock abundance, and lower estimated productivity of the anchovy stock. Several regulations governing harvest allocation, fishing areas and seasons, etc., as well as foreign and joint venture fishery management are established. This document integrates the Fishery Management Plan with the Final Supplementary Environmental Impact Statement, Draft Regulatory Impact Review, and Initial Regulatory Flexibility Analysis.

ES.0 Executive Summary

The proposed action is an amendment to the Northern Anchovy Fishery Management Plan (FMP). The FMP was approved by the Pacific Fishery Management Council (PFMC) in June of 1978 and was implemented by the Secretary of Commerce on September 13, 1978. Changes in regulations controlling the commercial harvest of northern anchovies in the United States' Fishery Conservation Zone in southern California will result from adoption of the proposed action.

ES.1 Summary of Proposed Action

The proposed FMP amendment incorporates recent advances in scientific information concerning the size and potential yield of the northern anchovy population. When the original anchovy FMP was developed, scientists had estimated that the central subpopulation of northern anchovies ranged up to about 4 million tons and could support an average annual catch of about 500 thousand tons. Current estimates, based upon recent advances in survey techniques, show that the population has a maximum size of only about 2.5 million m tons and a maximum average yield of about 340 thousand m tons per year. Since annual fishery catch quotas are based upon measurements of the population size, the old version of the FMP must be revised to incorporate optimum yield formulas consistent with the new scientific assessments.

Besides addressing the need to alter commercial harvest quotas, this FMP amendment represents an opportunity for the Pacific Fishery Management Council to recommend changes to a variety of other management measures included in the original FMP and previous amendments. These other management measures concern seasonal and geographic area closures for the commercial reduction fishery, minimum fish size limits or net mesh size requirements for the commercial reduction fishery, allocations of the optimum yield for non-reduction fishing, allocations of the reduction fishery quota for areas north and south of Point Buchon, and regulations applying to foreign fishing and joint venture fishing for anchovies in the FCZ.

ES.2 Alternatives Considered

Two or more alternative actions are being considered in each of six general categories (1) optimum yield and harvest quotas, (2) closed seasons for the reduction fishery, (3) closed areas for the reduction fishery, (4) allocation of the reduction fishery quota between northern and southern areas, (5) minimum fish size or mesh size, and (6) foreign fishery and joint venture fishery regulations. Alternatives being considered in each of these are described briefly below.

ES.2.1 Optimum Yield and Harvest Quotas

Using the best scientific information available concerning the central subpopulation of northern anchovies the PFMC must choose an annual level of harvest deemed to be "optimal" based upon biological, ecological, social and economic criteria. Because the anchovy population is both a major forage stock and a commercial resource the optimum yield must provide for a sufficient forage reserve while maintaining a viable commercial fishing fleet. Also, the optimum yield chosen for the U.S. FCZ must take into account the fishery on the same biological stock occurring in Mexican waters. Total optimum yield for the central population is the sum of the amount calculated by the reduction quota formula and an amount equal to the non-reduction allocation. This total OY is then allocated between the U.S. and Mexico and the U.S. portion is further allocated. The overall optimum yield decision is broken down into several sub-categories.

U.S.-Mexico Optimum Yield Allocation

Three categories of options are considered to account for Mexican harvests while setting the OY in U.S. waters.

(1) Allocate 70 percent of the total OY to the U.S. zone.

(2) Allocate 50 percent of the total OY to the U.S. zone.

(3) Set the U.S. OY equal to the total OY minus the expected Mexican catch.

(4) The OY in the U.S. zone is the total OY calculated after adjusting the spawning biomass estimate to reflect expected removals from the stock by the Mexican fishery after the biomass is estimated.

(5) Determine an Optimum Yield for the U.S. zone without explicit consideration of the Mexican harvest.

Under options (1) and (2) an OY would be calculated for the entire central subpopulation of northern anchovies and the U.S. optimum yield would be based upon a portion of this total. With options (3) and (4) the U.S. reduction fishery OY (and quota) would be adjusted to account for the actual levels of harvest expected to occur in Mexican waters. Under option (5) the U.S. regulations would be based upon the entire central subpopulation size but would refer only to harvests in U.S. waters. Without an international agreement to assure that Mexican and U.S. fisheries cooperate to achieve a given aggregate catch from the fish stock, the only affect of these alternatives is to alter the procedures used to determine the U.S. fishery quota.

Minimum Biomass Needed to Allow Commercial Harvest

Given the ecological importance of the anchovy population in coastal waters off California, it may be prudent to include safeguards against severe depletion of the stock in addition to the reduction fishery harvest quotas discussed below. One such safeguard is a moratorium on commercial catch when the stock declines below some minimum, critical level. This moratorium would apply to all harvests regulated under the optimum yield/harvest quota alternatives considered below. Three alternatives considered are: (1) minimum biomass of 90,700 metric tons (100,000 short tons); (2) a minimum biomass of 20,000 metric tons based upon the "egg production method" estimate of biomass; and (3) no moratorium on harvest at low biomass levels.

Treatment of Non-reduction Fishing

The previous version of the Anchovy FMP established separate OY allocations for two distinct segments of the commercial fishery. Reduction fishing (i.e. harvesting fish for delivery to plants that render whole fish into fish meal and oil) constitutes the major commercial harvest of anchovies, while non-reduction fishing (i.e live-bait harvests and deliveries of fish for frozen bait, canning and fresh marketing) accounts for a much lower volume. Despite the relatively small tonnages involved, live-bait harvests are critical to much of the economically important recreational fishery in southern California. Thus two different options are considered which give preference to the live-bait fishery and other non-reduction fishing.

(1) Reserve 16,330 metric tons (18,000 short tons) for non-reduction fishing from the OY for the entire central subpopulation of northern anchovies.

(2) Set a non-numerical OY for live-bait equal to whatever the existing live-bait fishing fleet can harvest, and allocate 7,000 metric tons of total OY to other non-reduction fisheries.

Reduction Fishery Quota Formulas

Inherent variability of anchovy populations suggests that any fixed annual harvest would be too large in some years and too low in other years. Thus an optimum yield formula, which relates allowable annual harvest to the current population size, is superior to a fixed OY. Several different reduction quota formulas are under consideration. Each of the formulas proposed has a "cut-off level", which is an anchovy biomass level below which the reduction fishery quota is set equal to zero, and each specifies how the anchovy reduction fishery quota is to be determined when the biomass is above the cut-off level.

Two generic types of formulas are considered. The first specifies a continuous increase in reduction quota as biomass increases, and the second type allows a rapid increase in quota as biomass increases from the cut-off level to a moderate size (300 to 500 thousand metric tons) and then holds the quota to a fixed ceiling. The main differences between the two types of formulas are (1) the continuous increase formulas allow larger harvests when biomass gets very large while the fixed ceiling formulas allow larger harvests at medium to low biomass levels; (2) with the continuous increase formulas the annual variability in the harvest quota will be greater than under the fixed ceiling type of formula; and (3) the fixed ceiling formulas would be less expensive to administer because extensive stock assessment work would be unnecessary whenever the fish stock is well above the level at which the ceiling is reached.

Eleven reduction quota formulas considered in the draft FMP are listed in Table ES-1. The first formula is equivalent to the optimum yield formula adopted under the September 1978 Anchovy FMP. This option is included for comparison to the newer options, but should not be considered a realistic alternative since it was developed to be used with biomass estimates based upon the old larva census method. Optimum yield formulas 2 through 6 represent variations on the continuous increase type of formula, and options 7 through 11 incorporate the OY ceiling concept. All these formulas are designed for use with the new "egg production method" estimates and the new anchovy population yield model. The group of options was selected to cover a reasonable range of biologically feasible alternatives. Choice of any given option requires a balancing of various biological and economic factors. These are discussed in Chapter 9 of the FMP.

Table ES-1. Summary of management measures considered. BIOMASS refers to spawning biomass estimated by the egg production method or its equivalent. BIOMASS*(L) refers to spawning biomasses that had been estimated by the larva census method or its equivalent.

U.S.-MEXICO OY ALLOCATION (Section 8.3.1)

1. (Present) US quota is 70% of OY	2. US quota is 50% of OY	3. US quota is remainder of OY after subtracting expected Mexican harvest
4. US quota is 100% of OY (based on BIOMASS minus expected Mexican harvest)	5. US quota is 100% of OY (Mexican harvest is implicitly treated as mortality factor)	

MINIMUM SPAWNING BIOMASS ALLOWING HARVEST (Section 8.3.2)

1. (Present) 90,720mtons BIOMASS*(L)	2. 20,000 mtons BIOMASS	3. No minimum specified

NON-REDUCTION ALLOCATION (Section 8.3.3)

1. (Present) 16,330 mtons total fishery	2. Non-numeric OY for live bait; 7,000 mtons other

REDUCTION QUOTA FORMULAS (Section 8.3.4)

1. (Present) QUOTA=1/3 of EXCESS over 907,200mtons BIOMASS*(L)	2. QUOTA=1/4 of EXCESS over 200,000 mtons BIOMASS	3. QUOTA=1/4 of EXCESS over 300,000 mtons BIOMASS	4. QUOTA=1/3 of EXCESS over 300,000 mtons BIOMASS
5. QUOTA=1/2 of EXCESS over 300,000 mtons BIOMASS	6. QUOTA=1/3 of EXCESS over 400,000 mtons BIOMASS	7. QUOTA=200,000 mtons if BIOMASS exceeds 300,000 mtons	
8. QUOTA=200,000 mtons if BIOMASS exceeds 400,000 mtons	9. QUOTA=1.0 of EXCESS over 200,000 mtons BIOMASS with limit of 200,000 mtons	10. QUOTA=1.25 of EXCESS over 300,000 mtons BIOMASS with limit of 250,000 mtons	11. QUOTA=1.0 of EXCESS over 200,000 mtons BIOMASS with limit of 300,000 mtons

Table ES-1 Continued. Summary of management options considered

REDUCTION QUOTA RESERVE (Section 8.3.5)

1. (Present) 1/2 US reduction quota	2. No reserve

GEOGRAPHIC ALLOCATION OF REDUCTION QUOTA (Section 8.3.6)

1. (Present) 10% or 9072 mtons reallocated on June 1 if necessary	2. 10% or 9072 mtons until June 1	3. No allocation

FISHING SEASONS (Section 8.3.7)

1. (Present) North: Aug 1-June 30 South: Sept 15-June 30 Feb and March closed	2. North: Aug 1-May 15 South: Sept 15-May 15	3. No closure

AREA CLOSURES (Section 8.3.8)

1. (Present) 5 areas of closure beyond 3 miles	2. Re-evaluate each closure independently

SIZE LIMIT AND/OR MESH RESTRICTION (Section 8.3.9)

1. (Present) No minimum but 10/16" mesh size restriction	2. 5" TL with 15% tolerance	3. 5" TL with 40% tolerance
4. 4.5" TL with 15% tolerance	5. 5" TL with 15% tolerance in effect Aug thru March only	

FOREIGN VESSEL AREA RESTRICTION (Section 8.4)

1. (Present) No closures	2. Catalina Channel closure and 3-6 miles from shore

The options presented in this section are intended to cover the likely range of Council action; they are not intended to constrain the Council to choosing precisely one of the options offered. In response to information from this plan and public hearings, the Council may choose an optimum yield formula that differs from these specific options.

Reduction Quota Reserve

As an additional safeguard against over-harvest of the anchovy stock an in-season quota reserve system has been considered. The two options considered are to incorporate a reserve or not. With the quota reserve one-half of the U.S. reduction fishery quota would be released at the beginning of the reduction fishing season, and the second half of the quota would be released in mid-season if available evidence indicates that continued fishing would not reduce the biomass below the cut-off level.

ES.2.2 Geographic Allocation of Reduction Quota

Both the original FMP and the California Management Plan that preceded it make a special allocation of the reduction fishery quota for the fishery in Monterey, California. This is accomplished by reserving 10% of the quota or 9,070 metric tons, whichever is smaller, for fishing north of Point Buchon. Pt. Buchon is north of the usual fishing grounds of the southern California fleet and south of the usual fishing grounds of the Monterey fishing fleet. With this allocation scheme it is possible that one part of the fleet would be prohibited from harvesting anchovies even while the other part of the fleet is not taking its allocation of the quota. To prevent this a previous FMP amendment incorporated a late-season reallocation of the northern area allocation. Three options are considered.

(1) On June 1, if requested by the industry, the reduction fishery quota reservation for the Northern Area will be modified as follows:

a. The expected Northern Area reduction catch for the year will be estimated based upon catch to date in the current year and the intentions of processors and fishermen in the fishery north of Pt. Buchon to harvest reduction fish in the remaining portion of the fishing year.

b. The expected harvest in the Northern Area fishery will be subtracted from the amount reserved for the Northern Area and, if the remainder is positive, the reservation for the Northern Area will be reduced by this amount.

(2) The reservation of the reduction quota for the Northern Area will not apply after June 1. Any of the Northern Area allocation which has not been caught prior to June 1 will be available for reduction fishing in both the Northern and Southern Areas until the end of the reduction fishing season.

(3) The reduction quota will be fully available to the northern and southern areas equally without specific allocation.

ES.2.3 Closed Seasons for Reduction Fishing

Closed seasons are utilized in anchovy fishery management to reduce conflicts with peak summertime recreational fishing and to prevent reduction fishing during the peak spawning periods. Three options considered are:

(1) Closed reduction fishery from July 1 to July 31 and from February 1 thru March 31 throughout the FCZ; and closed from August 1 through September 14 south of Pt. Buchon.

(2) Impose reduction fishery closure from May 15 through September 15 south of Pt. Buchon and from May 15 through July 31 north of Pt. Buchon.

(3) Impose no statutory reduction fishery season closure, but close fishery whenever reduction fishery quota has been reached.

ES.2.4 Area Closures

Closure of nearshore areas to round-haul net fishing generally or to anchovy reduction fishing specifically has been employed by California and the Anchovy FMP to separate the highly visible commercial operations from the numerous recreational fishing vessels in southern California and off San Francisco Bay. All of the areas closures in question are depicted in Figure S-1. The two options considered are (1) to retain all five existing fishery closures, and (2) to reconsider each of the five closures separately.

ES.2.5 Anchovy Minimum Fish Size Limits and Mesh Size Requirements

Two alternative means to restrain reduction fishing effort on small, immature anchovies are (1) minimum size limits on harvested fish and (2) minimum mesh size limits on the purse seine gear. The original anchovy FMP contained a 5-inch minimum size with an allowance for up to 15% undersize fish in any given load. FMP Amendment 4 replaced the 5-inch limit with a 10/16-inch minimum mesh size. Both of these are included among the five options considered here.

(1) No minimum size limit imposed on the catch or landings of northern anchovies, but a minimum wet stretch mesh size of 10/16" will be required in the body of nets used in the reduction fishery.

(2) Fish shorter than 5-inches total length may not be taken except for bait, with a 15 percent by weight incidental catch allowance.

(3) Fish shorter than 5 inches total length may not be taken except for bait, with a 40 percent by weight incidental catch allowance.

(4) Fish shorter than 4-1/2 inches total length may not be taken except for bait, with a 15 percent by weight incidental catch allowance.

(5) Fish shorter than 5 inches total length may not be taken except for bait, with a 15 percent by weight incidental catch allowance during August through March. No minimum size will be in effect during April through July.

ES.2.6 Foreign Fishing and Joint Venture Fishing Regulations

In case either joint venture or foreign fishing takes place in the

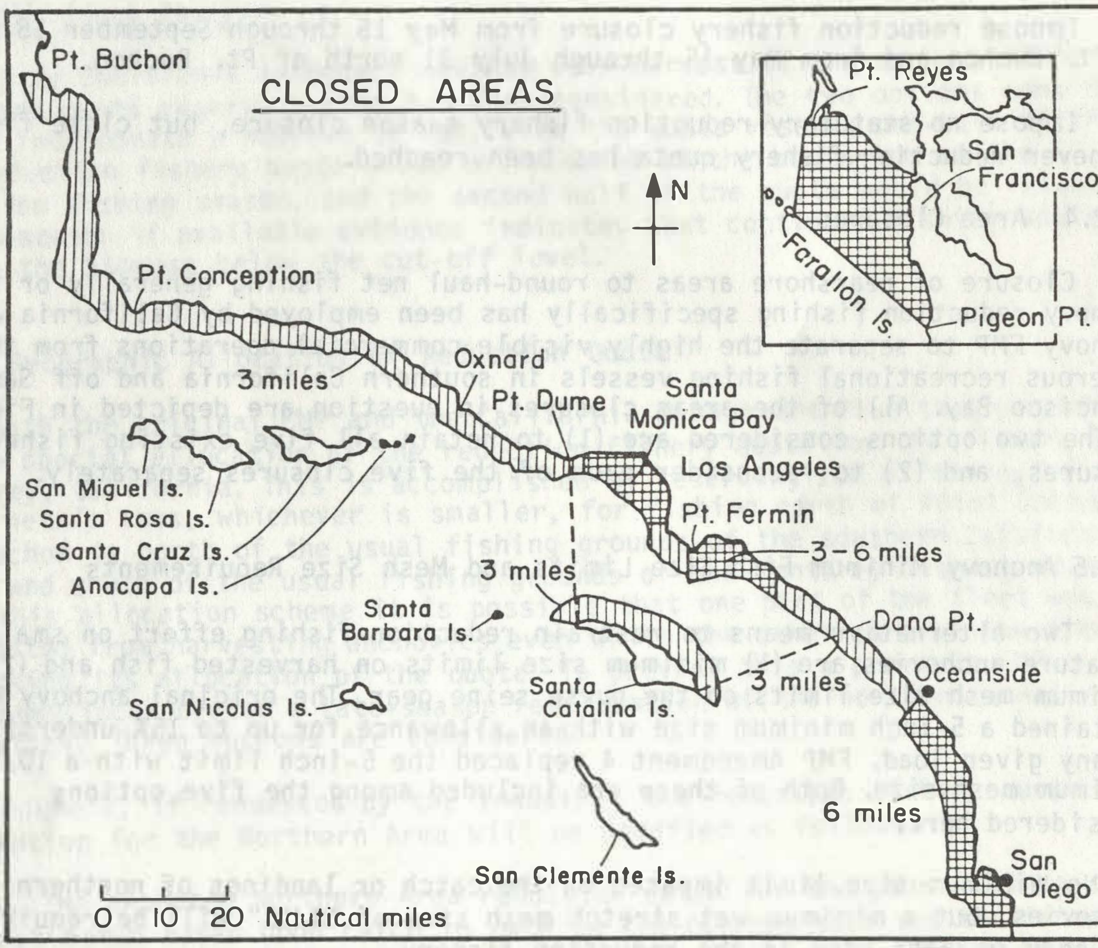


Figure ES-1. Existing California area closures (hatched areas extend to 3 miles offshore; cross-hatched areas extend beyond 3 miles offshore) and optional Catalina Channel foreign vessel closure (outlined by dashed lines).

anchovy fishery, foreign vessels and U.S. vessels fishing in conjunction with foreign fishing vessels (including foreign processing vessels) are required to observe all regulations imposed on domestic fishermen and processors. Two alternatives concerning additional restrictions on foreign and joint venture fishing operations are as follows:

(1) No additional regulations imposed on foreign fishing and processing vessels.

(2) Closure of Catalina Channel and inshore region to foreign vessels. Foreign fishing and processing vessels may not operate within six miles of the continental coastline, and may not operate in the Catalina Channel (bounded by a line from Point Dume to West End, Santa Catalina Island and from China Point, Santa Catalina Island to Dana Point).

ES.3 Controversial Issues Addressed in the FMP Amendment

Some historically important controversies are likely to recur during the consideration of this FMP amendment, and additional technical controversy regarding the scientific information on anchovy stock size and productivity may arise. A short summary of these follows.

ES.3.1 Anchovy as Forage versus Commercial Resource

Since the inception of the anchovy reduction fishery in 1965 this has been the most persistent and heated source of controversy. Two main groups of constituents hold different views on the importance of anchovy as forage and seek different uses of the fishery resource. Generally, the recreational fishermen and that segment of the industry that caters to recreational fishing (partyboats, live-bait businesses and gear manufacturers and retailers) emphasize the importance of nearshore concentrations of anchovy schools for attracting and maintaining stocks of recreationally important marine fish species. From this viewpoint, any substantial take of anchovies for reduction into meal and oil is inappropriate because it endangers, or at least diminishes, marine recreational fishing opportunities in the densely-populated southern California region.

A different view is generally held by commercial anchovy fishermen, fish reduction plant operators and associated labor unions. Like many other marine fish species, the anchovy stock is capable of sustaining some average level of harvesting without fear of severe depletion. From this standpoint, the fish stock represents a base for industry that can provide employment, income and useful products on a sustained basis. Although the commercial industry recognizes that forage stocks are necessary to the maintenance of predator species, there is a question of degree. Excessive conservatism in resource exploitation could unnecessarily sacrifice economic activities consistent with the optimum yield concept.

Unfortunately, scientific assessment and economic analysis cannot provide the decisive information needed to resolve this controversy. There are two reasons for this. First, although it is well known that anchovies are commonly eaten by a wide variety of recreationally and commercially important predator species, much uncertainty still persists concerning the degree of inter-species dependence. In other words, we cannot know with certainty whether the levels of harvest permitted by this FMP will significantly and deleteriously impact the local recreational fish stocks in southern California. Second, it is impossible to serve both interest groups simultaneously. To maintain a larger anchovy stock would address the interests of recreational fishing, but would also require that the commercial harvest be curtailed. Thus the controversy is largely one of "who gets the larger piece of the pie?". A reasonable compromise between the two positions is sought in this FMP, but this cannot eliminate the sources of controversy.

ES.3.2 Endangered species (the brown pelican)

Because anchovies comprise a major part of the diet of brown pelicans breeding on southern California islands, the anchovy stock can be considered an important part of the pelican's habitat. Since brown pelicans are on the endangered species list, it is incumbent upon the management authorities to consider and avoid deleterious impacts on the pelicans.

ES.3.3 Accuracy of the Anchovy Biomass Estimates and Yield Model

Because the size of the northern anchovy population is never directly enumerated, statistical estimates of stock biomass are not checked against some known, absolute measure. Consequently, alternative views regarding the accuracy of the measurements can be tested only through theory and cross-checking with other indirect methods. The previous version of the Anchovy FMP relied upon the so-called "larva census" estimate of biomass which gives results quite different from the newer "egg production" estimates of biomass. Scientists associated with the development of this FMP amendment currently feel that the "larva census" estimates used previously are in error; the old biomass estimates failed to correctly distinguish between changes in population fecundity and changes in size of spawning stock. The "egg production" estimates seem more scientifically rigorous and defensible, but the lower absolute size of the stock translates into lower estimates of average sustainable harvests and lower expected reduction fishery quotas. Commercial fishery participants and supporter are less ready to accept the new biomass assessment methods. Hence, a key feature of this FMP amendment--conversion of the biomass assessments, optimum yield determination, and reduction fishery quota formulas to the new biomass estimation procedures--is controversial.

ES.3.4 Fish Size Limit

This FMP amendment re-opens the controversy over elimination of the five-inch minimum size limit--a traditional regulation in the anchovy reduction fishery which was recently deleted from the FMP in favor of a minimum mesh size limitation by Amendment No.4. The main justification for removing the minimum size is that the previous rationale for it (i.e. that it specifically protects juvenile fish until they become spawners) is untenable. Recent evidence indicates that age and size at maturity varies considerably. In some years most of the one-year-old, first-spawning fish are less than five inches in length in the southern California region. Thus harvest of smaller fish cannot be assumed to significantly decrease the level of spawning by the anchovy population. The replacement of the size limit with a minimum mesh size requirement continues to be controversial, however.

ES.3.5 Lack of International Management Regime

It is correctly perceived by many observers and participants of the U.S. management effort that the lack of international cooperation in anchovy management is a serious deficiency. In recent years, Mexico's reduction fishery operating out of Ensenada, Baja California has grown to dominate the fishery. During the last four years the Mexican catch has been four or five times the U.S. catch. Of immediate concern is the possibility that the combined harvest by the two countries may exceed the amount that either nation considers optimal. This will continue to be a problem until a cooperative management agreement is established.

ES.4 Summary of Impacts

Both the environmental and socio-economic impacts of the proposed action are covered in FMP Sections 9.0 through 9.8. Due to the large number of alternative options and the variety of issues to be considered, the reader is referred to the summary of impacts given in Section 9.9.

ES.5 Recommended Options

The Pacific Fishery Management Council has recommended the following options to the Secretary of Commerce (also see Table ES-1):

U.S.-MEXICO OY ALLOCATION -- OPTION 1

MINIMUM SPAWNING BIOMASS ALLOWING HARVEST -- OPTION 3

NON-REDUCTION ALLOCATION -- OPTION 2

REDUCTION QUOTA FORMULA -- Revised Option: Quota is excess over 300,000 mtons with limit of 200,000 mtons

REDUCTION QUOTA RESERVE -- OPTION 2

GEOGRAPHIC ALLOCATION OF REDUCTION QUOTA -- OPTION 1

FISHING SEASONS -- OPTION 1, but delete February-March closure

AREA CLOSURES -- OPTION 1

SIZE LIMIT/MESH RESTRICTIONS -- OPTION 1

FOREIGN VESSEL AREA RESTRICTION -- OPTION 1

1.0 Contents and Special Indexes

1.1 TABLE OF CONTENTS

1.2 INDEX FOR USE AS ENVIRONMENTAL IMPACT STATEMENT

1.3 INDEX FOR USE AS REGULATORY IMPACT REVIEW (RIR)

2.0 Introduction

2.1 Relation to the Magnuson Fishery Conservation and Management Act

The Fishery Conservation and Management Act of 1976 (Public Law 94-265) provides for the United States' exclusive fishery management authority over the fishery resources within a Fishery Conservation Zone extending from the seaward boundary of the United States' territorial sea (3 miles from shore) to a point 200 miles from shore. The responsibility for developing management plans for the fisheries in the Zone is vested in eight Regional Fishery Management Councils. The Pacific Fishery Management Council is responsible for the fisheries off the coasts of the states of Washington, Oregon and California. Implementation and enforcement of any regulations pertinent to fisheries management within the Fishery Conservation Zone are the responsibility of the Secretary of Commerce. The original Anchovy Fishery Management Plan was implemented by the Secretary of Commerce in 1978 for management of the central subpopulation of northern anchovy (Engraulis mordax) which extends from approximately San Francisco to Punta Baja, Baja California, Mexico. This revision of the FMP was developed for and by the Pacific Fishery Managment Council and is submitted to the Secretary of Commerce for approval and implementation.

2.2 Need for and Purpose of Amendment

The primary reason for revision of the anchovy FMP is the development of a new technique for annual estimation of the spawning biomass. A directive of the FCMA is to use the best available information in development of fishery management plans. The original anchovy FMP specifies that scientific research be conducted to improve the accuracy of the bioeconomic model (Section 8.1-3a) and to develop a more cost-effective system for estimating spawning biomass (8.1-3b), and that the plan be revised if there is a documented change in the anchovy population response to exploitation (8.1-6b). The new technique is more cost-effective and accurate, and it indicates that the original FMP overestimated anchovy productivity, thus modifying the anticipated anchovy response to exploitation.

Annual harvest quotas will continue to be based on current estimates of spawning biomass and an optimum yield formula. This policy adapts the fishery to natural fluctuations in abundance. The yield formula is evaluated by a production model fit to the historical time series of spawning biomass. The old method for estimating spawning biomass utilized anchovy larva abundance as an index of spawn production and calibrated this index to spawner abundance, with the assumption that the calibration factor was proportional to the factor relating sardine larva abundance to sardine biomass. The new method utilizes anchovy egg production as a better measure of spawn production and relates spawn production directly to spawner abundance by measurement of anchovy reproduction. Biological information collected with the new egg production method indicates that reproductive output of anchovy is greater than previously assumed. Thus the larva census method overestimated spawning biomass because fewer spawners are actually required to produce the observed numbers of larvae.

A historical index of egg production has been calibrated to spawning biomass as estimated by the new egg production method to produce a time series of anchovy abundance from 1954-1982. The production model fit to this time series estimates an equilibrium unfished population size of 2,065 thousand metric tons of spawning biomass. The maximum sustainable yield is 336 thousand m tons occurring at a population size of 626 thousand m tons. However, the great variability of the anchovy biomass, independent of the effects of a commercial fishery, makes the management of this fishery subject to a level of uncertainty which calls for flexibility in setting annual allowable yield and a conservative stance in relation to preserving sufficient reproductive potential in the standing biomass to assure continued productivity of the stock.

The previous plan called for stoppage of the reduction fishery when the spawning biomass was below 907,200 m tons (one million short tons). This provided a forage reserve for the anchovy's predators, some of which are endangered species. The level of the reserve was established as a fraction of the perceived anchovy maximum equilibrium abundance and not as a measured requirement by the predators. In terms of the new and more accurate estimates of anchovy abundance, a forage reserve of 200-400 m tons provides equivalent protection for the resource.

In accordance with changes in estimated spawning biomass and productivity of the resource, management measures other than the reduction quota formula need to be reconsidered. Other measures which are directly affected are the minimum spawning biomass allowing harvest, the non-reduction allocation, geographic allocation, and the reduction quota reserve. The remaining management measures such as fishing seasons, area closures, and size limits may be affected indirectly. For example, if OY is smaller under the new FMP, profit margins in the fishing industry could also decrease, requiring considerations of other measures which may relate to costs of fishing operations. For this reason, it is appropriate to consider all management measures simultaneously in this revision of the Anchovy FMP.

The successful implementation of the Anchovy Fishery Management Plan will require unity of purpose between the Federal management regulations and the regulations enforced by the State of California. Authority for implementing fishery management regulations in California resides with the State Legislature and the California Fish and Game Commission. Enforcement of California fishery regulations is accomplished by the California Department of Fish and Game (CF&G).

Because the Fishery Management Plan is directed toward a fish stock which resides in the fishery conservation zone of Mexico as well as in the United States' Zone, cooperation and common objectives between the United States and Mexico will be necessary for the successful international management of the anchovy resource. At the very least, the two countries should share an overall objective with respect to total annual harvests from the stock. Bilateral negotiations between the United States and Mexico on fisheries management matters are the responsibility of the United States' Secretary of State, with the advice and counsel of the Secretary of Commerce and the Fisheries Management Council, whose authority covers the U.S. portion of the shared fishery resource.

An early draft of this revised FMP was reviewed for scientific accuracy. The reviews, the Plan Development Team's response to the reviews, and resultant changes in the technical analysis are presented in Methot and MacCall (1983).

3.0 Description of Fishery

3.1 Areas and Stock Involved

The commercial fisheries in Southern California and Mexico for pelagic schooling fish are conducted by fishing vessels using various round haul gear, typically purse seines and lampara nets. Many of the vessels are remnants of the collapsed Pacific sardine fishery. The major species in this fishery are the northern anchovy, Engraulis mordax; Pacific mackerel, Scomber japonicus; jack mackerel, Trachurus symmetricus; bonito, Sarda chiliensis; bluefin tuna, Thunnus thynnus; and market squid, Loligo opalescens. A variety of other incidental species are taken including Pacific sardines, Sardinops sagax caeruleus for which the incidental catches in the southern California fisheries have been increasing since 1979 (Klingbeil, 1981). The development of a management plan directed specifically at northern anchovy has been assigned high priority by the Pacific Fishery Management Council. Consequently, it is the fishery of the northern anchovy that is addressed by this management plan.

The northern anchovy, Engraulis mordax Girard, is a common pelagic schooling fish of the west coast of North America that ranges from Queen Charlotte Islands (Miller and Lea, 1972, p. 56) to approximately Magdalena Bay, Baja California (Ahlstrom 1968, p. 69 and Mais 1974, p. 50). Hubbs (1925, p.18) identified a subspecies, Engraulis mordax nanus, in San Francisco Bay, but this subspecies, if it actually exists, is very minor relative to the northern anchovy population. The population has been divided into northern, central and southern subpopulations based on variations in meristics (McHugh 1951, p. 157) and electrophoretic separation of the blood serum protein, transferrin (Vrooman et. al. 1981), as shown in Figure 3.1-1.

The northern subpopulation occurs off Oregon, Washington and northern California. Richardson (1980) found anchovy eggs and larvae in the Columbia River off Oregon. This discovery supports her hypothesis that early larva development is successful only offshore beyond the continental shelf (Richardson and Pearcy, 1977, p. 42). Tillman (1974, p. 214) determined from length frequency samples of trawl-caught anchovies taken off Washington and Oregon in the winter and spring of 1966 and 1967 that 0-age anchovies were present in the survey area. From this he concluded that successful spawning had occurred in the summers of 1965 and 1966 and that the northern subpopulation has self-sustaining capability.

Apparently, anchovies move seasonally in and out of the bays and estuaries in the northern area. Juvenile anchovy probably use these inshore areas as nursery grounds, but they are not areas of significant spawning (Richardson, 1980). Minor fisheries for anchovy of the northern subpopulation supply bait for albacore and recreational fisheries and take place nearshore in the vicinity of estuaries.

The boundary between the northern and central subpopulations is not well defined. Occasional surveys off California north of San Francisco have not found anchovies in abundance (Frey 1971, p. 49 and Mais 1974, p. 21). The percentages of the transferrin alleles from blood samples taken from anchovies in Humboldt Bay and nearshore at Salt Point, latitude 38°34', were similar to

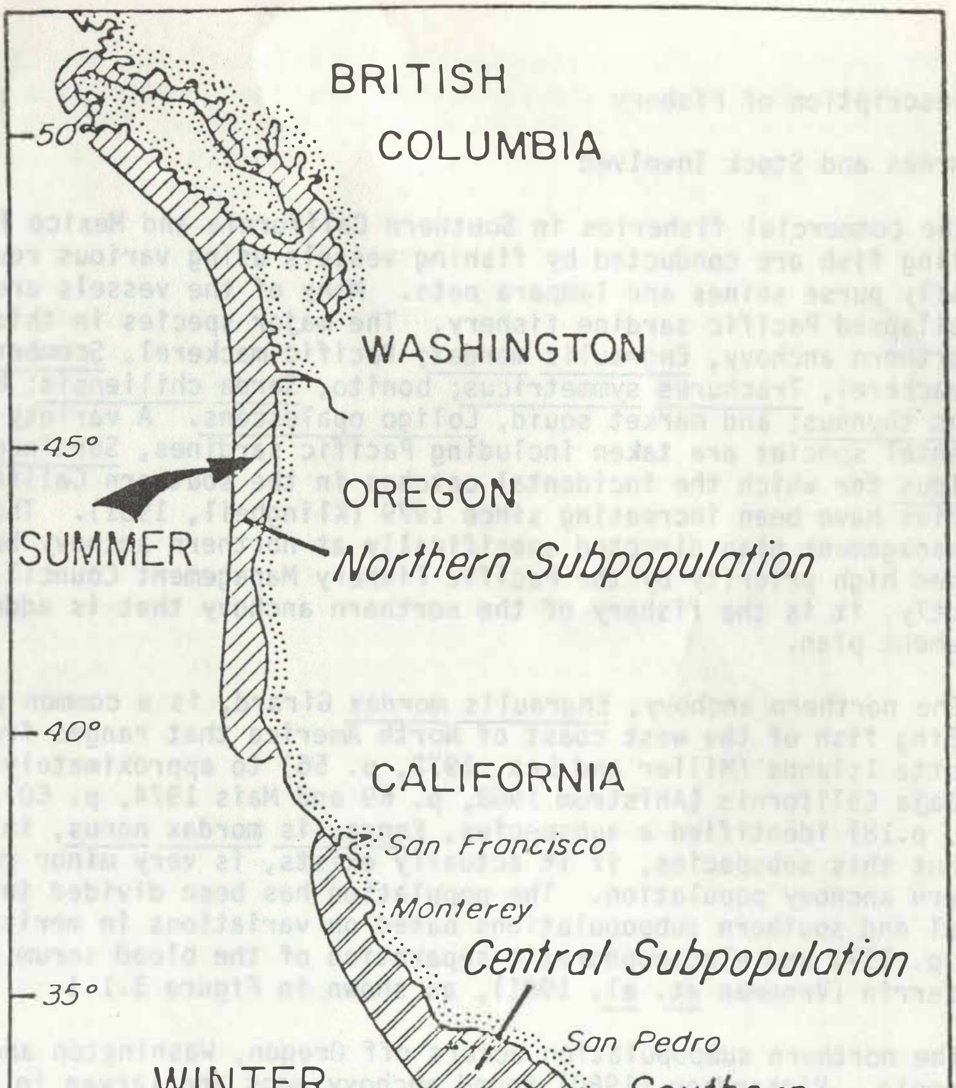


Figure 3.1-1. Geographic distribution and spawning seasons of the three subpopulations of northern anchovy, Engraulis mordax.

those for anchovies from Newport Bay, Oregon (Vrooman et. al. 1981). Two samples they collected from San Francisco Bay were classified as central subpopulation. Of the three samples from Monterey, California, one was identified as northern subpopulation. Sampling in the boundary area between the two subpopulations has been nearshore and too sparse to define the division. The boundary probably fluctuates seasonally and annually in the area just north of San Francisco, approximately 38°N.

The central subpopulation, the most abundant of the three subpopulations (Vrooman and Smith 1971, p. 51), extends from 38°N to approximately 30°N at Punta Baja, Baja California, in the south. Point Conception is considered a faunal boundary for many species but the anchovy central subpopulation is continuous across this point and biological data do not indicate a difference between anchovy collected in areas north and south of this point. Vrooman et. al. (1981) found no difference in the ratio of transferring alleles between these areas. Spratt (1972, p. 19) could not detect any difference in the relationship of otolith weight to fish length for anchovies between the two areas. Mais (1974, p. 25) found only a slight increase in average length for given age in the northern portion of the central subpopulation. Tagging conducted in the late 1960s demonstrated anchovies move between the two areas of the central subpopulation in both a northerly and southerly direction (Haugen, Messersmith and Wickwire, 1969, p. 81 and 82). The overall tag recovery rate was relatively low.

The bulk of the biomass in the central subpopulation is consistently located in the Southern California Bight, an approximate 20,000 sq. n. mi. area bounded by Point Conception, California in the north to Point Descanso, Mexico, in the south, and a series of banks and islands extending in a northwest-southwest direction from San Miguel Island to the Sixty-Mile Bank (Mais, 1974, p. 29). Anchovy eggs and larvae are frequently taken in abundance offshore as far as 200 miles (Smith 1972, p. 869) (see Figure 3.1-2). Based on the years 1951-1975 the estimated number of anchovy larvae from the egg and larva surveys, on the average, 50.7% of the anchovy spawning biomass is in the Southern California Bight. This percentage is consistent for the survey years 1969, 1972 and 1975, although the percentage has fluctuated from 97% in 1957 to 17% in 1961 (Fig. 3.1-3). The San Pedro and Port Hueneme anchovy reduction fisheries take place in the channel area of the Southern California Bight bounded in the north and west by the city of Santa Barbara and Santa Cruz Island and to the south and east by Santa Catalina Island and Dana Point, an area approximately 90 miles long and 22 miles wide or 2,000 sq. n. mi. The commercial harvest of anchovies also takes place to a smaller extent in Monterey Bay. Based on the more recent sea surveys conducted by California Dept. of Fish and Game, on the average, 30.9% of the anchovies monitored by acoustics in the Southern California Bight were inside the area described as the channel. An estimate of the average proportion of the central subpopulation in the channel then is 50.7% times 30.9% or 15.7%, approximately 1/6th of the central subpopulation.

The division between the central and southern subpopulations is relatively well defined although the offshore area has not been sampled adequately. Vrooman et. al. (1981) found a distinction in the percentages of transferrin alleles between 29°33'N and 28°33.2'N from a series of 10 samples taken between 30°50.5'N and 27°04'N. Differences in mean length at age for anchovies north and south of this zone support this division (Mais 1974, p.

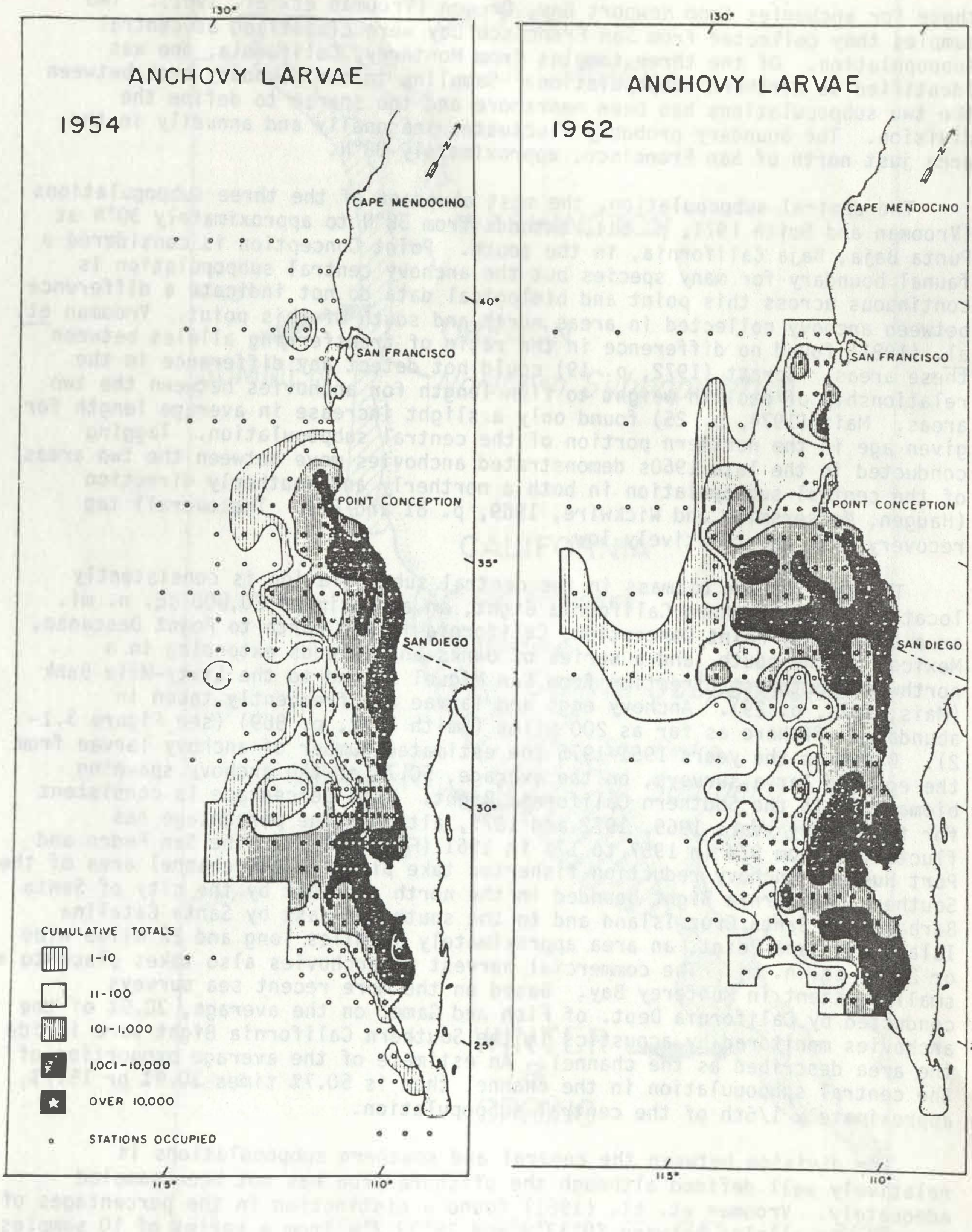


Figure 3.1-2. Distribution of anchovy larvae for years 1954 and 1962 (from Ahlstrom 1966). Legend is number of larvae per 10 square meters.

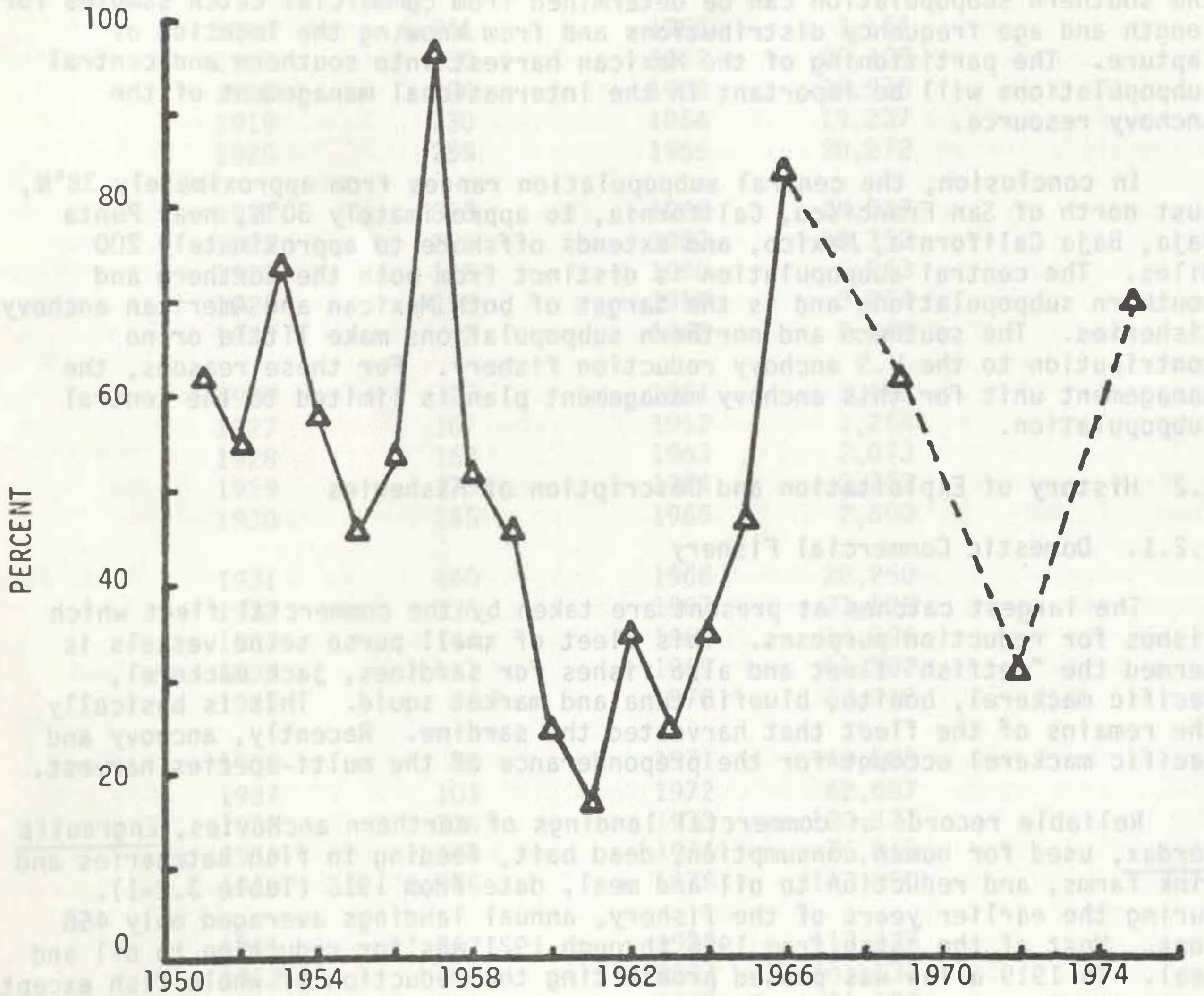


Figure 3.1-3. The percentage of central subpopulation anchovy larvae occurring in the Southern California Bight.

53). The actual location of this division in any one year probably depends on the environmental conditions.

The southern subpopulation resides entirely in Mexican waters and extends south from approximately 30°N, Punta Baja to approximately 24°N, Magdalena Bay (Ahlstrom 1968, p. 68 and Mais 1974, p. 50). Mais (1974, p. 53) found that anchovies in the southern subpopulation are considerably smaller for their age, shorter lived and attain less maximum length than anchovies in the central subpopulation. This subpopulation is harvested to some extend by the Mexican anchovy fishery. The percentage of the anchovy catch attributed to the southern subpopulation can be determined from commercial catch samples for length and age frequency distributions and from knowing the location of capture. The partitioning of the Mexican harvest into southern and central subpopulations will be important in the international management of the anchovy resource.

In conclusion, the central subpopulation ranges from approximately 38°N, just north of San Francisco, California, to approximately 30°N, near Punta Baja, Baja California, Mexico, and extends offshore to approximately 200 miles. The central subpopulation is distinct from both the northern and southern subpopulations and is the target of both Mexican and American anchovy fisheries. The southern and northern subpopulations make little or no contribution to the U.S anchovy reduction fishery. For these reasons, the management unit for this anchovy management plan is limited to the central subpopulation.

3.2 History of Exploitation and Description of Fisheries

3.2.1. Domestic Commercial Fishery

The largest catches at present are taken by the commercial fleet which fishes for reduction purposes. This fleet of small purse seine vessels is termed the "wetfish" fleet and also fishes for sardines, jack mackerel, Pacific mackerel, bonito, bluefin tuna and market squid. This is basically the remains of the fleet that harvested the sardine. Recently, anchovy and Pacific mackerel account for the preponderance of the multi-species harvest.

Reliable records of commercial landings of northern anchovies, Engraulis mordax, used for human consumption, dead bait, feeding in fish hatcheries and mink farms, and reduction to oil and meal, date from 1916 (Table 3.2-1). During the earlier years of the fishery, annual landings averaged only 458 tons. Most of the catch from 1916 through 1921 was for reduction to oil and meal. In 1919 a law was passed prohibiting the reduction of whole fish except under permit. By 1921, this law had reduced anchovy landings to an average of 150 tons for the next 17 years. During the period 1939-1946, landings averaged 1,319 tons.

Scarcity of Pacific sardine, Sardinops sagax caeruleus, caused processors to begin canning anchovies in quantity in 1946; and in 1947, the catch increased to 8,591 tons with landings exceeding canning needs and the excess deliveries being diverted to reduction plants. In order to lower the quantity of anchovies being reduced, the California Fish and Game Commission required each processor to place a large proportion of each ton of anchovies in cans (40-60% depending on can size). Anchovy canning declined with the temporary

Table 3.2-1. Yearly California Anchovy Landings

Year	Metric Tons	Year	Metric Tons
1916	241	1951	3,154
1917	239	1952	25,303
1918	394	1953	38,935
1919	730	1954	19,237
1920	259	1955	20,272
1921	883	1956	25,819
1922	296	1957	18,392
1923	140	1958	5,263
1924	158	1959	3,254
1925	42	1960	2,294
1926	27	1961	3,498
1927	167	1962	1,254
1928	162	1963	2,073
1929	173	1964	2,257
1930	145	1965	2,600
1931	140	1966	28,250
1932	136	1967	31,575
1933	144	1968	14,096
1934	117	1969	61,362
1935	82	1970	87,310
1936	89	1971	40,690
1937	103	1972	62,687
1938	334	1973	120,327
1939	974	1974	75,040
1940	2,866	1975	143,800
1941	1,862	1976	113,327
1942	768	1977	101,131
1943	712	1978	11,457
1944	1,765	1979	53,244
1945	733	1980	49,037
1946	872	1981	52,011
1947	8,591		
1948	4,915		
1949	1,510		
1950	2,213		

resurgence of the sardine population through 1951. With the collapse of the sardine fishery in 1952, anchovy landings again increased to 38,935 tons in 1953. Due to economic conditions, presumably low consumer acceptance of canned anchovies, and an upsurge of sardine in 1958, landings declined to 18,392 tons in 1957 and 5,263 tons in 1958. Landings remained below 4500 tons through 1965.

In November 1965, the California Fish and Game Commission authorized a 68,040 metric ton (75,000 short ton) anchovy harvest for reduction. Quotas ranging up to 150,957 metric tons (166,400 short tons) have been authorized since 1965 (Table 3.2-2). During the first four seasons, catches fell far short of the quotas. The third season (1967/1968) was a near failure with only 5,903 tons taken, almost all in the Monterey Bay area. A declining world price for fish meal and the resulting low price paid to fishermen for their catch, along with a lack of available anchovies close to port, were responsible for decreased landings. Economic conditions improved for the 1968-69 season, when 25,447 tons were landed, and continued to improve throughout the season. During the 1969/70 season, 75,721 tons were landed and the quota for the season was increased to 127,007 tons. The following year the quota was set at 99,791 tons and remained at that level for the next three seasons. During the 1973/74 season, the initial quota was reached and was increased to 122,471 tons. The reduction quota for the 1974/75 season was established at 104,327 tons but later in the season was increased to 117,935 tons. The 1975/76 quota was initially set at 104,327 tons and later raised to 149,687 tons. The quota for the 1976/77 season was 108,863 tons, and for the 1977/78 season the quota was set at 104,327. The 1978/79 season was the first under management of the Pacific Fishery Management Council (PFMC) Anchovy Plan. Fishery quotas under the Anchovy Plan are given in Table 3.3-1.

Vessels fishing anchovies range in length from 12 to 30 meters (38 to 100 feet), and use round-haul nets (purse and lampara). Most of the southern California fleet use purse seine gear, while the vessels fishing in the Monterey Bay area mainly fish with lampara nets. For further descriptions, see Scofield (1951) and Knaggs (1972).

Fishing effort for anchovies is at the present time mainly in southern California waters. Some catches for reduction are made in Monterey Bay and are landed at Moss Landing. Several vessels land anchovies at Port Hueneme (Oxnard) but the major reduction landings are made at Terminal Island (San Pedro). The principal areas of catch are the Catalina Channel and the Santa Barbara Channel. The California fleet fishing anchovies for reduction has fluctuated during the last few years (Table 3.2-2); however, the "basic" fleet has remained about the same and approximates 25 vessels.

3.2.2. Domestic Live-Bait Fishery

The live-bait industry consists of the harvest, maintenance, and sale of small, live marine fish to anglers for use as bait and/or chum. This unique fishery had its introduction in southern California in 1910 by Japanese albacore fishermen who employed blanket nets to capture small forage fish in their fishing operations. In 1912, the lampara net was introduced into the fishery and sport boats carrying anglers to the offshore fishing grounds began using their own nets to capture bait.

Table 3.2-2. Quotas and landings for the U.S. reduction fishery (metric tons). No. boats includes all boats landing at least one load of anchovies.

	YEARS																				
Seasons	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	Quota	Landings	No. Boats
1965-66	155	15,125																	68,040	15,280	30
1966-67		9,685	24,439																68,040	34,124	35
1967-68			4,907	996															68,040	5,903	41
1968-69				11,519	13,928														68,040	25,447	30
1969-70					45,225	30,496													127,007	75,721	31
1970-71						53,832	20,154												99,791	73,986	30
1971-72							19,447	29,022											99,791	48,469	38
1972-73								31,413	37,098										99,791	68,511	37
1973-74									81,334	28,108									122,471	109,442	40
974-75										45,293	61,314								117,935	106,607	44
975-76											80,272	47,720							149,687	127,992	50
976-77												64,550	32,042						108,863	96,592	45
977-78													67,632	1,032					104,327	68,664	48
978-79														9,307	40,033				52,919	49,340	34
979-80															7,375	27,167			132,541	34,542	30
980-81																16,532	44,032		150,957	60,564	37
981-82																	7,140	40,863	370,226	45,056	30
otals	155	24,810	29,346	12,515	59,153	84,328	39,601	60,435	118,432	73,401	141,586	112,270	99,674	10,339	47,408	43,699	51,172	40,863			

As the sport fishing industry grew, the demand for live-bait also increased, causing a greater degree of specialization in boats and nets, and in the methods of locating and distributing the live-bait. Shortly after WWII, the demands for live-bait became sufficient to support a fleet engaged solely to supply bait. This fishery is important today because the most prized sport fishes usually prefer live-bait to any other offering.

The live-bait fishery is located principally in southern California with smaller fisheries at Morro Bay and San Francisco. The mainstay of the live-bait fishery has always been anchovies, but prior to the virtual disappearance of the sardine, as much as 15 to 20% of the bait consisted of young sardines. Since 1957, when the last large influx of young sardines was observed, anchovies have comprised 98-99% of the live-bait catch. The remainder of the catch is comprised of white croaker, queenfish, Pacific sardine, jack mackerel, Pacific mackerel and squid.

In recent years, the live-bait fishery has landed between 4,800 and 6,400 tons of bait each year (Table 3.2-3). During 1975, between 40 and 45% of the live-bait taken in waters off California was caught off San Diego. Between 20 and 25% was taken off San Pedro, while Santa Monica Bay and waters off Newport each yielded from 10 to 20% of the total catch. Less than 5% of the total catch was taken in each of the following areas: Morro Bay-Avila, Port Hueneme and Oceanside.

During the period 1947 to 1969, the number of live-bait fishermen gradually declined as overhead costs and lack of good contracts took their toll of the small independent bait operator. The number of boats reporting their catch to the California Department of Fish and Game went from a high of 30 boats in 1940 to a low of 10 boats in 1969. At the present time, there are 13 bait operators who supply virtually the state's entire live-bait catch (Table 3.2-3). Some of these fishermen also participate in the anchovy reduction fishery.

This small but important fleet is faced with a difficult logistical problem. Daily commitments of quality bait during peak sport fishing activity exert a great deal of pressure. Bait haulers, by necessity, must fish relatively close to home. When live-bait becomes scarce or of poor quality locally, the amount of effort (time) expended to fish elsewhere and transport their catch can be considerable. During some years, the albacore fleet used anchovies for chumming albacore. This bait may be purchased from the live-bait industry, or, in many cases, be caught by the albacore fishermen. These "baiting" activities occur at a number of ports in California.

The seasonal distribution and behavior of the northern anchovy often has a major influence on the live-bait industry. Historically, live-bait dealers have had difficulty meeting their commitments during the summer months. Whenever live-bait becomes scarce, a great deal of anxiety within the recreational fishing industry surfaces and there seems little that can be done to allay fears of overfishing.

In past years, when bait shortages occurred during summer months, Los Angeles-Long Beach Harbor usually proved an exception and many live-bait fishermen along the coast depended on this traditional fishing area for their bait. In some years, the harbor provided as much as 30% of all live bait

Table 3.2-3. Commercial landings and live-bait catch of anchovies in California, 1939-1981 (metric tons).

Year	Commercial Landings*	Live-Bait	Total	Percent Live-Bait	Number of Live-Bait Boats Reporting
1939	974	1,364	2,338	58.3	--
1940	2,866	1,820	4,686	38.3	30
1941	1,862	1,435	3,297	43.5	--
1942	768	234	1,002	23.4	9
1943	712	--	712	--	--
1944	1,765	--	1,765	--	--
1945	733	--	733	--	--
1946	872	2,493	3,365	74.1	--
1947	8,591	2,589	11,180	23.2	--
1948	4,915	3,379	8,294	40.7	25
1949	1,507	2,542	4,049	62.8	23
1950	2,204	3,469	5,673	61.1	25
1951	3,154	4,665	7,819	59.7	22
1952	25,303	6,178	31,481	19.6	24
1953	38,935	5,798	44,733	13.0	30
1954	19,237	6,065	25,302	24.0	23
1955	20,272	5,557	25,829	21.5	22
1956	25,819	5,744	31,563	18.2	18
1957	18,392	3,729	22,121	16.9	17
1958	5,263	3,843	9,106	42.2	24
1959	3,254	4,297	7,551	56.9	16
1960	2,294	4,225	6,519	64.8	13
1961	3,498	5,364	8,862	60.5	16
1962	1,254	5,595	6,849	81.7	22
1963	2,073	4,030	6,103	66.0	23
1964	2,257	4,709	6,966	67.6	22
1965	2,601	5,645	8,246	68.5	24
1966	28,250	6,144	34,394	17.9	18
1967	31,575	4,898	36,473	13.4	16
1968	14,096	6,644	20,740	32.0	19
1969	61,362	4,891	66,253	7.4	10
1970	87,310	5,543	92,853	6.0	11
1971	40,690	5,794	46,484	12.5	11
1972	62,687	5,307	67,994	7.8	12
1973	120,327	5,639	125,966	4.5	12
1974	75,040	5,126	80,166	6.4	14
1975	143,800	5,577	149,377	3.7	14
1976	113,327	6,202	119,529	5.2	13
1977	101,131	6,410	107,541	6.0	13
1978	11,457	6,013	17,470	34.4	13
1979	53,244	5,364	58,608	9.2	13
1980	49,037	4,921	53,958	9.1	13
1981[1]	51,985	4,249	56,234	7.6	

*for all uses
1preliminary

caught and was the mainstay of the live-bait fishery in southern California. In particular, the 1957, 1963, 1965 and 1966 summer seasons found the majority of bait boats fishing the harbor throughout the summer months. Between 1956 and 1966 boats from as far away as San Diego were forced to fish Los Angeles Harbor on numerous occasions for five out of the ten seasons.

In some years, the quality of bait creates as many problems for the fishermen as a shortage of bait. In 1957, 1958 and 1959, tremendous quantities of "pinheads" (small, juvenile fish) moved inshore along the southern California coast and plagued the live-bait fishermen. At the same time, fishermen's observations, stomach analysis of offshore fish (tuna), and research cruises indicated large anchovies were abundant offshore in deeper waters where the lampara nets of the bait fishermen cannot work efficiently. Bait fishermen were forced to expend additional inshore effort in order to secure quality bait during these seasons.

The live-bait fishermen use lampara nets almost exclusively. The lampara net is a forerunner of the purse seine, but lacks the ability to close or "purse" the bottom of the net to prevent the fish from escaping. Therefore, lampara nets are usually used in shallow waters where the sea bottom serves this purpose. The use of such nets forces live-bait fishermen to fish in inshore areas, and does not allow them to catch offshore fish efficiently, even when they are abundant. Use of purse seine gear would ideally improve the bait fishermen's ability to supply live-bait, however, the purse seines that have been tried have tended to injure the fish, thus severely reducing survival in the bait wells. It appears likely that many of the problems of bait availability can be overcome through improvements in gear technology.

3.2.3 Mexican Fisheries

There are two user groups involved in the harvest of northern anchovies in Mexico. Both these groups are based in Ensenada, Baja California at the present time. The recreational fishery uses anchovies as bait for partyboats and for individual sportsmen. The commercial fishery is conducted by boats based at Ensenada. The anchovies are used for reduction and canning; and a small amount may be taken for use as bait by the albacore fleet.

Mexico's utilization of the anchovy resource off her west coast has increased considerably during the last few years (Table 3.2-4) with the increase in the processing capabilities at Ensenada as well as the size and quality of the fishing fleet; landings for the reduction fishery based in this port should continue to increase during the next few years.

The Mexican commercial fishing fleet contains a number of rather small purse seiners averaging less than 45 tons hold capacity. These vessels fish close inshore and relatively close to Ensenada. Part of the fleet consists of larger vessels that fish for anchovies part of the year, then move to the Gulf of California to participate in the sardine fishery. Six large purse seiners of 270 net ton capacity joined the anchovy fleet in 1976. These vessels will fish anchovies on an all-year basis.

While a large portion of the catch landed at Ensenada is from the central stock, part of the catch is made up of fish from the southern stock.

Table 3.2-4. Anchovy landings at Ensenada, Baja California (metric tons).

1965	9,171	1974	39,826
1966	13,243	1975	55,251
1967	20,104	1976	75,760
1968	14,267	1977	142,211
1969	3,871	1978*	142,000
1970	27,977	1979*	205,000
1971	20,079	1980*	246,000
1972	32,640	1981*	259,000
1973	14,853	1982*#	170,000

* Unofficial
\# Preliminary

3.3 History of Anchovy Management

3.3.1. California Management Institutions, Policies & Jurisdictions

Management of the anchovy fishery by the state of California is divided among three bodies: the California State Legislature, the California Fish and Game Commission, and the California Department of Fish and Game. The State Legislature is responsible for making laws governing most commercial fishing activities, including take of anchovies for bait and for human consumption (fresh or canned). The laws passed by the state legislature comprise the Fish and Game Code.

The California Fish and Game Commission is a panel of five people appointed by the Governor. The Commission's main purpose is to determine sportfishing and hunting regulations, which comprise "Title 14." At times, the legislature has voted to give the Commission management authority over certain commercial fisheries. In 1965, the Commission was given such authority to regulate the anchovy reduction fishery.

The Department of Fish and Game is responsible for enforcing the regulations set by both management authorities, which also includes monitoring of the fishery for quota purposes. The Department is a principal source of management advice to the legislature and to the Commission, and usually is the source of draft legislation on fishery matters.

With the enactment of the Fishery Conservation and Management Act of 1976, California State Legislature passed into law (section 7652 and 7653 of Fish and Game Code) a procedure by which the Director of Fish and Game can bring State law or Commission regulations into conformity with fishery management plans prepared by the Pacific Fishery Management Council and approved by the Secretary of Commerce. This law gives the Director the power to make inoperative any statute or regulation for up to 180 days and/or adopt new regulations effective for up to 180 days. The Director must then report such actions to the California State Legislature that need to be enacted as statutes to conform State law to the fishery management plan.

3.3.2. California Management of the Anchovy Reduction Fishery

Reduction of whole fish has been prohibited except by special permit in California since 1919. The current fishery management regime in California began in 1965 when the State Legislature authorized the Fish and Game Commission to promulgate regulations covering a commercial fishery for anchovy reduction plants. The fishing season was initially October 15 to April 15, but later was extended to September 15 to May 15 in southern California, and from August 1 to May 15 in northern California. In some years the month of February was closed to reduction fishing. A minimum size limit of 12.7 cm (5 inches) total length also was established with a percentage allowance for undersize anchovies. In each year, prior to opening the fishing season, the Commission would solicit testimony from various government agencies, the fishing industry, and from the public regarding the anchovy fishery and anchovy stock assessment. Based upon the information presented in the hearing, the Commission would establish a reduction quota for the subsequent fishing season. During the season the quota could be increased when the cummulative landings approached the quota.

California Fish and Game Commission quotas (see Table 3.2-2) grew from about 68,000 metric tons (75,000 short tons) to a peak of about 150,000 metric tons (165,000 short tons) in 1975/76. During the 1965/66 through 1967/68 seasons the quota was divided among several geographic regions. These regional quotas were abandoned after 1968, except for an allocation of 9,000 metric tons to the northern area (which includes Monterey). In southern California, fishing for reduction was prohibited within 3 nautical miles of the mainland shore, with some additional local closures (Fig. 3.3-1).

In anticipation of management under the Fisheries Conservation and Management Act or 1976, The Fish and Game Commission adopted a Management Plan for the Northern Anchovy in January of 1977. This Plan maintained the existing area closures, seasons and size limit regulations for the reduction fishery. In addition a formula was adopted which linked the annual reduction quota to the annual anchovy stock assessment. The Commission's "resource safeguards" were expressed in the following five points quoted from the Plan (see Greenhood, et al., 1978 page ii):

1) Establish one million short tons spawning population as a minimum reserve stock to adequately maintain the reproductive potential of the stock, as well as provide adequate forage for migratory and resident fish, marine mammals and birds, and sufficient stock size for live bait and fresh fish fisheries.

2) If the spawning population of the central stock falls below one million short tons, no fishing for reduction purposes will be permitted.

3) Annual quotas will be based on spawning population estimates.

4) If spawning population falls below 2.3 million short tons, the quota will be based on a formula of one-third of the excess over one million short tons. When the spawning population estimate exceeds 2.3 million short tons, the quota cannot exceed 450,000 short tons.

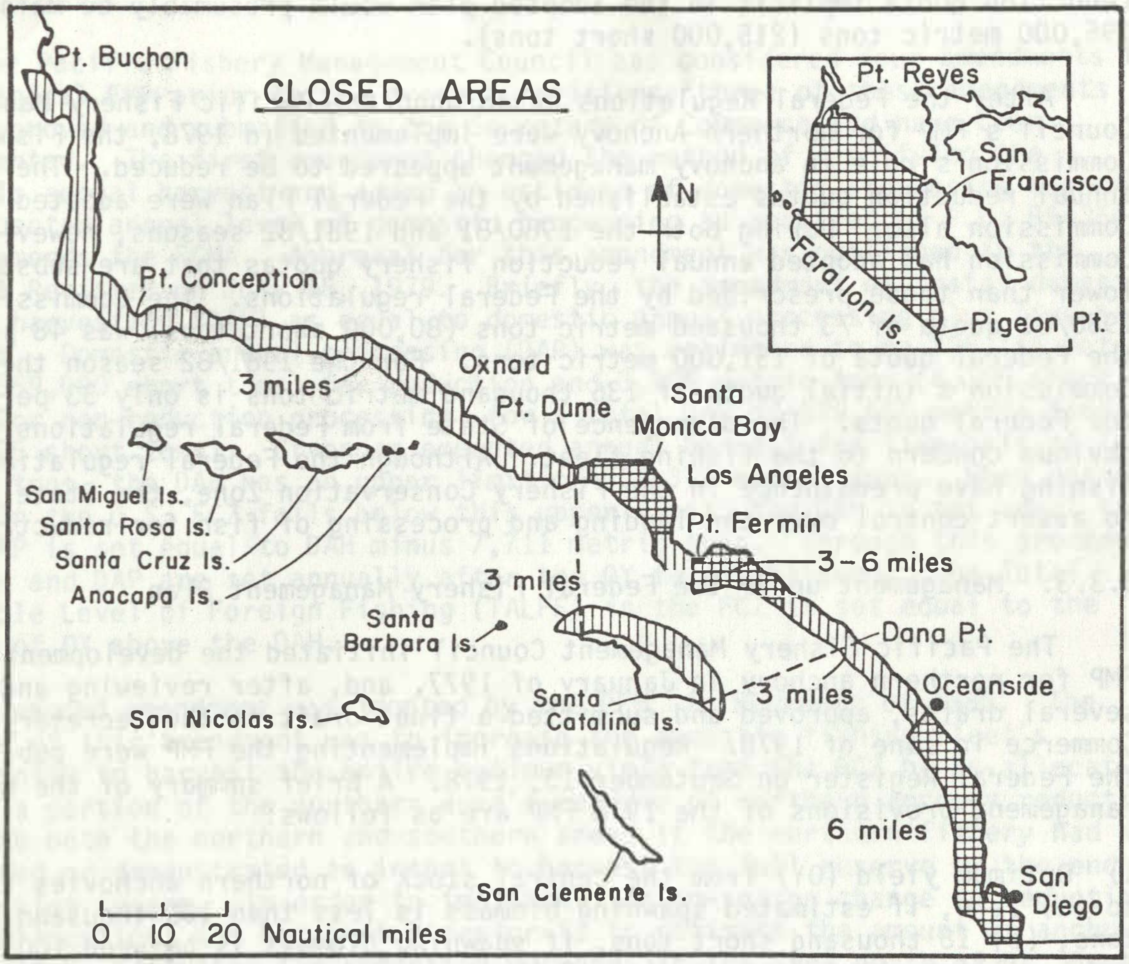


Figure 3.3-1. Existing California area closures (hatched areas extend to 3 miles offshore; cross-hatched areas extend beyond 3 miles offshore) and optional Catalina Channel foreign vessel closure (outlined by dashed lines).

5) Based on the optimum yield of anchovy from the central stock, the Department is recommending 215,000 short tons be allotted for reduction purposes as an interim California quota pending completed negotiations with Mexico.

Since the anticipated negotiations with Mexico has not occurred, the annual reduction quota implicit in the adopted plan would presumably be maintained at 195,000 metric tons (215,000 short tons).

After the Federal Regulations based upon the Pacific Fishery Management Council's FMP for Northern Anchovy were implemented in 1978, the Fish and Game Commission's role in anchovy management appeared to be reduced. The first two annual reduction quotas established by the Federal Plan were adopted by the Commission also. During both the 1980/81 and 1981/82 seasons, however, the Commission has adopted annual reduction fishery quotas that are substantially lower than those prescribed by the Federal regulations. The Commission's 1980/81 quota of 73 thousand metric tons (80,000 short tons) was 48 percent of the Federal quota of 151,000 metric tons. For the 1981/82 season the Commission's initial quota of 136 thousand metric tons is only 33 percent of the Federal quota. The divergence of State from Federal regulations presents obvious concern to the fishing fleet. Although the Federal regulations on fishing have preeminence in the Fishery Conservation Zone, the State continues to assert control over the landing and processing of fish for reduction.

3.3.3. Management under the Federal Fishery Management Plan

The Pacific Fishery Management Council initiated the development of an FMP for northern anchovy in January of 1977, and, after reviewing and revising several drafts, approved and submitted a final draft to the Secretary of Commerce in June of 1978. Regulations implementing the FMP were published in the Federal Register on September 13, 1978. A brief summary of the main management provisions of the 1978 FMP are as follows:

1) Optimum yield (OY) from the central stock of northern anchovies is equal to (a) zero, if estimated spawning biomass is less than 100 thousand short tons, (b) 18 thousand short tons, if spawning biomass is between 100 thousand and 1 million short tons, or (c) 18 thousand short tons or one-third of the biomass in excess of 1 million, whichever is greater, when spawning biomass exceeds 1 million short tons.

2) The overall harvest quota in the United States' Fishery Conservation Zone (FCZ) is equal to 70 percent of the optimum yield.

3) Twelve thousand six hundred (12,600) short tons of the U.S. quota is reserved for the non-reduction fishery.

4) A portion of the reduction fishery quota equal to the smaller of 10,000 short tons or 10 percent of the total reduction quota is reserved for the fishery north of Pt. Buchon.

5) No reduction fishing is allowed from July 1 through July 30 north of Pt. Buchon, July 1 through September 14 south of Pt. Buchon, and February 1 through March 30 both north and south of Pt. Buchon. Non-reduction fishing is

permitted all year.

6) A size limit of 5 inches is imposed upon the reduction fishery but not upon the non-reduction fishery. Incidental catch of short fish is allowable in quantities of less than 15 percent by weight in any load.

7) Certain portions of the FCZ are closed to anchovy reduction fishing (see Figure 3.3-1).

The Pacific Fishery Management Council has considered four amendments to the original FMP prior to the present revisions; three of these amendments were approved and submitted to the Secretary of Commerce and have been implemented. The first amendment changed the method of specifying the domestic annual harvest and added an estimate of domestic processing capacity and expected annual level of domestic processing as required by P.L. 95-354 which amends the FCMA. Approval for this amendment was published in the Federal Register on July 18, 1979. Briefly, the amendment estimates domestic annual harvesting (DAH) as equal to domestic annual processing plus live-bait harvest. Domestic annual processing (DAP) was estimated to be 325,756 metric tons (359,080 short tons) for reduction and 3,905 metric tons (4,305 short tons) for non-reduction processing, for a total DAP of 329,661 metric tons (363,385 short tons). Given an expected annual harvest for live-bait of 7,711 metric tons, the DAH has an upper limit of 337,372 metric tons. When optimum yield in the U.S. FCZ falls below this upper limit, the DAH is set equal to OY. DAP is set equal to DAH minus 7,711 metric tons. Through this procedure the DAH and DAP are set annually after the OY is established. The Total Allowable Level of Foreign Fishing (TALFF) in the FCZ is set equal to the excess of OY above the DAH.

A second amendment was adopted by the PFMC in February of 1980. The purpose of this amendment was to increase the domestic fishing fleet's opportunity to harvest the entire optimum yield from the FCZ by re-allocating all or a portion of the northern area's reserve of northern anchovy reduction quota to both the northern and southern areas if the northern fishery had not harvested or demonstrated an intent to harvest the full reserve by the end of the fishing season. In order to implement the in-season change in reduction quota allocation, the Regional Director is to estimate the amount of anchovies that will be harvested for reduction purposes in the area north of Pt. Buchon by May 15 during each fishing season. Specific procedures for making this estimate are established in the FMP amendment. To determine whether the special allocation should be modified, the expected harvest in the northern area must be compared to the special allocation for the season. If the expected harvest exceeds the special allocation, then no re-allocation is made. If the special allocation is greater than the expected catch, then the difference between the two numbers is a surplus which can be subtracted from the special allocation as of June 1.

During spring 1982 the PFMC considered a third amendment that divided the quota into two halves and made release of the second half conditional on the results of a mid-season review of the status of the stock. The amendment was intended primarily as a safeguard during the interim period when egg production estimates of spawning biomass were converted to larva census equivalent biomass estimates for calculation of the annual quota. The complexity of the methods proposed for the mid-season assessment were considered too difficult to implement and the amendment was not approved.

In November 1982 the PFMC submitted to the Secretary of Commerce amendment four to the original anchovy FMP. There were two clauses to this amendment. The first abolished the 5-inch size limit in the commercial fishery and established a minimum mesh size of 10/16 inch in its stead. The rationale was that the 5 inch size limit had little biological justification, was difficult to comply with during the spring fishery, and its intent was substantially accomplished by the nearshore area closure. The minimum mesh size was set at the prevalent mesh size in the fishery. Implementation of the minimum mesh size was delayed until April 1986 to allow the fleet adequate time for compliance without creating economic hardship.

The second clause to the fourth amendment established a mid-season quota evaluation that was simplier in design than the method proposed in amendment three. Amendment four split the annual quota into two halves. The first half would be allocated at the beginning of the season. The second half would be allocated unless evidence was presented to demonstrate that harvest of the second half would reduce the following year's spawning biomass below the level of one million short tons. Amendment four was implemented by the Secretary of Commerce in 1983.

The biomass estimates, optimum yields and reduction fishery quotas established under the anchovy FMP regulations are summarized below in Table 3.3-1. Actual U.S. catches have not matched the quotas allowed except in the first season when the southern area fishery took its portion of the quota and was closed on June 8, 1979.

3.3.4. International Aspects of Anchovy Fishery Management

An important consideration in establishing a conservation regime for the northern anchovy is the inclusion of all major fishing operations under one management program. Since the Mexican fishery in Ensenada developed rapidly during the 1973-1978 period (see Table 3.2-4), the primary difficulty in satisfying this criteria has been the lack of a bilateral agreement with Mexico. In regards to fishery matters, U.S.-Mexico relations have been unsettled and not very productive for cooperative fishery management. For example, a bilateral agreement allowing traditional U.S. fishermen access to Mexico's 12-mile zone was established in November of 1976, but Mexico announced its intention to terminate this agreement effective December 29, 1981. Similarly, the Governing International Fishery Agreement signed in August of 1977 was terminated as of June 29, 1981. Thus Mexico and the United States do not have effective means of jointly managing stocks, like anchovy, that are physically present in the coastal zones of both nations.

Under the anchovy FMP implemented in September 1978, the allocation of optimum yield from the central subpopulation of northern anchovy to the United States and Mexican waters is based upon the distribution of the anchovy larvae detected in historical ichthyoplankton surveys. The weighted average percent of larvae in the U.S. FCZ during the 1951-1975 period was 70 percent. Without a formal agreement with Mexico, the FMP established the U.S. optimum yield to be 70 percent of the total OY from the stock. An obvious difficulty with this procedure is that the Mexican harvest is not limited by a management authority to be only 30 percent of the OY established in the FMP. Thus the U.S. plus Mexican harvests may exceed the OY in some years.

Table 3.3-1. U.S. anchovy fishery under the federal regulations. Biomass optimum yield, reduction fishery quota and catch (metric tons).

Season	Estimated Spawning Biomass* (million tons)	Optimum Yield (1000 tons)	U.S. Reduction Quota (1000 tons)	U.S. Reduction Catch (1000 tons)
1978/79	1.18	91.6	52.9	49.3
1979/80	1.56	186.5	132.5	35.2
1980/81	1.61	232.0	150.9	60.6
1981/82	2.54	545.2	370.2	45.1
1982/83	1.87	320.5	212.9	-

*Estimated by larva census or equivalent

3.3.5. Problems and Controversies in Anchovy Management

Some historically important controversies continued under the Federal Anchovy FMP and some additional problems have appeared. A short summary of five prominent problems follows:

1) Forage reserve and bait supplies:

Since the inception of the anchovy reduction fishery in 1965, this has been the most prevalent and heated source of controversy. Northern anchovies are the most abundant small epipelagic fish in the California Current off central and southern California. As such, the anchovy is probably one of the prime forage stocks for larger pelagic fish. Controversy occurs on two fronts: first, what are the biological/ecological facts; and, second, whose interests are to be served by the public management regime? The extent to which the commercial fishery for anchovies has a deleterious effect upon the abundance and location of recreationally important fish stocks is not firmly established. Thus the field is open to competing claims. Similarly, the effects of reduction fishing on live-bait supplies are unclear. No valid statistical association between the level of reduction fishing and the availability of live-bait has been established. Yet the common belief persists among live-bait fishermen that the reduction fishery depletes in-shore bait fish.

The distribution of economic benefits from the anchovy stock constitutes the second aspect of the forage/bait topic. If there is a real trade-off between having more pelagic predator fish and bait fish versus having a larger commercial, reduction fishery, then a key decision for anchovy managers is to decide how to divide up the economic "pie". Greater reduction fishery quotas entail smaller catches of other pelagic fish species and smaller supplies of live-bait. Lack of scientific evidence to resolve the factual questions, however, leaves the controversy for resolution by other means.

2) Endangered species - the brown pelican:

The brown pelican (Pelecanus occidentalis californicus) has been classified as an endangered species according to the Endangered Species Acts (ESA) of the United States and the State of California. Because anchovies comprise a major part of the diet of pelicans, fishing activities potentially could have a negative impact on pelicans through reduction in anchovy availability near the breeding colonies and through direct disturbance of the nesting and foraging birds. Therefore it is incumbent upon fishery management agencies to consider anchovy as an important part of the habitat of brown pelican and to avoid any significant deleterious impacts on the pelican's ecosystem. Potential impacts are discussed in Section 4.2.6.3, and ESA requirements are given in Section 8.5.4.

The National Environmental Policy Act requires that an Environmental Impact Statement be prepared to describe the effects of the proposed regulations on this endangered species. This EIS is accomplished by cross-referencing within this document (see section 1.2).

3) Accuracy of biomass estimate:

Because the size of the northern anchovy population is never directly enumerated, the statistical method of estimating the population biomass can never be checked against a known, absolute measure. One consequence of this is that the stock abundance estimates presented by scientists cannot be proven to be accurate. Accuracy must be inferred from theory, sample design considerations, and careful treatment of samples and data collected. The two primary measures of abundance both require extensive sea surveys and substantial data manipulation and extrapolation. The larva census estimates the standing stock of larvae from a sequence of surveys covering the main spawning period for the anchovy. A historical calibration factor converts this standing stock to an estimate of spawning biomass. The egg production method estimates the rate of egg production from an egg and larval survey and simultaneously estimates the rate of egg production per unit spawning biomass from a trawl survey. The ratio of these two estimates is the spawning biomass; no calibration factor is necessary. The "larva census" has a long history of application, while the "egg production" estimate has been developed recently. Preliminary biomass estimates made with the "egg production" method in 1978 and since 1980 were substantially lower than the corresponding larva census estimates. The contemporaneous announcement of two alternative estimates in 1980 made the biomass estimate a focus for controversy. The egg production method is now considered more accurate because parameters that were assumed to be constant in the larva census method are measured annually with the egg production method. Potential biases in the egg production method are discussed in Methot and MacCall (1983) and are shown to be small.

4) Fish size limit for the reduction fishery:

During the development of the anchovy FMP no particular problems or issues arose over the traditional five-inch minimum size limit for reduction fish. In fact the computer model of the fishery provided some support for the establishment of a five-inch minimum size limit. This model showed that a larger average yield would be possible from the fishery if the youngest age class was protected from fishing mortality until it reached one year of age. Two assumptions based upon biological characteristics of the fish were that the fish reach a size of five inches in one year, and that the onset of maturity and spawning occur at about this same time. In 1980, however, the fishery found that many of the anchovy schools available were largely fish of less than five inches in total length. Also, evidence from the size composition data indicated that the one-year-old fish had failed to reach five inches. Thus there is some question of whether the five inch size limit had the intended effect of protecting pre-spawners. With a large incoming year class that remains below five inches in average size, the fishermen have a difficult time complying with the size limit. An amendment that replaces the five inch size limit with a minimum mesh size requirement was sent to the Secretary of Commerce by the PFMC in 1982, and was implemented in 1983.

5) International management:

As noted in Section 3.3.4 above, the transboundary management problem inherent in the U.S./Mexico fisheries for anchovy is not being addressed in a meaningful way. This will continue to be a problem, possibly a critical one until a cooperative management agreement is established. Of most immediate concern is that the total harvest from the central subpopulation may exceed the level desired by either the United States or Mexico.

A secondary problem arose in 1981 when the Marine Resources Company of Seattle, Washington sought permission to harvest anchovies, jack mackerel, Pacific mackerel and squid from the FCZ off of southern California using local, domestic fishing vessels and a leased processing vessel owned by the USSR. The anchovy plan originally implemented by the Secretary of Commerce did not provide for an allocation of the OY to foreign processors. In fact the FMP called for a review and revision when foreign fishing or joint venture processing became important in the fishery. Thus the current regulations are insufficient to deal smoothly with the development of a foreign processing operation in the FCZ. This and the public reaction to the introduction of a foreign element to the fishery have made the joint venture a troublesome problem under the current management regime.

The five areas of controversy listed here arose under the pre-FCMA setting and under the first Anchovy FMP. All must be addressed by the proposed fishery management regulations in this Plan.

3.4 History of Research

3.4.1 Domestic Research

Research on the population of northern anchovy is relatively recent. In general, it began as studies incidental to sardine research in the early 1950s. As sardines disappeared and anchovies became more abundant, research in the pelagic fish stocks took on multiple species objectives. The research of California Department of Fish and Game (CF&G), National Marine Fisheries

Service (NMFS), Scripps Institution of Oceanography (SIO) and California Academy of Science has been coordinated through California Cooperative Oceanic Fisheries Investigations (CalCOFI). The CalCOFI research led to the hypothesis that the expanding anchovy population filled the void in the ecological niche once occupied by the sardine. A fishing experiment was planned that proposed to reduce the anchovy stocks by harvesting 200,000 tons annually so that the sardine might have a chance to return (Hewitt, MS, p. 10). The experiment was never carried out, but the anchovy reduction fishery did begin in the fall of 1965.

NMFS (then the Bureau of Commercial Fisheries) conducted egg and larva surveys in the California Current region beginning in 1949. Anchovy biomass information is available for 1951 to present. In the early 1960s, NMFS initiated physiological research on anchovies that has developed into a thorough investigation of the parameters of the stock-recruitment process. The logbook system for aerial fish spotters that scout for the purse seiners was initiated in 1962. In 1978 NMFS began research on the development of the egg production method of estimating anchovy biomass as an alternative to the larva census method utilizing CalCOFI egg and larva data. CF&G has conducted sea surveys for mapping the distribution and density of adult fish throughout the year, also since the early 1950s to the present. Once the anchovy reduction fishery began in 1965, CF&G instigated a logbook system and stepped up their catch sampling program, both of which are ongoing. Little has been done with the logbook data with respect to catch per effort information. CF&G has developed ageing methods using scales and otoliths. Age compositions of the samples from sea surveys and port sampling are routinely published. Rates of growth and mortality have subsequently been estimated using this age composition data. With the development of underwater acoustic technology, both CF&G and NMFS developed sonar surveys. CF&G's objective was to assess anchovy biomass available to the fishery in the Southern California Bight. NMFS emphasized research and development of technology for assessing pelagic fish stocks. A major tagging program was initiated in the mid-1960s that provided information on fish movement but was terminated. Identification of subpopulations in the anchovy population has been studied by the two agencies since 1950.

Since 1979, research at the NMFS Southwest Fisheries Center has been directed at developing an "egg production method" for estimating anchovy biomass (see section 4.3.1). This method is able to produce a spawning biomass estimate, with statistical confidence limits, within a few months of completion of a one-month survey of egg abundance and adult fish gonad condition. A wealth of information on behavior, physiology and demography (fecundity, size at maturity, etc.) has been gained from the sampling and theory development of the egg production method.

SIO has emphasized research on the oceanography of the California Current to describe the environment of the pelagic fishery resources. They also have compiled a 2000 year time series on relative biomass of sardine and anchovy from scale deposits in the bottom sediments of anaerobic deep-sea basins. California Academy of Science supported the coordinator of CalCOFI programs in the past but now is no longer active in CalCOFI. Their research has emphasized population dynamics of the sardine population and food habits of the various pelagic species.

3.4.2 Foreign Research

The Soviet Union has been interested in the anchovy resource off California since it began its fishery for Pacific hake (Merluccius productus) in 1966. In cooperation with NMFS they have conducted egg and larva surveys particularly directed at Pacific hake. They also have studied the fishery resources using acoustic and midwater trawl surveys. From this research they have attempted to map the density and distribution of the anchovy resources although their results are incomplete because of the limited number of surveys both within a season and between years. They have expressed an interest in developing a commercial fishery for anchovies, but this has never been attempted.

Partially as a result of the well-documented U.S. research on the magnitude of northern anchovy resource off the States of California and Baja California, Mexico, with FAO sponsorship, developed plans for expanding its anchovy fishery in the mid-1970s. Increased research priorities in Mexico resulted in U.S.-Mexico cooperative research studies and information exchanges. This work is informally coordinated though CalCOFI under the INP-CalCOFI Stock Assessment Committee which meets approximately twice a year. This provided a forum for discussing (at the scientific level) research objectives, national fishery objectives and future management policies. Unfortunately as Mexico expanded its fishery to 250,000 tons annually in 1980, anchovy research by INP waned to the point that collection of catch data on fish size and age composition practically ceased. Pesquera Zapata, the primary processor of anchovies in Ensenada has maintained an active catch sampling program, and some of their information has been made available on an informal basis.

3.5 Socio-Economic Characteristics

Salient economic characteristics of the anchovy fisheries of California are discussed with respect to the commercial fleets landing anchovies and the live-bait fleet selling fish to recreational fishermen and commercial partyboat operators. Little comprehensive economic data is available with respect to the live-bait fishery or the recreational fisheries occurring in California. Nevertheless, the social and economic importance of the recreational sector is reflected in the data and descriptive material presented below.

3.5.1. Output of Domestic Fishery

During the period 1970 through 1980, the annual landings of anchovies for reduction purposes averaged 75,561 metric tons, while the average reported take for live-bait was 5,627 tons. Miscellaneous uses for northern anchovy in California accounted for an average of 2,444 tons of fish per year. As indicated in Tables 3.5-1 and 3.5-2, the landings are heavily concentrated in the Los Angeles (San Pedro) and Santa Barbara (Port Hueneme) areas.

3.5.1.1. Value of Catch

The landings monitored by CF&G (not including bait catches) had an

Table 3.5-1. Anchovy landings by geographical area, 1966-1981 (metric tons).

Year	San Francisco	Monterey	Santa Barbara	Los Angeles	San Diego	Total
1966	31	7,548	4,101	16,571	0	28,250
1967	16	7,600	3,760	20,200	0	31,575
1968	24	3,856	1,818	8,398	0	14,096
1969	44	2,509	9,009	49,795	4	61,362
1970	99	865	8,897	77,450	0	87,310
1971	144	1,093	8,946	30,507	0.2	40,690
1972	163	539	12,463	49,521	0.6	62,687
1973	361	3,664	15,163	101,139	0.1	120,327
1974	381	4,599	16,359	53,701	0.9	75,040
1975	389	6,464	23,077	113,870	0.2	143,800
1976	288	4,513	17,522	91,004	0.09	113,327
1977	231	8,026	13,410	79,464	0.6	101,131
1978	372	386	6,067	4,630	0.1	11,457
1979[1]	n.a.	n.a	n.a.	n.a.	n.a	53,244
1980[1]	n.a.	n.a.	n.a.	n.a.	n.a.	49,037
1981[1]	211	4,398	9,091	38,309	2	52,011

n.a. = not available

[1] preliminary

Table 3.5-2. Value of anchovy landings by geographical area, 1966-1981. ($1000)

Year	San Francisco	Monterey	Santa Barbara	Los Angeles	San Diego	Total
1966	3	176	89	376	0	644
1967	5	162	80	455	0	701
1968	3	84	30	168	0	284
1969	9	69	202	1,072	0	1,353
1970	22	33	225	1,877	0	2,157
1971	35	30	268	760	0	1,093
1972	29	24	364	1,260	0	1,678
1973	67	219	859	5,500	0	6,646
1974	73	208	700	2,450	0	3,432
1975	74	231	794	3,905	0	5,008
1976	54	199	748	3,626	0	4,628
1977[1]	43	401	671	3,973	0	5,088
1978[2]	118	27	307	240	0	693
1979[1]	n.a.	n.a.	n.a.	n.a.	n.a.	2,900
1980[1]	n.a.	n.a.	n.a.	n.a.	n.a.	2,671
1981[2]	53	257	570	2,339	1	3,219

n.a. = not available

[1]preliminary estimates based on 1976 average price for San Francisco and $50/ton for fish landed in Monterey through San Diego.

[2]preliminary estimates based on CF&G records.

estimated exvessel value of $3.2 million in 1981. Most of this value (about 98 percent) accrues from the landings for reduction. In response to domestic and world markets for fish meal and other protein meals, the exvessel price of anchovy varies considerably. By agreement between the Fishermen's Cooperative Association of San Pedro and major buyers of anchovy for reduction, the exvessel price is tied directly to the established market price for protein. The current arrangement calls for a minimum price of 25 dollars per ton of anchovy when the price of protein is 3 dollars or less per unit. (The price per unit of protein equals the price per ton of meal divided by 65). Each additional 10 cent increase in the unit price of protein calls for a 75 cent increase in the exvessel price of anchovies.

As a result of the pricing arrangements and the great variability exhibited by protein meal markets, it can be expected that anchovy exvessel prices will continue to fluctuate. In future price variations, an important role will be played by the Peruvian anchoveta fishery. A flood of new fish meal production from Peru could easily dampen the domestic market prices for anchovy and for domestic fish meal generally. Expanding world demand for fish protein may, however, divert most Peruvian meal to other nations.

Since live-bait catches are never "landed", the state taxes and landing tickets do not apply. Consequently, the best information on value of live-bait harvests comes from a special study by Gruen Gruen and Associates in 1978. Based a survey of vessel operators, Gruen Gruen estimated that the southern California live-bait fleet sold $2.6 million of bait in 1977. Most of this (an estimated 84 percent) was sold to partyboat operators. Given the estimated 1977 catch of 6,410 metric tons, the per unit value of bait is about $406 per ton--approximately ten times the unit value of anchovies landed for reduction.

3.5.1.2. Description and Value of Products

The major uses for anchovy are for fishery industrial products and for bait, while minor portions of the annual harvest go into such products as fresh fish for human consumption, canned fish for human consumption, canned anchovy paste, and frozen bait. At present, the fishery industrial products consume most of the anchovy landings, and are likely to continue to do so. These products consists of meal, oil and solubles. The meal produced from anchovies is generally 65% protein, compared to 50-55% protein for other fish meals. The oil and liquids are separated and the oil sold in competition with other similar oils. The residual liquid is evaporated to produce a 40 percent solution containing about 30 percent protein and is sold as fish solubles.

The market prices for the three products of the reduction fishery in 1980 average $389 per metric ton for meal, $320 per metric ton for oil, and $121 per ton for solubles. The total value of all industrial anchovy products is estimated at $3,614,000 for 1980 (see Table 3.5-3). The 5-year average value (1976-1980) for industrial anchovy products is $4,858,400.

3.5.1.3. Markets, Domestic and Export

The domestic market for anchovy meal is the widely distributed animal feed mix business. All fish meals, including tuna, menhaden, herring and imported Peruvian anchovy meals, contain high levels of proteins with well-

Table 3.5-3. Industrial Products from Anchovies

	Fish Meal		Fish Oil		Fish Solubles[1]	
Year	Metric Tons	$1000	Metric Tons	$1000	Metric Tons	$1000[2]
1966	4,053	676	351	57	2,779	n.a.
1967	5,058	722	455	39	3,287	n.a.
1968	2,506	337	408	32	1,402	n.a.
1969	10,375	1,738	2,205	207	6,320	n.a.
1970	14,697	2,787	2,796	439	9,445	n.a.
1971	7,002	1,195	1,437	176	4,435	n.a.
1972	10,101	1,892	1,983	234	6,769	n.a.
1973	19,994	8,879	4,784	1,180	13,264	n.a.
1974	12,753	4,189	2,541	835	8,221	n.a.
1975	25,133	6,559	5,832	1,547	15,858	n.a.
1976	19,929	6,353	2,351	726	12,575	1,525
1977	10,705	4,732	1,588	507	11,164	1,354
1978	544	241	136	43	1,158	140
1979	8,981	4,007	1,270	406	5,310	644
1980	7,076	2,818	635	203	4,894	593
1981	9,281	3,695	778	267	5,046	693

[1] Solubles are not reported for anchovies specifically. These figures are based upon the rule-of-thumb that the yield of solubles equals 11.2 percent of raw anchovy input.

[2] Values for solubles are approximations based on $121/metric ton in 1976.

balanced amino acid content. This amino acid balance, as well as some trace minerals and other nutritive factors, are highly desirable components in poultry feed, hog feed, and fish feed. Much of the meal produced in California is sold to poultry growers in the state; but the market can extend as far east as Arkansas, depending upon the price and availability of competitive meals. Also, anchovy meal is used in preparing feed mixes for various freshwater fish, including trout and salmon raised in hatcheries.

Fish solubles can be returned to the fish meal to create a product known as whole meal. The process requires substantial additional drying by the producers. Such drying is not only expensive, but causes additional air pollution control problems for the producer. As a result, most of the solubles from California anchovy reduction plants is sold directly in liquid form. The liquid can be sprayed and mixed into feed mixes as an additional supplement having nutritional value similar to that of meal itself.

The poultry industry in California which absorbs much of the locally produced meal and solubles is a substantial portion of the state's agricultural complex. California is the leading state in production of chicken eggs, and is the second leading state in production of turkeys. When feed mixers cannot obtain desired quantities of high protein fish meals, the dietary requirements can be met for the most part by substitution of vegetable protein products, such as soybean meal, or of meals made from meat by-products. Some nutritionists express a preference for fish meal due to high concentration of the amino acids lysine and methionine and the presence of other growth factors. Analysis of the nutritional elements indicates that the previously "unidentified growth factor" in fish meal is a combination of trace minerals, B vitamins, and well-balanced amino acid complex. Whether or not fish meal is essential to the feeding of poultry stock, it is superior to vegetable proteins in that a smaller volume of fish meal carries a more concentrated load of protein and other nutritional elements.

Fish oil is utilized domestically in paints and lubricants, while export markets in Europe channel fish oil into human consumable items, such as margarine, as well as into other industrial uses. The oil content of anchovies influences directly the output of oil from the reduction plants. To the extent that oil yields from anchovy reduction vary, so must the revenue earned by processors per ton of anchovy.

The preponderance of the domestic market for fish meal is supplied with menhaden and imported (primarily Peruvian) meal. Tuna (or tuna/mackerel) meal is produced by all major tuna canneries in California and Puerto Rico. Menhaden meal originates from the Atlantic and Gulf Coasts. Because of shipping costs, the menhaden meal is generally not sold in California, while the anchovy meal produced in California is not sold in the eastern portion of the United States. Nevertheless, the boundaries of the markets are fluid with market prices and supplies having a controlling influence on the extent to which a batch of meal will be shipped inter-regionally.

The output of California's anchovy reduction fishery is small relative to the domestic menhaden fishery and foreign fish meal industries. Consequently, market prices for domestic anchovy meal follow the dominant national and worldwide market (see figure 3.5.1). Success or failure in U.S. soybean harvests or Peruvian anchovy harvests will be a significant factor in

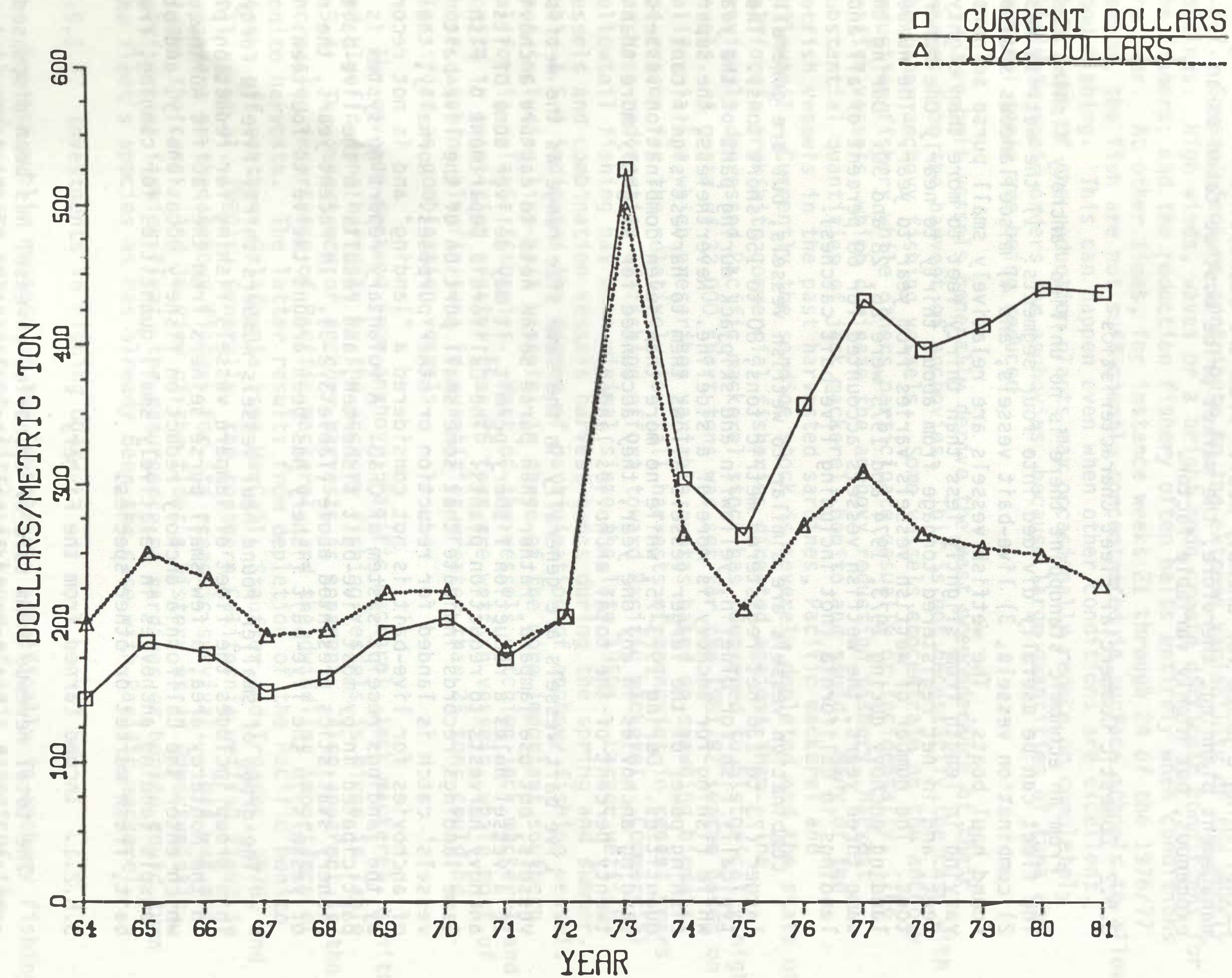


Figure 3.5-1. Price of fish meal (menhaden) in U.S. market.

establishing a price for anchovy meal. From the standpoint of anchovy management planning, therefore, the market price must be taken as an exogenous, but highly variable factor.

3.5.2 Domestic Commercial Fleet Characteristics

From an economic standpoint there is no unified "anchovy fishing fleet." The fleet can be usefully divided into four segments: 1) the wetfish vessels, 2) combination vessels, 3) live-bait vessels, and 4) miscellaneous smaller round haul boats. The wetfish vessels are relatively small purse seiners varying in length from slightly less than thirty feet to more than eighty feet, and in net registered tonnage from about thirty to nearly one hundred tons. The number of wetfish vessels varies from year to year. The numbers landing anchovy during 1973, 1974 and 1975 were 26, 28 and 30. During these same three years, the wetfish vessels accounted for 68 percent of all anchovy landings in California (not including live-bait catches).

Combination vessels are similar to wetfish vessels, but are generally larger (73 to 136 net registered metric tons, 80 to 150 short tons). They typically fish for bluefin, yellowfin and skipjack during part of the year, while fishing for anchovy is more of a sideline. Nevertheless, the superior fishing power of the larger vessels allows them to harvest significant quantities. During 1973-75, while no more than seven combination vessels were landing anchovies in any one year, they accounted for slightly more than twenty percent of the total anchovies landed.

Live bait vessels are generally in the same size range as the wetfish vessels, but use lampara, rather than purse seine nets to capture anchovies. If a vessel holds a reduction fishery permit, it may deliver some of its anchovy harvests to reduction plants. The California Department of Fish and Game landings records indicate that some small portion of the live-bait vessels' catch is landed for reduction or other purposes. Normally, the catch of anchovies for live-bait is not considered a "landing" and is not recorded by the landings receipt system of CF&G. A voluntary reporting system is participated in by most live-bait fishermen, and results in the live-bait fishery statistics presented above (Table 3.2-3). In recent years, the number of vessels in the live-bait fishery has been around twelve to fourteen.

The group of smaller round haul vessels numbers thirty-five to forty. This group includes the fleet of lampara vessels fishing for reduction plants in the Monterey area, a few small purse seiners from the Pacific Northwest which enter the California anchovy reduction fishery occasionally, and other vessels landing anchovies in relatively small quantities for canning, frozen bait, fresh market or other species.

3.5.2.1. Income Earned from the Fishery

The total revenue from sale of anchovies exvessel has been discussed in section 3.5.1.1., but some additional characteristics of the commercial value are of interest. The income earned from anchovy fishing is clearly unevenly distributed among vessels, and it is highly variable during the year. Also, most vessels earn income from sales of other pelagic schooling fish that can be captured by purse seining.

The variability of the anchovy reduction fishery is illustrated in Figure 3.5-2. Several factors contribute to the extreme variability of the weekly landings. High winds, waves or a bright moon create difficult conditions for the fishers; and the reduction fishery often halts entirely when conditions are poor. At other times, for instance weeks 21 through 24 of the 1976/77 season, the fish are not sufficiently concentrated in surface schools to allow good fishing. This can happen even when other conditions are excellent. Also, some of the reduction plants may occasionally reduce or completely eliminate their orders for anchovies, because large quantities of tuna and mackerel scrap are being reduced.

Live-bait vessels generally derive the vast preponderance of their incomes from the harvest of anchovies. This is not necessarily the case with the other anchovy fishing vessels. Some vessels concentrate on the anchovy reduction fishery while others participate casually or incidentally. The wetfish vessels, which dominate the anchovy reduction fishery, harvest substantial quantities of jack mackerel, bonito and squid. Many of the wetfish vessels in the past harvested sardines, Pacific mackerel and yellowtail. Currently the sardine stock is severely depleted and the state of California prohibits commercial fisheries directed against them. The previously depressed Pacific mackerel stock has recovered to historically high levels. A quota of 32,000 short tons was set for the 1981/82 season based on California law which prescribes variable quotas based on spawning biomass. One reason for the relatively low fall harvests of anchovies in recent years has been redirection of fishing effort toward Pacific mackerel. Commercial yellowtail fishing has been minimal since the late 1950s. Larger wetfish vessels and combination vessels harvest tunas during the spring and summer. Table 3.5-4 indicates the degree of participation of anchovy fishing vessels (not including live-bait vessels) in three of the more important southern California pelagic fisheries. Most of the vessels catching jack mackerel and bonito in quantities greater than 25 tons are wetfish vessels, while most of those catching bluefin tuna in quantities greater than 25 tons could be classified as combination vessels.

The revenue derived from anchovy, Pacific mackerel, jack mackerel, bonito and bluefin tuna harvests by the anchovy fishing vessels is given in Table 3.5-4. The importance of anchovy harvests is apparent. Also apparent is the increasing importance of Pacific mackerel, and the dwindling importance of bonito harvests. The latter results from depletion of the Pacific bonito stocks off southern California (see MacCall, Stauffer and Troadec, 1976, and Collins et al. 1980). Generally, the southern California wetfish fleet is dependent on the anchovy fishery for its economic survival. This was not always the case. And in view of the fleet's history as an opportunistic, multispecies fishing fleet, the resurgence of sardines or bonito could turn the fleet's species as has already been the case with Pacific mackerel.

3.5.2.2. Investments in Fishing Gear

Because public records of the investments specifically in anchovy fishing vessels and gear are non-existent, little is known of this aspect of the fishery. County property tax records give some indication of the value of the fishing vessels, however, and a sample of wetfish vessels demonstrates a wide variance in assessed values. Projected market values (100 times assessed value) run from $70 thousand for some of the smaller, older vessels to as much

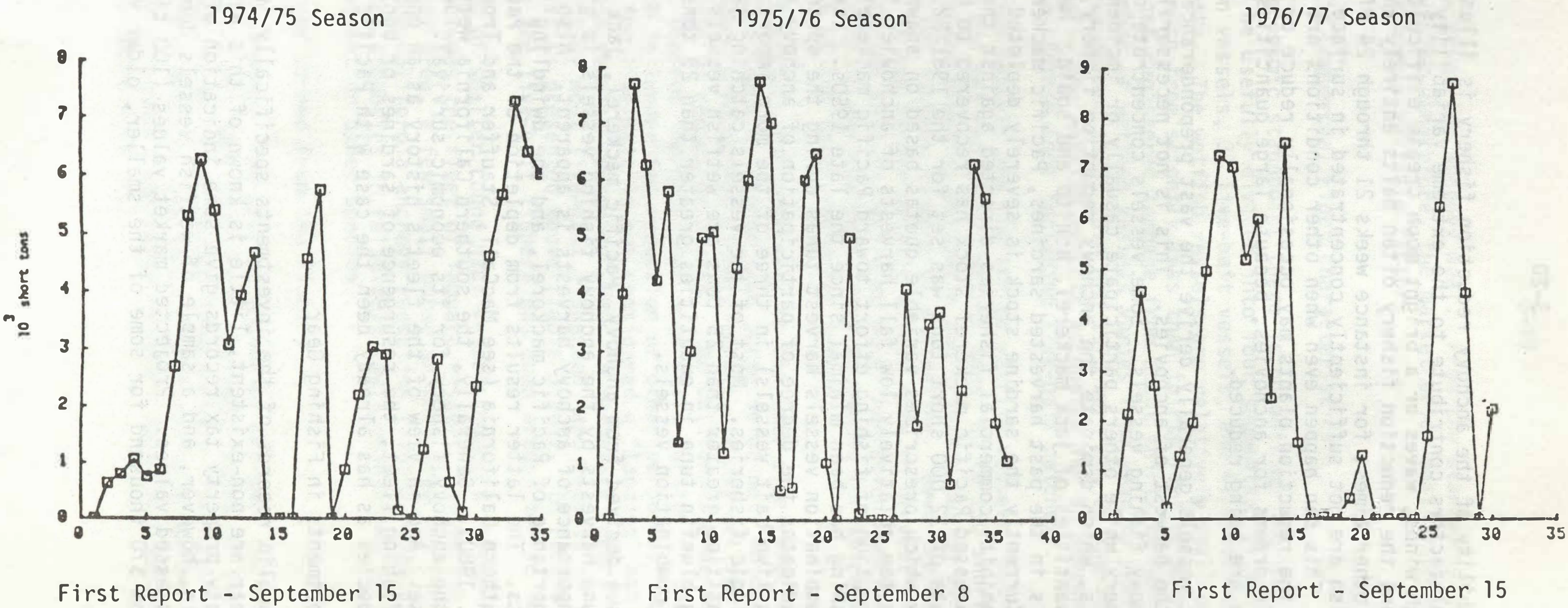


Figure 3.5-2. Anchovy reduction fishery landings by week of season.

Table 3.5-4. Catch and revenue of five major species caught by anchovy vessels, 1973-1976; extrapolations made for 1977, 1978, 1979 and 1980.

Landings (metric tons)	Anchovy (reduction)	Jack mackerel	Pacific mackerel	Pacific bonito	Bluefin tuna	Total	Real Values[3]
1973	118,432	9,072	5	8,643	1,497	137,649	
1974	73,401	11,343	24	5,260	1,957	91,985	
1975	141,586	15,267	125	1,698	2,177	160,853	
1976	112,270	19,607	153	2,044	1,760	135,834	
1977[1]	99,674	45,596	3,176	4,756	771	153,973	
1978[1]	10,339	29,529	10,746	3,175[2]	1,067	54,856	
1979[1]	47,408	15,334	25,533	240	1,326	89,841	
1980[1]	43,699	19,307	28,101	5,847	523	97,477	
Ex-Vessel Values ($1000)							
1973	6,646	962	1	1,982	772	10,361	17,268
1974	3,357	1,470	3	1,548	1,225	7,603	11,697
1975	4,931	1,526	13	525	1,153	8,148	11,476
1976	5,465	2,161	17	638	1,125	9,406	12,542
1977[1]	5,442	5,026	350	1,688	862	13,368	16,710
1978[1]	513	3,581	1,302	1,365	964	7,725	9,088
1979[1]	2,405	2,535	4,221	103	1,242	10,506	11,297
1980[1]	2,697	3,724	5,421	866	2,881	15,589	15,589

[1]Extrapolations using 1973-1976 average of percentage of total landings caught by anchovy fleet.

[2]CF&G estimate.

[3]Values deflated according to GNP price deflator, 1980 = 100.

as $1.8 million for a newer, larger vessel. Without additional information, the capital value of the anchovy fishing fleet cannot be adequately estimated.

3.5.2.3. Manpower Employed

Just as the number of vessels participating in the fishery varies, so does the number of fishermen. For any given year, the number of fishermen involved in anchovy fishing can be estimated by adding up the number of crew members for each participating vessel as indicated in CF&G's vessel registration file. For 1975 there were an estimated 472 crew members on vessels fishing anchovies, distributed among vessel types as follows: wetfish, 291; combination vessels, 43; others, 138; and bait vessels, about 70. The live-bait vessel crewmen are probably employed nearly year around in anchovy fishing, while the other vessel's crewmen are, in varying degrees, part-time anchovy fishermen.

3.5.3. Domestic Commercial Processing

The processing of anchovy into industrial products takes place in two companies at Terminal Island, one company at Oxnard, and one company at Salinas. The companies at Terminal Island are all engaged primarily in canning tuna and mackerel, using the reduction plants to produce tuna/mackerel meal. The annual landings of anchovies and the production of industrial products is concentrated in the Terminal Island location. As indicated in Table 3.5-1, the Los Angeles area landings of anchovy account for most of the tonnage and value.

The canning of anchovies in a "sardine-style" pack takes place occasionally in the Monterey area. Potentially, many canners in other locations could produce canned anchovies. At prices sufficiently high to cover costs, however, there is currently little domestic demand for canned anchovies. As a result, the annual case pack (5 oz.-100 equivalents) dropped from a high of 1,144,757 in 1953, to an average of 33,000 in the 1960s and an average of 500 in the 1970s.

Gross income from fish reduction plants in California includes revenue from tuna/mackerel meal, oil and solubles. Offal from the tuna canning industry at Terminal Island and San Diego is reduced to meal in quantity exceeding that of the anchovy meal. The two canneries in San Diego produce exclusively tuna meal, but could include anchovy meal in the future if economic and political conditions make it profitable.

The employment directly attributable to the reduction plants is minimal. While no accurate employment figures are available, there are probably about 50 people directly employed at reduction plants in southern California as a result of the anchovy reduction fishery.

3.5.4. Recreational Fishing Characteristics

While there is no recreational fishery for anchovies *per se*, the central subpopulation of anchovies plays an important role in California's recreational fishery. The species is an abundant forage species for many important recreational and commercial fish. More directly, the California commercial partyboats and private boats use anchovies as bait. The anchovy is the preferred bait species and it was widely used even in the 1950s when the sardine stock was the more dominant epipelagic fish stock in the California Current. Fish of about 100-120 mm in length (age 1-2 years) are generally preferred. Juvenile fish, often called "pinheads" are unacceptable due to their small size, while larger adult fish are too sluggish and are difficult to maintain in a healthy state.

Live-bait dealers generally supply bait to partyboats on a contract basis, receiving approximately 10-15 percent of the revenue generated from passenger fees. Also bait is sold by the "scoop" to private vessels. The volume of business of partyboats in California is large and has been fairly constant in recent years (see Table 3.5-5). The live-bait catch reported by California Department of Fish and Game has also been relatively constant (see Table 3.2-3).

Recreational fishing from private vessels in southern California has been surveyed twice, once in 1964 by CF&G and again in 1975-76 by CF&G contract with NMFS. The 1964 survey (Pinkas, et al., 1968) resulted in an estimate of activity of private boats from marinas and launching ramps. A total of 1,863,996 angler hours of fishing, equivalent to 303,786 angler days of fishing, and 106,301 boat days were estimated for boats launched from trailers in 1964. Private boats operating from mooring sites in marinas increased total angler days by an additional 50% and boat days by an additional 33%. Although the number of private boats registered in California increased from less than 300,000 to over 500,000 during the period from 1963 through 1976, the private boat survey in 1975-76 (Wine and Hoban, 1976) did not indicate a similar increase in fishing activity from trailerable private boats. For the 12 month period covered in the 1975-76 survey, a minimum of 336,000 angler days and 127,000 boat days were expended in southern California.

3.5.4.1. Seasonal and Geographic Characteristics

Recreational fishing activity of southern California partyboat fleet is the highest in the months of May through September with August being the peak month. This typical seasonal cycle for partyboat fishing activity is demonstrated by the monthly summaries of the 1980 partyboat logbook data (Table 3.5-6). A somewhat more detailed view of southern California activity patterns is provided by the six individual reporting areas from Santa Barbara to San Diego (Table 3.5-7). The Santa Monica and San Diego regions are of similar magnitudes and account for about half the southern California partyboat effort between them. Seasonality is shown by comparing the effort expended during the three peak months of June, July and August, with the three slow months of December, January and February. As a summer/winter ratio (Table 3.5-7), this measure shows greater seasonal variation for the more southern reporting areas, particularly Oceanside and San Diego.

Table 3.5-5 Recreational fishery statistics.

Year	Number of sport* fishing licenses in California (1000's)	Number of anglers on commercial partyboat (1000's)	Number of fish caught on the partyboats (1000's)
1960	1,476	637	4,090
1961	1,492	594	3,454
1962	1,588	596	3,656
1963	1,702	643	4,279
1964	1,769	695	4,434
1965	1,839	688	4,635
1966	1,981	857	5,408
1967	2,000	780	4,444
1968	2,152	850	5,731
1969	2,168	803	5,726
1970	2,330	873	5,631
1971	2,287	728	4,604
1972	2,004	793	5,462
1973	2,147	880	5,923
1974	2,363	809	5,692
1975	2,289	748	5,354
1976	2,250	736	5,149
1977	2,168	717	4,849
1978	2,383	732	5,256
1979	2,389	786	6,631
1980	2,450	762	6,404

*Includes licenses bought with stamps allowing freshwater angling.

Table 3.5-6. Monthly partyboat catch and anglers in California, 1980 (1000's).

Month	Southern California No. fish	Southern California No. anglers	Central & Northern California No. fish	Central & Northern California No. anglers
January	196.6	19.6	39.5	3.9
February	195.7	20.9	57.5	7.9
March	272.1	29.7	99.9	17.5
April	313.9	37.7	91.4	17.3
May	350.7	43.3	93.1	16.6
June	482.5	63.5	155.1	24.8
July	562.6	83.2	202.8	29.8
August	862.1	95.8	254.7	31.4
September	611.0	58.5	190.9	22.6
October	385.6	38.3	167.4	18.0
November	347.3	33.7	136.0	12.5
December	258.2	27.6	76.6	6.9
Total	4,838.3	522.0	1,565.3	209.5

Table 3.5-7. Southern California Regional Partyboat Angler Effort in 1980.

Region	San Diego	Oceanside	Newport	Long Beach	Santa Monica	Santa Barbara	Total
Annual angler trips	129,752	67,520	46,748	108,502	113,721	85,786	552,029
Percent of annual total	24	12	8	20	21	16	
Summer/ winter ratio*	5.60	5.87	4.51	3.49	2.56	2.01	3.56

*Summer/winter ratio is (June-August)/(December-February)

Partyboat logbook information for the year 1970 was summarized by CF&G statistical reporting block (10 minute square), providing a rough indication of the geographic distribution of recreational fishing activity (Figure 3.5-3). The compilation does not include distant water albacore fishing effort, or long-range trips to Mexico, which account for over 50,000 angler trips annually, and represent trips of much longer duration than local day trips. Most of the angling effort was near the mainland shore from Oxnard south. Considerable amounts of effort were expended around islands, particularly the Coronado Islands, San Clemente and Santa Catalina Islands, and the Channel Islands in the Santa Barbara area (which accounts for most of the Santa Barbara activity). While the reporting grid is too coarse to supply detailed inshore-offshore information, the San Pedro Channel, between Santa Catalina Island and the mainland appears to be heavily fished both inshore and offshore, as is the area between Oxnard, Santa Barbara and the Channel Islands.

3.5.4.2. Species Composition of Catch

A summary of fish species caught from commercial partyboats in California is presented in Table 3.5-8. Notable patterns in partyboat species composition are (1) the dramatic increases in rockfish and Pacific mackerel catches in recent years, (2) substantial decreases in catches of barracuda, white seabass and California halibut, and (3) an up-and-down pattern in catches of salmon, yellowtail, Pacific bonito, and albacore. Possible reasons for these changes are many. They include (1) water temperature affecting fish distributions, (2) overfishing by recreational fishing or commercial fishing or both, (3) habitat degradations (water pollution in the Los Angeles area, loss of kelp beds), (4) changes in fishing regulations such as size and bag limits, and (5) reduction or dispersion of forage fish due to the commercial anchovy reduction fishery. Although insufficient scientific evidence has been compiled to explain observed variations in abundance of recreational fish species in southern California, many recreationalists tend to place

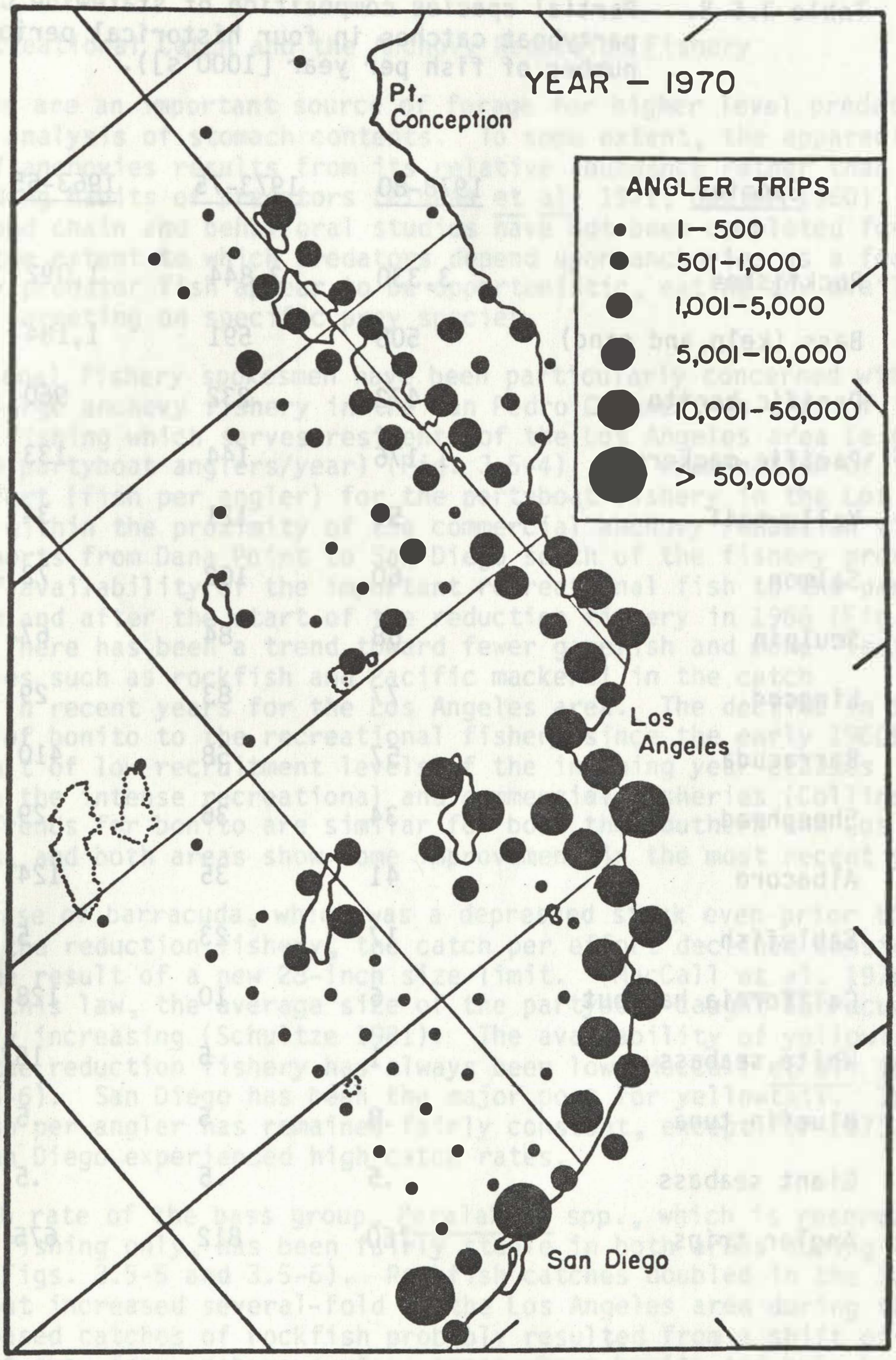


Figure 3.5-3 Geographical distribution of Southern California Partyboat Angling Effort in 1970.

Table 3.5-8. Partial species composition of statewide California partyboat catches in four historical periods (average number of fish per year [1000's]).

Species	1978-80	1973-75	1963-65	1956-58
Rockfishes	3,330	3,844	1,092	1,664
Bass (kelp and sand)	508	591	1,184	578
Pacific bonito	472	232	960	248
Pacific mackerel	1,176	144	133	137
Yellowtail	51	121	34	132
Salmon	60	102	72	71
Sculpin	68	84	67	21
Lingcod	77	83	29	385
Barracuda	57	58	410	483
Sheephead	34	36	29	16
Albacore	41	35	124	38
Sablefish	17	23	5	2
California halibut	6	10	128	16
White seabass	1	5	15	24
Bluefin tuna	.8	5	.5	14
Giant seabass	.5	.5	.5	.1
Angler trips	760	812	675	639

substantial weight on the fifth possible cause--the reduction in available forage to attract and nuture gamefish near populated areas in southern California.

3.5.4.3. Recreational Catch and the Anchovy Reduction Fishery

Anchovies are an important source of forage for higher level predators as indicated by analysis of stomach contents. To some extent, the apparent importance of anchovies results from its relative abundance rather than from specific feeding habits of predators (Pinkas et al. 1971; Baxter 1960). Sufficient food chain and behavioral studies have not been completed for determining the extent to which predators depend upon anchovies as a food supply. Many predator fish appear to be opportunistic, eating any available prey and not targeting on specific prey species.

Recreational fishery spokesmen have been particularly concerned with the impact of a large anchovy fishery in the San Pedro Channel, an area of intense recreational fishing which serves residents of the Los Angeles area (e.g., about 250,000 partyboat anglers/year) (Fig. 3.5-4). An examination of the catch per effort (fish per angler) for the partyboat fishery in the Los Angeles area within the proximity of the commercial anchovy reduction fishery and for the ports from Dana Point to San Diego south of the fishery provides a comparison of availability of the important recreational fish to the partyboat angler before and after the start of the reduction fishery in 1966 (Fig. 3.5-5 and 3.5-6). There has been a trend toward fewer gamefish and more "last choice" species such as rockfish and Pacific mackerel in the catch compositions in recent years for the Los Angeles area. The decline in the availability of bonito to the recreational fishery since the early 1960s has been the result of low recruitment levels of the incoming year classes combined with the intense recreational and commercial fisheries (Collins et al. 1980). Trends for bonito are similar for both the southern and Los Angeles areas, and both areas show some improvement in the most recent years.

In the case of barracuda, which was a depressed stock even prior to the beginning of the reduction fishery, the catch per effort declined considerably in 1971 as the result of a new 28-inch size limit. (MacCall et al. 1976, p.9). Since this law, the average size of the partyboat-caught barracuda has been gradually increasing (Schultze 1981). The availability of yellowtail in the area of the reduction fishery has always been low (MacCall et al. 1976, p. 23) (Fig. 3.5-6). San Diego has been the major port for yellowtail. The number of fish per angler has remained fairly constant, except for 1973 and 1974, when San Diego experienced high catch rates.

The catch rate of the bass group, *Paralabrax* spp., which is reserved for recreational fishing only, has been fairly stable in both areas during the later 1970s (Figs. 3.5-5 and 3.5-6). Rockfish catches doubled in the San Diego area, but increased several-fold in the Los Angeles area during the 1970s. Increased catches of rockfish probably resulted from a shift of fishing effort away from inshore surface areas where bonito and kelp bass had declined in abundance. However, since effort directed at rockfish is unlikely to catch inshore surface species, the catch rates of the latter may have decreased proportionally more than their actual abundance.

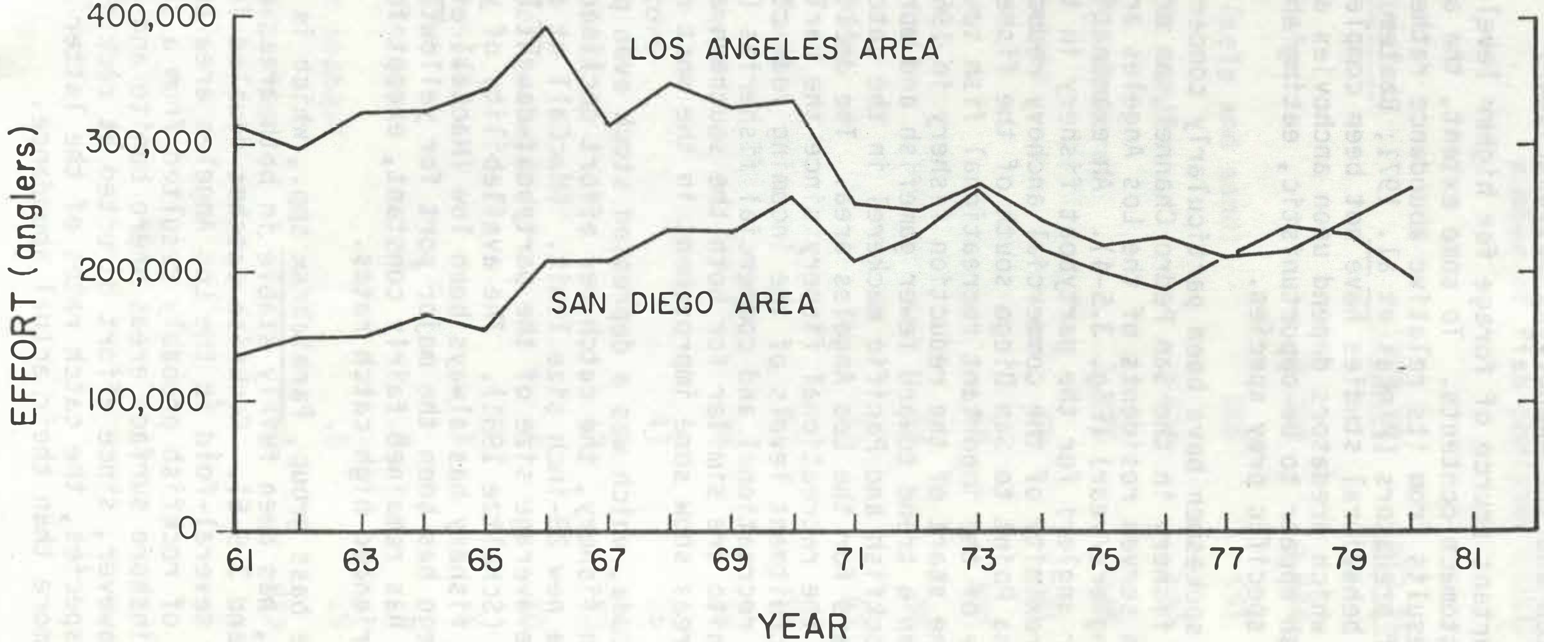


Figure 3.5-4. Annual partyboat effort in angler trips for the Los Angeles area and Oceanside to San Diego (source: CDF&G partyboat records).

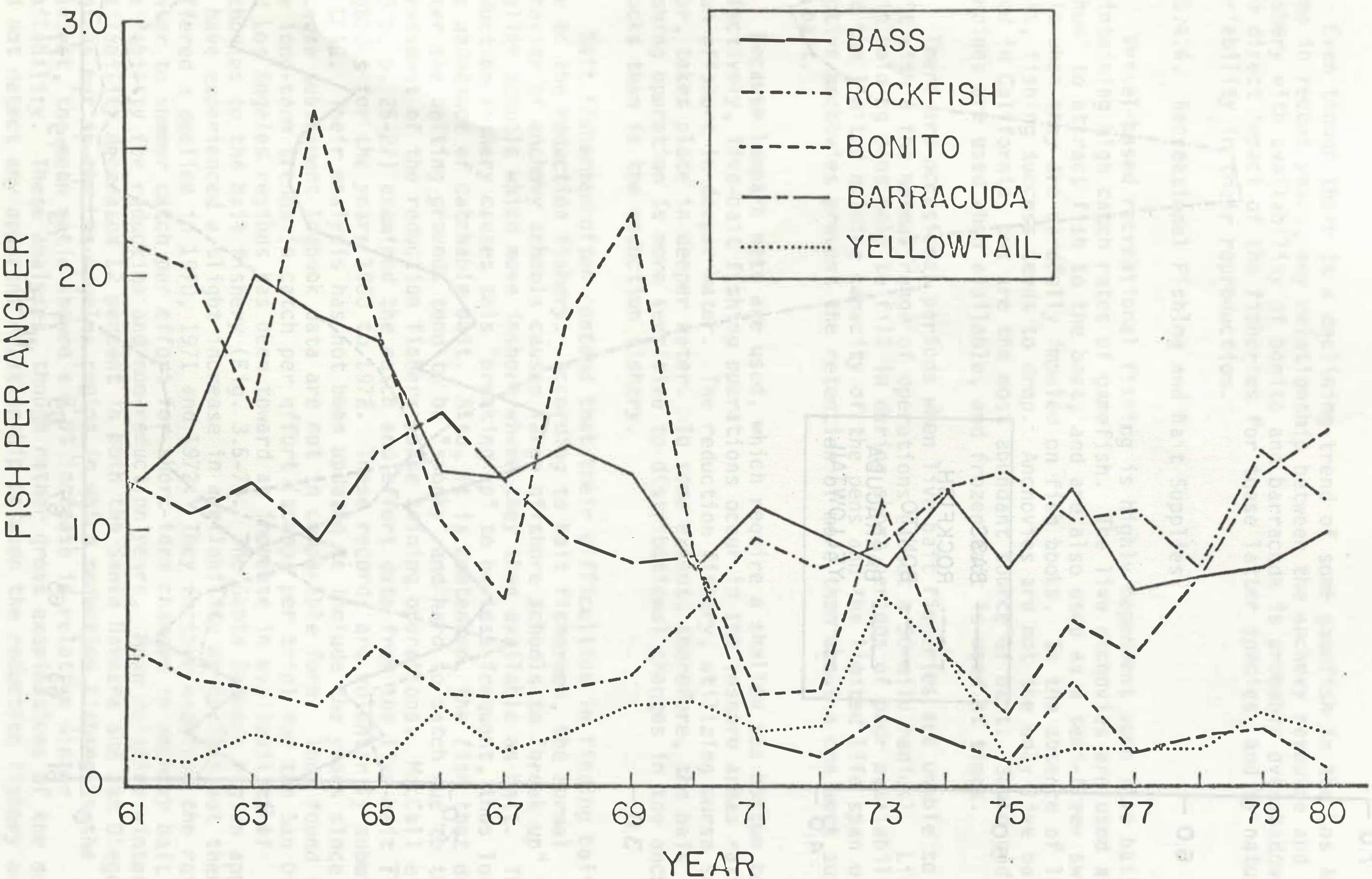


Figure 3.5-5 Annual partyboat catch per effort (fish per angler) for important recreational species for southern ports. Source: CF&G partyboat records.

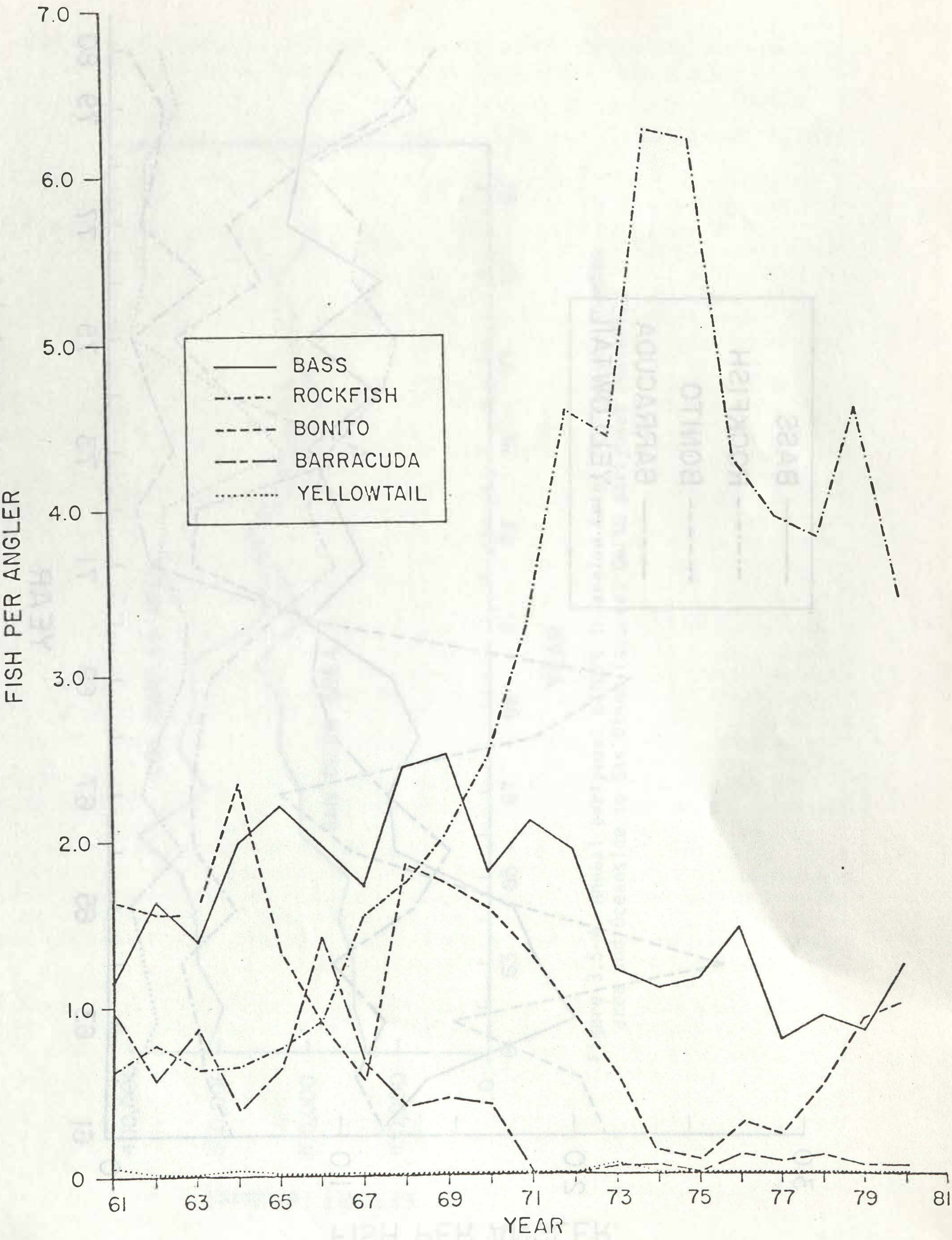


Figure 3.5-6 Annual partyboat catch per effort (fish per angler) for important recreational species for the Los Angeles area.

Even though there is a declining trend of some gamefish in the Los Angeles area in recent years, any relationship between the anchovy resource and its fishery with availability of bonito and barracuda is probably overshadowed by the direct impact of the fisheries for these latter species, and by natural variability in their reproduction.

3.5.4.4. Recreational Fishing and Bait Supplies

Vessel-based recreational fishing is highly dependent upon live bait for maintaining high catch rates of gamefish. The live anchovies are used as "chum" to attract fish to the boat, and are also used as a semi-free- swimming bait when they are carefully impaled on fish hooks. In the absence of live bait, fishing success tends to drop. Anchovies are not the only live bait used in California, but are the most abundant source of bait. Squid and sardines are used when available, and frozen bait is used at times.

There are occasional periods when live-bait fisheries are unable to find bait within the normal range of operations (about a 50-mile radius). Live-bait holding pens help to fill in during short periods of poor availability, but the limited holding capacity of the pens and the limited life span of captive anchovies prevent the retention of more than about a one week supply of bait.

Because lampara nets are used, which require a shallow sea bottom to work effectively, live-bait fishing operations occur in the inshore areas rather than offshore in deeper water. The reduction fishery, utilizing purse seine gear, takes place in deeper water. To some extent, therefore, the bait fishing operation is more sensitive to distributional changes in the anchovy stocks than is the reduction fishery.

Bait fishermen often contend that their difficulties in finding bait are due to the reduction fishery. According to bait fishermen, the normal behavior of anchovy schools causes large offshore schools to "break up" into smaller schools which move inshore where they then available as bait. The reduction fishery causes this "breaking up" to be less frequent, thus lowering the abundance of catchable bait. Also, it is contended, the fish that do enter the baiting grounds tend to be "spooky" and hard to catch due to the harassment of the reduction fishery purse seining operations. MacCall et al. (1976, p. 25-27) examined the catch and effort data from the live-bait fishery logbooks for the years 1960 to 1972. These records are voluntarily submitted to CF&G. Their analysis has not been updated to include the years since 1972 because subsequent logbook data are not in comparable form. They found that the long-term trends in catch per effort (scoops per trip) for the San Diego and Los Angeles regions has been toward an increase in availability of anchovies to the bait fishery (Fig. 3.5-7). The Santa Barbara region appeared to have experienced a slight increase in availability up to 1969 but then suffered a decline in 1970, 1971 and 1972. They further examined the ratio of winter to summer catch per effort for short-term changes in anchovy bait availability for reduction and non-reduction years. Mean relative winter availability decreased 12 percent in both the Santa Barbara and San Diego regions but in the Los Angeles region in which reduction fishing is the heaviest, the mean ratio showed a 8.6% increase in relative winter availability. These analyses, though rather gross examinations of the data, did not detect any apparent relationship between the reduction fishery and

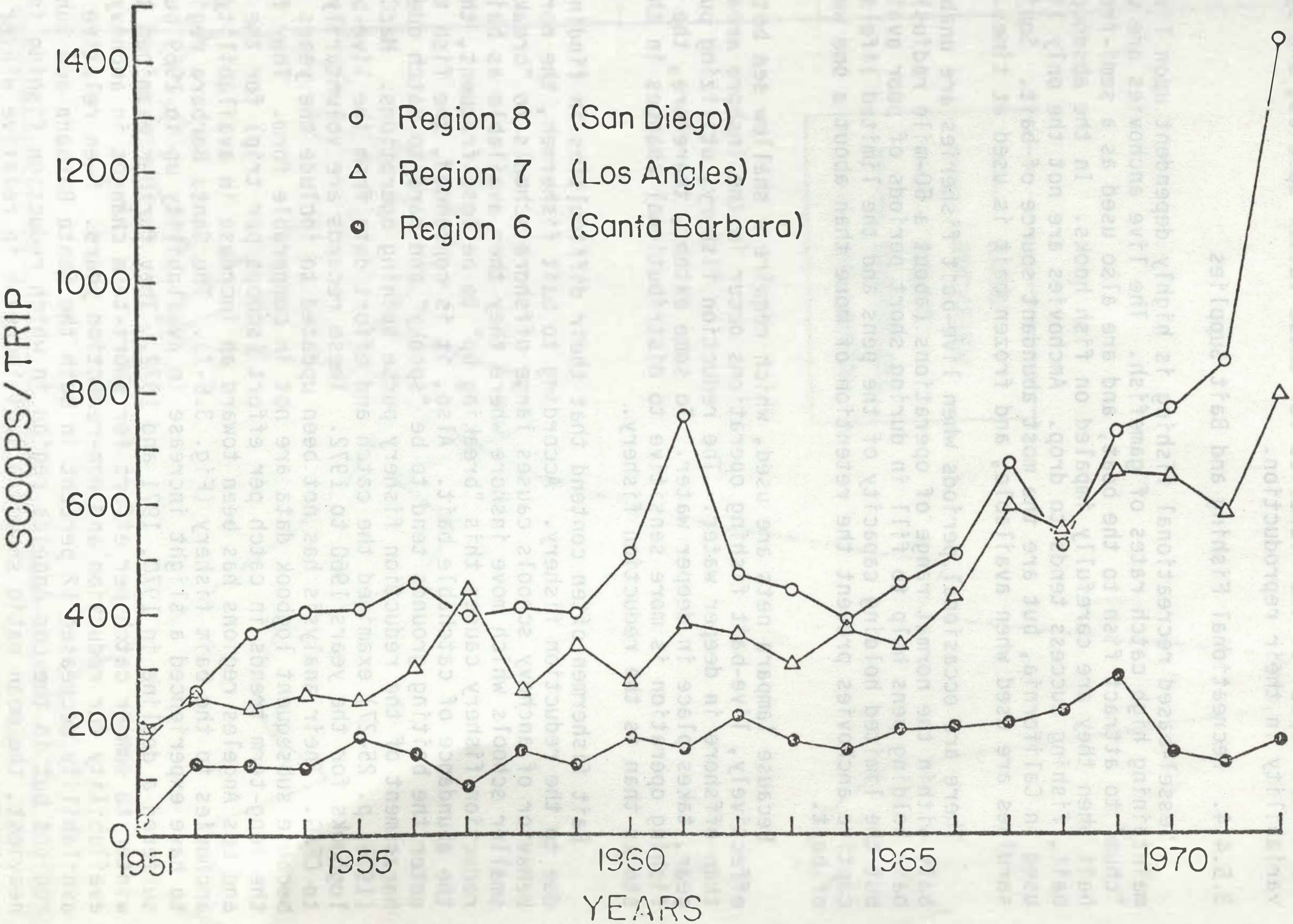


Figure 3.5-7 Anchovy live-bait catch per effort (annual scoops/trips).

availability of bait.

Using lampara nets, the bait fishery is not able to move offshore to avoid problems which seem to occur only inshore at times. The use of purse seine gear to take live bait has been largely unsuccessful due to injuries and mass "die-off" when a net "roll-up" occurs. Recently, however, one bait fisherman has employed a purse seine net which can be used for both bait and reduction fishery operations. The success of this venture may suggest a possible solution to some of the bait fishing problems.

3.6 State Revenues Derived from the Fishery

When the price paid to the fishermen is less than $50.00 per short ton, a California tax of $1.20 per short ton ($1.32 per metric ton) is collected. When the price is above $50.00 per short ton, the tax is $2.60 per short ton ($2.87 per metric ton). These taxes, along with revenues from license sales, fines and penalities are deposited in the Fish and Game Preservation Fund which partially supports operations of the Department of Fish and Game and the California Fish and Game Commission.

4.0 Biological Descriptions

4.1 Distribution and Stock Units

4.1.1 General Description

The population of northern anchovy Engraulis mordax is distributed from the Queen Charlotte Islands, British Columbia to Magdalena Bay, Baja California as discussed in section 3.1. The central subpopulation, the management unit of this plan, ranges from approximately San Francisco, California, 38°N to Pt. Baja, Baja California 30°N. The eggs and larvae are common out to 200 miles offshore and have been taken out as far as 300 miles in some years (Ahlstrom 1967, p. 121). Based on the relative abundance of anchovy larvae, the greatest density of anchovies is in the inshore regions (Ahlstrom 1967, p. 121 and Smith 1972, p. 869).

The distribution and movement patterns of the northern anchovy in northern Baja California and southern California documented by Mais (1974, p. 29-43) are presented here as summarized by Knaggs (MS, p. 5-8). These seasonal patterns though are not well defined. The information is based on CF&G acoustic transect-midwater trawl surveys (frequently refered to as the sea surveys) for the period June 1966 to February 1973. "Anchovies in this area are widely distributed from shore to 157 km seaward. The greatest concentrations were generally within 37 km of shore and deep water basins.

"The more distant deep water basins lying 37 to 111 km offshore collectively contained the largest portion of the anchovy population in this region with small but very numerous schools distributed over large areas.

"Relatively small amounts of fish were found in the shallow banks and inshore waters. School groups or concentrations rarely exceed or equaled those of deeper water. However, these areas may be more important than results indicated since acoustic equipment, particularly sonar, is less efficient in detecting schools in shallow water. In addition, a common scattered schooling behavior in shallow water often made school enumeration difficult or impossible.

"Anchovy distribution within the Southern California Bight varied considerably both seasonally and annually. During the fall months, a large portion of the population was located inshore and in the more northern part of the Bight. Schools were generally larger in size but fewer in number than in any other season.

"Commencing in late winter, an offshore and southeasterly movement occurred coinciding with the onset of major spawning activity. At this time the population was widely spread over large areas offshore and south of San Pedro. Schools became extremely numerous and small reaching peak numbers usually in April or May. A return northward also occurred at this time with part of the population forming large daytime surface schools during some years. Time of formation of these schools varied from the middle of March to late June.

"Seasonal distribution in northern Baja California was less varied and different than in southern California. During a large portion of the year, anchovies were found in concentrations in deep water close to shore similar to the southern California fall distribution. In contrast to southern California, however, very few schools were detected during spring months, and few or no fish were found more than 27.8 km offshore except near the offshore border area between the two localities.

"By far the most prevalent and common schooling behavior observed in the Southern California Bight was the formation of small very low density near surface schools during daylight hours. After dark, anchovy schools invariably dispersed into a thin surface scattering layer and remained so until the following dawn.

"Small low density schools near the surface were always found over bottom depths of more than 183 m and were widely distributed over thousands of square miles of sea surface area. Although they were found over deep water everywhere, they were the only type schools distributed in the more offshore areas. Schools of this type comprised an estimated 90% of all detected by sea surveys. They were dominant type during all seasons but were most numerous and prevalent during the late winter and spring. At this time, schools are very small (probably 0.5 to 6.0 tons) and vary. All the actively spawning anchovies collected during the sea survey were from this type of school.

"The rapidity of vertical migration and the large differential in temperatures encountered indicate a eurythermal tolerance for anchovies."

Baxter (1967, p. 110) reported that northern anchovies have been taken in waters of temperatures 8.5°C to 25.0°C. The temperature range for the central subpopulation is probably not as wide. Anchovy eggs have been sampled in temperatures ranging from 9.9°C to 23.3°C (Ahlstrom 1956, p. 38) but most eggs occur in temperatures between 13.0°C and 17.5°C. In a study of the relationship of surface temperature to sexual development, Mais (1974, p. 48) found anchovies from the central subpopulation over a temperature range of 12°C to 21.5°C. The data indicated that a pronounced peak of spawning activity occurs in a range of 13.5°C to 14.0°C with minor peaks at 15.5°C to 16.0°C and 17.0°C to 17.5°C. In a recent study Brewer (1976, p. 441) presented a summary figure of the thermal limits for the distribution and survival of larval and adult anchovies, this is reproduced as Fig. 4.1-1.

Tagging conducted in the late 1960s demonstrated that anchovies move alongshore between central California (San Francisco Bay to Morro Bay), and southern California in both a northerly and southerly direction (Haugen, Messersmith and Wickwire 1969, p. 81 and 82). There is some evidence from Haugen et al. (1969, p. 82) that anchovies in southern California move from offshore areas to inshore and vice versa. Anchovies tagged off Catalina and San Clemente Islands were later recovered in the Los Angeles-Long Beach Harbor. Tagged fish released in the Harbor area were caught in southern California fishing grounds and off Baja California. Knaggs (MS, p.8) reported on one tagged anchovy that was released off San Diego and recovered at Monterey 129 days later. The fish travel at least 370 miles at a rate of nearly 3 miles per day. Unfortunately the overall tag recovery rate was low.

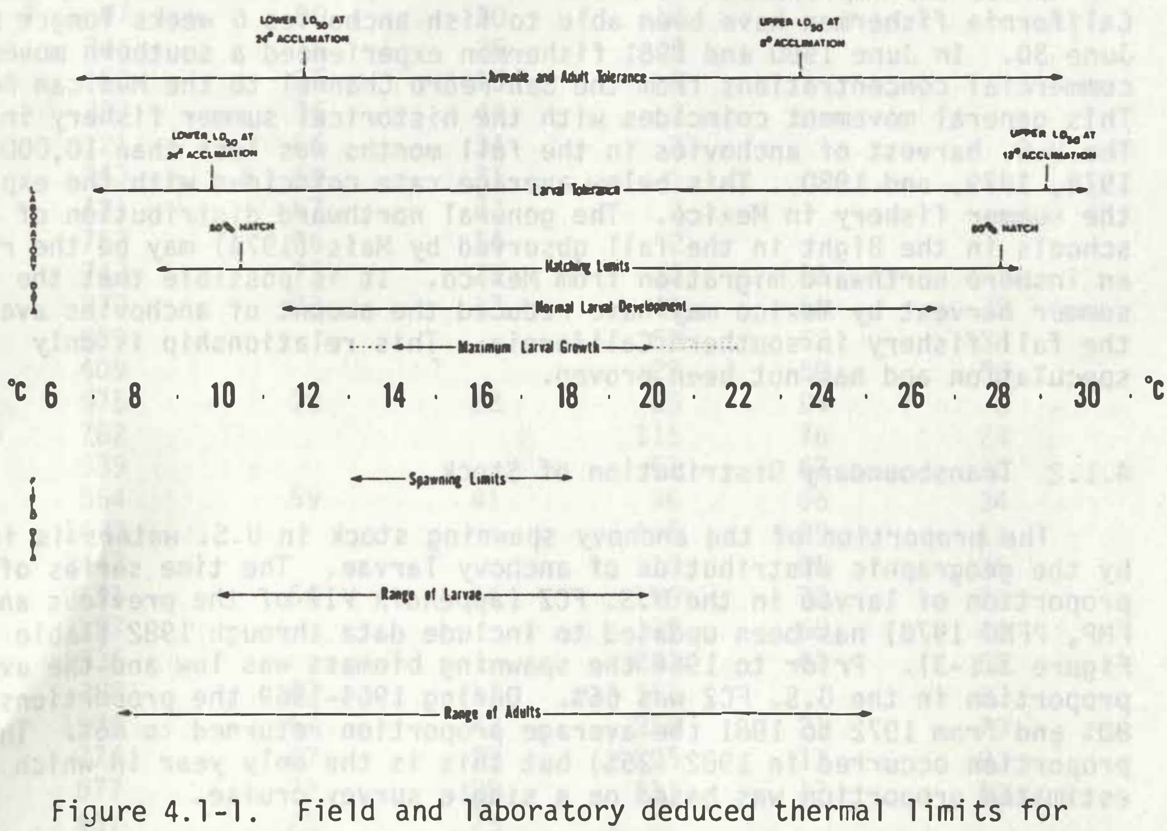


Figure 4.1-1. Field and laboratory deduced thermal limits for the distribution and survival of northern anchovy (reproduced from Brewer 1976, p. 441).

Lasker (pers. comm., April 1977) measured the swimming speed of a small school of 90-100 mm SL anchovies in the laboratory at 3 body lengths per second. If a school of 130 mm SL anchovies maintained an average speed of 3 body lengths per second, they could travel a distance of approximately 34 kilometers (18 nautical miles) in 24 hours. This is greater than the average velocity in the tagging study mentioned above, but it is unlikely that a school travels in a straight line for a distance of 34 kilometers.

Analysis of CFG anchovy sea survey data indicates that fish length at age increases at higher latitudes (Section 4.2.1). Anchovies inhabiting offshore waters within the Southern California Bight are generally larger and older than anchovies in the nearshore regions. In addition, preliminary studies show anchovies of the same age are larger offshore. This indicates that mixing is limited or systematic, creating this heterogeneity within the central subpopulation.

Since the implementation of the PFMC's first northern anchovy FMP, California fishermen have been able to fish anchovies 6 weeks longer until June 30. In June 1980 and 1981 fishermen experienced a southern movement of commercial concentrations from the San Pedro Channel to the Mexican Border. This general movement coincides with the historical summer fishery in Mexico. The U.S. harvest of anchovies in the fall months was less than 10,000 MT in 1978, 1979, and 1980. This below average rate coincides with the expansion of the summer fishery in Mexico. The general northward distribution of anchovy schools in the Bight in the fall observed by Mais (1974) may be the result of an inshore northward migration from Mexico. It is possible that the increased summer harvest by Mexico may have reduced the amount of anchovies available to the fall fishery in southern California. This relationship is only speculation and has not been proven.

4.1.2 Transboundary Distribution of Stock

The proportion of the anchovy spawning stock in U.S. waters is indicated by the geographic distribution of anchovy larvae. The time series of the proportion of larvae in the U.S. FCZ (appendix VII of the previous anchovy FMP, PFMC 1978) has been updated to include data through 1982 (Table 4.1-1 and Figure 3.1-3). Prior to 1964 the spawning biomass was low and the average proportion in the U.S. FCZ was 66%. During 1964-1969 the proportions averaged 80% and from 1972 to 1981 the average proportion returned to 66%. The lowest proportion occurred in 1982 (25%) but this is the only year in which the estimated proportion was based on a single survey cruise.

The long-term average proportion of larvae in the U.S. FCZ (67%) adequately describes the long-term average transboundary distribution during the spawning season because the proportion did not show significant trends with year or with biomass. However, the seasonal stock movements described in Section 4.1.1 may lead to a different transboundary distribution during the fishing season.

During the period 1964-1977 the U.S. and Mexican harvests increased and the average U.S. proportion of the total harvest was 64% (Table 4.1-1). Thus,

Table 4.1-1. Proportion of the spawning biomass and harvest occurring in the U.S. Fishery Conservation Zone and off Mexico. Units of biomass and catch are thousand metric tons. Transboundary distribution of biomass could not be estimated in years without egg and larva surveys.

Year	Biomass[1]	% U.S.	% Mexico	Total[2] Catch	% U.S.	% Mexico
1951	2	64	36	3		
1952	3	57	43	25		
1953	11	66	34	39		
1954	31	74	26	19		
1955	58	45	55	20		
1956	27	54	46	26		
1957	67	80	20	18		
1958	236	74	26	5		
1959	183	85	15	3		
1960	327	56	44	2		
1961	121	66	34	3		
1962	243	69	31	1		
1963	421	67	33	2		
1964	767	86	14	2		
1965	743	73	27	12	25	75
1966	972	83	17	41	68	32
1967	989			52	62	38
1968	409			28	50	50
1969	575	78	22	65	94	6
1970	782			115	76	24
1971	539			61	67	33
1972	554	59	41	96	66	34
1973	1423			135	89	11
1974	2467			115	65	35
1975	2491	54	46	199	72	28
1976	1197			189	60	40
1977	1536			243	42	58
1978	388	87	13	153	7	93
1979	1679	57	43	258	21	79
1980	774	67	33	295	17	83
1981	677	72	28	311	17	83
1982	457	25	75			

[1] Biomass for years 1968-1982 adjusted using age composition data (Methot 1982)

[2] Total catch does not include Mexican catch for years 1951-1964.

the harvest was distributed similarly to the transboundary distribution of the stock. Since 1977 the transboundary distribution of the stock has remained essentially unchanged but the U.S. harvest has declined and the Mexican harvest has increased, resulting in a domination of the total harvest by the Mexican fishery.

4.2 Life History

4.2.1 Age and Growth

The age of northern anchovies has been determined from annual rings on scales and otoliths. Clark and Phillips (1952) used scales for age determination. Miller (1955) verified that annuli on scales indicate the age of the anchovy. Collins and Spratt (1969) verified the use of otoliths for aging anchovies and concluded that the age composition obtained from otoliths did not significantly differ from that for scales. Because 40% of the anchovies sampled from the fishery did not have readable scales, California Fish and Game now uses otoliths for aging. Miller (1955, p. 24) found that scale annuli formed during early winter and spring months. Collins and Spratt (1969, p. 43) defined a complete annual ring for otoliths as the interface between an inner hyaline and an outer opaque zone. They indicated the peak time of ring formation in otoliths is late spring and that nearly all new rings were completed by June 1st.

Length-at-age varies considerably with geographic locality. Parrish, Mallicoate and Mais (MS) have shown that anchovies sampled by CDF&G midwater trawls show a clinal variation in length-at-age, with progressively smaller mean lengths at more southerly latitudes (Figure 4.2-1). Importantly, there are not only differences between subpopulations, but within the central subpopulation itself. Furthermore, there is an inshore-offshore cline in length-at-age in the Southern California Bight (Figure 4.2-2). These differences suggest that the central subpopulation may not be as homogeneous as genetic studies and tag recapture patterns indicate (see 3.1 and 4.1.1)

Clark and Phillips (1952) and Spratt (1975) have presented growth curves for anchovies from commercial fishery samples. Size at the end of the year from these two papers are shown in Figure 4.2-1. The samples of Clark and Phillips were from the fishery in central California while Spratt collected samples from southern California. The growth curves given by Clark and Phillips and by Spratt differ considerably from the growth curves obtained from CDF&G midwater trawl catches (Figure 4.2-1). The reasons for these differences are not known, but may include year to year variability and differences in time, location, and method of capture. The directly sampled data of Parrish, Mallicoate and Mais (MS) (Figures 4.2-1,2,3) are the most useful for discussion of the anchovy fishery.

Spratt (1975, p. 123) fitted the von Bertalanffy growth curve to back-calculated lengths for age groups 1 through 6 using otoliths. The equation is

$$l_t = L_\infty(1-\exp(-K(t-t_o))$$

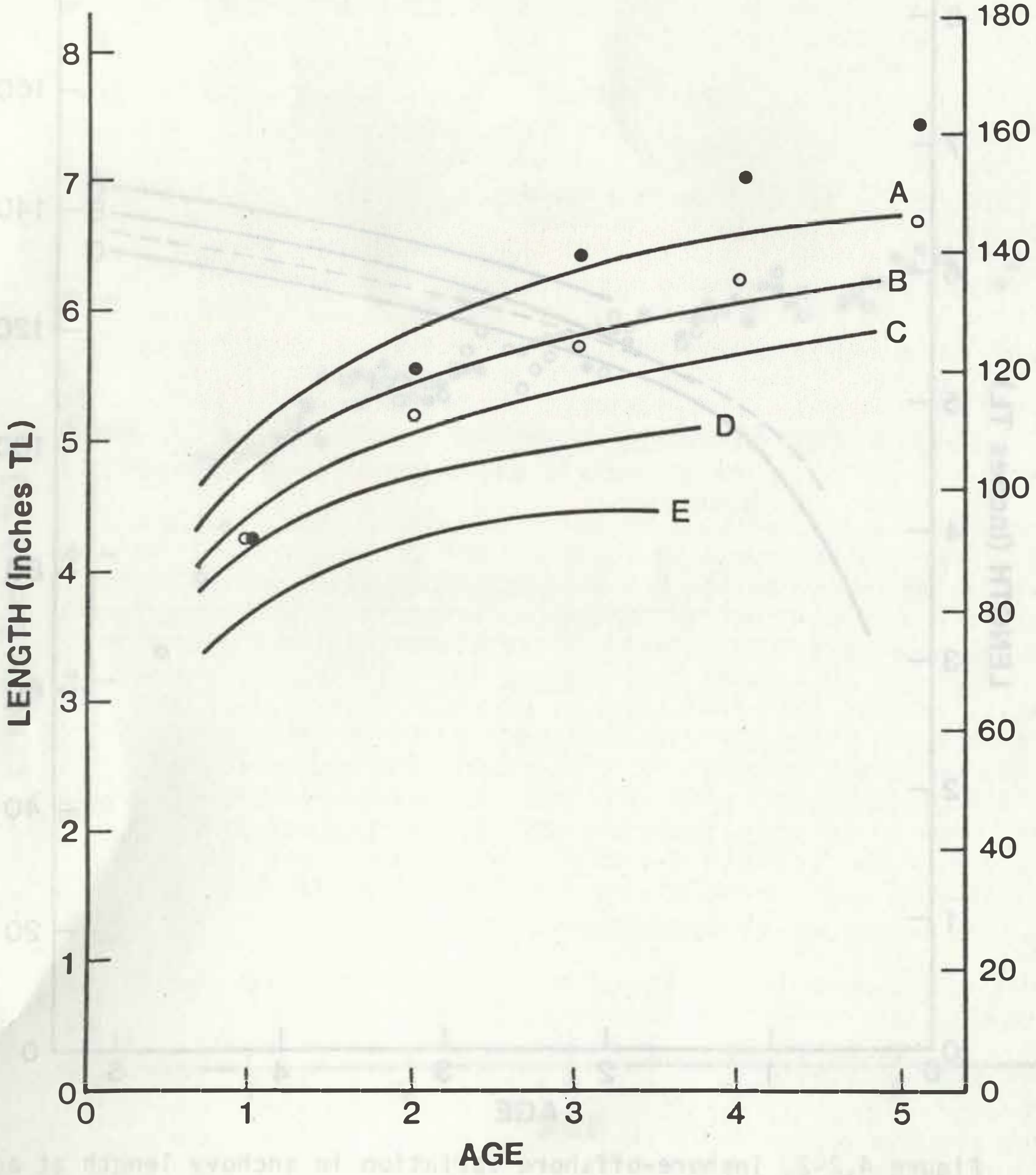


Figure 4.2-1. North-south variation in anchovy length at age. Solid dots are from Clark and Phillips (1952) for central California. Open dots are from Spratt (1975) for southern California. Lines are from CDF&G midwater trawls (Parrish, Mallicoate and Mais, MS): A. Central California; B. Southern California; C. Northern Baja California; D. Sebastian Vizcaino Bay; E. Southern Baja California.

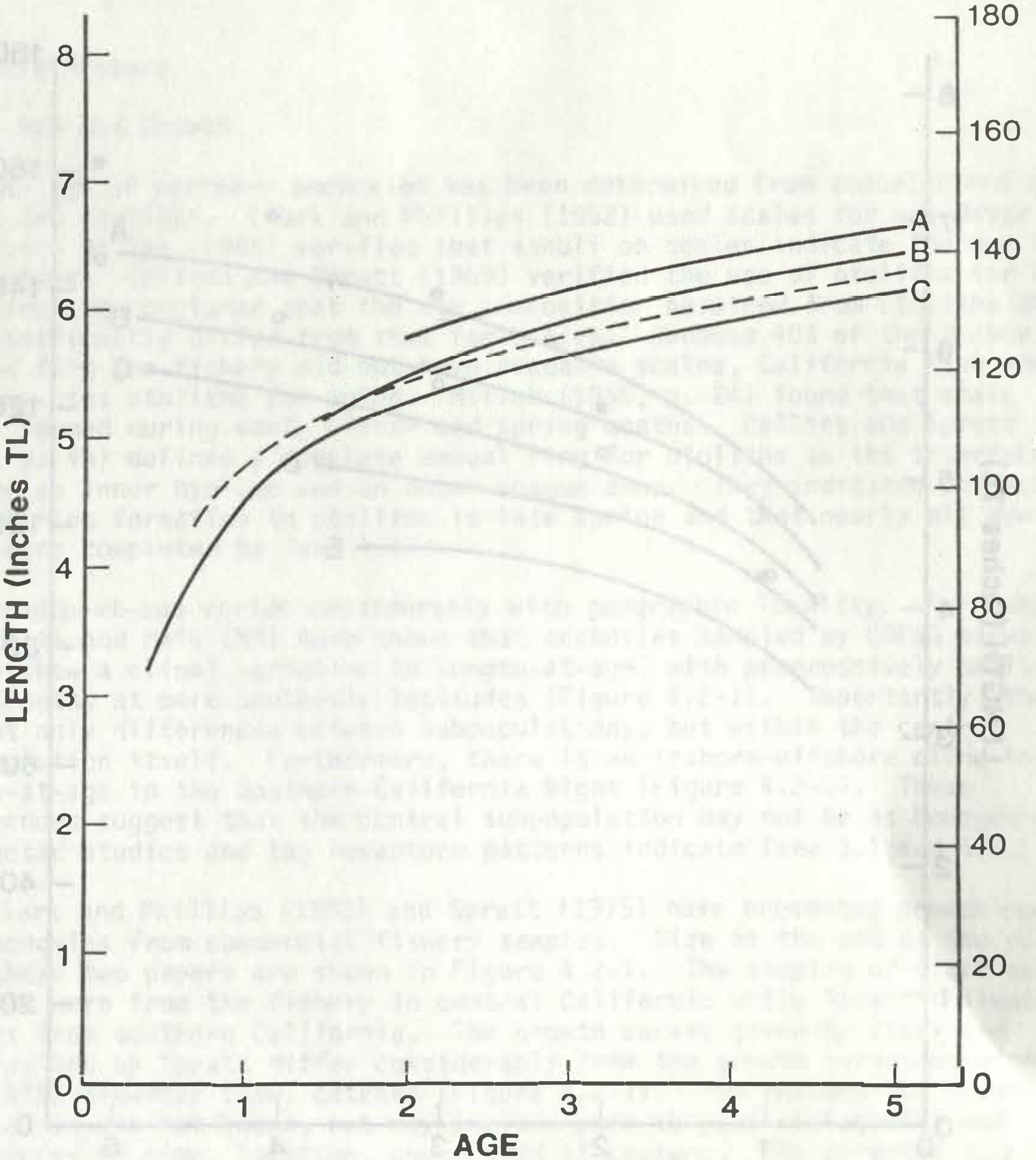


Figure 4.2-2. Inshore-offshore variation in anchovy length at age in southern California. A. Over 80 miles offshore; B. 40 to 80 miles offshore; C. Less than 40 miles offshore. Dashed line is southern California average (Line B in Figure 4.2-1). Incomplete lines are due to absence of small fish.

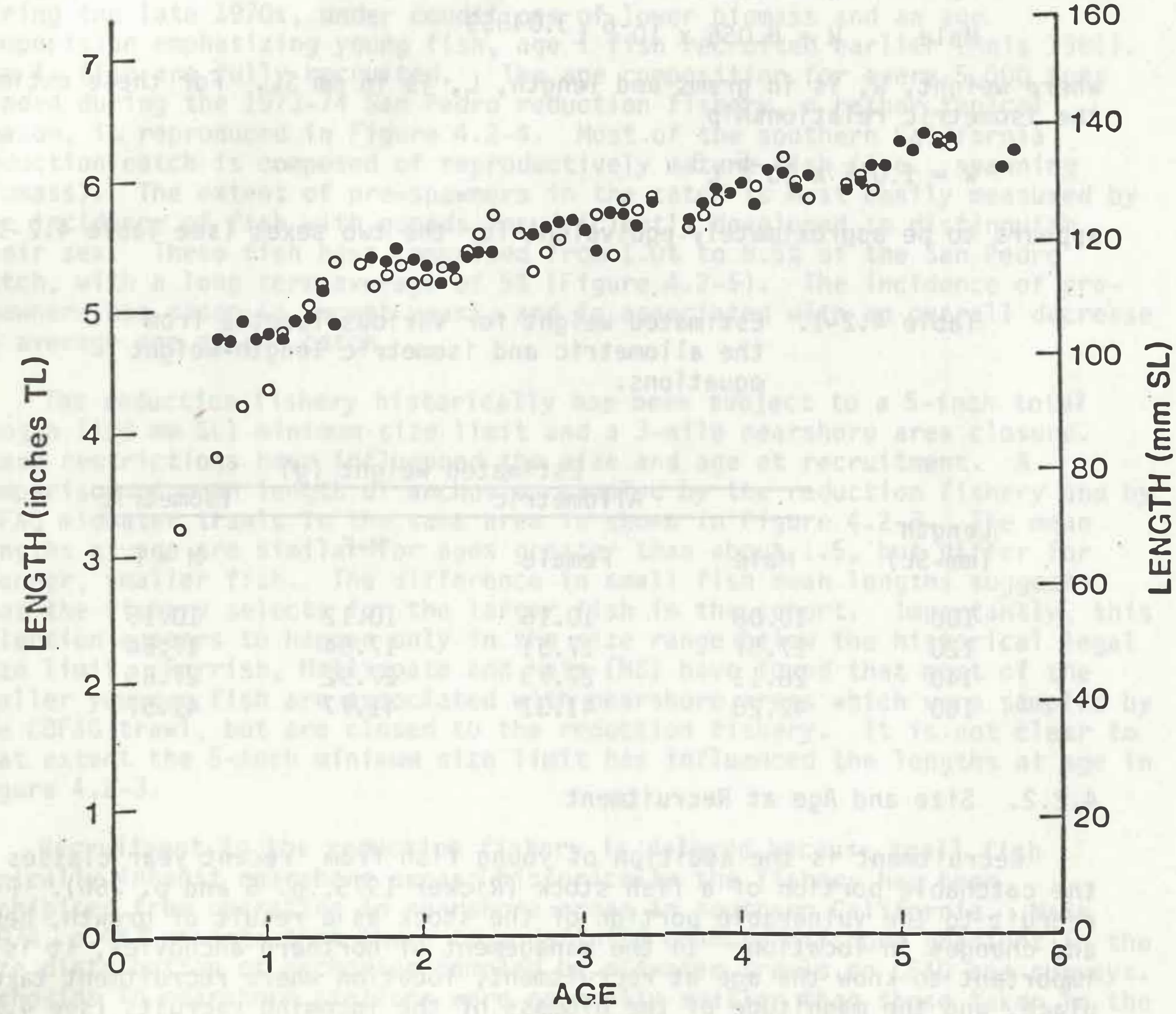


FIGURE 4.2-3. Comparison of mean length at age of anchovies caught in the San Pedro Channel. Solid dots are from reduction fishery landings. Open dots are from CDF&G midwater trawl samples.

with parameter estimates L_∞ = 165.5 mm SL, K=0.2987 and t_o = -1.714. Total length (TL) of the anchovy in millimeters can be estimated by multiplying standard length in millimeters by 1.17111 (Clark and Phillips 1952, p. 197). A 5-inch TL anchovy is approximately 108 mm SL.

The length-weight relationship has been found to vary significantly within seasons and between seasons (Knaggs, MS, p.3). Collins (1969, p. 68) gave the following allometric relationship for southern California anchovies from the 1966-67 fishery:

Female $W = 1.0933 \times 10^{-5} L^{2.98408}$

Male $W = 8.056 \times 10^{-6} L^{3.04859}$

where weight, W, is in grams and length, L, is in mm SL. For these estimates the isometric relationship

$$W = 1.015 \times 10^{-5} L^3$$

appears to be approximately equivalent for the two sexes (see Table 4.2-1).

Table 4.2-1. Estimated weight for various lengths from the allometric and isometric length-weight equations.

	Estimated weight (g)			
	Allometric			Isometric
Length (mm-SL)	Male	Female	M+F	M + F
100	10.08	10.16	10.12	10.15
120	17.57	17.51	17.54	17.54
140	28.11	27.73	27.92	27.85
160	42.23	41.31	41.77	41.57

4.2.2. Size and Age at Recruitment

Recruitment is the addition of young fish from recent year classes to the catchable portion of a fish stock (Ricker 1975, p. 5 and p. 265). Fish recruit to the vulnerable portion of the stock as a result of growth, behavior and changes in location. In the management of northern anchovies, it is important to know the age at recruitment, location where recruitment takes place, and the magnitude of the biomass of the incoming recruits (see 4.3-7).

Age of recruitment for anchovies is different for the live-bait and commercial reduction fisheries. From a live-bait sampling program in the summer of 1968, Crooke (1969, p. 92) found that age I fish accounted for 62% of the catch by weight. Age groups 0 and II contributed 15% and 19% of the catch by weight, respectively. Age groups III and older made up 4% of the catch (these percentages were adjusted to account for the 4% of the sampled fish that could not be aged). These data suggest that recruitment to the live-bait fishery occurs over a 6 to 12 month age interval beginning with age 0 fish in the middle of their first year of life (anchovies of this small size are commonly referred to as "pinheads").

Age of recruitment to the California commercial reduction fishery is older than for the live bait fishery. Recruitment to the San Pedro reduction fishery begins with age 0 fish in the winter months near the end of their first year of life (Sunada 1976, p. 221). Age I fish approach full recruitment in the following winter near the end of their second year of life. During the late 1970s, under conditions of lower biomass and an age composition emphasizing young fish, age I fish recruited earlier (Mais 1981). Age II fish are fully recruited. The age composition for every 5,000 tons landed during the 1973-74 San Pedro reduction fishery, a rather typical season, is reproduced in Figure 4.2-4. Most of the southern California reduction catch is composed of reproductively mature fish (i.e., spawning biomass). The extent of pre-spawners in the catch is most easily measured by the incidence of fish with gonads insufficiently developed to distinguish their sex. These fish have comprised from 1.0% to 8.5% of the San Pedro catch, with a long term average of 5% (Figure 4.2-5). The incidence of pre-spawners has risen in recent years, and is associated with an overall decrease in average age of the catch.

The reduction fishery historically has been subject to a 5-inch total length (108 mm SL) minimum size limit and a 3-mile nearshore area closure. These restrictions have influenced the size and age at recruitment. A comparison of mean length of anchovies sampled by the reduction fishery and by CDF&G midwater trawls in the same area is shown in Figure 4.2-3. The mean lengths at age are similar for ages greater than about 1.5, but differ for younger, smaller fish. The difference in small fish mean lengths suggests that the fishery selects for the larger fish in the cohort. Importantly, this selection appears to happen only in the size range below the historical legal size limit. Parrish, Mallicoate and Mais (MS) have found that most of the smaller younger fish are associated with nearshore areas which were sampled by the CDF&G trawl, but are closed to the reduction fishery. It is not clear to what extent the 5-inch minimum size limit has influenced the lengths at age in Figure 4.2-3.

Recruitment to the reduction fishery is delayed because small fish typically inhabit nearshore areas; historically the fishery has been prohibited from operating in nearshore areas in southern California. Mais (1974, p.46) reports that there is a definite onshore-offshore gradient in the size distribution of anchovies sampled by midwater trawls on CF&G sea surveys. Anchovies in nearshore stations were generally smaller than those taken in the offshore areas while the larger and older fish exhibited a greater offshore distribution. His observation that the sea survey undersampled age 0 and I anchovies has been quantified by Methot (1982). Crooke (1976, p5) reports the results of a nearshore survey which indicates that age 0 anchovies occurred in the nearshore zone with a higher frequency relative to offshore surveys of previous years. This and the age composition of the live-bait catch strongly suggest that the younger anchovies (ages 0 and I) predominate in the nearshore

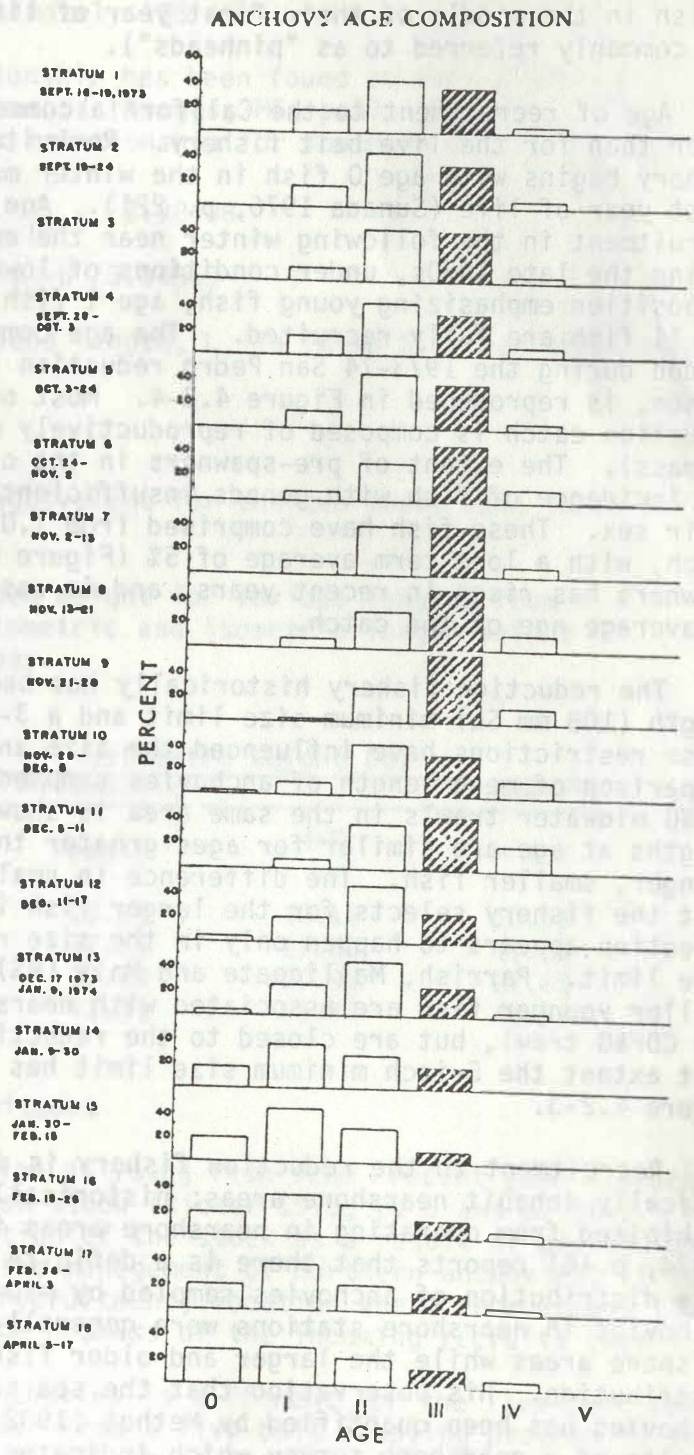


Figure 4.2-4 Percent frequency occurrence of age groups per 5,000 ton stratum, 1973-74 San Pedro landings (barred figures - 1970 year class) (Sunada 1975, p. 221).

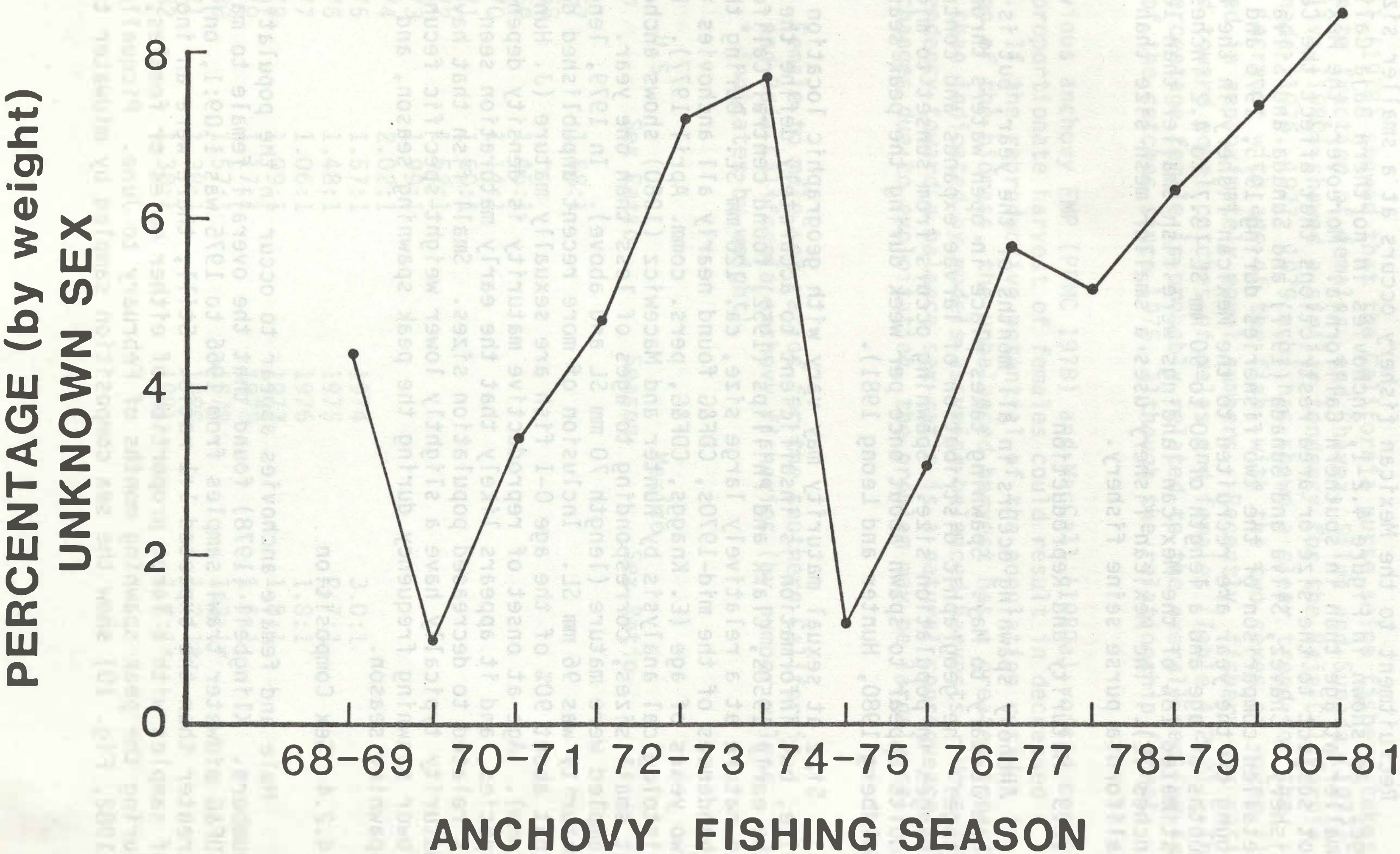


Figure 4.2-5. Percentage of pre-spawners in the southern California fishery as evidenced by fish of indeterminate sex (source:published anchovy landings reports and CDF&G data).

zone, the area of the bait fishery. These younger fish make only a small contribution to the spawning biomass because many are probably sexually immature.

Recruitment to the Mexican fishery occurs at a smaller size and younger age. As shown in Figure 4.2-1, anchovies in northern Baja California are smaller at age than in southern California. Moreover, the Mexican fishery is not subject to the size or area restrictions that affect the California fishery. Chavez, Silva and Sunada (1977) and Sunada and Silva (1980) give a detailed comparison of the two fisheries during 1975, 1976 and 1977. The young of the year are recruited to the Mexican fishery in the fall, at 6 months of age and a length of 80 to 90 mm SL (3.7 to 4.2 inches TL). An estimated 18% of the Mexican landings were fish smaller than 100 mm SL (4.6 inches TL). The Mexican fishery uses a smaller mesh size than does the California purse seine fishery.

4.2.3 Maturity and Reproduction

Anchovy spawning occurs in all months of the year, but is most intense from January to May. Spawning takes place in open waters throughout the range. The geographic distribution of larvae expands and contracts with changes in population size. Spawning occurs from sunset to midnight, and adults appear to spawn about once per week during the peak season (Hunter and Goldberg 1980, Hunter and Leong 1981).

Size at sexual maturity may vary with geographic location and population size, but information is insufficient to accurately define the pattern. In the early 1950s, Clark and Phillips (1952) found central California anchovies to mature at a relatively large size, ca. 120 mm SL. During the peak abundances of the mid-1970s, CDF&G found nearly all anchovies to be mature at two years of age (E. Knaggs, CDF&G, pers. comm. April 1977). Recent histological analysis by Hunter and Macewicz (1980) shows anchovies to mature at small sizes, corresponding to ages of less than one year. In 1978 all fish sampled were mature (length 70 mm SL and above). In 1979, length at 50% maturity was 96 mm SL. Inclusion of more recent unpublished data indicates that about 90% of the age 0-I fish are sexually mature (J. Hunter, SWFC, pers. comm). Age at onset of reproductive maturity is density dependent in many species, and it appears likely that the early maturation seen in recent years is related to decreased population sizes. Small fish that have attained maturity typically have a slightly lower weight-specific fecundity, slightly lower spawning frequency during the peak spawning season, and a shorter spawning season.

4.2.4 Sex Composition

Male and female anchovies appear to occur in the population in equal numbers. Klingbeil (1978) found that the overall female to male ratio in CDF&G midwater trawl samples from 1966 to 1975 was 1.09:1, only slightly greater than the expected 1:1 ratio. Still, there were an inordinate number of samples with a large proportion of either males or females, particularly during the peak spawning months of February to June. Picquelle and Hewitt (1982, Fig. 10) show the sex composition sampled by midwater trawl to vary with time of night. The largest discrepancies from 1:1 occur during the hours of peak spawning. All evidence points to a tendency for male and female fish to segregate in association with spawning behavior.

Klingbeil (1978) showed that the California purse seine fishery takes a disproportionate fraction of females, and Chavez, Silva and Sunada (1977) and Sunada and Silva (1980) showed a similar tendency for the Baja California fishery. Sunada (1976, 1977, 1979 a,b) has shown a clear trend for the imbalance to increase with age of the fish, with the two sexes of young fish being captured in approximately equal numbers. Recently, fishery sex ratios have declined toward equal catches of males and females (Table 4.2-2). The decline in percentage female is probably related to the overall decline in average age of the catches since 1975, although the relationship is not precise.

The previous anchovy FMP (PFMC 1978) and MacCall (1980a) voiced concern that the disproportionate harvest of females could result in decreased productivity. If the reproductive potential of the population resides in the female portion of the biomass, the unbalanced harvest has a greater impact on productivity than indicated by models assuming balanced harvests. However, if the recent tendency toward a balance sex ratio is a natural consequence of age composition changes due to exploitation, the problem may be largely self-correcting.

Table 4.2-2. Female to male sex ratios for the southern California and Baja California anchovy fisheries (by number unless * indicates by weight).

U.S. Season	U.S. Sex Ratio	Mexico Season	Mexico Sex Ratio
1966-67	1.58:1		
1967-68	-		
1968-69	1.45:1		
1969-70	1.14:1		
1970-71	1.60:1		
1971-72	1.52:1		
1972-73	1.99:1		
1973-74	2.02:1		
1974-75	1.57:1	1974	3.0:1
1975-76	1.48:1	1975	2.7:1
1976-77	1.06:1	1976	1.8:1
1977-78	1.09:1	1977	1.8:1
1978-79	1.17:1	1978	1.5:1
1979-80	1.57:1	1979	1.3:1*
1980-81	1.38:1	1980	1.2:1*
1981-82	1.38:1	1981	1.2:1*

4.2.5 Mortality

The age composition of anchovy from CDF&G midwater trawl catches has been used to estimate total mortality rate (Z) of adults age 2+ (MacCall 1974, Hanan 1981). Hanan (1981) also shows long-term fluctuations in apparent adult mortality, and Mais (1981) notes that the decreased life span of recent year-classes is suggestive of increased mortality.

Methot (1982) has reanalyzed the age composition data by a technique that accounts for variable recruitment, changes in biomass, and the commercial harvest. He notes that anchovy are incompletely available to the trawl through their second birthday therefore mortality at ages 1 and 2 must be assumed to be the same as mortality at age 3. Age-specific natural mortality rate (M=Z-F) during the period from 1968-1981 has averaged 0.50 for ages 1-3, 0.97 for age 4 and 1.19 for age 5. The long-term trend identified by Hanan (1981) and Mais (1981) was evident in this analysis; minimum mortality occurred during 1971-74. (Table 4.2-3).

Fishing mortality (F) increased about ten fold during the period from 1974 to 1978 (Table 4.2-3) and currently is similar in magnitude to natural mortality. The average relative availability of age classes to the fisheries is as follows:

Age	1	2	3	4	5
F_i/F_{total}	.66	1.74	2.26	1.80	1.01

Methot (1982) constructed the following hypothetical stable population with the fishery parameters observed during 1977-1982. The recruitment level (i.e., initial biomass) was selected to yield a result similar to that observed during recent years. Biomass here refers to total biomass, not spawning biomass.

Age	1	2	3	4	5	6	Sum
wt(g)	12.2	17.2	20.5	23.4	26.9	30.4	
M	.50	.50	.50	.97	1.19	1.19	
F	.28	.69	.96	.81	.81	.81	
Initial Biomass (10^3m tons)	610	396	145	39	8	1	1198
Catch (10^3m tons)	121	159	73	15	3	0	371

The average natural mortality rate (M) of all ages combined is 0.55, while the average natural mortality rate of biomass (M-G) of this population is 0.36. The equilibrium biomass with no fishery is 1939 thousand m tons.

4.2.6 Predation

The anchovy is a prey species throughout all its life stanzas: egg,

Table 4.2-3. Anchovy spawning biomasses, catches, and mortality rates. Biomass and catch have units of thousand metric tons. Mortality rates are not presented for ages 1 and 5 because of inadequate sampling.

Year	Spawning Biomass*	Total Catch**	Mortality for ages 2-4 Natural	Mortality for ages 2-4 Fishing
1968	409	31	1.07	0.08
1969	575	69	1.20	.25
1970	782	106	.89	.32
1971	539	71	-0.01***	.15
1972	554	66	-0.42	.12
1973	1423	145	.00	.11
1974	2467	117	.27	.07
1975	2491	195	.54	.19
1976	1197	177	.80	.31
1977	1536	213	.91	.84
1978	388	151	1.04	.64
1979	1679	249	.70	.82
1980	774	293	.35	.74
1981	677	296	.63	.75
1982	457			

*Adjusted spawning biomass from Methot (1982).

**U.S. and Mexican catch during period from April through March.

***Natural mortality rate of older age groups will be negative when the increase in spawning biomass cannot be fully accounted for by the incoming year class. Previous estimates of mortality rate (MacCall 1974, Hanan 1981) were based on mean age of fish in the fully recruited age groups. These previous estimates could not be negative but were biased by variation in recruitment and did not separate fishing and natural mortality.

larvae, juvenile, and adult. The list of predators is long and includes almost every predator species of fish, birds and mammals in the California Current region (Table 4.2-4). Anchovy eggs and larvae, as part of the zooplankton complex, fall prey to the assortment of invertebrate and vertebrate planktivores including adult anchovies. Because of the rapid larval growth rates, the duration of this life stanza is about 2 to 4 months, but the mortality is high. As juveniles in the nearshore zone, anchovies are vulnerable to gamefish of recreational and commercial importance although these species must compete with a variety of other predators of less recreational value. Important recreational species in southern California are Pacific bonito (Sarda chiliensis), yellowtail (Seriola dorsalis), California barracuda (Sphyraena argentea) and in northern California salmon (Oncorhynchus sp.) and striped bass (Roccus saxatilis). Less valued species such as Pacific electric ray (Torpedo californica) and the abundant white croaker (Genyonemus lineatus) have been observed feeding on anchovy schools (A. Mearns, Southern California Coastal Water Resources Project, pers. comm. May 1977).

As adults offshore, anchovies are fed upon by numerous predators that include recreationally and commercially important fish (i.e., albacore, bonito, Pacific mackerel), marine mammals, and marine birds. Many of these predators are opportunistic feeders preying on whichever species is available. Unfortunately, very little is known about the actual quantities of anchovy consumed or the percentage of anchovies in the predator diets in relation to other forage species (Baxter 1967, p. 112). The annual fraction of adult anchovies that succumb to predation can be calculated by the equation (from Ricker 1975; equations 1.38 and 1.41):

$$P/B = M(1-e^{-(Z-G)})/(Z-G)$$

where P/B is the ratio of predator consumption to initial biomass; M, Z, and G are instantaneous rates of natural mortality, total mortality and body growth respectively. Based on values in Section 4.2.5, predators consume 46% of the initial spawning biomass of anchovies in an average year. This percentage will decrease, as will the average biomass, as fishing pressure increases. The biomass of pre-recruit anchovies which is available to predators cannot be measured directly, but the analysis in Section 4.2.5 shows that a year class achieves maximum biomass before first spawning.

Table 4.2-4. Known or suspected predators of the northern anchovy.
(* denotes endangered species)

MARINE MAMMALS

Callorhinus ursinus	Northern fur seal
Arctocephalus townsendi	Guadalupe fur seal
Eumetopias jubatus	Steller sea lion
Zalophus californianus	California sea lion
Mirounga angustirostris	Northern elephant seal
Phoca vitulina	Harbor seal
Delphinus delphis bairdi	Common dolphin
Phocoenoides dalli	Dall porpoise

Lagenorhynchus obliquidens	Pacific striped dolphin
Tursiops truncatus	Pacific bottlenose dolphin
Globicephala macrorhynca	Pilot whale
Balaenoptera musculus*	Blue whale
Balaenoptera physalus*	Fin whale
Balaenoptera acutorostrata	Minke whale
Balaena glacialis*	Pacific right whale
Megaptera novaeangliae*	Humpback whale
Eschrichtius robustus*	California gray whale

MARINE BIRDS

Diomedea nigripes	Black-footed albatross
Fulmarus glacialis	Fulmar
Puffinus griseus	Sooty shearwater
Puffinus puffinus	Manx shearwater
Oceanodroma leucorhoa	Leach's petrel
Oceanodroma homochroa	Ashy petrel
Loomelania melania	Black petrel
Pelecanus occidentalis*	Brown pelican
Phalacrocorax auritus	Double-crested cormorant
Phalacrocorax penicillatus	Brandt's cormorant
Phalacrocorax pelagicus	Pelagic cormorant
Larus glaucescens	Glaucous-winged gull
Larus occidentalis	Western gull
Larus heermanni	Heerman's gull
Larus delawarensis	Ring-billed gull
Larus californicus	California gull
Rissa tridactyla	Black-legged kittiwake
Uria aalge	Common murre
Cepphus columba	Pigeon guillemot
Brachyramphus marmoratum	Marbled murrelet
Endomychura craveri	Craveri's murrelet
Endomychura hypoleuca	Xantu's murrelet
Synthliboramphus antiquum	Ancient murrelet
Ptychoramphus aleutica	Cassin's auklet
Cerorhinca monocerata	Rhinoceros auklet
Fratercula corniculata	Horned puffin
Lunda cirrhata	Tufted puffin
Haliaeetus leucocephalus*	Bald eagle
Pandion haliaetus	Osprey
Sterna elegans	Elegant tern
Sterna caspia	Caspian tern
Sterna forsteri	Forster's tern
Sterna albifrons browni*	Least tern

MARINE FISHES

Engraulis mordax	Northern anchovy
Sardinops sagax caeruleus	Pacific sardine
Merluccius productus	Pacific whiting
Alopias vulpinus	Common thresher shark

Isurus oxyrinchus	Bonito shark
Galeorhinus zyopterus	Soupfin shark
Prionace glauca	Blue shark
Torpedo californica	Pacific electric ray
Oncorhynchus kisutch	Silver salmon
Oncorhynchus tshawytscha	King salmon
Sebastes spp.	Rockfishes (many species)
Roccus saxatilis	Striped bass
Paralabrax nebulifer	Barred sand bass
Paralabrax clathratus	Kelp bass
Caulolatilus princeps	Ocean whitefish
Trachurus symmetricus	Jack mackerel
Seriola dorsalis	Yellowtail
Atractoscion (Cynoscion) nobilis	White seabass
Seriphus politus	Queenfish
Menticirrhus undalatus	California corbina
Genyonemus lineatus	White croaker
Embiotocidae spp.	Surfperches (many species)
Sphyraena argentea	California barracuda
Scomber japonicus	Pacific mackerel
Sarda chiliensis	Pacific bonito
Thunnus alalunga	Albacore
Thunnus thynnus	Bluefin tuna
Xiphias gladius	Swordfish
Tetrapturus audax	Striped marlin
Paralichthys californicus	California halibut

INVERTEBRATES

Loligo opalescens	Market squid
Decapoda (oegopsida)	Oceanic squids

4.2.6.1 Fish

Some species of predatory fish have shown large variations in abundance. Pacific bonito became abundant in southern California in the early 1960s, at about the time when the anchovy population increased. MacCall, Stauffer and Troadec (1976) examined the relationship, and concluded that the parallel trends were probably coincidental, since the increase in bonito abundance preceded the increase in anchovy abundance. It is notable that the anchovy biomass increased at a time when predator abundance, and therefore predation, was high. Pacific mackerel (Scomber japonicus) were abundant in the early 1960s, but subsequently declined until they recovered in the late 1970s. From a total biomass of 125,000 metric tons in 1962 (Parrish and MacCall 1978), the biomass of Pacific mackerel fell to less than 5,000 tons by 1970. In 1981, the total biomass was estimated to be 166,000 metric tons, the highest level since 1936 (Klingbeil 1981). Based on the predation rates determined by Hatanaka and Takahashi (1960), the Pacific mackerel could consume 450,000 tons of anchovies per year under conditions similar to those assumed for Japanese waters (50 day-equivalents of predation per year). Methot (1982) suggests that increased predation by Pacific mackerel may be responsible for recent increased natural mortality of anchovy. While this estimate of anchovy consumption is speculative, it suggests that net productivity of the anchovy resource (i.e. the surplus available to the fishery) is likely to vary with predator abundance.

4.2.6.2. Marine Mammals

Many marine mammals are anchovy predators. The California sea lion (Zalophus californianus), the northern fur seal (Callorhinus ursinus), and the northern elephant seal (Mirounga angustirostris) are known anchovy predators (Antonelis and Fiscus 1980), and it is likely that the remaining pinnipeds may be included as well (Table 4.2-4). Again, all of the smaller cetaceans are likely to be anchovy predators. Among the larger cetaceans, Minke whales (Balaenoptera acutorostrata) and humpback whales (Megaptera novaeangliae) have been observed eating anchovies (respectively Wm. Evans, Hubbs Sea World Inst., pers. comm. and James Lecky, NMFS, SWR, pers. comm.). Fin whales (Balaenoptera physalus) are known to be fish eaters and should be included as probable anchovy predators. The remaining large whales may consume anchovies incidentally. This group includes the California gray whale (Eschrictius robustus).

4.2.6.3 Birds

Nearly all seabirds and many shorebirds in California and Baja California consume anchovies. While the large birds prey on adult anchovies, some of the smaller birds, such as murrelets, prey on anchovy larvae and juveniles as well. Hunt and Butler (1980) describe relationships between western gull (Larus occidentalis) and Xantu's murrelet (Endomychura hypoleuca) nesting timing and success, and apparent abundance of anchovies.

Anderson et. al. (1980) and Anderson, Gress and Mais (1982) describe a ten-year detailed study of the relationship of brown pelicans (Pelecanus occidentalis californicus) to anchovy abundance in southern California. They conclude that pelican reproductive success is weakly related to overall anchovy abundance, but strongly related to local anchovy abundance/availability especially near the major breeding colonies on Anacapa and Los Coronados Islands. However, pelican reproductive success is more closely correlated with the new egg production-based time series of anchovy spawning biomasses (Figure 4.2-6). Reproductive success (R, fledglings per nest attempt) is related to anchovy spawning biomass (B, thousand metric tons) by $R = -1.638 + 0.337 \ln B$ ($r^2 = 0.81$). This relationship is non-linear (note the logarithmic scale of spawning biomass), so pelican reproductive success shows reduced sensitivity to high levels of anchovy abundance. Sensitivity increases at lower levels of anchovy abundance, but the relationship is not known for spawning biomass below about 300,000 metric tons. The extent to which pelicans switch to alternate prey at low levels of anchovy abundance is not known; also it is very likely that sardines were an important prey in the past, and its recovery would augment the pelican's forage base. Also, the above relationship between reproductive success and anchovy abundance is based on observations made since 1972, a period during which reproductive success

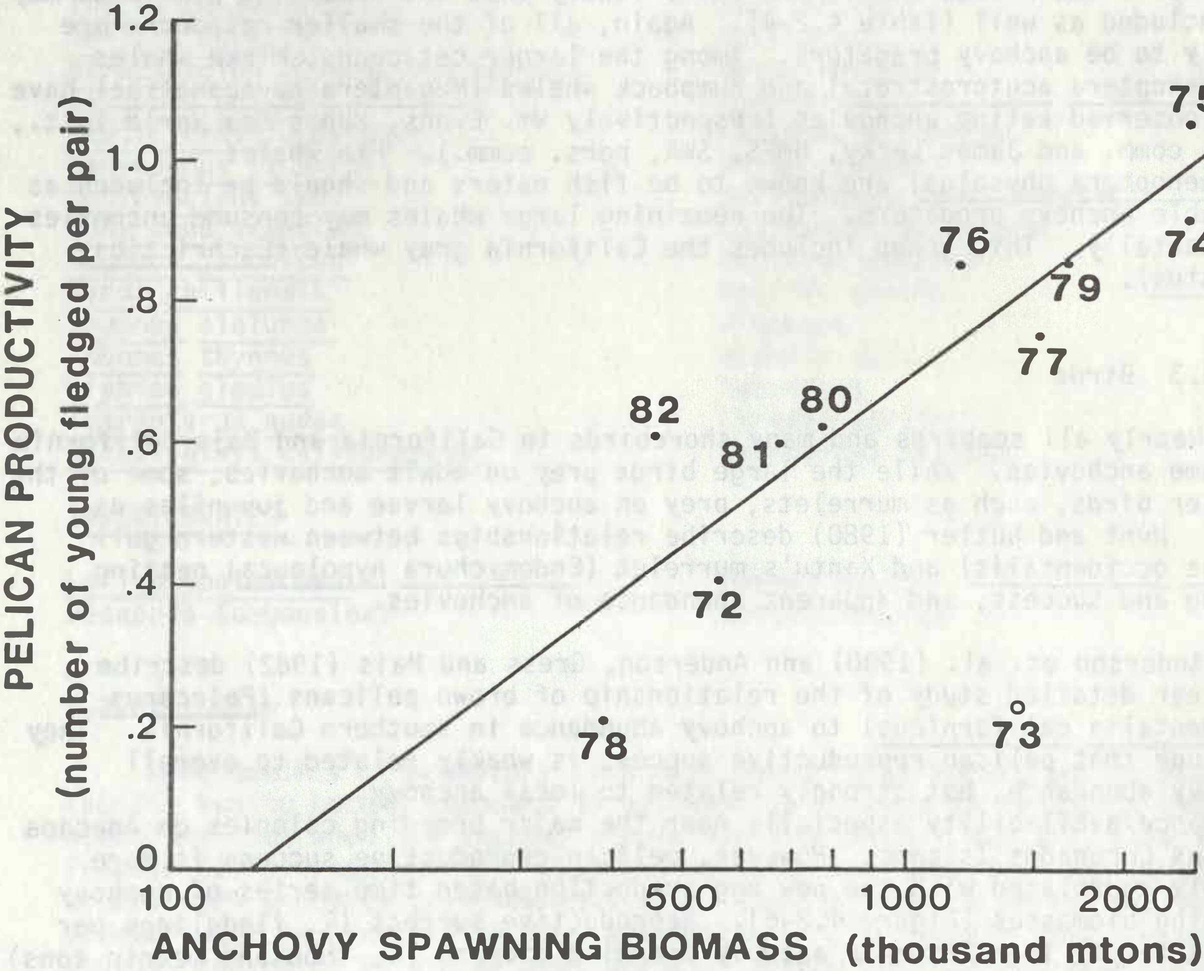


Figure 4.2-6. Relation between brown pelican productivity (Anderson et al 1980; Anderson, Gress and Mais 1982) and anchovy spawning biomass. The 1981 and 1982 productivity values are unpublished data from Anderson and Gress (UC Davis). The 1973 value is biased and is excluded from the regression for reasons described in Anderson et al (1980).

has been depressed due to chronic effects of pesticide residues. As pesticide residues decrease, pelican reproductive success can be expected to improve at all levels of forage abundance.

The impact of the anchovy fishery on marine birds is likely to be somewhat greater than that on other predators, since the purse seine fishery will directly compete for surface schools on which marine birds feed. An extreme situation was experienced in Peru, where an intense purse seine fishery, combined with El Niño conditions, resulted in a severe decline in bird populations (Clark 1975, p. 285). Seabird declines associated with intense pelagic fisheries have also been described for South Africa (Crawford and Shelton 1978). Both the Peruvian and South African experiences were associated with depletion of pelagic fish stocks; stopping the anchovy reduction fishery at low stock levels will reduce the possibility of severe impacts due to anchovy harvesting. The effects of various anchovy harvest options on expected pelican reproductive success are presented in Table 8.3-3.

4.2.7 Food Habits

The food of anchovies has been examined by Loukashkin (1970). He estimated the percentage of food items by number from stomach samples as crustaceans, 50.78%; other zooplankters, 35.76%; phytoplankton, 10.99% and foreign matter, 2.4%. Loukashkin concluded that the northern anchovy is an omnivorous species feeding predominantly on zooplankters and to a lesser extent on phytoplankton. The most important food items of the adults are copepods and euphausiids. Anchovies may also feed on amorphic organic material (Soule and Oguri 1980: p.434); the extent of this behavior may be underestimated by usual stomach contents analyses. In relation to feeding habits, the anchovy is diurnal, feeding mostly during the day. The northern anchovy is primarily a filter feeder, but may also be a particulate or selective feeder, depending on the size of the available food. Experiments have shown that prey organisms less than 1 mm are consumed by filter feeding and organisms a few millimeters in length are taken by particulate biting (Anonymous 1967, p. 19). When presented with a mixture of large and small food items, anchovies tend to adopt the feeding mode which results in the highest caloric intake (O'Connell 1972).

Hunter and Kimbrell (1980) have shown that a significant portion of eggs spawned by anchovies may subsequently be cannibalized. Based on 31 samples of 10 or more fish, they concluded that 17.2% of the daily egg production was consumed. MacCall (1980b) examined both the evidence from stomach contents and from theoretical filter-feeding rates, and concluded that cannibalism is an important mechanism regulating the reproduction of anchovies.

Food habits of anchovy larvae have been examined by Arthur (1976). Copepod eggs and nauplii were the most abundantly consumed food items. Unarmored dinoflagellates may also be an important food source, especially for first-feeding anchovy larvae. Lasker (1978) has hypothesized that dense local concentrations of edible food items are required for successful first-feeding, and that recruitment strength may be strongly influenced by the formation and destruction of these habitats.

4.2.8. Habitat

The northern anchovy is an epipelagic species although it has been observed at depths of 300 m. Adults tend to remain relatively offshore. Juveniles are often found close inshore, in shallow waters, and in estuaries, as well as offshore. As is common among clupeoids, the range of the central subpopulation of anchovy expands and contracts with population size.

Adult anchovies have been regularly observed in waters ranging from 12 to 20°C surface temperature in southern California. There is some evidence that anchovies tend to avoid high surface temperatures by remaining deeper in the water column, as demonstrated by the anomalous conditions in November 1976 (Mais 1976). The lower lethal temperature for adult northern anchovy was 7°C in laboratory acclimation tests, while temperatures below 10°C were lethal to developing larvae (Brewer, 1976). Spawning usually occurs in temperatures between 12 and 15°C, which are typical during late winter.

There is relatively little information regarding the water quality requirements and preferences of anchovy. Oxygen depletion has caused occasional fish kills in both Santa Cruz Harbor and Fish Harbor at Terminal Island, Los Angeles. In 1973-74, oxygen depletion due to die-off of massive dinoflagellate blooms caused fish kills in Fish Harbor, as well as at other locations in coastal waters. Prior to regulatory control, oxygen depletion due to excessive dumping of high oxygen demand wastes into waters with reduced circulation caused episodes of fish kills as well, but such areas provided attractive food supplies preliminary to the oxygen depletion events. Anchovies often congregate around areas of sewage outfall, such as White's Point off Palos Verdes Peninsula, and formerly, around the outfalls of the Terminal Island fish processors and sewage treatment plant.

The impacts of the cannery and sewage waste on anchovy have been studied extensively only in the Los Angeles Harbor area. In this case, anchovy reduction processing is only one of the various fishery products that contribute to canner effluent. Cannery wastes for many years were dumped into Inner Fish Harbor along with pumpings from boat holds and human wastes. The waters were frequently anoxic and the debris laden bottom was devoid of benthic macroorganisms. In 1964, two cannery discharges were relocated intertidally outside Fish Harbor in Los Angeles Harbor not far from the sewage treatment outfall (Soule and Oguri, 1973, p.7). The Way Street Station outfall receives wastes from various canneries and the other discharges effluent from only Starkist canneries. The discharge of cannery wastes is most critical during the fall of the year when seasonal die-off of biota from late summer and early fall plankton blooms and water column turnover place a heavy natural oxygen demand on the receiving waters (Chamberlain, 1975, p. 13). Soule and Oguri (1976, p. ii) report that "under (then) present conditions, a small zone within approximately 200 feet of the outfalls exists where numbers of species are low. Adjacent to this zone is a zone of enrichment which extends through most of the outer harbor. Beyond that, conditions return to average coastal populations. The regulations of waste loadings and control of pollutants in the past 6-year period has brought the harbor ecosystem from a depauperate biota to a moderately rich one in the immediate outfalls zone, with a very rich biota in the adjacent outer harbor area."

Soule and Oguri (1973, p. 15-16) reported that "Nothing is known about the distance traveled by individual anchovies within the harbor, nor about the degree to which they move in and out of the harbor. Catches by the bait boats, presently being surveyed, indicate that there may be an area of inhibition in the immediate vicinity of the cannery outfalls . . . There are indications that the anchovies move away from the area when the oxygen is low and also when it is excessively high, during plankton blooms. Weather conditions may exert influence as well, for anchovies apparently disappeared from harbor catches prior to heavy winter storms and subsequent rainwater runoff. They also were not caught in the harbor near the end of the season when the Davidson Current brought warmer southerly waters into the area, but reappeared just after water temperatures dropped."

Turbid waters with high densities of edible fine particulate matter apparently made harbor waters an excellent habitat for larval and juvenile fishes. However, fish productivity began to decrease when dissolved air flotation treatment (DAF) was installed on the cannery waste streams in 1975, even though esthetically the harbors waters were improved. The installation of secondary waste treatment at the Terminal Island Treatment Plant and the subsequent connecting of cannery waste streams to the treatment plant in 1977-78 resulted in a dramatic decrease in harbor biota and, in particular, in anchovies (Soule and Oguri, 1979, p. VIII; 1980, p. IX). Benthic populations decreased three-to four-fold in the outer harbor between 1973 and 1978, and the fish populations, sampled by otter trawl, also dropped four-fold. Trawl catches of anchovy in the outer harbor decreased about 10-fold between 1973 and 1974 and continued to decrease at a slower rate through 1978 (Soule and Oguri, 1980, p. 372). The offshore anchovy population increased from 1973 to 1974 then decreased about 5-fold through 1978 and recovered in 1979 (Figure 4.3-4). The harbor anchovy population has not recovered since that time, regardless of whether the winter has been warm or cold, wet or dry. Anchovy and other fish have been attracted to the harbor during episodes when the treatment plant malfunctioned and released high BOD floc and wastes, and when dredging created high levels of turbidity and resuspended edible particulates and microbiota. There is presently an application pending to EPA for a secondary waiver for the Terminal Island Treatment Plant, to permit some direct release of fish processing wastes to the harbor to relieve the BOD load on the waste facility and to enrich the harbor (Soule and Oguri, 1982).

Fish catches by commercial party boat decreased dramatically off the Orange County Sanitation District outfall after conversion to a deep water outlet (Soule and Oguri, 1982 p. 373).

Recent studies (Lasker, 1975, 1976, 1978; Lasker and Smith, 1977) have shown that larval habitat is critical to larval survival and therefore governs subsequent recruitment strength. Spawning occurs from January to May throughout the area inhabited by the central stock, with heaviest concentrations occurring inshore. Favorable larval habitat consists of dense plankton blooms of edible and nutritious organisms. Edibility is governed by size, but nutrition is governed by species. Some organisms of the proper size, such as armored dinoflagellates, cannot be digested by the anchovy larvae. These plankton blooms characteristically form as thin layers often extending over large geogarphic areas.

Formation and destruction of these thin layers are the key events to larval survival. Upwelling must initially bring nutrients to the surface, allowing a plankton bloom to occur. Subsequent conditions must be stable, such that layers of planktonic forage attain sufficient concentrations for anchovy larvae to feed efficiently. Disturbance of these layers result in dispersal of the plankton, and concentrations may drop below levels necessary for survival. In the spring of 1974, Lasker (1975) observed the extensive destruction of plankton layers by a severe storm. Although this storm was a short-lived phenomenon, it may have been a contributory cause of the extremely poor 1974 year class of anchovies (see section 4.5). In the following year, Lasker (1976) observed destruction of the layers by a period of intense upwelling during the midst of spawning. Optimal larval habitat, therefore, depends on a delicate balance between too little and too much wind, which in turn affects the extent and timing of upwelling as well as direct agitation of the water column (Lasker, 1978).

4.2.9 Oil Content

The value of anchovy to processors is somewhat dependent on the oil content which is cyclic over the season. It is low in the winter and spring spawning season and increases in the summer to a peak around September (Lasker and Smith 1977). This cycle is given in Figure 4.2-7. During the low period, the oil in the flesh is replaced by moisture. Small fish typically have a lower oil yield so are less desired by the processors.

Menhaden fish oil has a specific gravity of approximately 0.93 at 15°C. (From Handbook of Chemistry and Physics, table of contents of oils, fats and waxes. Chem. Rubber Publ. Co.) Assuming the same value for anchovy oil, then one gallon weighs about 7.75 pounds. The oil content of anchovies was reported by Messersmith (1969, p. 29) to fluctuate between 15 and 45 gallons per ton of anchovy (5.8 to 17.4% body weight) in Monterey and between 5 and 30 gallons per ton (1.9 to 11.6% body weight) in southern California. The low values occurred during the spawning season. Oil yields from laboratory studies are about 50-60% greater than those from reduction plants.

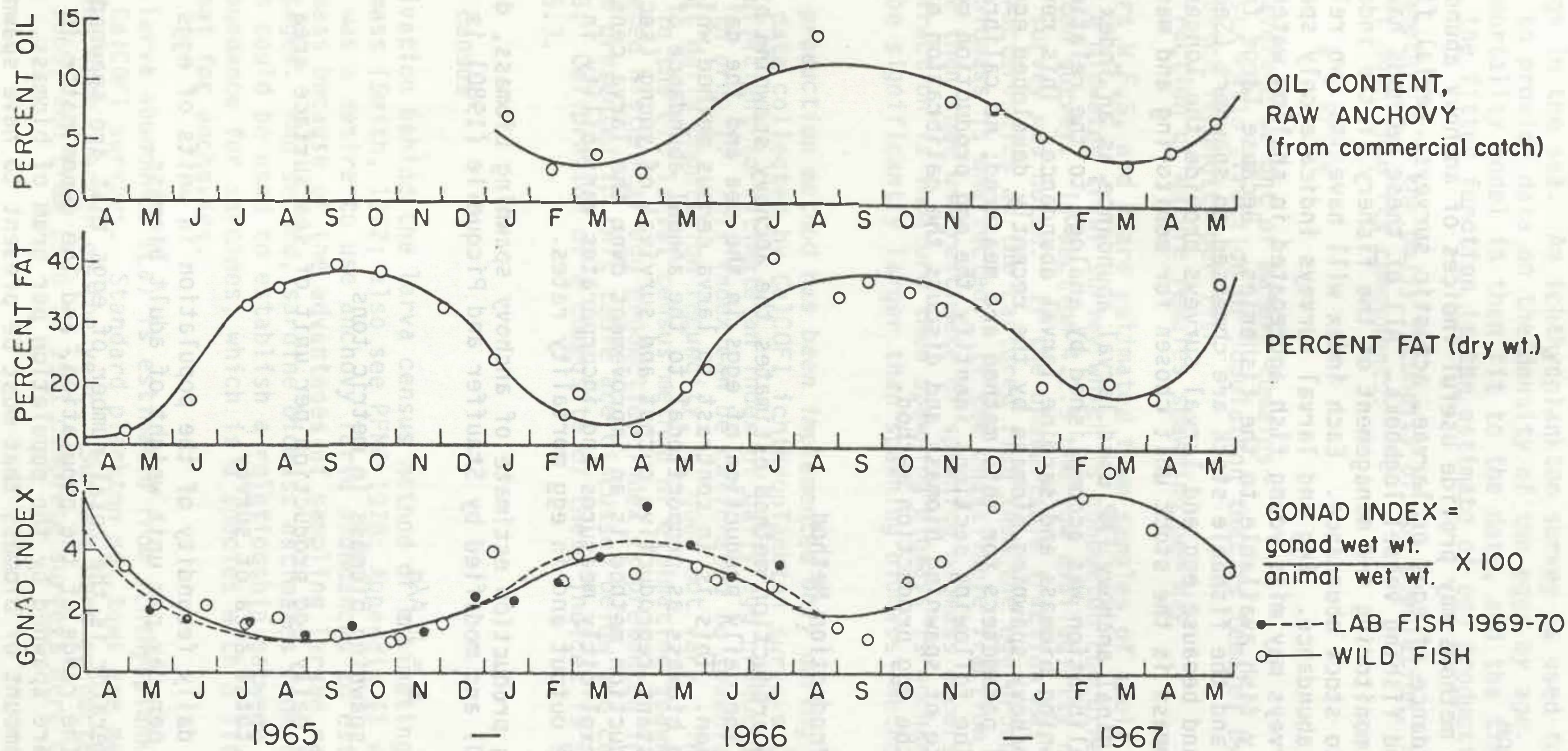


Figure 4.2-7. Annual northern anchovy fat and gonad cycles for 1965-67. (Lasker and Smith 1977)

4.3 Abundance

Various methods may provide useful indices of anchovy abundance. These include abundance of eggs or larvae, acoustic surveys, aerial fish spotter logbooks, and fishing vessel logbooks. All of these methods have potential utility for monitoring and management of the fishery if the index can be calibrated to stock abundance. Each index will have its own relationship to total stock abundance. Egg and larval surveys indicate only spawning biomass. Acoustic surveys may miss young fish aggregated in shallow water. Logbooks indicate only fish available to the fisheries. Because large fractions of the total stock and the fishable stock are composed on spawners (Sections 4.2.2 and 4.2.3) and because egg and larval surveys provide the longest time series, spawning biomass is the stock unit chosen for monitoring and management.

The original anchovy FMP used larval abundance as an index of spawning biomass. Calibration was accomplished by analogy to the relation between sardine spawning biomass and sardine larval abundance. This revised FMP estimates anchovy spawning biomass by the recently developed egg production method. All parameters for this method are measured; no calibration factor is required. The following sections identify the egg production method as our best estimate of spawning biomass and discuss the calibration of the other methods to the egg production method.

4.3.1 Egg Production Method

The egg production method estimates the anchovy spawning biomass by the quotient of the daily production of eggs in the sea and the daily fecundity of the population. This is in contrast to larva census method which estimates the spawning biomass as proportional to the annual abundance of larvae and assumes constant reproductive output and survival of young (section 4.3.2). The egg production method is an improvement over the larva census method because it explicitly measures and incorporates variability in adult reproductive output and in egg mortality rates.

The egg production estimate of anchovy spawning biomass, derived by Parker (1980) and modified by Stauffer and Picquelle (1980) is

$$B = P_o A/q$$

where B = spawning biomass in metric tons

P_o = daily egg production per unit of sea surface area per day

A = total area of survey

q = daily fecundity of the population in units of eggs spawned per day per unit weight of adult biomass.

The numerator is the total number of eggs that are spawned per day throughout the range of the population, and the denominator is the rate at which eggs are spawned by the population per gram of biomass. Hence, "B" is simply the amount of biomass that must be present to have spawned the observed number of eggs in the sea. An ichthyoplankton survey is used to sample anchovy eggs to provide data on the density of the eggs by age. An exponential mortality model is then fit to the data, and the time-zero intercept of the fitted function is the estimate of egg production (P_o).

The parameter "q", the daily fecundity of the population, is calculated by breaking it down into its components:

$$a = RFS/W$$

where W = average weight of mature females
R = sex ratio (fraction of population that is female) by weight
F = batch fecundity per fish
S = fraction of mature females spawning per day

The parameters W,F,S, and R are estimated from samples of adult anchovies collected by a midwater trawl survey which is conducted concurrently with the ichthyoplankton survey. In section 4.2.5 the low availability of young fish to the trawl survey was noted. If the unavailable fraction has the same spawning characteristics as the captured fish then the egg production estimate of spawning biomass is unaffected. If the unavailable fraction has a lower spawning rate then some underestimate of spawning biomass occurs. If the unavailable fraction is immature then spawning biomass is unchanged, but total biomass may be significantly larger than spawning biomass (Methot and MacCall 1983).

The egg production method has been implemented only during 1980-82. In prior years, data collected by CalCOFI ichthyoplankton surveys (see Section 4.3.2) are sufficient to estimate an index of daily egg production (P_o) (see N. Lo, SWFC, in prep.). This index can be calibrated to spawning biomass if we assume that daily population fecundity, q, does not vary. This assumption was implicit in the old larval census method of estimating spawning biomass. The uncalibrated historical egg production index is presented in Table 4.3.-1. Other indices presented in this table are discussed below and compared in Section 4.3.6. Calibration of a composite of these indices is presented in Section 4.3.6.3.

4.3.2 Larva Census

The motivation behind the larva census method of estimating anchovy spawning biomass (Smith, 1972; also see PFMC 1978: Appendix I) was two-fold. First, there was a desire to use anchovy larva abundances to estimate anchovy spawning biomass because of the advantages of sampling larvae rather than other life stages. And second, sardine biomass estimates from fishery data existed which could be used to establish a relationship between adult biomass and larval abundance for sardines, which is a species with a life history similar to that for anchovies.

Anchovy larva abundance (La) is estimated from ichthyoplankton data collected by CalCOFI surveys. Standard plankton net tows are made at standard stations during each quarter of the year. Surveys were conducted annually from 1951 to 1966, and from 1966 to 1981 complete surveys were conducted every three years.

Table 4.3-1. Historic indices of anchovy abundance. Section in which method is discussed is indicated in (). A composite of the historical egg production, acoustic survey, and aerial logbook indices is calculated and then calibrated to recent spawning biomasses estimated by the egg production method (see Section 4.3.6).

Year	Egg Production Method (1000 tons) (4.3.1)	Historical Egg Production (4.3.1)	Larva Census (10^{12} larvae) (4.3.2)	Acoustic Survey (schooled surface area) (4.3.3)	Aerial Logbook Index (night) (4.3.4)	Catch per Effort (tons per hour) (4.3.5.1)	Catch per Effort (tons per hour) (4.3.5.1)
	spring	spring	spring	winter-spring	annual	spring	fall
1951		0.01	1.8				
1952		0.01	1.6				
1953		0.07	5.2				
1954		0.17	7.8				
1955		0.32	8.6				
1956		0.15	4.9				
1957		0.36	12.0				
1958		1.27	15.1				
1959		0.99	15.4				
1960		1.77	15.7				
1961		0.65	11.8				
1962		1.31	30.5		2.0		
1963		2.27	43.4		3.0		
1964		4.15	29.6		3.9		
1965		4.02	47.5		4.2		
1966		5.26	36.5		3.6		
1967					4.3	2.1	
1968					1.5		2.4
1969		3.82	30.6	191	4.4	4.6	6.7
1970				148		5.6	5.8
1971				137	2.3	4.2	6.6
1972		1.66	28.4	293	1.4	3.9	3.3
1973				518	15.0	4.6	6.4
1974				326	7.9	5.6	6.9
1975		19.69	36.8	879	11.4	6.4	7.4
1976				177	5.4	4.4	5.0
1977				600	4.6	6.4	4.2
1978		2.33*	13.3	172	1.9		2.2
1979		5.43	17.6	125		6.0	
1980	852	2.67	18.1	253			
1981	639	4.38	28.6	283			
1982	421	3.29		116			
1983	652						

*Value is based on pre-1978 egg retention by CalCOFI ring net. Alternative value of 10.74 is based on post-1978 egg retention by bongo net.

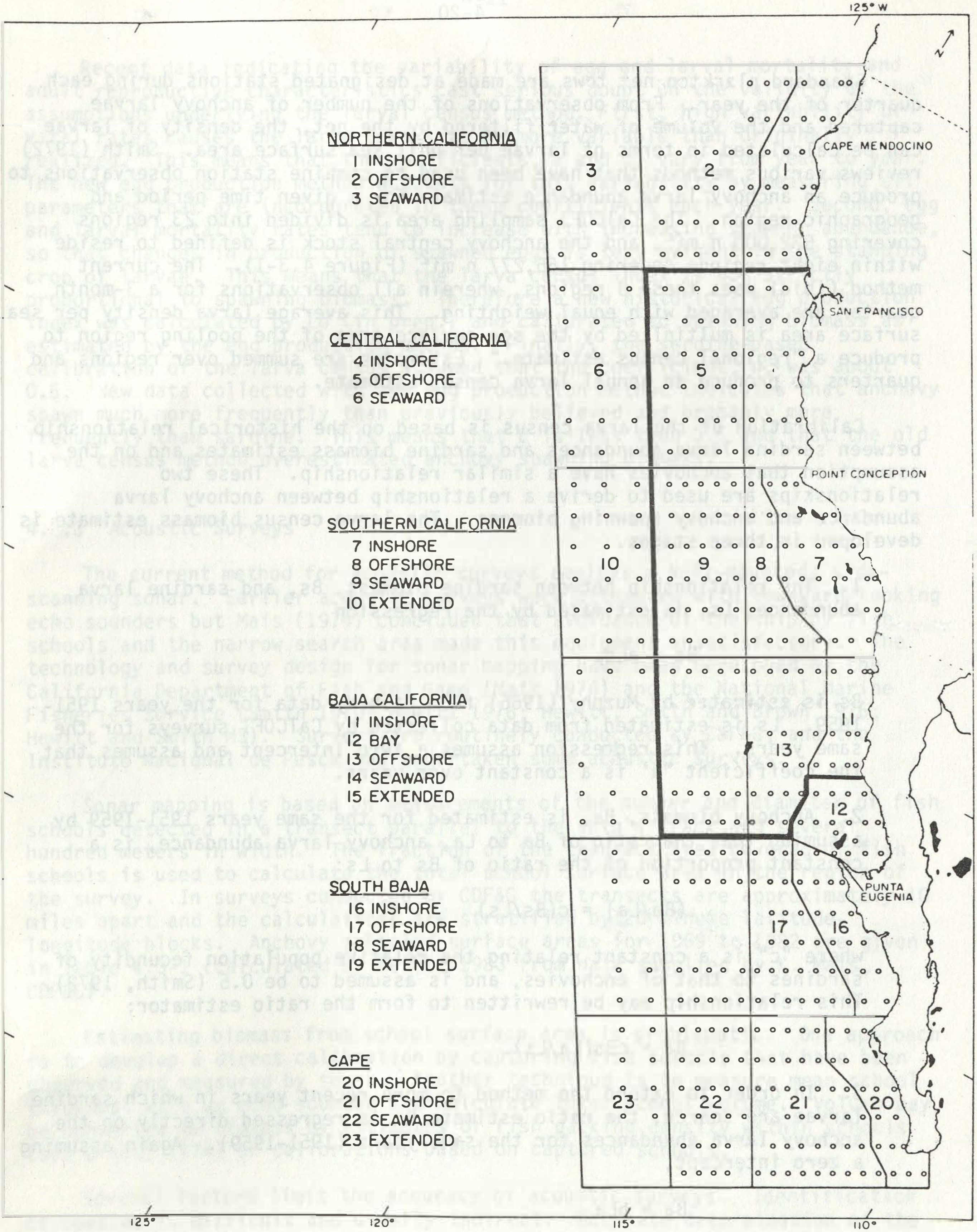


Figure 4.3-1. Regions of the CalCOFI area with sampling stations. Regions of the central subpopulation are enclosed in heavy line (from Duke 1976).

Standard plankton net tows are made at designated stations during each quarter of the year. From observations of the number of anchovy larvae captured and the volume of water filtered by the net, the density of larvae can be calculated in terms of larvae per unit sea surface area. Smith (1972) reviews various methods that have been used to combine station observations to produce an anchovy larva abundance estimate for a given time period and geographic region. The CalCOFI sampling area is divided into 23 regions covering 532,000 n mi^2, and the anchovy central stock is defined to reside within eight regions covering 166,277 n mi^2 (Figure 4.3-1). The current method (ibid) uses these 8 regions, wherein all observations for a 3-month quarter are averaged with equal weighting. This average larva density per sea surface area is multiplied by the sea surface area of the pooling region to produce a "regional census estimate." Estimates are summed over regions and quarters to produce an annual larva census estimate.

Calibration of the larva census is based on the historical relationship between sardine larva abundances and sardine biomass estimates and on the assumption that anchovies have a similar relationship. These two relationships are used to derive a relationship between anchovy larva abundance and anchovy spawning biomass. The larva census biomass estimate is developed in three stages.

1. The relationship between sardine biomass, Bs, and sardine larva abundance, Ls, is estimated by the regression

$$Bs = aLs.$$

Bs is estimated by Murphy (1966) from fishery data for the years 1951-1959. Ls is estimated from data collected by CalCOFI surveys for the same years. This regression assumes a zero intercept and assumes that the coefficient "a" is a constant over years.

2. Anchovy biomass, Ba, is estimated for the same years 1951-1959 by assuming that the ratio of Ba to La, anchovy larva abundance, is a constant proportion of the ratio of Bs to Ls:

$$(Ba/La) = c(Bs/Ls)$$

where "c" is a constant relating the relative population fecundity of sardines to that of anchovies, and is assumed to be 0.5 (Smith, 1972). This relationship may be rewritten to form the ratio estimator:

$$Ba = cBs(La/Ls).$$

3. In order to extend the method to more recent years in which sardine larvae are scarce, the ratio estimate Ba is regressed directly on the anchovy larva abundances for the same years (1951-1959). Again assuming a zero intercept,

$$Ba = bLa$$

The resulting estimate of "b" is 9.8×10^{-8} short tons/larva (8.9×10^{-8} metric tons/larva). This equation is used to estimate anchovy spawning biomass from the larva census.

Recent data indicating the variability of egg and larval mortality and adult reproductive characteristics cast serious doubt on the validity of the assumptions underlying the larval census method. First, high variability of vital rates causes the larva census to be more variable than originally realized. This means that the coefficients, a and b, vary from year to year. The new egg production method accounts for this variability by measuring all parameters that are incorporated in these coefficients each year. Second, egg and larval mortality rates tend to increase with increasing spawner abundance, so that changes in production of spawned eggs is less evident in the standing crop of larvae. This means that the larva census index is not strictly proportional to spawning biomass. Therefore a new historical egg production index was calculated by Lo (in prep.) and calibrated to spawning biomass as estimated by the egg production method. Finally, the sardine-based calibration of the larva census assumed that the coefficient, c, was about 0.5. New data collected with the egg production method indicates that anchovy spawn much more frequently than previously believed and probably more frequently than sardine. This means that c is less than 0.5 and that the old larva census method overestimated anchovy spawning biomass.

4.3.3 Acoustic Surveys

The current method for acoustic surveys employs a hull-mounted, side-scanning sonar. Earlier acoustic surveys were attempted with downward-looking echo sounders but Mais (1974) concluded that avoidance of the ship by fish schools and the narrow search area made this equipment unsatisfactory. The technology and survey design for sonar mapping have been developed by the California Department of Fish and Game (Mais 1974) and the National Marine Fisheries Service (Smith 1970; Hewitt 1976; Hewitt, Smith and Brown 1976; Hewitt and Smith MS). Surveys are routinely conducted by CDF&G, and the Instituto Nacional de Pesca has undertaken some acoustic surveys.

Sonar mapping is based on measurements of the number and diameter of fish schools detected in a transect parallel to the ship's track and several hundred meters in width. The fraction of the transect area covered by fish schools is used to calculate the total school surface area in the region of the survey. In surveys conducted by CDF&G the transects are approximately 10 miles apart and the calculations are stratified by 20 minute latitude-longitude blocks. Anchovy schooled surface areas for 1969 to 1982 are given in Table 4.3-1 (calculated by Methot 1983 from data supplied by K. Mais, CDF&G).

Estimating biomass from school surface area is problematic. One approach is to develop a direct calibration by capturing fish schools that have been observed and measured by sonar. Another technique is to measure mean school thickness with an echo sounder and calculate total school volume. Volume may be converted to biomass by estimates of fish packing density within schools (see Graves 1974) or calibrations based on captured schools.

Several factors limit the accuracy of acoustic surveys. Identification of species is difficult and usually indirect. Accurate determination of the biomass of individual schools has not been demonstrated. It is difficult to work in shallow water and the effective width of the transect is variable under certain oceanographic conditions. Finally, unschooled fish are not detected.

Despite these reservations, sonar mapping is a useful technique. Total school area is an index of population abundance which is relatively easy to obtain and may be calibrated to other techniques such as egg production. Sonar mapping is likely to be a useful component of mixed-technology surveys. For example, it may be possible to use the egg production method in a limited area of expected high abundance and to expand the result to the entire population by an extensive acoustic survey. Finally, the results of a day's mapping activities can be used to efficiently allocate sampling by trawl during the night.

4.3.4 Aerial Fish Spotter Logbooks

Since 1962, the NMFS, SWFC has contracted with a selected group of airplane pilots to fill out logs of their observations while locating fish for commercial fishermen. This program has been described by Squire (1972) and Caruso (1979). The pilots are provided with maps of the region, on which they record their flight path, and locations and estimated abundance of fish species. Information is compiled by 10-minute grid blocks (about 8 miles by 10 miles). Squire (1972) defined larger regions wherein all blocks were pooled, and combined these regions to produce an overall index of apparent abundance. Day observations are processed separately from night observations, and provide separate indices of abundance (Squire prefers the night index for assessment of anchovies). The abundance indices are measurements of observable biomass per unit area. Since observability of anchovies varies with time and season, short-term aerial observations are of limited utility. When averaged over a long period of time, aerial observations may produce a cost-effective index of anchovy abundance. However, due to the length of time over which averaging is required (e.g., one year), the technique does not produce indices of current abundance.

Squire's aerial indices are available for 1962 through 1978 (Table 4.3-1). More recent logbook observations are being stored in a computer data base and preliminary abundance indices have been prepared. A complete statistical review of the data base is planned and may result in a well-defined index that can be interpreted on a seasonal basis.

No systematic aerial survey for anchovy has been attempted on a regular basis, although much of the methodology exists. Objective measurements of fish schools can be obtained by use of low light level television (LLTV), which has been used experimentally. An extensive systematic aerial/acoustic monitoring program has been developed in Southwest Africa (Cram 1977).

4.3.5 Fishery Sampling

Fishery sampling has often provided much, if not all, of the information on which management of fisheries has been based. This information usually consists of catch and effort data and/or age composition of the catches. Catch per unit effort may provide a direct assessment of relative availability or abundance, whereas age composition analysis consists of mathematical reconstruction of historic populations.

4.3.5.1 Catch-effort Data

California Department of Fish and Game has maintained a fish receipt system since 1916 whereby fish dealers and processors, at time of delivery, record purchases of landed fish. For each transaction, the dealer records the species, weight, exvessel price, fisherman's name, vessel number, gear type, capture area, and intended use (McAllister 1976). These data routinely are edited, punched on cards, and summarized for various uses. These data could be used to calculate catch per trip statistics, but this is not done routinely for the anchovy reduction fishery. Receipts include landings for anchovy reduction, canning, dead bait, and fresh and frozen market for human consumption. They do not include the catch of anchovies for live bait used by recreational fisheries.

Operators of live bait are required to keep a log of daily operations, from which the annual bait catch can be obtained. Prior to 1978 some live bait fishermen submitted voluntary logs. These earlier logs have been analysed and reviewed by Alpin (1942), Wood and Strachan (1970), Maxwell (1974), and MacCall et al. (1976). Live bait catch per unit effort is at best an indication of local availability of the younger age groups.

Trip logs are required of all boat operators who land anchovies for reduction. The format of these logs has changed several times since their beginning in 1965, but they have consistently provided information on catch, area, and time away from port. Logs for unsuccessful trips are not necessarily reported. These logs have been analyzed by Messersmith (1969) for the 1965-66 and 1966-67 seasons, and by Doyle Hanan (CF&G, pers. comm.) for 1966 to 1979. Hanan examined logs from seven typical vessels most of which were active from 1969 to 1979. Each fishing season was divided into a fall and a spring semester. Hanan developed two measures of CPUE, catch per day (Figure 4.3-2) and catch per hour (Figure 4.3-3). Catch per day has been rather constant, reflecting the tendency for boats to catch their capacity (or the prevailing delivery limit) over a wide range of fish abundance or availability. Catch per hour appears to be more sensitive to availability, and varies markedly from semester to semester.

The southern California reduction fishery operates in a limited area with respect to the overall range of the central stock. CPUE reflects availability in that limited area, and does not necessarily reflect abundance of the entire stock. For example, the CPUE of commercial purse seiners fishing for anchovies in the San Pedro Channel undergoes large fluctuations over very short time periods. These changes are more likely a result of environmental and behavioral factors rather than changes in overall abundance.

A rather important complicating factor is limited vessel hold capacity and reduction processing capacity. A fishing trip for anchovy reduction is almost always less than 24 hours and usually no farther than 50 miles from port. Because of limited reduction capacity, processors often impose landings limits on the vessels which are generally less than vessel capacity so that a vessel will catch its limit in 1 or 2 sets. Aerial fish spotters routinely scout for fishable concentrations of fish and in many cases direct the setting of the net. This minimizes vessel search effort and increases the success rate. As a result, the catch per trip or catch per hour may reflect vessel or reduction capacity more than abundance of the stock.

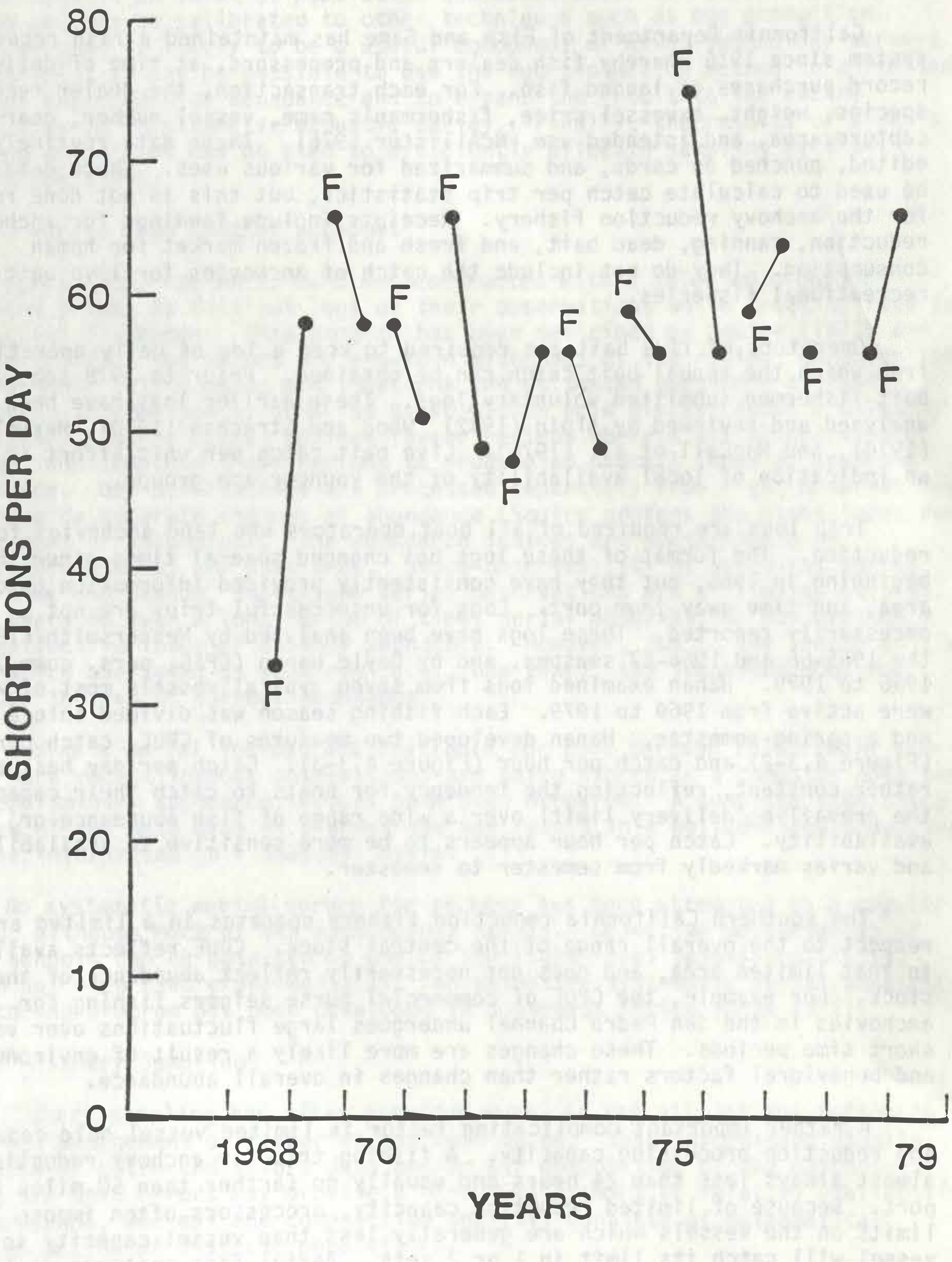


Figure 4.3-2 Anchovy catch per day for seven selected vessels combined lines connect fall (F) and spring semesters within fishing seasons.

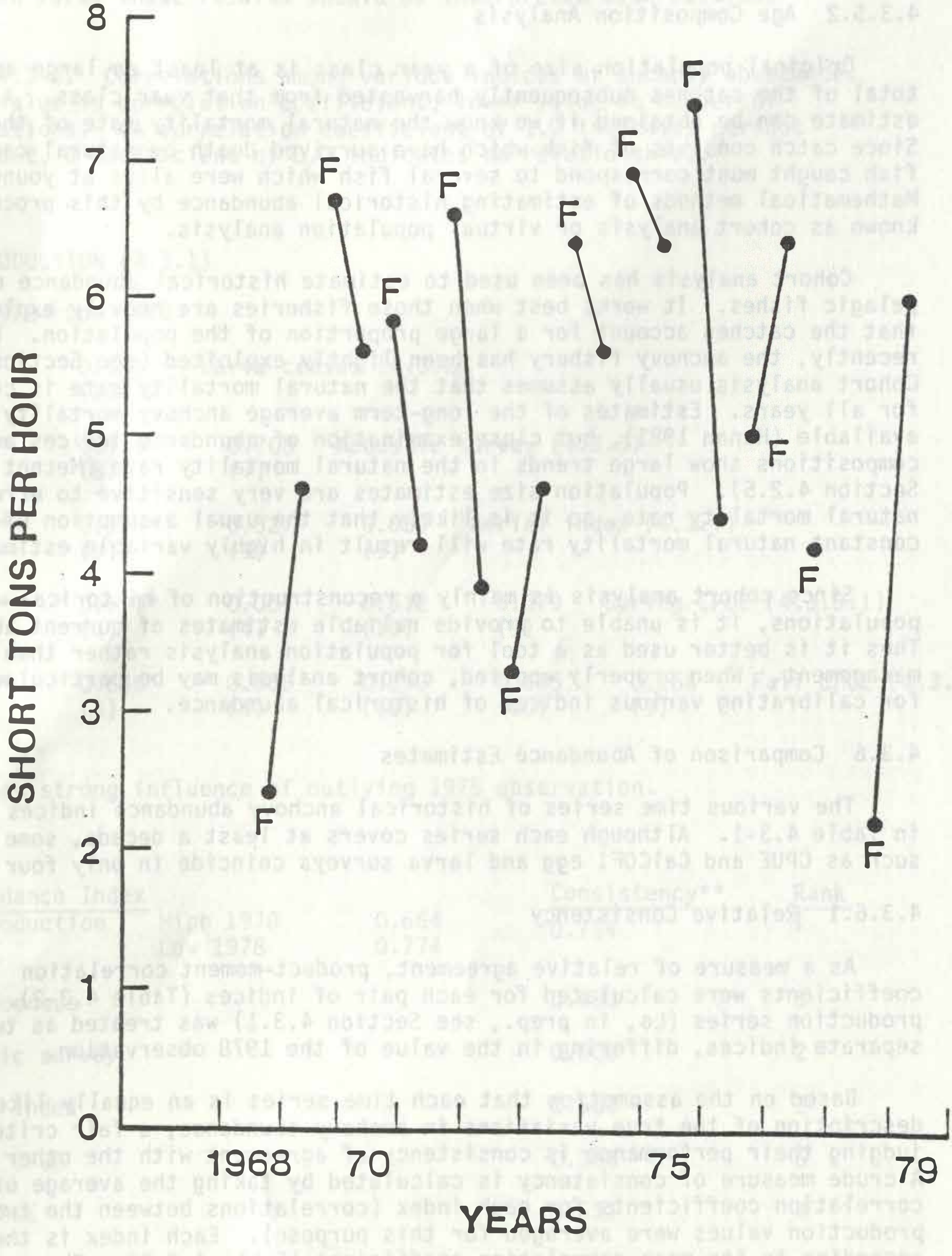


Figure 4.3-3 Anchovy catch per hour for seven selected vessels combined. Lines connect fall (F) and spring semesters within fishing seasons.

4.3.5.2 Age Composition Analysis

Original population size of a year class is at least as large as the total of the catches subsequently harvested from that year class. A better estimate can be obtained if we know the natural mortality rate of the fish. Since catch consists of fish which have survived death by natural causes, each fish caught must correspond to several fish which were alive at younger ages. Mathematical methods of estimating historical abundance by this procedure are known as cohort analysis or virtual population analysis.

Cohort analysis has been used to estimate historical abundance of many pelagic fishes. It works best when those fisheries are heavily exploited, so that the catches account for a large proportion of the population. Until recently, the anchovy fishery has been lightly exploited (see Section 4.2.5). Cohort analysis usually assumes that the natural mortality rate is constant for all years. Estimates of the long-term average anchovy mortality rate are available (Hanan 1981), but close examination of abundance indices and age compositions show large trends in the natural mortality rate (Methot 1982, see Section 4.2.5). Population size estimates are very sensitive to errors in the natural mortality rate, so it is likely that the usual assumption of a constant natural mortality rate will result in highly variable estimates.

Since cohort analysis is mainly a reconstruction of historical populations, it is unable to provide reliable estimates of current abundance. Thus it is better used as a tool for population analysis rather than management. When properly applied, cohort analysis may be particularly useful for calibrating various indices of historical abundance.

4.3.6 Comparison of Abundance Estimates

The various time series of historical anchovy abundance indices are shown in Table 4.3-1. Although each series covers at least a decade, some pairs such as CPUE and CalCOFI egg and larva surveys coincide in only four years.

4.3.6.1 Relative Consistency

As a measure of relative agreement, product-moment correlation coefficients were calculated for each pair of indices (Table 4.3-2). The egg production series (Lo, in prep., see Section 4.3.1) was treated as two separate indices, differing in the value of the 1978 observation.

Based on the assumption that each time series is an equally likely description of the true variations in anchovy abundance, a fair criterion for judging their performance is consistency of agreement with the other indices. A crude measure of consistency is calculated by taking the average of the correlation coefficients for each index (correlations between the two egg production values were averaged for this purpose). Each index is then ranked according to its mean correlation coefficient (Table 4.3-2). The egg production time series is the most consistent, with the "Low 1978" series performing substantially better than the "High 1978" series. Acoustic and aerial methods rank second and third, and are fairly close to each other in relative consistency. The least consistent time series were the two CPUE indices and, surprisingly, the larva census index upon which the previous anchovy plan was based. Because many of the correlation coefficients are based on very few observations and others are strongly influenced by the large value in 1975, these results should be interpreted with caution.

Table 4.3-2. Correlations among various indices of anchovy abundance. Upper value is correlation coefficient, lower value is number of observations. (A correlation coefficient of 1.0 indicates perfect agreement, a coefficient of 0.0 indicates no relationship).

EGG PRODUCTION (4.3.1)

High 1978	Low 1978					
0.458 (23)	0.541 (23)	Larva census (4.3.2)				
0.807* (8)	0.919* (8)	0.708 (7)	Acoustic survey (4.3.3)			
0.818* (9)	0.976* (9)	0.327 (9)	0.659 (9)	Aerial index (4.3.4)		
0.791* (4)	0.791* (4)	0.004 (4)	0.512 (10)	0.379 (9)	Spring CPUE (4.3.5.1)	
0.395* (4)	0.646* (4)	0.865 (4)	0.290 (10)	0.655 (10)	0.256 (9)	Fall CPUE (4.3.5.1)

*Denotes strong influence of outlying 1975 observation.

Abundance Index			Consistency**	Rank
Egg production	High 1978	0.654	0.714	1
	Low 1978	0.774		
Larva census			0.480	5
Acoustic survey			0.606	2
Aerial index			0.583	3
Spring CPUE			0.388	6
Fall CPUE			0.517	4

**Consistency is mean of correlation coefficients (see 4.3.6)

4.3.6.2 Operational Considerations

When selecting a method for estimating biomass, accuracy and precision are of primary importance, but cost and timeliness also should be considered. The most expensive is the larva census method because of its great demands on shiptime and plankton sorting. The least expensive is an extrapolation based on the previous year's biomass and age composition estimates. The least timely is the aerial census which currently requires accumulation of a year of observation. The egg production method and acoustic surveys are reasonably timely. However, with greater effort and proper calibration the aerial survey has the potential to be inexpensive and timely but probably not precise.

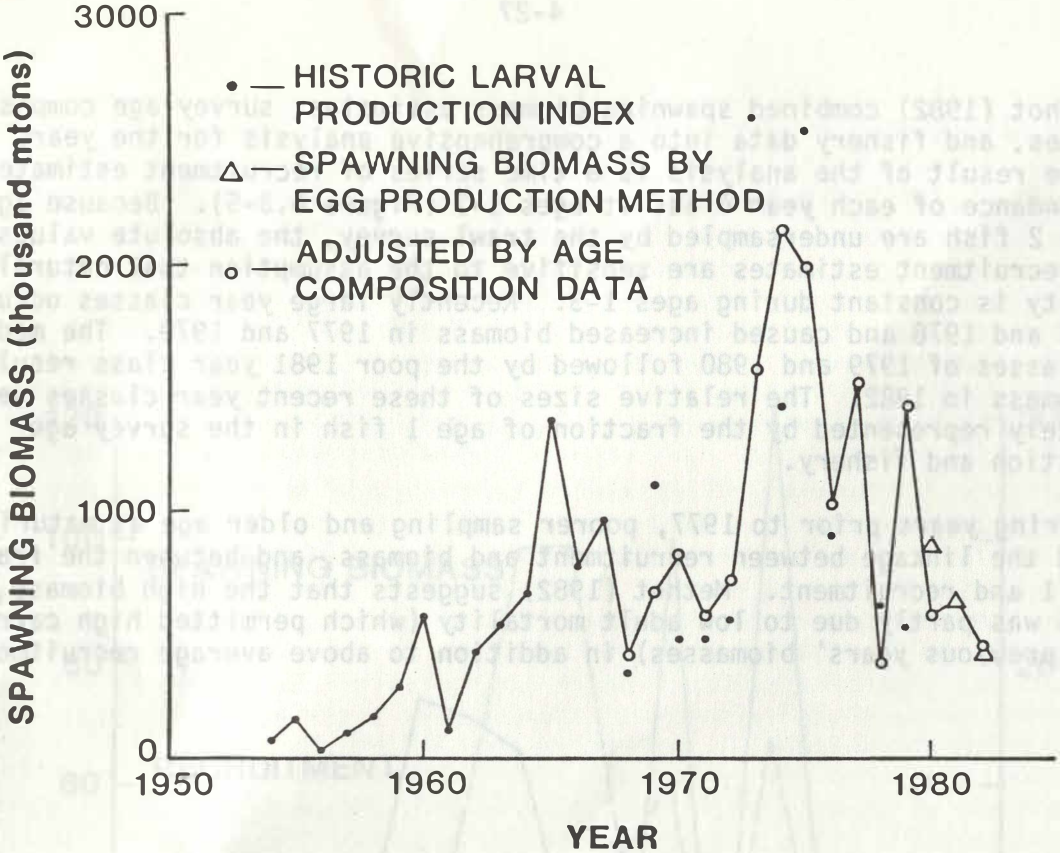
In the future a mixture of methods may be the optimal policy. One possibility is to conduct an accurate survey every second or third year and to use other less costly techniques to detect relative changes in intervening years. Another possibility is to use pre-cruise information on overall anchovy distribution from aerial surveys, acoustic surveys, and oceanography to concentrate the accurate survey in the region with most of the anchovy. This would reduce the cost of the estimate. Any alternative techniques used in future must be calibrated to the egg production method.

4.3.6.3 Composite Historic Estimate

During 1980-82 the new egg production method was used to estimate spawning biomass. Other types of abundance data collected during 1951-79 have been calibrated to current egg production estimates of spawning biomass. Lo (in prep.) used egg abundance, larval abundance, and apparent larval mortality to estimate egg production in years with CalCOFI ichthyoplankton surveys (Table 4.3-1). MacCall (1982b) calibrated these historical estimates of egg production to current estimates of spawning biomass by the egg production method (Figure 4.3-4). This calibration assumes that maturity, fecundity, and spawning frequency of anchovy has not varied systematically during 1951-1982. MacCall (1982b) also calibrates historical acoustic and aerial indices to historical egg production to fill in the missing egg production estimates (Figure 4.3-4). Finally, Methot (1982) used age composition data available since 1968 to adjust the biomass time series. The adjustment is based on the assumption that natural mortality does not vary greatly from one year to the next. MacCall (1982a) used Methot's adjusted time series for 1968-82 and unadjusted data from 1954-1967 to estimate the production model for anchovy spawning biomass (section 4.4).

4.3.7 Recruit Abundance

Although variation in adult growth and mortality does occur, variation in biomass is primarily due to fluctuations in recruitment. Because the fishery's Optimum Yield is linked to annual estimates of biomass, less costly methods to estimate biomass or to predict changes in biomass are desirable. Knowledge of recruit abundance and adult mortality rates may enable prediction of annual changes in biomass which could aid planning by the fishing industry and possibly permit reduction in the frequency or intensity of biomass estimates.



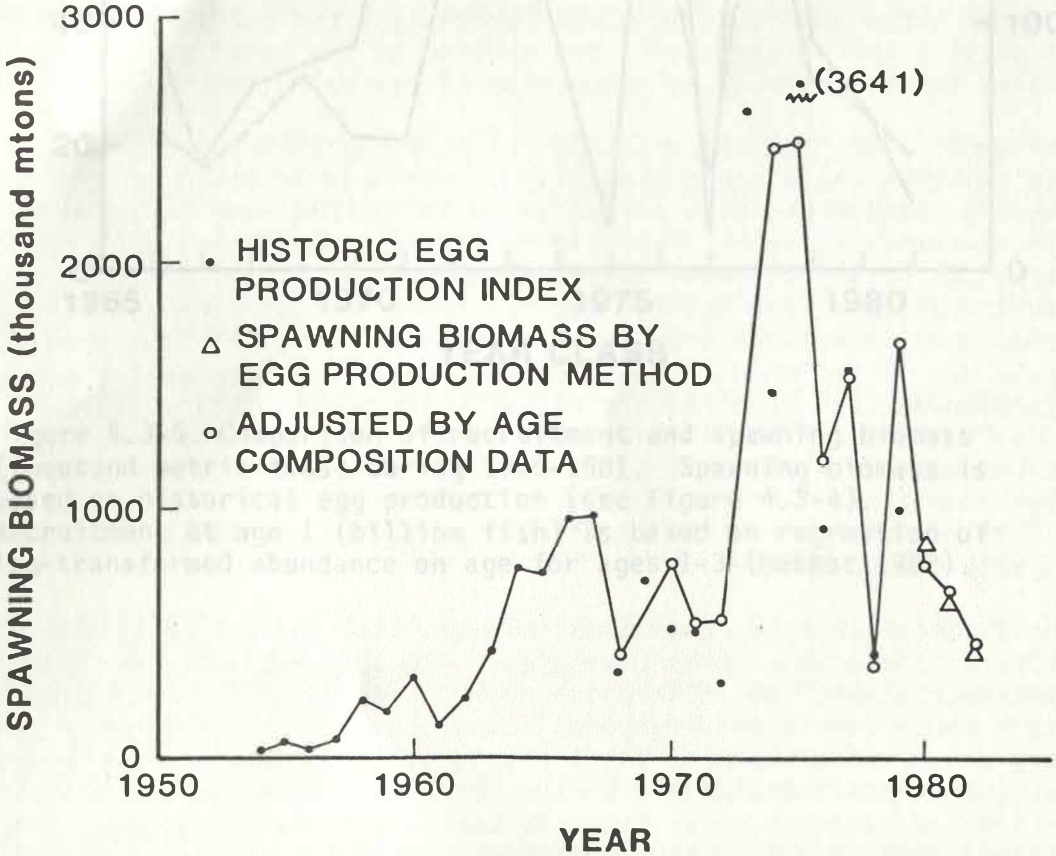


Figure 4.3-4. Composite historic estimates of spawning biomass. Top: based on production of hatching larvae; Bottom: based on production of eggs.

Methot (1982) combined spawning biomass estimates, survey age composition estimates, and fishery data into a comprehensive analysis for the years 1968-82. One result of the analysis is a time series of recruitment estimated from the abundance of each year class at ages 1-3 (Figure 4.3-5). Because age 1 and age 2 fish are undersampled by the trawl survey, the absolute values of these recruitment estimates are sensitive to the assumption that natural mortality is constant during ages 1-3. Recently large year classes occurred in 1976 and 1978 and caused increased biomass in 1977 and 1979. The mediocre year classes of 1979 and 1980 followed by the poor 1981 year class resulted in low biomass in 1982. The relative sizes of these recent year classes were accurately represented by the fraction of age 1 fish in the survey age composition and fishery.

During years prior to 1977, poorer sampling and older age at maturity reduced the linkage between recruitment and biomass, and between the fraction at age 1 and recruitment. Methot (1982) suggests that the high biomass of 1973-75 was partly due to low adult mortality (which permitted high carry-over of the previous years' biomasses) in addition to above average recruitment.

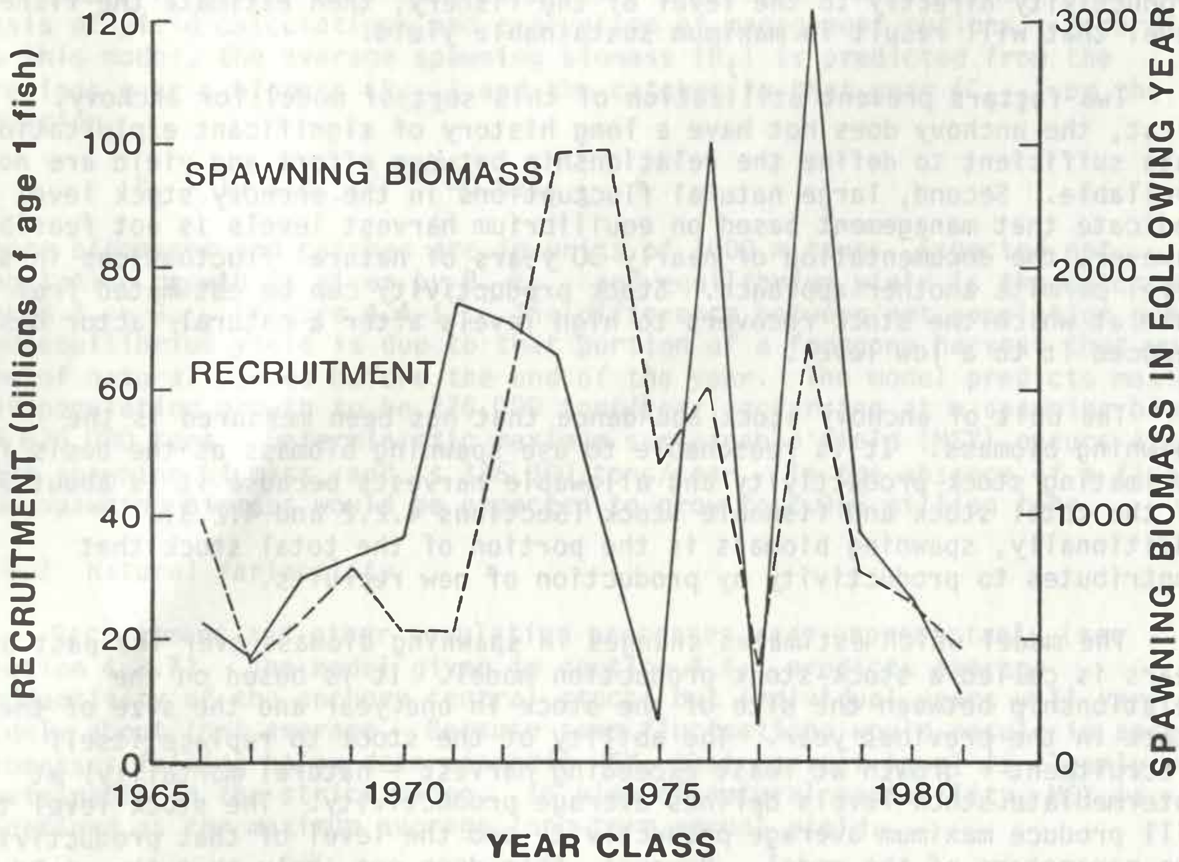


Figure 4.3-5. Comparison of recruitment and spawning biomass (thousand metric tons) during 1966-1981. Spawning biomass is based on historical egg production (see Figure 4.3-4). Recruitment at age 1 (billion fish) is based on regression of log-transformed abundance on age for ages 1-3 (Methot 1982).

4.4 Productivity

When a harvest reduces a stock below its virgin level, increased recruitment, increased growth, decreased age at first maturity, and other factors will increase the productivity of the stock and tend to compensate for the increased adult mortality imposed by the fishery. If the fishery remains at a constant level then the average stock level will decline until the enhanced productivity is balanced by the harvest. Some fishery models relate productivity directly to the level of the fishery, then estimate the fishery level that will result in maximum sustainable yield.

Two factors prevent utilization of this sort of model for anchovy. First, the anchovy does not have a long history of significant exploitation so data sufficient to define the relationship between effort and yield are not available. Second, large natural fluctuations in the anchovy stock level indicate that management based on equilibrium harvest levels is not feasible. However, the documentation of nearly 30 years of natural fluctuations in stock level permits another approach. Stock productivity can be estimated from the rate at which the stock recovers to high levels after a natural factor has reduced it to a low level.

The unit of anchovy stock abundance that has been measured is the spawning biomass. It is reasonable to use spawning biomass as the basis for estimating stock productivity and allowable harvests because it is about 95% of the total stock and fishable stock (Sections 4.2.2 and 4.2.3). Additionally, spawning biomass is the portion of the total stock that contributes to productivity by production of new recruits.

The model which estimates changes in spawning biomass over the past 30 years is called a stock-stock production model. It is based on the relationship between the size of the stock in one year and the size of the stock in the previous year. The ability of the stock to replace itself (recruitment + growth at least exceeding harvest + natural mortality) at intermediate stock levels defines average productivity. The stock level that will produce maximum average productivity and the level of that productivity are parameters of the model. However, this does not imply that the yield corresponding to that level of productivity is indefinitely sustainable. The natural variability in stock level that permits estimation of the stock-stock production model also prevents application of this model as if an equilibrium state was attainable. The evaluation of harvest options will depend on the variability of stock productivity as well as the mean relationship between productivity and stock level.

The stock-stock production model assumes that average recruitment tends to decline as spawning biomass decreases. One alternative model is a "constant recruitment" model in which average recruitment is independent of spawning biomass over a wide range of abundance. While recruitment is clearly dependent on spawning biomass at low levels of abundance, the two models or hypotheses are indistinguishable on the basis of data since the mid-1960s. The constant recruitment model predicts larger sustainable yields, since it assumes that harvest has little or no effect on subsequent recruitment. However, management based on this assumption runs a risk of overfishing if it proves to be untrue. This FMP uses the more risk-averse assumption that harvest does tend to reduce subsequent recruitment. If the latter assumption is untrue, the resource can be expected to maintain a higher abundance than that predicted by the model, with attendant unanticipated benefits of potentially higher fishery quotas, fewer fishery closures, and increased forage for predators.

4.4.1 Equilibrium Yield

MacCall (1982a) developed an anchovy stock-stock model which forms the basis of yield calculations and evaluation of management options. According to this model, the average spawning biomass (B_t) is predicted from the previous year's biomass (B_{t-1}) and the catches in that year (C_{t-1}) by the equation

$$B_t = 10.3\, B_{t-1}^{0.69} - 0.82 C_{t-1}$$

where biomasses and catches are in units of 1000 m tons. Expected net population growth is given by $B_t - B_{t-1}$ and equilibrium yield is the catch which makes $B_t = B_{t-1}$ (Figure 4.4-1). The difference between net population growth and equilibrium yield is due to that portion of a foregone harvest that would die of natural causes before the end of the year. The model predicts maximum net population growth to be 276,000 tons/year, occurring at a spawning biomass of 626,000 tons. Deterministic maximum sustainable yield (MSY) occurs at the same spawning biomass, and is 336,000 tons/year. In the absence of a fishery, the spawning biomass would be expected to grow to 2.065 million tons.

4.4.2 Natural Variability

Recruitment and other population processes vary unpredictably (see Section 4.3.7). The model given in section 4.4.1 predicts average productivity of the anchovy central stock, but individual years will vary widely about that average. Because some fluctuations would result in anchovy biomasses falling below deterministic MSY, that harvest level is clearly not sustainable in the strict sense. In view of natural variability, MSY is redefined as the maximum average long-term annual yield.

The production model in section 4.4.1 was used to estimate this redefined MSY including natural variability. Computer simulations, where recruitment and biomass estimates vary randomly about their deterministic values, provide a more realistic view of resource behavior (MacCall 1982a). An unfished resource would vary about a mean value of 1.89 million tons, but would fall either below 1.1 or above 2.4 million tons fifty percent of the time.

An approximate MSY harvesting policy consists of taking 122% of the excess over 350,000 tons observed spawning biomass (this policy harvests the deterministic MSY when the population is observed to be at the biomass producing it, see section 4.4.1). This policy produces a long-term average catch of 311,000 tons, although the catch would be zero in 37% of the years. Thus, realistic MSY requires a highly fluctuating fishery.

In general there is a trade-off between yield and constancy of harvest. High average yields can be achieved at the expense of a highly variable fishery. Conversely, a relatively constant fishery requires a relatively low

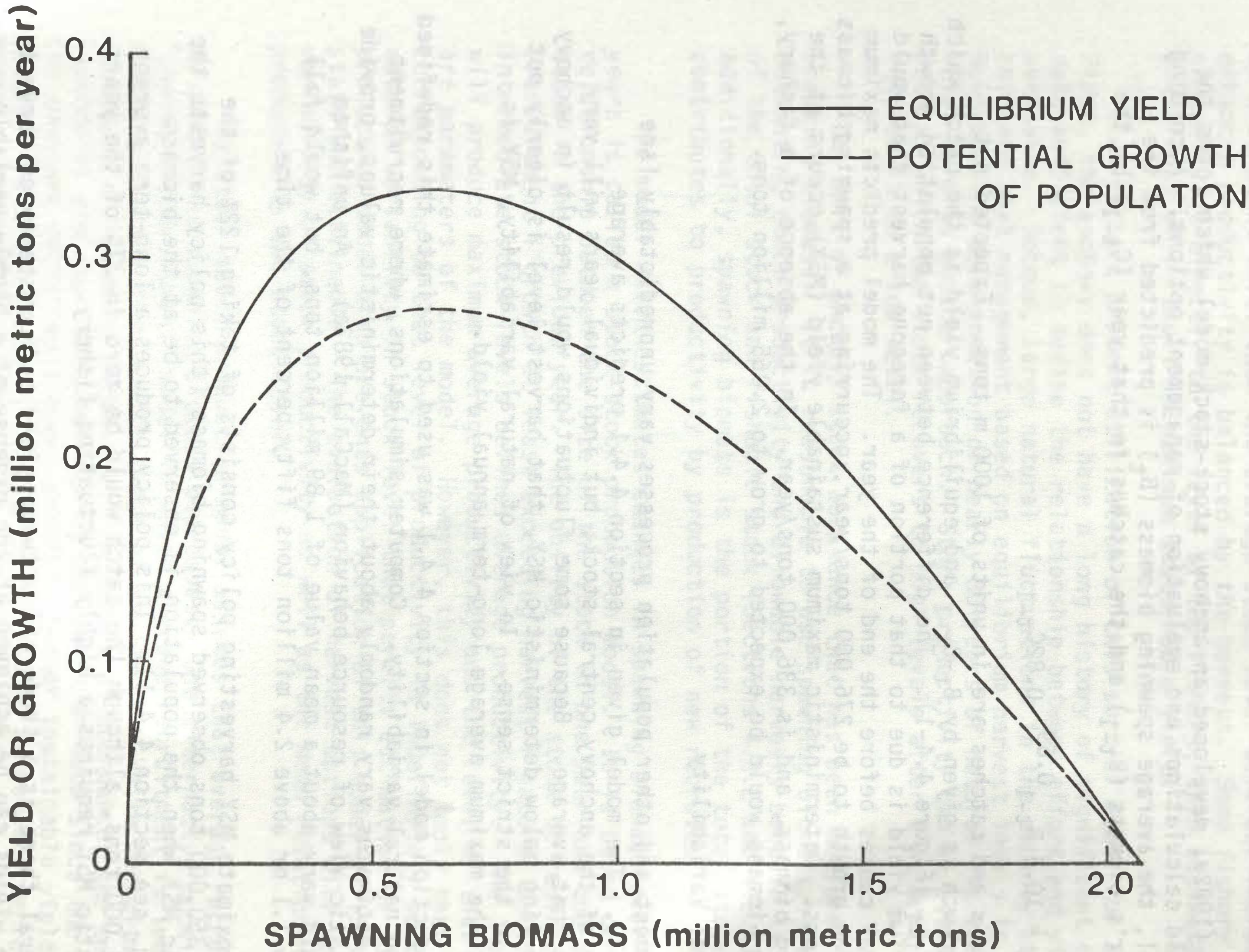


Figure 4.4-1. Anchovy equilibrium yield and potential annual population growth rate.

annual catch. The simulation model described above (MacCall 1982) allows these factors to be evaluated for various harvesting policy options (Section 8.3.4).

4.5 Review Status of the Stock

Abundances during the early to mid-1970s were above normal, presumably due to favorable environmental conditions. Abundance subsequently declined due to a combination of more normal environment and increasing fishing pressure. As the egg production method was being evaluated during 1979-81, the larva census estimates of spawning biomass indicated some increase in abundance and generally higher stock levels than indicated by egg production. At that time is was realized that smaller estimates of anchovy stock size implied lower productivity than was assumed by the previous FMP, but the apparent increase in anchovy larva abundance since 1978 indicated a healthy resource. In 1981 concurrent surveys were undertaken to develop a calibration between the two surveys. At this time it became apparent that the egg production method indicated a decline in anchovy abundance, while decreases in egg and larva mortality rates caused the larva census to severely overestimate spawning biomass. In 1982 the biomass survey was conducted by the egg production method and the results of the survey were converted to a larva census equivalent biomass for calculation of the harvest quota. During 1982 biases such as extrusion of eggs through the plankton nets were shown to be small and correctable. The anchovy Plan Development Team now has much greater confidence in the accuracy of the egg production method than the larva census method. A new historical time series based on egg production has been assembled and indicates that the biomass of 1973-75 was even greater (on a relative scale) than previously believed and that the biomass declined greatly during 1979-82.

The 1983 egg production method estimate of spawning biomass shows an increase in abundance to about the level of maximum net productivity (B_{1983} = 652,000 m tons, BMNP = 626,000 m tons). Both the CDF&G acoustic/trawl surveys in early 1983 (Mais 1983) and the egg production cruise found the population to be dominated by the recruiting 1982 year class, with older year classes at low levels of abundance. The stock appears healthy; the current status is within the range of fluctuation anticipated from combined harvests by U.S. and Mexican fisheries (Table 4.2-3) which are near the level of maximum equilibrium yield (Figure 4.4-1). However, there is little excess biomass and the stock will require continued good recruitment to withstand recent levels of harvest.

5.0 Harvesting and Processing Capacity

Section 303(a)(4) of the Magnuson Fisheries Conservation and Management Act (P.L. 94-265 as amended by P.L. 95-354) requires that each fishery management plan assess and specify:

(1) the capacity and extent to which fishing vessels of the United States, on an annual basis, will harvest the optimum yield;

(2) the portion of such optimum yield which, on an annual basis, will not be harvested by fishing vessels of the United States and can be made available for foreign fishing; and

(3) the capacity and extent to which United States fish processors, on an annual basis, will process that portion of such optimum yield that will be harvested by fishing vessels of the United States.

In the following sections the "capacity" of both the fishing vessels and the domestic processors will be assessed based on the maximum feasible rate of harvesting and processing given good fishing and marketing conditions. The expected level of domestic annual harvesting (called DAH) and domestic annual processing (DAP) will be assessed, and procedures for modifying these estimated levels annually will be established.

5.1 Domestic Harvesting Capacity

The amount of domestic harvesting that will occur in the anchovy fishery during any given year is limited by the physical capacity of the fishing fleet. But several other factors enter the complex determination of annual harvest by the fleet. These other factors include market prices, government regulations, bargaining strategies of fish buyers and sellers, and largely unpredictable in-season variations in fish availability. For the purposes of this FMP, harvesting capacity is defined as the total annual harvest that the existing fishing fleet could reasonably be expected to take assuming (a) market prices are high enough to permit profitable fishing up to the optimum yield; (b) the fishing vessels are dedicated to harvesting anchovies rather than some other species such as mackerel, and (c) anchovy schools are available in the usual fishing areas off southern California. This estimated capacity limits the annual harvest that could be taken by the fleet. To estimate the DAH we must take into consideration some of the reasons that this peak capacity will not be mobilized to harvest anchovies in any given year.

As in previous versions of this FMP the domestic reduction fleet capacity is based upon the estimated hold capacities of the reduction fishing vessels and assumptions regarding season length, number of days fished per month, and hold capacity utilization rate. Hold capacities for twenty-four active anchovy reduction fishing vessels were estimated by California Department of Fish and Game employees in Long Beach, California. For these twenty-four vessels an empirical relationship between estimated hold capacity(mtons) and vessel length(feet) is

$$\text{Capacity} = -68.66 + 2.18\ \text{length} + .0014\ (\text{length})^2.$$

This is an ordinary least squares regression with $R^2 = .80$. This relationship was used to estimate the hold capacities of vessels not included in the CDFG examination. Based upon this procedure the estimated fleet hold capacity north of Pt. Buchon is 322 mtons (355 short tons), and to the south of Pt. Buchon is 3377 mtons (3722 short tons) (see Table 5.1-1).

Current union rules call for fishing no more than five days per week and fishing does not take place during the "light of the moon", roughly 25 percent of each lunar cycle. Given the potential season length under previous management regulations of 228 days north of Pt. Buchon, we would expect the total number of fishing days to be roughly 122 days (equals 5/7 times 3/4 times 228). If each vessel fishes each of these 122 days and fills its hold to ninety percent of capacity, then the total harvest north of Pt. Buchon would be 35,356 mtons (38,979 short tons). This is the estimated domestic harvest capacity north of Pt. Buchon.

A similar procedure is used to estimate harvest capacity south of Pt. Buchon where the season length has been 192 days. The number of fishing days would be 103. With a ninety percent utilization of the 3377 mton fleet hold capacity on each fishing day, the total annual harvest capacity in the south would be 313,048 mtons. For the entire fishery, the estimated reduction fishery harvesting capacity is 348,404 mtons (384,046 short tons).

Unlike the reduction fishing fleet, the live-bait harvesters tend to specialize in their fishery and have not experienced large fluctuations in demand. Thus the recent past harvest rates represent a reasonable estimate of harvesting capacity. As shown in Table 3.2-3, the annual live-bait harvest during the 1970-1981 period ranged from about 4900 mtons (5390 short tons) to about 6400 mtons (7040 short tons). During this period the size of live-bait fishing fleet was quite stable with twelve to fourteen vessels reporting. Since CDF&G's live-bait reporting program was probably incomplete for at least some years, there may have been some under-reporting of catch. To account for this possibility the estimated capacity of the live-bait fishing fleet is set at 7730 mtons (8500 short tons).

Since other non-reduction harvests (i.e. fish used for frozen bait and human consumption) are caught by anchovy reduction fishing vessels additional capacity need not be added to account for these other uses of anchovy. The total estimated harvesting capacity for the combined reduction and non-reduction fisheries is 356,134 mtons (392,567 short tons).

Table 5.1-1. The anchovy reduction fishing fleet in 1982. Numbers and hold capacity.

	Number of vessels	Hold capacity	Maximum catch in full season
		---------metric tons---------	
Northern Area	7	322	35,356
Southern Area	35	3377	313,048
Total	42	3699	348,404

Source: California Department of Fish and Game, Long Beach.

Table 5.2-1. Characteristics of the reduction fishery in the Northern Area, 1973/74 thru 1981/82.

	No. Weeks in open season	No. Weeks fish landed	Average landings per week	Maximum weekly landing	Total annual landings
			-------	metric tons	-------
1973/74	38	20	205	490	4,104
1974/75	40	18	340	834	6,121
1975/76	40	18	266	608	4,790
1976/77	41	21	215	581	4,538
1977/78	39	17	358	707	6,093
1978/79	39	4	266	416	1,064
1979/80	39	7	302	583	2,112
1980/81	39	19	226	715	4,294
1981/82	39	19	236	805	4,490

Source: California Department of Fish and Game, weekly Anchovy Reduction Fishery Reports.

Table 5.2-2. Characteristics of the reduction fishery in the Southern Area. 1973/74 thru 1981/82.

	No. Weeks in open season	No. Weeks fish landed	Average landings per week	Maximum weekly landings	Total annual landings
			------- metric tons ----------		
1973/74	36	28	2,924	7,818	105,260
1974/75	35	33	3,018	5,882	99,570
1975/76	37	35	3,516	8,775	123,050
1976/77	35	31	2,964	9,155	91,876
1977/78	35	19	3,269	7,485	62,096
1978/79	32	20	2,383	7,015	47,658
1979/80	35	23	1,304	5,430	29,997
1980/81	35	25	2,249	6,169	56,219
1981/82	35	22	1,976	8,634	43,472

Source: California Department of Fish and Game. Weekly Anchovy Reduction Fishery Reports.

5.2 Processing Capacity Estimates

Two alternative concepts of peak annual processing capacity are "nominal" production capacity, i.e. the stated full rate of production associated with the physical plant, and "observed" or "proven" capacity of the processing sector. The proven capacity may be based upon the rate of production observed when the pro-cessing sector is essentially fully utilizing its facilities. In this section the "proven" capacity of the anchovy reduction industry is estimated based upon both a maximum weekly production rate and a maximum annual production rate. As explained below, the most reasonable estimate of processing capacity seems to be the annual proven capacity, which is 127,840 mtons (140,918 short tons) for the California anchovy reduction industry.

Tables 5.2-1 and 5.2-2 summarize the pertinent information regarding anchovy reduction for both the northern and southern permit areas. During the 1981/82 fishing season the maximum weekly landing in the northern area was 805 mtons (887 short tons). Taking this as an estimate of the short term peak processing capacity in the northern area, the annual processing capacity would be this amount extended over 39 weeks, or 31,395 mtons (34607 short tons). In the southern area the greatest weekly landing during the past five years was 8634 mtons (9517 short tons). Taking this maximum rate as an estimate of short term peak capacity and extending it over a 35 week fishing season, the processing capacity in the southern area is 302,190 mtons (333,102 short tons). Total estimated peak annual processing capacity in California is 333,585 mtons (367,711 short tons).

Neither of these two capacity estimates recognizes that fish cannot be expected to be available consistently during an entire fishing season and that weather and other external factors will prevent the fishing fleet from delivering a steady flow of fish to the processors. Thus the capacity estimates based upon maximum weekly landings are somewhat unrealistic. Given the uncertainties of fish supply to the processors during a fishing season a more realistic notion of processing capacity would be based upon an entire year's production. The only recent year in which the processing sector operated at near capacity for as much of the fishing season as it could was the 1975/76 fishing year when the total landings amounted to 127,840 mtons (140,918 short tons). This magnitude will be taken as the proven annual processing capacity.

Changes in physical plant configuration or fishing regulations can cause a change in the processor's proven capacity. In order to provide flexibility in the implementation of this FMP, the proven capacity figure can be modified yearly by the NMFS Regional Director based upon information provided by the processors which shows that reduction plants or related facilities have been expanded or have been closed down. This new information will be solicited during July of each year and any new capacity figure adopted will be published with the annual fishery regulations on August 1 of each year.

5.3 Expected Domestic Annual Processing (DAP), Domestic Annual Harvest (DAH), and Joint Venture Processing (JVP).

The procedure for determining the quantities of DAP, DAH and JVP by this FMP is intended to be applicable to future years so that no FMP amendment will be necessary unless a change in policy is desired. The general approach is (1) to set the annual DAP based upon recent past experience, (2) to set JVP based upon past experience and existing applications and permits, (3) to set DAH as the sum of DAP and JVP. In step (2), of course, the JVP cannot be allowed to exceed the difference between OY in the U.S. FCZ and the DAP. This assures preference to U.S. processors. Procedures for determining the Total Allowable Level of Foreign Fishing are described in section 7.0.

On July 1 of each year the Regional Director will calculate the initial DAP for the upcoming fishing season as the maximum level of reduction plus non-reduction processing experienced during the previous three years. During the month of July the Regional Director will examine evidence received from processors that the initial DAP should be modified. A beginning DAP for the fishing season will be announced on August 1.

During the month of July of each year the Regional Director will examine recent past JVP harvests, if any, and applications for JVP operations to take place during the coming fishing season. On August 1 the Regional Director will announce an allowed JVP equal to the lesser of (a) the desired JVP level as evidenced by past experience and recent applications, and (b) the surplus of OY in excess of DAP. Thus if the OY is just sufficient to satisfy the DAP, no JVP will be allowed.

DAH is the sum of DAP and JVP as calculated by the procedures described above. In order to assure that the domestic industry has ample opportunity to process anchovy, the JVP and DAH will be re-calculated by April 1 of each year. During the spring fishery (April, May and June) the maximum amount of harvest allowed for JVP will equal the OY in the U.S. FCZ minus the total quantity of harvest by U.S. vessels during the fall fishery (i.e. domestic processing plus JVP actually experienced during August-January) and minus the maximum U.S. domestic catch that has occurred in the past three spring fishing seasons.

6.0 Optimum Yield

Achievement of the optimum yield of the fishery is central to the goal of fishery management under the Fishery Conservation and Management Act of 1976. According to the Act, the optimum yield (OY) for any fishery is the quantity of fish which equals the maximum sustainable yield (MSY) as modified by social, economic and ecological considerations such that the greatest benefit to the nation is provided. The deterministic MSY for the central subpopulation of the northern anchovy is estimated to be 336 thousand metric tons per year, and long-term average OY is necessarily less in light of the above considerations. Natural variability in recruitment to the stock will not allow 336 thousand tons to be taken every year. Consideration of the trade-offs between average annual yield and the variability of yield is the principal point of section 6.1.

Ecological considerations require that the role of the anchovy as forage for predators be recognized. Section 6.2 discusses the benefit arising from the stock as a source of forage. An important social consideration is the fact that a major commercial fishery for anchovies in California, the reduction fishery, is widely unpopular among the State's recreational fishermen. Aspects of this factor are discussed in Section 6.3. Economic considerations discussed in Section 6.4 focus on the issue of economically efficient patterns of commercial exploitation. A reasonable allocation of the yield of the stock to the fishery in the U.S FCZ is discussed in Section 6.5, and the final optimum yield formula is presented in 6.6.

6.1 Biological Considerations

The most common biological criterion invoked in the fishery management field is maximum sustainable yield (MSY). This concept emerges from theoretical models of population growth which often rely heavily on the assumption of constant environmental conditions. An MSY value of 336 thousand tons per year is estimated for the central subpopulation of northern anchovy (Section 4.4). While MSY is generally recognized as an average sustainable yield, the consequences of treating this average as a stable rate of yield are rarely recognized and considered to the extent that they must be with regard to the northern anchovy.

The MSY estimated for the central subpopulation of the northern anchovy is the average or "expected value" calculated from a statistical fit of a theoretical population growth curve. The data used to calculate the fitted equation were the anchovy spawning biomass estimates from the California Cooperative Oceanic Fishery Investigations (CalCOFI), a consortium of agencies including the California Department of Fish and Game, the California Academy of Sciences, the National Marine Fisheries Service, and the Scripps Institution of Oceanography. The spawning biomass estimates are the best available estimates of the anchovy biomass. The observed population levels regularly deviate from the expected values of the estimated population growth curve by as much as 50 percent. Thus, while the deterministic MSY of 336 thousand tons occurs at the population biomass of 626 thousand tons, natural variability makes it impossible to maintain this population size. The technical solution to the problem of maximizing total yield over time is to specify a policy which assigns a level of catch smaller than MSY when the population is below 626 thousand tons of biomass. Similarly, the policy assigns an annual yield greater than MSY in years when population size is greater than 626 thousand tons. Algebraically, the policy is approximately as follows:

Catch = 0 if biomass <350 thousand tons;
Catch = 1.22 x (biomass - 350) otherwise.

Thus a sliding scale is used to assign yearly catch according to the anchovy biomass available at the beginning of the year. A simulation model incorporating this policy and natural variability indicates that the long-term maximum average yield is 311 thousand m tons. Although this policy is a dynamic extension of the usual MSY criterion, it has some detrimental characteristics. Given the expected variability of the anchovy biomass, this policy would require the fishery to gyrate between tremendously large catches in some years to no catch at all in many years. It is expected that under this maximum yield policy the fishery would be shut down entirely in 31% of the years.

Clearly, the economic and social advisability of MSY harvest policy is suspect. Thus the biological criterion of maximizing total fish yield from the stock requires tempering. From a biological standpoint, any harvest policy should (1) maintain an average population size equal to or greater than that associated with MSY (i.e., 626 thousand tons), (2) require the annual harvest to fall below expected annual productivity when the population size is less than 626 thousand tons, and (3) call for a substantial unfished reserve stock to protect against accidental depletion and ecological disasters. Any optimum yield which satisfies these conditions can be considered biologically acceptable. Actual sustainable yields will necessarily be smaller as sustainability becomes more rigorously invoked.

Another biological consideration is the problem of unusual sex ratios in the reduction fishery catch. The disproportionate catch of female fish by the fishery could lead to a more severe impact than calculations based on equal catches predict. In essence, the reproductive potential of the anchovy population consists of the female spawning biomass, and therefore, fishery effects on this population segment are of importance to anchovy management. There has been a tendency toward more even sex ratios as the age composition of the catches has shifted toward younger fish, presumably as a result of increased exploitation rate.

6.2 Ecological Considerations

The northern anchovy plays a highly important role in the ecology of California coastal waters. Food habits studies have shown it to provide the bulk of forage requirements to predatory fish and invertebrates (many of which are fished recreationally and commercially) and to marine mammals and birds. Of particular interest among marine birds is the California brown pelican (Pelecanus occidentalis californicus), an endangered species. The effects of various levels of anchovy biomass are difficult to predict due to the complexity of the ecosystem and our superficial knowledge of it. Since most predators are opportunistic in feeding habits, they could switch to alternative prey. However, there is no clear indication that equivalent alternatives exist in the ocean; most likely alternatives will be less nutritious. On the other hand, anchovies themselves consume large quantities of fish eggs and larvae, including their own, and may exert considerable mortality on the early life stages of their predatory fish.

It is very difficult to place a value on anchovies for their forage role in the ecosystem. The extent to which they support economically valuable resources, such as sportfish, market fish, and squid, is variable and difficult to determine. Non-valued resources such as birds and marine mammals are also largely supported by anchovies, lending further difficulty to their valuation. The conclusion which arises from these ecological considerations is that benefit to the nation occurs by leaving fish in the ocean. If the domestic fishery is unable to harvest its quota allotment for a given year, ecological benefit still occurs from the unharvested fraction.

The time series of anchovy spawning biomass estimates indicates that large natural fluctuations in abundance must be expected independently of fishery effects. The effect of a fishery will be to lower the average levels of abundance, thus causing more frequent periods of low abundance relative to an unfished resource. These periods of low abundance are likely to affect the carrying capacity of higher predators in the ecosystem. Minimizing the duration of these periods of low abundance requires cessation of the reduction fishery when the spawning biomass falls below a level termed the "reduction cut-off." While this lower limit cannot guarantee a minimum anchovy biomass to support higher predators, it 1) gives predators first priority for use of the resource, and 2) gives the resource maximal opportunity to recover to higher levels of abundance (further declines in abundance cannot be attributed to fishery causes, thus preventing avoidable depletion).

There are no clear criteria for an optimal level of reduction cutoff. The cutoff level in the original anchovy FMP (PFMC 1978) was set at 907,200 m tons (1 million short tons). One approach would be to attempt to translate the reduction cutoff to an approximately equivalent value according to the revised biomass estimates and model:

A. Previous cutoff is 26% of equilibrium unfished spawning biomass (1.0 million/3.841 million short tons). The revised model (Section 4.4.1) gives an equilibrium unfished spawning biomass of 2.06 million metric tons, so an equivalent reduction cutoff would be 536 thousand metric tons. Due to the different shape of the new production model, this criterion may not be appropriate. Note that this "equivalent" cutoff is near the 626 thousand m tons producing deterministic MSY.

B. Previous cutoff is 57% of the spawning biomass producing deterministic MSY (1.0 million/1.74 million short tons). The revised model gives MSY at a spawning biomass of 626 thousand metric tons, so an equivalent reduction cutoff would be 360 thousand metric tons.

Another approach is historical comparison:

C. The years 1957 through 1960 showed unusually high catch rates of larger migratory predators by the recreational fishery. This was due mainly to abnormally warm oceanic temperatures, but circumstantially there must have been sufficient forage to support this influx. The average anchovy spawning biomass during 1957-1960 was approximately 200 thousand tons and the average sardine spawning biomass was approximately 100 thousand tons (MacCall, 1979).

D. During the early 1950s the resource was at a low level of abundance and was slow to increase. Apparently the spawning biomass was too small to produce a large year class. Although there is no clear stock-recruitment relationship in the spawning biomass range above about 400 thousand m tons, during the recent 15 years several large year classes (1968, 1971-72, 1978, and 1982; see Figure 4.3-4) have been produced by spawning biomasses as low as 400 to 500 thousand m tons. This suggests that a reduction cutoff in the vicinity of 400 thousand m tons would help maintain anchovy abundance at levels which have demonstrated good recruitment and rapid recovery.

These criteria suggest reduction cutoff in the range of 200 to 400 thousand metric tons. However, these values are not limiting, and conservative management could well justify a larger reduction cutoff.

6.3 Social Considerations

Commercial harvest of forage species (likely anchovy and sardine) off the California coast occurs in a highly-charged political environment. As noted by Kaneen (1977), the anchovy reduction fishery must "walk in the shadow of the sardine fishery." A major component of the sardine harvest was for both shore-based and floating processing plants. The sardine fishery collapsed in the early 1950's due to overfishing and poor recruitment. One legacy of the sardine fishery, consequently, is public awareness of commercial fishery managers' fallibility. Also there is widespread appreciation of the importance of the anchovy as forage for more desirable predatory fish. These conditions coupled with a generally negative public attitude toward reduction fisheries makes the anchovy optimum yield determination an important social decision.

While hard scientific evidence on anchovy/sportfishing interactions is meager, many of southern California's thousands of saltwater anglers using anchovies for live-bait know that anchovies are an acceptable food for rockfish, kelp bass, mackerel bonito, yellowtail, and other species. Therefore, it is important that OY be set with full advance recognition of potential reactions by marine anglers to reduced anchovy abundance. The discontent that could be caused by fishery-induced collapse of the anchovy stock would be exceedingly disadvantageous. Thus social considerations should make the OY choice more conservative than would otherwise be the case.

A second "social" consideration concerns the place of marine mammals and endangered species in the public's perception of the health of marine ecosystems. Congressional actions (the Marine Mammal Protection Act and the Endangered Species Act) apparently reflect public willingness to forego some direct economic benefits in exchange for maintenance of populations of mammals and designated "endangered" species. Sea lions, seals, porpoises and other marine mammals are prevalent in southern California waters. Maintenance of anchovy stocks as forage for these predators is a clear, but unquantified, factor in setting OY. Similarly, an endangered species, brown pelican, would benefit from enhanced anchovy populations; especially if this makes anchovy schools near major breeding colonies on Anacapa Island more readily available. Bird watchers and interested conservationists would probably approve of lower commercial harvests as a way of enhancing bird and mammal populations.

6.4 Economic Considerations

The economics of resource conservation is a well-developed branch of economics that has some pertinence to the choice of optimum yield. As applied to fisheries, both the theory and the applied models developed by economists emphasize the importance of choosing rates of resource use that conserve economic value, as opposed to preserving physical resource size. The economic value of interest is the "net" value which is generally measured as market value minus full production costs. This is consistent with "economic efficiency" in resource conservation. For renewable resources like marine fish stocks, the key to "economic conservation" is the maintenance of the resource base to provide as large a margin as possible between the between market value and costs. Clearly, the proper economic management of the anchovy stock will seek to maintain the population at a reasonably large size in order to achieve a large annual, sustainable harvest. In addition, since the costs of catching a ton of fish is generally lower when the fish population is more abundant (because the catch-per-unit-effort is higher), a larger population helps to bring down costs of harvest. Thus economic efficiency calls for a particular form of resource conservation.

Although there are several other economic considerations that will be mentioned below, it is instructive to examine the economic version of conservation using the simple diagram in Figure 6.4-1. There are three steps in constructing this diagram from basic economic and biological information. First, the relationship between catch and fishing effort (measured here as hours of fishing by representative San Pedro purse seiners) must be determined. Anchovy catch per hour fishing (CPUE) has been examined from logbook records for the years of 1969 thru 1979 (see Sec. 4.3.5.1). A relationship between the weighted average of spring and fall CPUE and the anchovy biomass time series used in Sec.4.3.6.3 above is represented by the equation:

$$CPUE = .000321(Biomass)^{.7021}$$

This equation was computed from linear regression of logarithms of CPUE and biomass.(The procedure involved using the geometric mean of X-on-Y and Y-on-X regressions to avoid bias in the regression coefficients due to measurement errors in the independent variable.)

The second step involves constructing the sustained revenue curve. For any sustainable yield level, the necessary fishing effort can be computed based upon the biomass needed to sustain that level and above CPUE equation. After multiplying by the market price of anchovies, the sustainable yield is converted from metric tons to thousands of dollars. Figure 6.4-1 illustrates two possible sustainable revenue curves. The upper curve was computed assuming an exvessel price of fifty dollars and the lower curve assumes a price of forty dollars. The figure indicates what level of revenue would correspond to any given level of fishing effort.

The third step is to display the cost of fishing. Huppert(1981) reported that a modern efficient anchovy purse seiner would have operating costs of approximately $1920 per day. Assuming that the vessel would be in operation for 12 hours per day, the estimated cost per hour (i.e. cost per unit effort) is $160. Hence the total costs of fishing is just equal to the level of effort times $160. This is depicted in Figure 6.4-1 as the straight line labelled "Fishing Cost".

Based upon the economic model of the fishery represented by these relationships, the net economic yield is greatest at that level of fishing effort corresponding to the greatest distance between the revenue and cost curves. This occurs at a fishing effort level of about 50 thousand hours per year which corresponds to an annual harvest of about 280 thousand tons and a biomass level of 1.1 million tons. Clearly, the estimated point of optimum economic performance depends critically upon all the model assumptions. With a lower fish price the net economic yield is reduced and the best level of effort and harvest are lower. This is shown in Figure 6.4-1 by the revenue curve corresponding to a price of $40. Just as important is the cost assumption. Rising vessel operating costs would raise the fishing cost curve and lower the optimum level of fishing effort. Finally, natural variation in stock abundance can cause a shrinkage or expansion in the annual harvest and effort levels deemed economically efficient.

One additional factor that should be considered is the effect of the Mexican fishery on the U.S.'s optimum harvest. Incorporating the impact of Mexico's fishery is somewhat problematical, since the future harvest policies in that fishery may be influenced by the harvest policy adopted in this FMP. One approach is to consider the Mexican harvest as another type of natural mortality. For any given level of Mexican harvest, the sustainable U.S. yield curve would be lower due to the lower anchovy population levels. Adequate consideration of Mexico's impact on U.S. fishing policy requires many non-economic factors, including international negotiating strategy and biological models to predict trans-boundary migration and dispersion rates.

Additional economic considerations that remain unquantified include the interaction of the anchovy reduction fishery with the live-bait fleet and the economic importance of fish stock that depend upon anchovies as forage. The live-bait fleet is clearly an important factor in California's marine recreational fisheries and it should be considered a competing user of the anchovy population. Since the live-bait harvests are relatively small compared to the potential yield of the stock (usually around 7000 tons per year), only the anchovy reduction fishery could possibly utilize the fish stock fully. Nevertheless, the greater value per unit harvest in the live-bait fishery should give it more weight in management decisions than the harvested tonnage would suggest. One practical means of doing this is to add special allocations to this fleet and to incorporate safeguards to assure that the reduction fishery in the FCZ does not deplete the anchovy population severely. The same kinds of policies work to protect the other fish species. Choice of the degree to which the reduction fishery should be restricted in order to protect these other interests is a matter

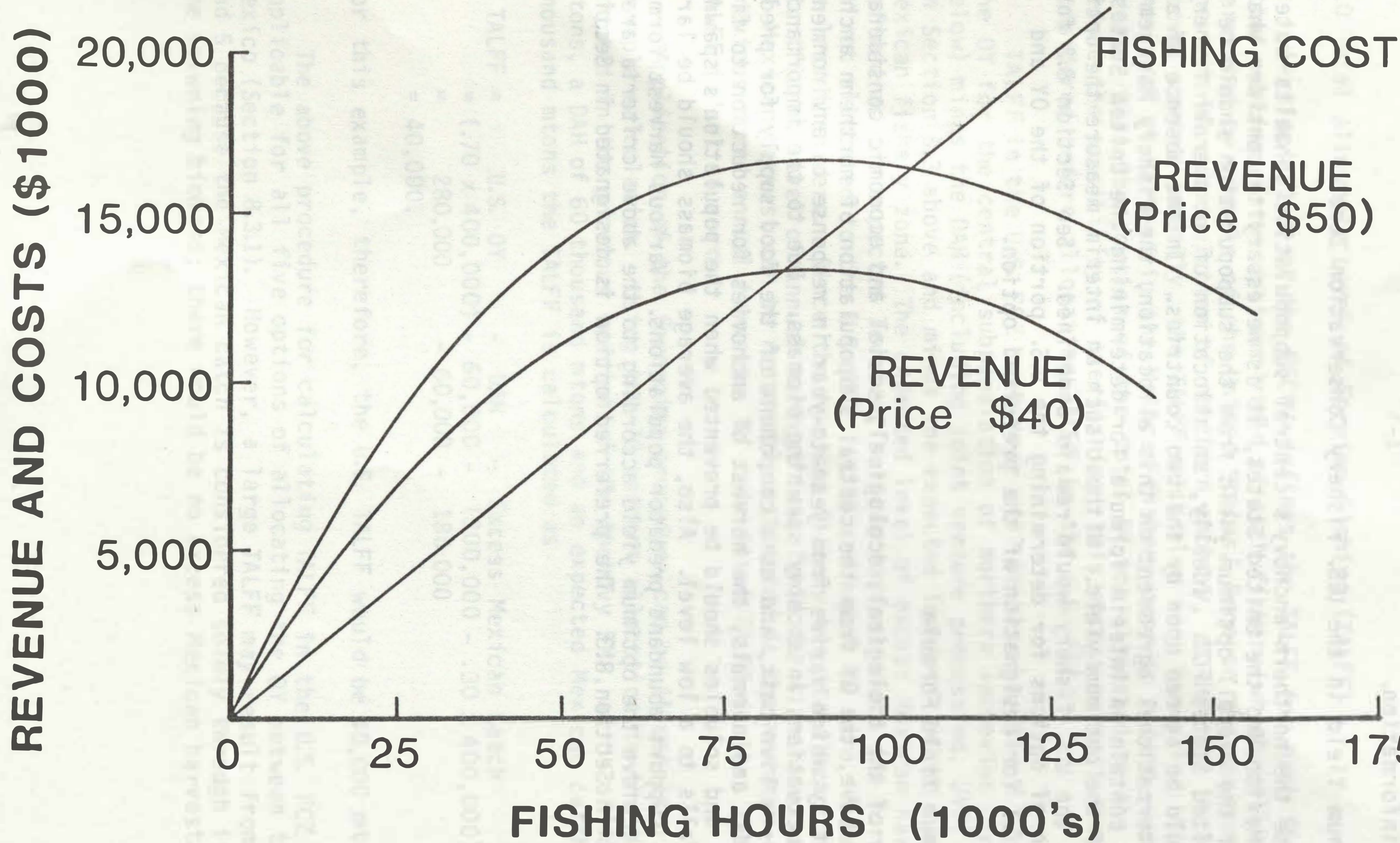


Figure 6.4-1. Economic model of the anchovy fishery.

of judgement which unfortunately is not greatly enhanced by the available economic information.

6.5 Optimum Yield in the U.S. Fishery Conservation Zone

Because the northern anchovy's central subpopulation inhabits waters off both Mexico and the United States, it is necessary to consider what portion of the overall optimum yield from the subpopulation should be taken in the United States FCZ. Ideally, an allocation of an overall fishery quota should be agreed upon by the two countries. In the absence of a ruling international agreement on this allocation, the Fishery Management Plan must contain an interim formula for determining the United States' portion of the optimum yield. Without such an interim measure the optimum yield for the U.S. fishery would remain undefined. See Section 8.3 for a discussion of options for determining the U.S. portion of the OY and Section 10.1 for designation of the preferred option.

6.6 Optimum Yield Formula

In view of the biological, ecological, social and economic considerations reviewed above, the OY from the central subpopulation of northern anchovies is a quantity which varies from year-to-year in response to environmentally caused fluctuations in anchovy spawning biomass. Due to the importance of anchovy as a live bait, and as a component of the food supply for predator fish, birds, and mammals, the harvest of anchovies for reduction to fish meal, oil and solubles should be prevented when the population's spawning biomass falls to a low level. Also, the average biomass should be large enough to support abundant predator populations. Various harvest formulas that may achieve the optimum yield according to the above criteria are discussed in Section 8.3. The preferred option is designated in Section 10.2.

7.0 Total Allowable Level of Foreign Fishing (TALFF)

Section 201(d) of the MFCMA defines the TALFF for each fishery as "that portion of the optimum yield of such fishery which will not be harvested by vessels of the United States." Because the optimum yield from the central subpopulation of northern anchovy, as defined in Section 6.6 above, varies annually, the TALFF must also vary annually. Additionally, the level of harvest in the Mexican fishery zone in recent years has been greater than the portion of the total OY not allocated to the U.S. FCZ. To reduce the possibility of overfishing, this excess harvest should be considered before allocating TALFF in the U.S. FCZ.

TALFF in the U.S. FCZ each year will be based on the U.S. portion of the OY for the central subpopulation of northern anchovies (Section 8.3.1 below) minus the DAH (including joint venture processing, JVP) as specified in Section 5.3 above and minus the expected level of excess harvest in the Mexican fishery zone. The expected level of excess Mexican harvest is defined as the expected level of Mexican harvest minus the portion of total OY not allocated to the U.S. FCZ; it is set equal to zero if calculated to be less than zero. Since the Mexican fishery has stabilized at a significant level of annual harvest (see Table 3.2-4), the expected level of Mexican harvest can be reasonably estimated as the maximum of the previous three annual harvests. If calculated TALFF is less than zero, the TALFF is set to zero.

Application of the foregoing procedure can be illustrated by an example calculation. Using the 70 percent allocation to the U.S. FCZ adopted in the previous version of the Anchovy FMP, an OY of 400 thousand mtons, a DAH of 60 thousand mtons and an expected Mexican catch of 300 thousand mtons the TALFF is calculated as

$$\begin{aligned}
\text{TALFF} &= \text{U.S. OY} - \text{DAH} - \text{Excess Mexican Catch} \\
&= (.70 \times 400{,}000) - 60{,}000 - (300{,}000 - .30 \times 400{,}000) \\
&= 280{,}000 - 60{,}000 - 180{,}000 \\
&= 40{,}000.
\end{aligned}$$

For this example, therefore, the U.S. TALFF would be 40,000 mtons.

The above procedure for calculating TALFF in the U.S. FCZ is applicable for all five options of allocating the OY between the U.S. and Mexico (Section 8.3.1). However, a large TALFF may result from options 4 and 5 because the Mexican catch is considered solely through its effect on the spawning biomass; there would be no excess Mexican harvest.

8.0 Management Objectives and Options

8.1 Objectives

The objectives to be achieved by management measures adopted under this fishery management plan are:

(1) to prevent overfishing of the central subpopulation of northern anchovy (Engraulis mordax) within the United States' Fishery Conservation Zone, and to promote conservation throughout its range;

(2) to allow a fishery for anchovies within the U.S. Fishery Conservation Zone and to pursue such a fishery so as to achieve the optimum yield on a continuing basis;

(3) to maintain an anchovy population within the U.S. Fishery Conservation Zone of sufficient size to sustain adequate levels of predator fish, birds and mammals;

(4) to avoid conflicts between U.S. recreational and commercial fishermen;

(5) to promote efficiency in the utilization of the central subpopulation of anchovies within the U.S. Fishery Conservation Zone.

In order to achieve the management objectives there are a group of operational needs that will have to be met regardless of which particular management measures are chosen from among the optional measures discussed below. These are:

(1) A U.S. monitoring and implementation scheme which:

(a) sets the annual quota and closes the fishing season when the quota has been filled;

(b) monitors the fish catch and the size distribution in the catch;

(c) estimates the anchovy spawning biomass each year; and

(d) estimates the capacity and extent to which the U.S. fishery will take the optimum yield annually.

(2) Enforcement procedures for:

(a) surveillance of fishing vessels to assure compliance with area and season closures;

(3) Scientific research to:

(a) continue to improve the accuracy of the bioeconomic model underlying the management plan; and

(b) develop a more cost-effective system for estimating the spawning biomass.

(4) A workable, interim, unilateral harvest policy for use by the U.S. managers until a cooperative anchovy management system is negotiated with Mexico.

(5) A cooperative management agreement with Mexico which includes:

(a) an agreed common annual harvest quota policy; and

(b) a fishery monitoring system which provides consistent data from both the U.S. and Mexican fisheries and facilities:

1. monitoring of annual landings; and

2. separation of catches from southern and central subpopulations.

(6) A system for reviewing and revising the Anchovy Management Plan when one of the following occurs:

(a) a bilateral agreement with Mexico is signed;

(b) a documented change in the anchovy population response to exploitation occurs;

(c) management plans are adopted for other southern California pelagic fisheries which affect the operation of, or value of, the anchovy fishery;

(d) a substantial anchovy fishery for human consumption develops;

(e) the sardine population grows to the extent that incidental catches of sardines in anchovy harvests become significant;

(f) a scientifically documented adverse impact of the commercial fishery on the abundance and/or availability of live bait and predator fish; and

(g) an adverse impact of the anchovy fishery on other species of animal or plant life, especially those listed as endangered or threatened, is scientifically documented.

8.2 Areas, Fisheries and Stocks Involved

The stock involved is the central subpopulation of the northern anchovy which ranges from approximately 38°N, north of San Francisco, to 30°N, Punta Baja, Baja California, Mexico and as far as 200-300 miles offshore as described in section 3.1. The management regime must include this entire area. This will eventually require a bilateral agreement with Mexico and will require consistent management within both the 0-3 mile zone under California State jurisdiction and the 3-200 mile zone.

Both U.S. and Mexican fleets fish anchovies in their respective waters. The fleets consist of round haul commercial reduction vessels predominantly, and to a lesser extent, live-bait fishing vessels. The U.S. domestic fleet, as described in section 3.5.2, fishes for reduction purposes out of Moss Landing, Oxnard and San Pedro. The expanding Mexican fishery with homeport in Ensenada, B.C., fishes along the coast from Coronado Islands to Cape Colnett. the Mexican fishery also harvests the southern subpopulation. The live-bait fishery, using lampara nets, operates nearshore predominantly in southern California from Santa Barbara to San Diego. There is also an anchovy live-bait fishery that supplies recreational fisheries in Ensenada.

8.3 Management Measures - Options Considered

The management measures for the domestic fishery considered by the Pacific Fishery Management Council are discussed throughout section 8.3. A summary of the management options is presented in Table 8.3-1.

Because of existing management regulations established under the previous anchovy FMP (PFMC 1978), previous regulations will remain in effect unless they are specifically modified or eliminated. In order to aid the process of revising the previous anchovy management regime, existing regulations are given as the first in each of the following sets of options.

8.3.1 U.S.-Mexico OY Allocation

Since the mid-1970's the Mexican harvest has increased to about 250,000 mtons/year, while the U.S. harvest has declined to about 50,000 mtons/year. Ideally, the anchovy central subpopulation should be managed as a unit stock involving U.S.-Mexico cooperation. Until a bilateral agreement between the United States and Mexico is obtained, however, the U.S. domestic anchovy fishery is being managed on a unilateral basis. This means that the OY applied to the domestic fishery should be specified appropriately to account for the Mexican fishery.

Whatever option is chosen to account for Mexican harvests in determination of U.S. OY, U.S management will have little or no influence on near-term Mexican harvests. Proposed options to allocate the OY between U.S and Mexico fall into three general categories. Category 1: Options 1 and 2 assign a nominal fraction of total OY to the U.S. and Mexican fisheries respectively, and manage the U.S. fishery accordingly. This is the method used in the previous Anchovy FMP (PFMC 1978). Category 2: Options 3 and 4 account for actual or anticipated Mexican harvests prior to setting U.S. OY. Category 3: Option 5 sets U.S. OY with implicit rather than explicit recognition of Mexican harvests.

The U.S. fishery does not pose a threat to the health of the anchovy stock under any of these options so long as the OY formula (Section 8.3.4) includes a reduction cutoff that curtails the U.S. fishery whenever the spawning biomass reflects a need for such action. Continued unregulated harvests by the Mexican fishery could, however, cause stock depletion.

The five options are discussed below and the expected impact of each

Table 8.3-1. Summary of management measures considered. BIOMASS refers to spawning biomass estimated by the egg production method or its equivalent. BIOMASS*(L) refers to spawning biomasses that had been estimated by the larva census method or its equivalent.

U.S.-MEXICO OY ALLOCATION (Section 8.3.1)

1. (Present) US quota is 70% of OY	2. US quota is 50% of OY	3. US quota is remainder of OY after subtracting expected Mexican harvest
4. US quota is 100% of OY (based on BIOMASS minus expected Mexican harvest)		5. US quota is 100% of OY (Mexican harvest is implicitly treated as mortality factor)

MINIMUM SPAWNING BIOMASS ALLOWING HARVEST (Section 8.3.2)

1. (Present) 90,720mtons BIOMASS*(L)	2. 20,000 mtons BIOMASS	3. No minimum specified

NON-REDUCTION ALLOCATION (Section 8.3.3)

1. (Present) 16,330 mtons total fishery	2. Non-numeric OY for live bait; 7,000 mtons other

REDUCTION QUOTA FORMULAS (Section 8.3.4)

1. (Present) QUOTA=1/3 of EXCESS over 907,200mtons BIOMASS*(L)	2. QUOTA=1/4 of EXCESS over 200,000 mtons BIOMASS	3. QUOTA=1/4 of EXCESS over 300,000 mtons BIOMASS	4. QUOTA=1/3 of EXCESS over 300,000 mtons BIOMASS
5. QUOTA=1/2 of EXCESS over 300,000 mtons BIOMASS	6. QUOTA=1/3 of EXCESS over 400,000 mtons BIOMASS	7. QUOTA=200,000 mtons if BIOMASS exceeds 300,000 mtons	
8. QUOTA=200,000 mtons if BIOMASS exceeds 400,000 mtons	9. QUOTA=1.0 of EXCESS over 200,000 mtons BIOMASS with limit of 200,000 mtons	10. QUOTA=1.25 of EXCESS over 300,000 mtons BIOMASS with limit of 250,000 mtons	11. QUOTA=1.0 of EXCESS over 200,000 mtons BIOMASS with limit of 300,000 mtons

Table 8.3-1 Continued. Summary of management options considered

REDUCTION QUOTA RESERVE (Section 8.3.5)

1. (Present) 1/2 US reduction quota	2. No reserve

GEOGRAPHIC ALLOCATION OF REDUCTION QUOTA (Section 8.3.6)

1. (Present) 10% or 9072 mtons reallocated on June 1 if necessary	2. 10% or 9072 mtons until June 1	3. No allocation

FISHING SEASONS (Section 8.3.7)

1. (Present) North: Aug 1-June 30 South: Sept 15-June 30 Feb and March closed	2. North: Aug 1-May 15 South: Sept 15-May 15	3. No closure

AREA CLOSURES (Section 8.3.8)

1. (Present) 5 areas of closure beyond 3 miles	2. Re-evaluate each closure independently

SIZE LIMIT AND/OR MESH RESTRICTION (Section 8.3.9)

1. (Present) No minimum but 10/16" mesh size restriction	2. 5" TL with 15% tolerance	3. 5" TL with 40% tolerance
4. 4.5" TL with 15% tolerance	5. 5" TL with 15% tolerance in effect Aug thru March only	

FOREIGN VESSEL AREA RESTRICTION (Section 8.4)

1. (Present) No closures	2. Catalina Channel closure and 3-6 miles from shore

option is summarized in Table 8.3-2. This table shows interactions between U.S.-Mexico allocation options and OY formula option (Section 8.3.4).

Option 1. The OY in the U.S. Zone is 70% of the Total OY

This is the option chosen in the previous FMP. It has a biological basis in that it reflects the historical average distribution of the central subpopulation as evidenced by anchovy larvae (see section 4.1.2, Table 4.1-1). This option has minimal adverse effect on the U.S. fishery, and is easy to implement. The option implies that the U.S and Mexico share the resource without defined priority. The U.S. OY is not adjusted for expections of Mexican harvests greater the OY. Total harvests in excess of total OY will decrease the stock level and lead to smaller total OY in subsequent years.

Option 2. The OY in the U.S. Zone is 50% of the Total OY

This option is similar to option 1 except that the OY is divided evenly between the U.S. and Mexico. All considerations are similar to Option 1, except that the U.S OY will be smaller by about 29%.

Option 3. The OY in the U.S. Zone is Total OY Less Expected Mexican Harvest

This option would preclude a U.S. fishery in years when the Mexican harvest exceeds total OY. It effectively gives first priority to the Mexican fishery. Because U.S. OY would be set without consideration of U.S. fishery benefits, this option may not satisfy FCMA OY requirements.

At low stock levels the effect of this option is similar to raising the level of the reduction cutoff. At high stock levels this option is likely to be incompatible with OY formulas which place a constant upper limit on OY (Table 8.3-2, reduction quota Options 7,8,9,10 and 11), as the magnitude of the Mexican fishery could permanently preclude a U.S. fishery.

Option 4. The OY in the U.S. Zone is the total OY calculated after adjusting the spawning biomass estimate to reflect expected removals from the stock by the Mexican fishery subsequent to the time of biomass estimation.

This option is less extreme than Option 3. The effect of the Mexican fishery on the U.S. OY occurs indirectly through its effect on the anchovy stock. The U.S. fishery would be reduced and occasionally precluded by this calculation, depending on the OY formula which is implemented (Table 8.3-2). This option also implicitly gives the Mexican fishery first priority, but a U.S. fishery would be allowed more often than under Option 3. FCMA OY requirements are satisfied because the U.S. OY is set according to the U.S. benefits in view of the status of the stock.

Option 5. The OY in the U.S. Zone is determined by formula without explicit regard for the Mexican Harvest.

Table 8.3-2. Evaluation of options regarding the U.S.-Mexico allocation of the total OY (Section 8.3.1).

	U.S.-Mexico OY Allocation Option				
	1	2	3	4	5
Specification of U.S. quota:	70% of OY	50% of OY	Remainder of OY after subtracting expected Mexican harvest**	100% of adjusted OY (based on biomass minus expected Mexican harvest)**	100% of OY*
Consistent with FCMA OY definition:	YES	YES	NO	YES	??
TALFF recognizes Mex. harvest:	YES	YES	YES	YES	NO
Impact of fishery on the stock:	VAR.	VAR.	LEAST	OK	MOST
Approximate percentage of years with no U.S. fishery*** QUOTA OPTION NO.:					
2	2	2	51	8	2
3	5	5	55	13	5
4	7	7	48	17	7
5	11	11	42	24	11
6	12	12	50	22	12
7	10	10	>90	21	10
8	15	15	>90	24	15
9	3	3	>90	13	3
10	10	10	20	23	10
11	7	7	24	24	7

*Mexican catch is considered implicitly as an external source of mortality that affects the future biomass and U.S. OY levels based on that biomass.

** Mexican harvest is assumed to be 200,000 mtons.

*** Percentages given for allocation options 1,2 and 5 are nominal. Actual percentages cannot be calculated but would be highest for option 5 and lowest for option 2 due to impact of total harvest on stock abundance (unregulated Mexican harvest may be greater than portion of OY not allocated to the U.S. fishery).

This option treats the Mexican harvest implicitly rather than explicitly. The effect of Mexican, as well as U.S., harvests will be to decrease the spawning biomass in subsequent years. Since the OY formula responds to stock abundance, it inherently responds to fishery levels during previous years. Thus the Mexican harvest is treated similarly to natural mortality as an implicit rather than explicit factor. Since the Mexican allocation is not addressed, this option does not allow the Mexican harvest to be considered before allocating TALFF in the U.S. Zone (see Section 7.0). Therefore a TALFF may have to be allocated in some years in which the total harvest by the U.S. and Mexico is expected to be greater than total OY.

8.3.2 Minimum Biomass Allowing Harvest

There may be some lower level of abundance at which all harvests from the anchovy stock should be curtailed. However, it is important to recognize that anchovy spawning biomass fell to very low levels in the early 1950's even though there was no substantial fishery. If such minimum biomass is established it should be set at a historically realistic level, and it will probably be invoked at some future time.

Option 1: OY for all uses will be zero if the spawning biomass falls below 90,700 metric tons (100,000 short tons). This minimum was originally based on a larva census estimate of anchovy abundance, by which measure the spawning biomass has never fallen below 141,500 metric tons. This may be an unrealistic minimum in view of re-estimated egg production method equivalent historical biomasses (see Section 4.3.6.3), which show spawning biomasses less than 90,700 metric tons in seven historical years. During these years there was live bait harvest and a substantial cannery harvest (ca 20,000 tons annually).

Option 2: OY for all uses will be zero if the spawning biomass falls below 20,000 metric tons (egg production method equivalent).

If a minimum spawning biomass allowing harvest remains a feature of the Anchovy FMP, the value of this minimum should reflect the revised perception of historical anchovy abundance resulting from the egg production method. There are no well-defined criteria for the exact level of such a minimum. The original specification of 100,000 short tons was based on the ad hoc perception that this value was in the vicinity of the lowest spawning biomasses which had been observed historically. The value of 20,000 m tons is an approximately equivalent minimum according to the egg production method. Anchovy spawning biomass may have fallen below this level in 1951-1953, but our abundance estimates for these years are of low reliability.

Option 3: No lower limit of abundance need be specified. The reduction OY formula provides sufficient protection, given that the resource has recovered from previous low abundances while being fished for live-bait and canning purposes.

8.3.3 Non-reduction Allocation

The previous FMP reserved a portion of the OY for non-reduction fisheries. The discussion of optimum yield in section 6.4 suggested that the reduction fishery is somewhat less valuable per unit of harvest than for non-reduction fisheries (i.e., fishing for live-bait, dead bait, and for human consumption). Under 1982 economic conditions, it is unlikely that the live-bait catch or the other non-reduction fishery catches will expand significantly. Also, it is noted that the non-reduction anchovy harvests are small in comparison to the reduction fishery harvests. To assure the continuation of the non-reduction fisheries and to minimize the administrative cost of managing the minor non-reduction components of the anchovy fishery, a constant non-reduction allocation is separated from a variable reduction allocation which will be determined by one of the formulas presented in 8.3.4. When the spawning biomass is below the reduction cutoff, the OY is equal to the non-reduction allocation.

Option 1: Non-reduction allocation for the total fishery is 16,330 metric tons (18,000 short tons). Allocation between U.S. and Mexican zones is in accordance with the option chosen in 8.3.1.

Under the previous FMP, 70% of the total OY was allocated to the U.S. FCZ, resulting in U.S. non-reduction allocation of 11,430 metric tons (12,600 short tons). This has been sufficient to cover the U.S. non-reduction demand for anchovy.

Option 2: Non-numeric live bait OY; 7,000 metric tons allocated for other non-reduction fisheries.

This option establishes OY for live bait as the total catch which is made using gear which preserves the fish in a live state for use as bait. The live bait fishery catch is dictated by availability and demand from recreational fishermen which has been and is expected to remain constant at 4 to 6 thousand metric tons per year. An additional small live bait catch is made by commercial albacore fishermen. Unlike other anchovy harvests, the live bait catch is returned to the ecosystem. The allocation of 7,000 metric tons for other non-reduction fisheries is according to the option chosen in 8.3.1 and is sufficient to meet non-reduction demand unless anchovy canning increases substantially.

8.3.4 Reduction Quota Formulas

Total OY is the sum of an amount calculated by a reduction quota formula and an amount equal to the non-reduction allocation. The reduction fishery is potentially the largest user of anchovy and has demonstrated an ability to harvest several hundred thousand tons per year. The anchovy resource is expected to fluctuate in biomass under any level of fishing pressure. Allowable levels of harvest must reflect the current status of the stock, so that a margin of growth is allowed when the biomass is low, and so that greater quantities may be harvested when the biomass is high. In order to avoid unnecessary FMP amendment each year, and in order to respond to the status of the stock as rapidly as possible, reduction quotas are established by a formula which is based on the current spawning biomass (estimated in egg production method equivalent value as of the winter-spring spawning season of each year).

Table 8.2-3. Comparison of harvest policies. Spawning biomass and catch units are thousand metric tons.

HARVEST POLICY DESCRIPTIONS													
Option:	Reference		1	2	3	4	5	6	7	8	9	10	11
Harvest Formula:	no fishery	approx. MSY	old OY*	Reserve with slope					Reserve with limit		Reserve with slope and limit		
cut-off:	-	350	907	200	300	300	300	400	300	400	200	300	200
Slope:	-	1.22	1/3	1/4	1/4	1/3	1/2	1/3	-	-	1.0	1.25	1.0
Max. catch:**	0	--	500	500	500	500	500	500	200	200	200	250	300
SPAWNING BIOMASS STATISTICS													
Mean:	1892	604	1429	1178	1233	1131	996	1192	1215	1281	1216	1146	973
Quartiles of biomass:													
25%	1077	301	808	616	660	590	507	640	550	614	553	524	409
50%	1603	504	1237	978	1026	940	799	998	961	1028	956	909	737
75%	2430	810	1836	1546	1624	1449	1299	1555	1615	1705	1614	1543	1300
Biomass level: Percent of years biomass will be below specified level:													
100	0%	8	0	0	0	0	1	0	0	0	0	0	1
300	0	25	3	4	3	4	7	3	7	4	6	6	13
500	2	50	7	15	13	17	24	14	21	17	21	23	33
1000	21	84	37	51	48	53	62	50	52	49	52	55	63
Mean pelican reproductive success (number fledged per nesting pair):	0.85	0.46	0.76	0.68	0.70	0.67	0.61	0.69	0.68	0.70	0.67	0.66	0.59
CATCH STATISTICS (REDUCTION FISHERY)													
Mean:	0	311	156	212	202	224	248	212	180	171	181	202	232
Std. dev.	0	416	184	155	159	172	186	176	59	70	50	88	107
Quartiles of catch:													
25%	0	0	0	104	90	97	103	80	200	200	200	250	209
50%	0	188	110	195	182	213	250	199	200	200	200	250	300
75%	0	561	310	336	331	383	499	385	200	200	200	250	300
Percent of years with no fishery:	--	36.7	37.0	2.2	4.8	7.1	10.8	11.9	9.8	14.5	3.0	10.3	7.4
Average duration of fishery closure (years):	--	2.0	2.1	1.2	1.2	1.3	1.4	1.3	1.2	1.3	1.1	1.3	1.2

*:Old OY formula which had been developed for spawning biomass as estimated by the larva census method and applied here to egg production method equivalent spawning biomass estimates.

**:500 thousand m tons is the assumed capacity of the total fishery

The choice of harvest formula should take into consideration the probable effect that the alternative formulas will have on the fish stock (including forage supply), the annual harvests, and the nature of the expected fluctuations in these quantities. The characteristics of each alternative reduction quota formula do not lead to any obvious conclusion as to what is optimal. This is because there are several unquantifiable objectives which are not given relative values in Table 8.3-3. Any one of the proposed harvest policies could achieve the management objectives outlined in Section 8.1. Whether or not one of these policies is the "best" or whether there is any "best" policy is essentially a matter of judgement which, according to the FCMA, is to be exercised by the Council. The options presented in this section are intended to cover the likely range of Council action; they are not intended to constrain the Council to choosing precisely one of the options offered. In response to information from this Plan and public hearings, the Council may choose an optimum yield formula that varies from these specific options.

The various options of reduction harvest formulas are summarized in Table 8.3-3, and are illustrated in Figure 8.3-1. Each formula can be described in terms of a CUTOFF below which spawning biomass no reduction catch is allowed; a SLOPE which is the fraction of the spawning biomass in excess of the CUTOFF which is to be harvested; and a LIMIT, which is the maximum amount of harvest. These three characteristics relate roughly to important objectives of anchovy fishery management, namely, conservation of the fish population, maximum economic utilization of the resource, and stability of the fishing industry.

The harvest formula options fall into three categories. The first category is "CUTOFF WITH SLOPE" formulas, which include the type of formula established under the previous FMP. For purposes of evaluating the expected performance of each of these options, combined U.S.-Mexican harvest capacity was assumed to be 500,000 metric tons. The formula established by the previous FMP is evaluated as if it were implemented in terms of egg production method equivalent spawning biomass rather than larva census equivalent biomass (the basis of its use under the previous FMP).

The second category of harvest formula option is "CUTOFF WITH LIMIT," wherein the reduction quota is a fixed amount if the spawning biomass exceeds the CUTOFF, and is zero otherwise. The third category of harvest formula option is a compromise which softens the transition from maximum to zero catch. This is accomplished by a SLOPE rising steeply from the CUTOFF to the LIMIT.

CUTOFF with SLOPE options:

Option 1: (This formula is based on the larva census method of estimating anchovy spawning biomasses, and is included only because of its status as the formula used in the previous FMP.) Reduction OY is 1/3 (33.3%) of the (larva census) spawning biomass in excess of 1 million short tons.

Option 2: Reduction quota is 1/4 (25%) of the egg production method equivalent (EPME) spawning biomass in excess of 200,000 metric tons.

Option 3: Reduction quota is 1/4 (25%) of the EPME spawning biomass in

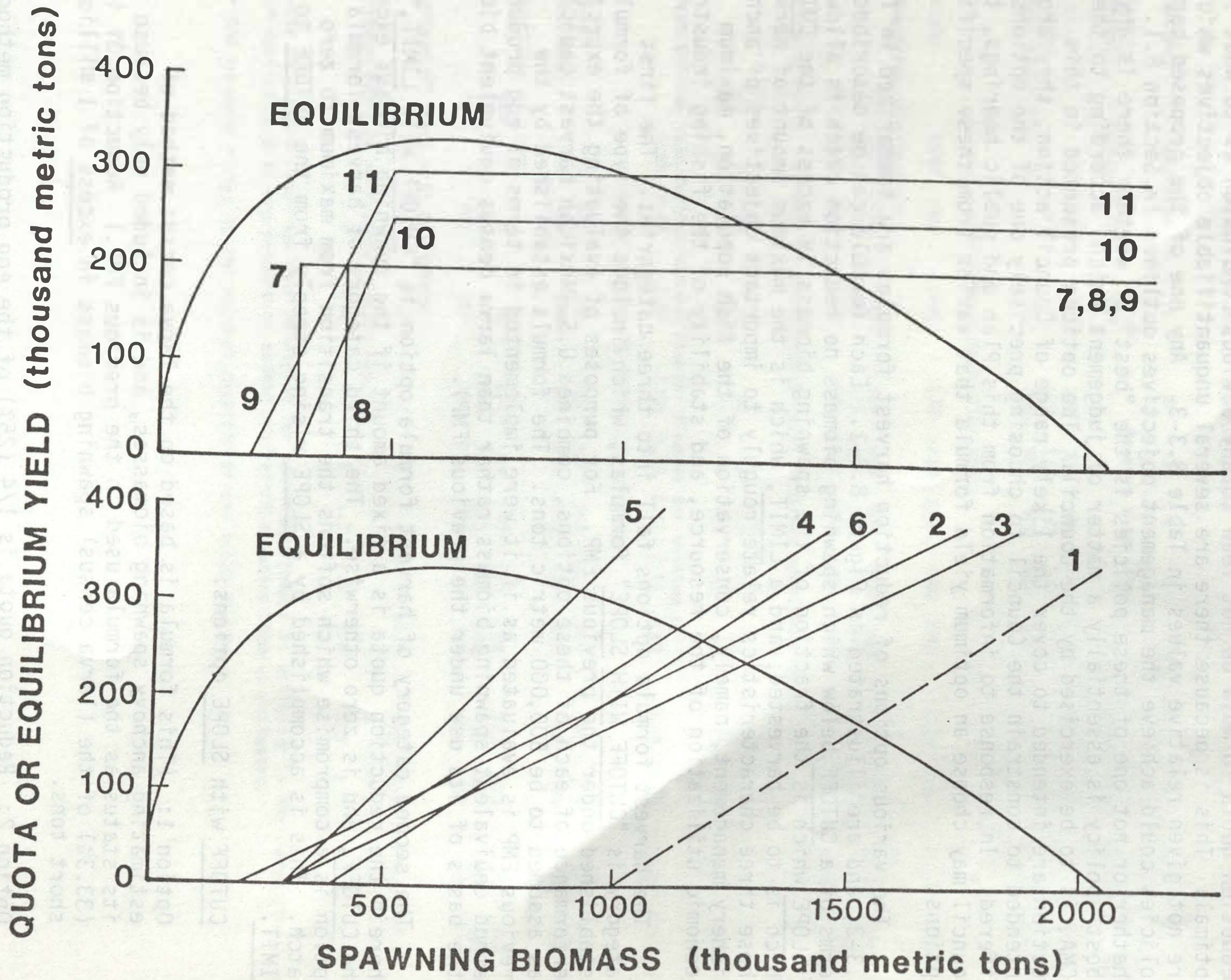


Figure 8.3-1. Options for harvest quota formulas.

excess of 300,000 metric tons.

Option 4: Reduction quota is 1/3 (33.3%) of the EPME spawning biomass in excess of 300,000 metric tons.

Option 5: Reduction quota is 1/2 (50%) of the EPME spawning biomass in excess of 300,000 metric tons.

Option 6: Reduction quota is 1/3 (33.3%) of the EPME spawning biomass in excess of 400,000 metric tons.

CUTOFF with LIMIT option:

Option 7: Reduction quota is 200,000 metric tons if the EPME spawning biomass exceeds 300,000 metric tons.

Option 8: Reduction quota is 200,000 metric tons if the EPME spawning biomass exceeds 400,000 metric tons.

Compromise options:

Option 9: Reduction quota is equal to the excess of the EPME spawning biomass over 200,000 metric tons, with an upper limit of 200,00 metric tons.

Option 10: Reduction quota is equal to 125% of the excess of the EPME spawning biomass over 300,000 metric tons, with an upper limit of 250,000 metric tons.

Option 11: Reduction quota is equal to the excess of the EPME spawning biomass over 200,000 metric tons, with an upper limit of 300,000 metric tons.

Options 2-6 place no upper limit on the reduction quota, but require a relatively precise and costly estimation of spawning biomass each year. The cost of biomass estimation is very large with respect to the economic benefit from the reduction fishery, and should be a consideration in optimality. Options 7 and 8 require much less costly biomass estimates under most circumstances. Because Options 7 and 8 result in an "all-or-nothing" fishery, Options 9, 10 and 11 seek a more gradual transition, but by doing so, incur some of the estimation costs Options 7 and 8 are intended to avoid.

8.3.5 Reduction Quota Reserve

During 1982 the PMFC approved a FMP amendment establishing a reduction quota reserve. At that time there were concerns that the anchovy stock could be overexploited due to uncertainties in estimating spawning biomass. The quota has been based on a larval census equivalent estimate of spawning biomass which recently has been several times larger than the spawning biomass estimated by egg production and acoustic methods. With the new biological model based on egg production (section 4.4) and the new harvest options (section 8.3.4) the need for a reduction quota reserve is diminished. Retention of the reduction quota reserve would greatly complicate calculation of the allowable catch for joint venture programs (section 5.3).

Option 1: To reduce the chance of overexploitation, the U.S. reduction quota and TALFF will be allocated in two halves. The first half of each will be released at the beginning of the season. When one quarter of the total quota has been landed, but not later than February 1, the Southwest Regional Director will issue a public notice of the intent to release the second half of the quota and TALFF, and ask for evidence that the second half should not be released. This evidence consists of documented indices of anchovy abundance indicating that the spawning biomass would fall below the level of the reduction cutoff if continued harvest in U.S. waters were allowed. The second half of the quota and TALFF will be released 1) if no evidence is presented or 2) if the Southwest Regional Director (with advice of the PFMC and California Department of Fish and Game) determines that the evidence is insufficient to warrant withholding the second half of the quota and TALFF.

Option 2: No reduction quota reserve. In-season allocation to non-domestic processors will be according to sections 5.3 and 7.0.

8.3.6 Geographic Allocation of Reduction Quota

In the previous version of the FMP, two reduction quotas were established -- one for the "Northern Permit Area" and one for the "Southern Permit Area." The separation of the overall catch quota into two geographical zones was primarily intended to prevent the larger southern fleet from taking the entire reduction quota before the smaller fleet in the northern area has a reasonable chance to fish. The quota separation was, in other words, a response to social and economic considerations rather than to biological conservation needs. This need continues to have pertinence under the FCMA.

After establishing an overall optimum yield in the FCZ under any of the quota options considered in Section 8.3.4, a measure of protection can be afforded the Northern Area fishery by allocating a portion of the quota to the Northern Area. Since the primary northern fishery is in Monterey Bay, the two areas are adequately defined as the FCZ north and south of Point Buchon. It is proposed that a portion of the reduction fishery quota equal to 10% of the quota or 9,070 m tons, whichever is smaller, be reserved for harvest north of Point Buchon. This amount is adequate to meet the needs of the Monterey area industry under normal circumstances, and assures that the northern fishermen can participate in the reduction fishery. This allocation is <u>not</u> a special quota on the northern fishery; it is a reduction in the overall amount available to the southern fishery.

The special allocation described above, however, raises the possibility that U.S. fishermen are prevented from catching anchovies for reduction even though the optimum yield for the season has not been taken. Suppose, for example, that the overall quota is 90,000 tons with 9,000 tons reserved for the Northern Area. The southern fishery might take 80,000 tons and be closed during the statutory season, while the northern fishery fails to take its 9,000 ton allocation by the end of the season. Fishermen in southern California would be prevented from taking the available yield even when Northern Area fishermen are unable or unwilling to take the special allocation reserved for them. To prevent this kind of paradox, the special allocation should be revised near the end of the reduction fishery season to allow full utilization of the optimum yield.

Option 1: On June 1 the reduction fishery quota reservation for the Northern Area will be modified (if necessary) as follows:

1. The expected Northern Area reduction catch for the year will be estimated based upon catch to date in the current year and the expected intentions of processors and fishermen in the fishery north of Pt. Buchon to harvest reduction fish in the remaining portion of the fishing year.

2. The expected harvest in the northern reduction fishery will be subtracted from the amount reserved for the northern fishery, and any positive remainder may be reallocated to the Southern area.

Option 2: The reservation of the reduction quota for the area north of Pt. Buchon will not apply after June 1. Any of the Northern Area allocation which has not been caught prior to June 1 will be available for reduction fishing in both the northern and southern areas until the end of the reduction fishing season.

Option 3: The reduction quota is fully available to the northern and southern areas equally without specific allocation.

8.3.7 Fishing Seasons

Rationale: Closure of seasons for all anchovy fishing, or for some types of anchovy fishing, can be utilized to strengthen management control over total annual harvests or to assist in attaining other objectives of management. Current Federal and California state regulations prohibit fishing for delivery to reduction plants from July 1 through July 31 north of Pt. Buchon, July 1 through September 14 south of Pt. Buchon, and February 1 through March 30 both north and south of Pt. Buchon. These season closures eliminate to a large extent the possibility of commercial purse seiners and recreational vessels being in direct physical conflict, and they also reduce the possibility of conflicts between reduction and bait fishermen during periods of peak demand for live-bait. The southern permit area is the area of most intense fishing for the live-bait and for the fish species most likely to be dependent upon anchovies for forage. In the northern area, the commercial fishery for reduction is much smaller, and the summer peak recreational fishing season is less in conflict with the commercial fishery.

Because the reduction fishery has rarely approached its annual landings quota prior to the season closure date, the season, rather than the quota, has acted as a restraint upon anchovy harvests as well as a means to avoid recreational/commercial conflicts. The closed summer period may be a period of potentially productive commercial fishing. The Mexican fishery achieves its peak harvest rates in the summer, but the lack of U.S. experience during the summer leaves unknown the question of whether the reduction fishery would be very successful in California in summertime. This fact, together with the known difficulties in catching anchovies during poor weather and peak spawning activity in the winter, suggests that the current season structure reduces the productivity of fishing vessels in the anchovy reduction fishery. Finally, the oil yield of anchovies is especially low during the months of January, February, March and April (see Figure 4.2-6). The lower yield of oil reduces the commercial value of a ton of anchovies during the winter and early spring.

The magnitude of the loss of commercial value due to the summer season closure is unknown, but potentially substantial. The options concern the extent to which season closures should be imposed in order to minimize conflicts involving recreational fishermen and live-bait fishing vessels. Also, to a largely unknown extent, the summer closure may help to maintain anchovy densities in the intense recreational fishing grounds in southern California.

The socio-economic concerns of the various interest groups are summarized as follows:

Live-Bait and Recreational Fishermen are opposed to extension of the reduction fishery into the summer months. The period beginning May 15 is believed by live-bait fishermen to be critical to meeting bait supply commitments for the coming summer. If the summer season is to be opened to reduction fishing, the recreational fishermen would prefer that this occur in the later summer rather than in the early summer.

The Reduction Fishermen and Processors are willing to forego fishing during the poor months of February and March in exchange for opening the summer months to the end of June. There is relatively less industry interest in opening the period July to mid-September since other more lucrative species such as bonito and bluefin tuna become targets of the fleet. Higher oil yield occurs during the late summer, increasing the economic value of fish harvested at that time.

Option 1: Retain existing season closures: July 1 through July 31 north of Pt. Buchon; July 1 through September 14 south of Pt. Buchon; and February 1 through March 31 both north and south of Pt. Buchon.

Option 2: Impose reduction fishery closure from May 15 through September 15 south of Pt. Buchon; and from May 15 through July 31 north of Pt. Buchon, with no February-March closure.

Option 3: Eliminate statutory reduction fishery season closures and close the fishery only when a quota has been reached.

8.3.8 Area Closures

Rationale: Historically, nearshore areas have been closed to anchovy reduction fishing or to purse seine gear generally as a means of addressing the concerns of recreational and live-bait fishermen. Evidence from NMFS recruitment studies and CF&G sea surveys indicate that the 3-mile inshore zone is a major habitat of pre-recruit anchovies. This zone is also the focus of most live-bait fishing and recreational fishing. The state of California which has jurisdiction within islands, has closed the 3-mile zone in the southern permit area south of Pt. Buchon. These are also five separate area closures that extend beyond 3 miles, all of which were incorporated into the Anchovy Plan adopted in 1978 (see Figure 3.3-1). These are described below under Option 1.

Nearshore area closures have two main effects: (1) they shift reduction fishing effort from areas that are intensively used by recreationists, and (2) they tend to shift effort away from the youngest year class of anchovies. By forcing fishing vessels to move outside the nearshore zone, this regulation probably imposes some costs upon the commercial fishery. These costs are thought to be minor, because the extra distance traveled (three to six miles at most) is small in relation to the distances routinely traveled on anchovy fishing trips. The second effect, reduced capture of pre-recruits, may be a safety factor in anchovy management strategy as explained more fully below in regards to the size limit options. Also, this effect may tend to reduce the reduction fishery harvest during periods when inshore, small fish are more abundant than larger fish offshore. Quantitative analysis of these effects are impeded by the fact that historical fishery statistics reflect the consequences of prevailing size limits and area closures. Thus estimates of the potential size distribution and tonnage of harvests from the closed, nearshore area in southern California are unavailable:

Option 1: Retain existing reduction fishery area closures, defined as follows:

1. Farallon Islands closure. The portion of the northern permit area bounded by:

a. A straight line joining Pigeon Point Light (37°10.9'N., 122°23.6°W) and the U.S. navigation light on Southeast Farallon Island (37°42.0'N, 123°00.1°W); and

b. A straight line joining the U.S. navigation light on Southeast Farallon Island (37°42.0 N, 123°00.1'W) and the U.S. navigation light on Point Reyes (37°59.7'N, 123°01.3°W).

2. Southern permit area: That portion of southern permit area described as:

a. Oxnard Closure: The area that extends offshore 4 miles from the mainland shore between lines running 250° true from the steam plant stack at Manadalay Beach (34°12.4'N, 119°15.0'W) and 220° true from the steam plant stack at Ormond Beach (34°07.8'N, 119°10.0'W).

b. Santa Monica Bay closure. Santa Monica Bay shoreward of that line from Malibu Point (34°01.8'N, 188°40.8'W) to Rocky Point (Palos Verdes Point) (33°46.5'N, 118°25.7'W).

c. Los Angeles Harbor closure. The area outside Los Angeles Harbor described by a line extending 6 miles 180° true from Point Fermin (33°42.3'N, 118°17.6'W) and then to a point located 3 miles offshore on a line 225° true from Huntington Beach Pier (33°39.2N, 118°00.3'W).

d. Oceanside to San Diego closure. The area 6 miles from the mainland shore south of a line running 225° true from the tip of the outer breakwater (33°12.4'N, 117°24.1'W) of Oceanside Harbor to the United States-Mexico International Boundary.

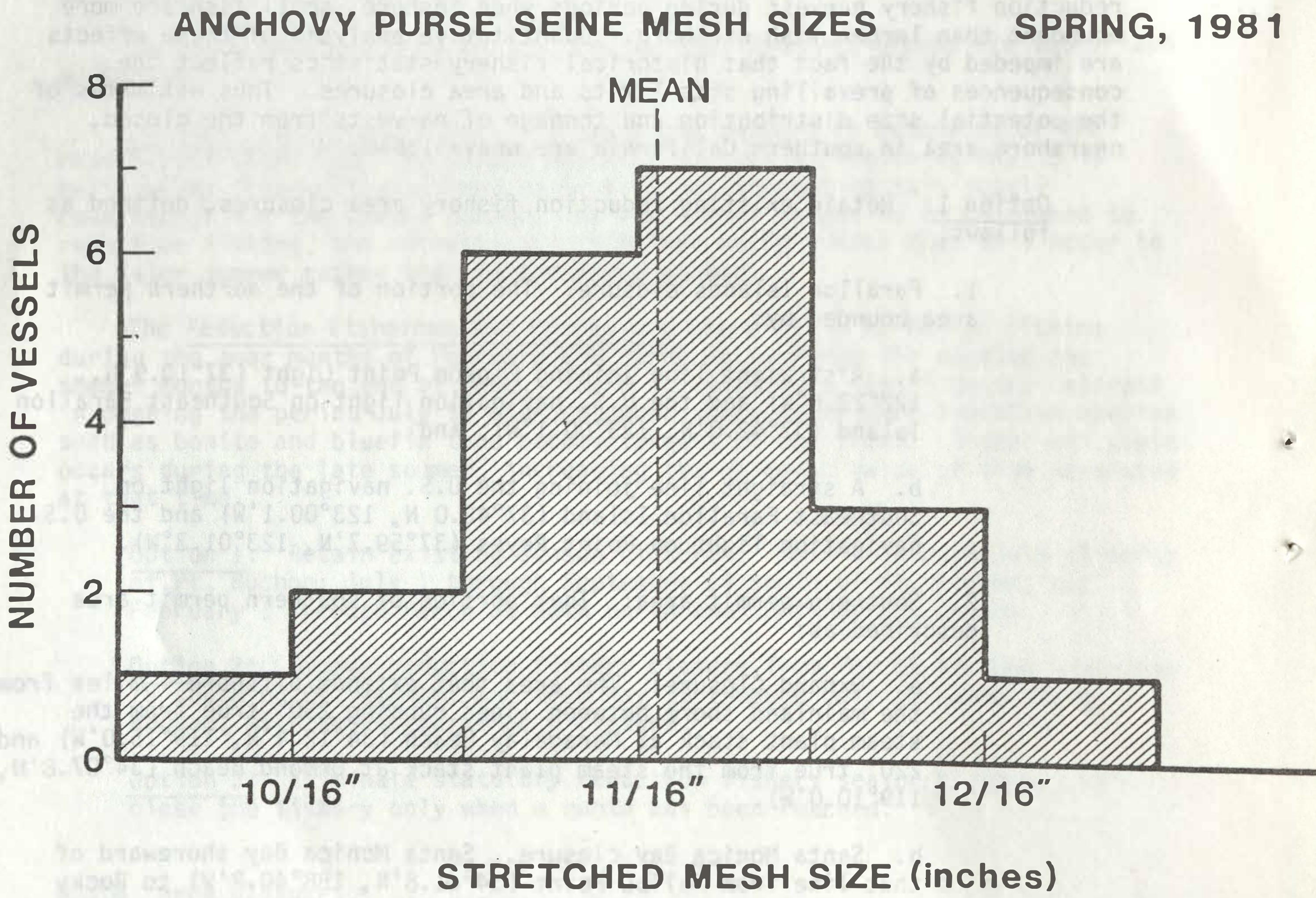


Figure 8.3-2. Anchovy purse seine mesh size for 20 vessels in the San Pedro wetfish fleet. Nets were measured at the unloading docks after vessels had returned from a fishing trip. Stretched-mesh (knot-to-knot) measurements were made from at least 5 different mesh panels . Measurements were not made in the bag region, areas of repair, or near the corkline or chainline. Data from Robert Read, California Department of Fish and Game (personal communication).

Option 2: Reconsider separately each of the five area closures listed in Option 1.

8.3.9 Anchovy Size Limit and Mesh Size Regulation

Background: Under California law anchovy landings have been subject to a minimum size limit of 5 inches total length (with 15% allowance for undersized fish) for nearly 30 years. The 1978 anchovy FMP adopted identical provisions on the basis that the size limit protected pre-spawning fish. By delaying fishing pressure on smaller fish until they become active spawners, it was reasoned, the average annual yield could be increased by around 16%. This conclusion rests upon the observation that anchovies mature and begin spawning at about 1 year of age and that they are about 5 inches in total length at that age. In 1982 the PFMC reconsidered the biological information regarding young fish and approved and submitted to the Secretary of Commerce amendment four to the anchovy FMP. This amendment abolished the size limit and established 10/16" as the minimum wet mesh size. A three year grace period was granted to allow sufficient time for complete compliance without creating economic hardship.

The harvest quota formula is designed to prevent the U.S. fishery from overfishing the anchovy stock but protection of the youngest age class provides an additional safety factor. Optimum yield considerations dictate that the annual reduction fishery quota in the United States' Fishery Conservation Zone be cut to zero when the estimated spawning biomass falls below the level established as a reduction cutoff. This should prevent overfishing in most forseeable circumstances. Due to the variable nature of spawning biomass estimates, the optimum yield occasionally may be overestimated. The protected young fish buffer the population from rapid decreases when an overharvest is inadvertently allowed.

Recent information and events in the fishery raises the question as to the extent of protection required by the small fish. A large proportion of fish smaller than 5 inches in total length were found to be sexually mature in 1980, 1981 and 1982. Also, examination of historical data on length-at-age indicates that the average size of anchovies at one year of age varies substantially among year classes. Few year classes are larger than the 5-inch size limit after one year of growth. This means that the amount of fish available to the fishery with a 5-inch size limit is influenced by the growth rates and actual birthdates of young fish. A stable relationship between age, length and maturity does not seem to hold.

Operational considerations in the fishery are also important in discussing size limits. During most years the 5-inch size limit for the anchovy reduction fishery posed no particular problem to the fishermen or the enforcement agents. This was particularly true during the early 1970s when older age groups were abundant. During the 1979/80 and 1980/81 fishing seasons, however, the reduction fishing vessels encountered an unusually large proportion of undersized fish. Several boatloads were found to contain excessive amounts of small fish and the enforcement agents seized the fish and initiated legal procedures to punish the skippers responsible. These actions are time-consuming and expensive for both the fishing fleet and for the enforcing agencies. If the undersized fish problem was caused by slow growth rate of young fish, and if protection of these fish does not result in substantial benefits, these costs of monitoring and enforcing the size limit may be unjustified. Whether or not the small fish are actually protected by the size limit is uncertain, since fishermen claim that they do not know if a given school contains undersized fish until it is captured and sampled. Once it is determined that the school should be released due to a large proportion of undersized fish, substantial mortality may have already occurred.

Without a size limit, a minimum mesh size discourages fishermen from increasing fishing pressure on small fish. An important consideration in the selection of mesh size is the tendency for small fish to become entangled (gilled) in the mesh. Removal of the gilled fish is time-consuming for the fishermen. Fish smaller than about 4" are known to gill in the mesh which is most commonly used in the body of anchovy nets (Figure 8.3-2) so fishermen would need smaller mesh to harvest this size class effectively. Adoption of a minimum wet mesh size of 10/16" prevents future reductions in mesh size while posing no hardship to fishermen because existing gear will remain usable.

Options for Anchovy Minimum Size Limits

Option 1: No minimum size limit imposed on the catch or landings of northern anchovies but a minimum wet stretch mesh size of 10/16" will be required in the body of nets used in the U.S. reduction fishery. The body of the net excludes the bag which will be a continuous portion of the net comprising no more than 20% of the net.

This option differs only slightly from the amendment approved by the PFMC in 1982 and by the Secretary of Commerce in 1983. Under Option 1 monitoring and enforcement activities would be lessened and the overall cost of managing the anchovy fishery would presumably be reduced as would wastage of the resource since occasional catches containing small fish would not have to be dumped at sea. Other existing management measures and practical considerations already lead to reduced fishing of young fish: the nearshore area closure protects the habitat of much of the youngest age class and the low oil yield of small fish makes them economically undesirable. Implementation of the minimum mesh size was delayed until April 1986 to allow adequate time for compliance without creating economic hardship.

Regulations based on amendment 4 specified the minimum mesh size in the bag of the purse seine as 8/16 of an inch and the bag was defined as a single unit of the net not exceeding 12.5 percent of the total area of the net. Specification of a minimum mesh size in the bag of the net is an unnecessary regulation. Being able to use finer mesh in the bag will not enable the fishermen to harvest substantially greater quantities of smaller fish. Specification of a maximum extent of the bag is necessary, but 12.5 percent of the total area was too restrictive and would have required costly modification of some existing nets. A bag which comprises no more than 20% of the net is a reasonable restriction; the exact method of determining the extent of the bag will be specified in the regulations.

Option 2: Fish shorter than 5 inches total length may not be taken except for bait, with a 15 percent by weight incidental catch allowance.

This option is equivalent to an existing regulation in Title 14 of the California Fish and Game Commission and the Northern Anchovy FMP adopted in 1978.

Option 3: Fish shorter than 5 inches total length may not be taken except for bait, with a 40 percent by weight incidental catch allowance.

This option retains the 5-inch size limit but provides a much broader latitude for landing undersized fish. Monitoring and enforcement activities would be much the same under Options 2 and 3, but the third would result in fewer findings of illegal loads under present fishing conditions.

Option 4: Fish shorter than 4-1/2 inches total length may not be taken except for bait, with a 15 percent by weight incidental catch allowance.

This option has essentially the same effect as the second option, but with a lower expected incidence of undersized loads in years of slow growth by the youngest age class of anchovies.

Option 5: Fish shorter than 5 inches total length may not be taken except for bait, with a 15% by weight incidental catch allowance, during August through March. No minimum size will be in effect during April through July.

This option would delay fishing on most of the incoming year class until first spawning and spring growth are nearly completed.

8.4 Foreign Fishing Management Measures - Options Considered

In the case of joint venture and/or foreign participation in the anchovy fishery, foreign vessels will be required to observe all regulations imposed on domestic fishermen and processors. In addition, management may wish to consider imposing other regulations on foreign vessels.

Option 1: No additional regulations imposed on foreign fishing and processing vessels.

Option 2: Closure of Catalina Channel and inshore region to foreign vessels. Foreign fishing and processing vessels may not operate within six miles of the continental coastline, and may not operate in the Catalina Channel (Bounded by a line from Pt. Dume to West End, Santa Catalina island and from China Pt. Santa Catalina Is. to Dana Pt.(see Figure ES-1 or 3.3-1)).

This option would prevent foreign fishing activity in an FCZ area heavily fished by recreational fishermen (cf. Figure 3.5-3), and would reduce competition with the domestic anchovy fishery.

8.5 Relationship of the Proposed Action to Other Plans, Laws and Regulations

This amendment to the 1978 anchovy plan and the regulations that will implement it relate to a variety of state and federal acts, plans and regulations.

8.5.1 State Laws and Regulations

This action recognizes that any state law which pertains to fishing vessels registered under the laws of that state while operating in the Council's fishery management area, and which is consistent with the anchovy management plan, including any state landing law, shall continue to have force and effect with respect to fishing activities that are addressed in this action or the regulations that implement this action.

This anchovy FMP is related to fishery management efforts by the State of California. California has a regulatory system for vessel licensing, seasons, quotas, reduction permits, and other aspects of the fishery. State input to the anchovy management process in the FCZ is ensured through participation on the Council and the Anchovy Plan Development Team.

8.5.2 Federal Laws and Regulations

This action, which is authorized under the Magnuson Act, relates to numerous other federal laws and regulations including the following:

	Section
1. Coastal Zone Management Act (CZMA)	8.5.3
2. Endangered Species Act (ESA)	8.5.4
3. Marine Mammal Protection Act (MMPA)	8.5.5
4. National Environmental Policy Act (NEPA)	8.5.6
5. Magnuson Act Amendment	8.5.7
6. Paperwork Reduction Act	8.5.8
7. Regulatory Flexibility Act	8.5.8
8. Executive Order 12291	8.5.8

The California Coastal Act of 1976 is included under the general topic of the CZMA.

8.5.3 Coastal Zone Management Act (CZMA)

The Coastal Zone Management Act of 1972 (CZMA) specifies at Section 307(c)(1) that "Each Federal agency conducting or supporting activities directly affecting the coastal zone shall conduct or support those activities in a manner which is, to the maximum extent practicable, consistent with approved state management programs."

The Magnuson Act specifies at Section 303(b) that "Any fishery management plan which is prepared by any Council or by the Secretary, with respect to any fishery, may ...(5) incorporate (consistent with the national standards, the other provisions of this Act, and any other applicable law) the relevant fishery conservation and management measures of the coastal states nearest to the fishery."

Both the CZMA and the Magnuson Act establish policies that affect the conservation and management of fishery resources, and both Acts are administered by NOAA. Moreover, it is NOAA's policy that the two statutes are fundamentally compatible and should be administered in a manner to give maximum effect to both laws. It is also NOAA's policy that most FMPs (and amendments of FMPs) constitute a federal activity that "directly affects" the coastal zone of a state with an approved coastal zone management program. NOAA recognizes that fisheries constitute one of the key resources of the coastal zone and that the preparation and implementation of FMPs to regulate fisheries in the FCZ could have a direct effect on the state's coastal zone because of the division of the fishery resources between the FCZ and state territorial and internal waters.

The CZMA and the Magnuson Act establish time frames for consistency review and approval of FMPs and amendments that are approximately equal. However, these time frames may, on occasion, cause procedural problems in coordinating consistency review and approval of FMPs or amendments.

NOAA regulations require that consistency determinations be provided to states with approved programs "at least 90 days before final approval of the federal activity unless both the federal agency and the state agency agree to an alternative notification schedule" (15 CFR 930.54(b)). Similarly, NOAA regulations encourage federal agencies to provide consistency determinations "at the earliest practical time" in the planning of an activity, "before the federal agency reaches a significant point of decisionmaking in its review process" (930.54(b)). A state must indicate its agreement or disagreement with the consistency determination within 45 days from receipt of the determination. If the state fails to respond within 45 days, the state's agreement may be presumed. However, the state may request one 15-day extension before the expiration of the 45-day period, and the federal agency must comply. Longer extensions may be granted by the federal agency (15 CFR 930.41).

The Magnuson Act requires that the Secretary of Commerce review an FMP or amendment prepared by a Council and notify such Council of his approval, disapproval or partial approval within 95 days after he receives the FMP or amendment (P.L. 97-453).

The primary effect of this FMP will be to establish an annual optimum yield level according to the spawning biomass of the anchovy stock and the formula described in this plan. For the purpose of this anchovy plan amendment, a general consistency determination will be issued to the State of California in accordance with 15 CFR 930.37(b) which states:

> "In cases where federal agencies will be performing repeated activity other than a development project (e.g., ongoing maintenance, waste disposal, etc.) which cumulatively has a direct

effect upon the coastal zone, the agency may develop a general consistency determination thereby avoiding the necessity of issuing separate consistency determinations for each incremental action controlled by the major activity. A general consistency determination may only be used in situations where the incremental actions are repetitive or periodic, substantially similar in nature, and do not directly affect the coastal zone when performed separately. If a federal agency issues a general consistency determination, it must thereafter periodically consult with the state agency to discuss the manner in which the incremental actions are being undertaken."

8.5.3.1 California State Coastal Zone Management Program

The California Coastal Zone Management Plan is based upon the California Coastal Act of 1976, Division 20, California Public Resources Code, Sections 30000, et. seq.; and the California Urban and Coastal Park Bond Act of 1976, Division 5, CPRC 5096.777 et. seq.; and the California Coastal Commission Regulations, California Administrative Code, Title 14.

The California Coastal Act establishes a structure for state approval of local coastal programs (Section 30050). The California Coastal Commission is the state's coastal zone agency (Section 30300). The coastal zone boundaries are generally the seaward limit of state jurisdiction, and inland to 1,000 yards from the mean high-tide line.

The general provisions of the California Program that address issues significant to this analysis concern the protection of the ocean's resources, including marine fish and the natural environment. The plan also calls for the balanced utilization of coastal zone resources, taking into account the social and economic needs of the people of the state. Specific coastal zone policies developed to achieve these general goals and which are applicable or potentially applicable to the regulatory measures proposed in the amendment to the anchovy plan have been identified as follows:

(a) Section 30210. "...recreational opportunities shall be provided for all the people consistent with the need to protect natural resource areas from overuse."

This goal is consistent with several of the objectives of the anchovy fishery management plan. The plan seeks to provide an adequate supply of live bait and predator forage, consistent with the needs of other user groups and the need to protect the resource.

(b) Section 30230. "Uses of the marine environment shall be carried out in a manner...that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific and educational purposes."

The action proposed in this FMP amendment is directed to achieving this goal. In particular, the OY and reduction quota respond to the population size so that harvest levels are commensurate with the status of the resource.

(c) Section 30234. "Facilities serving the commercial fishing and recreational boating industries shall be protected, and where feasible, upgraded."

This amendment does not specifically address the development of shoreside facilities that serve the commercial and recreational fishing industries. Consideration of fisheries-dependent commercial industries is an important social-economic factor in the harvest formula determined by the Council. (See Sections 6.3 and 6.4 of this plan for a summary of socio-economic factors that have been considered in the development of the fishery management plan.)

(d) Section 30260. "Coastal-dependent industrial facilities (such as fishing support) shall be encouraged to locate or expand within existing sites and shall be permitted reasonable long-term growth where consistent with the Act."

(e) Section 30708. "All port-related developments shall be located... so as to...give highest priority to the use of existing land space within harbors for port purposes including...necessary (commercial fishing) support and access facilities."

The amendment does not address the location of coastal-dependent industry or ports. However, the amendment does provide the mechanism to manage anchovy fisheries in order to assure the conservation of the anchovy stock and the continuance of established recreational and commercial fisheries. This will result in the continued need for support and access facilities that are located on shore.

(f) Section 30411. "The California Department of Fish and Game and the Fish and Game Commission are the state agencies responsible for the establishment and control of wildlife and fishery management programs.."

The Director of the California Department of Fish and Game (CDFG) is a voting member of the Pacific Council. Anchovy fishery experts from the CDFG participate on the Council's Anchovy Plan Development Team and have helped develop this proposed framework amendment. The Magnuson Act mandated that all interested individuals, including state fishery management personnel, would have the opportunity to participate in the preparation of fishery management plans and amendments. This action is consistent with the provisions of Section 30411 because the CDFG has been involved in the planning process for those parts of the proposed action that pertain to the management of California fisheries.

8.5.3.2 Consistency Determination

This determination of consistency with the California Coastal Act of 1976 has been prepared in compliance with the Federal Coastal Zone Management Act (CZMA) and the Magnuson Fishery Conservation and Management Act (Magnuson

Act). Both the CZMA and Magnuson Act are administered by the National Oceanic and Atmospheric Admninistration which as adopted a policy that most fishery management plans, developed under the Magnuson Act, constitute Federal activities that "directly affect" the coastal zone. The National Marine Fisheries Service (NMFS), Southwest Region, has determined that this amendment to the Northern Anchovy Fishery Management Plan (FMP) is consistent with the California Coastal Act of 1976. Information supporting this determination is contained in the draft environmental impact statement and the regulatory impact review for the proposed amendment to the FMP and regulations.

The coastal zone policies listed in Section 8.5.3.1 have been considered in this determination of consistency. The proposed amendment specifies a revised production model and harvest formula based on new scientific information on the size and productivity of the resource. This revision reduces the possibility of overfishing and complies with coastal zone policies (sections 30210 and 30230) because maintenance of a productive anchovy stock is vital to predatory fish which are important to commercial and recreational fishermen. In addition marine bird and mammal populations rely to differing degrees on anchovy for food.

Optimum yield and commercial harvest quotas are likely to be somewhat smaller than under the previous FMP. However, in view of the revised estimates of the productivity of the stock, the previous quotas were too large, and if consistently met, would reduce the spawning biomass below the level cutting off the reduction fishery. This revised FMP should lead to more stable harvests over the long term, and no alterations to port facilities for vessels and processing are expected to result from its implementation. Therefore, this revised FMP is consistent with Sections 30234, 30260, and 30708.

Finally, the FMP and proposed amendment are consistent with Section 30411 in that the development of these policies were a cooperative effort of the California Department of Fish and Game (CDFG), the Pacific Fishery Management Council and the NMFS. Administration and enforcement of the regulations implementing this FMP are cooperative efforts involving CDFG and the NMFS.

8.5.4 Endangered Species Act (ESA) of 1973

The purposes of the ESA are to provide a means to conserve the ecosystems upon which endangered species and threatened species depend, to provide a program for the conservation of such endangered and threatened species, and to take such steps as may be appropriate to achieve the purposes of a number of international treaties (ESA section 2(a)(4)) regarding wildlife conservation.

Two agencies are responsible for administering the ESA: The Department of Commerce, National Marine Fisheries Service is responsible for endangered marine mammals, and the Department of the Interior, U.S. Fish and Wildlife Service is responsible for the remaining species, including seabirds. Section 7 of the ESA requires all Federal departments and agencies, in consultation with and with the assistance of the Secretary of the appropriate department, to utilize their authorities in furtherance of the purposes of the ESA. The ESA requires these agencies to take such action as is necessary to insure that actions authorized, funded, or carried out by them do not jeopardize the continued existence of such endangered species and threatened species or result in the destruction or modification of habitat which is determined to be critical for such species. When notified of a proposed action by a Federal agency, the administering agency (USFWS and/or NMFS) reviews the proposed action and decides whether a formal "Section 7 consultation" is necessary. If such a consultation is undertaken, the administering agency reviews the information on the endangered species and the anticipated impacts of the proposed action. Subsequently a "Biological Opinion" is issued containing recommended actions or mitigating measures which will bring the proposed action into compliance with the Endangered Species Act.

A number of formal documents are important to this process. In the case of a fishery being managed under the Magnuson FCMA, the draft Fishery Management Plan and Environmental Impact Statement contain alternative options relating to the proposed action, and evaluate the anticipated impact of these options. For many endangered species a formal Recovery Plan has been developed, which defines the habitat requirements of the species and the criteria by which to judge progress toward recovery (eventually resulting in downgrading from endangered to threatened status, or to removal from the list altogether). The Biological Opinion implements Section 7 of the Endangered Species Act.

8.5.4.1 Biological Opinion/Endangered Marine Mammals

Section 4.2.5 (anchovy predators) of this FMP lists the Guadalupe fur seal and a number of large whales as endangered species designated by the ESA. The NMFS has reviewed the proposed actions, and has determined that the management options in the Anchovy FMP amendment will not have significant impact on marine mammals (including those designated as endangered). The NMFS concluded that Section 7 consultation is not necessary.

8.5.4.2 Biological Opinion/Endangered Birds

Section 4.2.6 (anchovy predators) of this FMP lists three birds, the bald eagle, the least tern, and the brown pelican, determined to be endangered species under the ESA. Potential impact on the brown pelican was considered sufficient to warrant Section 7 consultation with the USFWS. The following Biological Opinion was issued by the USFWS in a letter to the Southwest Regional Director, NMFS (April 29, 1983):

> Based on the (information discussed in the letter), it is our Biological Opinion that implementation of any of the options of the subject amendment to the Northern Anchovy Fishery Management Plan is not likely to jeopardize the continued existence of the endangered California brown pelican.
>
> We are, however, concerned that this Opinion is based on models and predictions which continue to be tested and refined. Therefore, it is incumbent on NMFS, as the action agency, to continue to work closely on monitoring the possible impacts of anchovy harvest on the brown pelican.
>
> Therefore, in furtherance of the purposes of the Endangered Species Act (Sections 2(c) and 7(a)(1)) which mandates that Federal agencies shall utilize

their authorities to carry out programs for the conservation of listed species, we recommend that NMFS consider the following:

1. Implement one of the Options, such as numbers 2,3,4,5 (later corrected to 6) or 8, which appears to have less effect on brown pelican reproduction.

2. Continue to study the relationship between anchovy abundance and brown pelican production in cooperation with the California Department of Fish and Game, FWS, and academic researchers. We suggest that our staffs continue to meet annually with researchers to discuss anchovy quotas, catches and pelican productivity. These meetings can provide the basis for research guidance.

Should significant new biological or NAFMP (Northern Anchovy Fishery Management Plan) information become available which indicates that impacts of the proposed plan may affect the brown pelican or if the plan is significantly modified beyond that which is discussed in this Opinion, reinitiation of Section 7 consultation should be considered.

8.5.5 Marine Mammal Protection Act (MMPA) of 1972

The purpose of the MMPA is to protect marine mammals and to prevent certain marine mammal species and stocks from falling below their optimum sustainable population which is defined in Section 3(8) as "... the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element."

Live bait and reduction anchovy fishermen occasionally will have an incidental involvement with marine mammals. Any commercial fishermen that may expect to become involved with marine mammals incidental to normal fishing operations should apply to the NMFS for a free certificate of inclusion. The certificate of inclusion prevents the fishermen from being in violation of the MMPA in the event a marine mammal is taken incidental to normal fishing operations. Taking marine mammals incidental to commercial fishing is only permitted by the MMPA for marine mammals which are not depleted as defined by Section 3(1).

The anchovy fishery allowed under this FMP potentially impacts the food supply of many marine mammals (see Section 4.2.6), and consequently the carrying capacity of the habitat (see above). In its biological opinion (section 8.5.4.1), NMFS has determined that the management options in the Anchovy FMP will not have significant impact on marine mammals.

8.5.6 National Environmental Policy Act (NEPA)

In accordance with NEPA and Council on Environmental Quality regulations that implement NEPA, the Pacific Fishery Management Council and the NMFS have prepared a draft Environmental Impact Statement for this proposed amendment to the Anchovy FMP. The EIS is integrated with the draft FMP, and elements of the EIS are indexed in section 1.2. This integrated EIS, the draft FMP, and the RIR describe the proposed action and assess the impacts that may be expected as a result of the proposed action. A 45-day comment period will be provided for public review and comment on the proposed action.

8.5.7 Magnuson Act Amendment

Public Law 97-243 amending the Magnuson Act passed Congress and was signed by the President early in 1983. Among other things, the amendment substantially revises the process of plan review by the Secretary of Commerce.

Under the new system, the Secretary must publish in the FEDERAL REGISTER any plan and proposed regulations received from a council, requesting comments for a 75-day period. Following the close of the comment period, the Secretary must complete a review of the plan within 20 days, addressing the public comments, data and views received, consultations with the Secretary of State regarding foreign fishing, and consultations with the Coast Guard regarding enforcement issues.

At any time during this period, the Secretary may notify the appropriate council of his approval, disapproval, or partial approval. If approval is granted, the plan becomes effective upon such approval. If no action is taken by the Secretary, the plan becomes effective upon the close of the 20-day period (95 days after receipt).

If the plan is disapproved or only partially approved, the Secretary of Commerce must immediately notify the appropriate council of such action and the reasons for disapproval. The council is then free to pursue the revision of the plan without time restrictions. All of the provisions relating to plans relate to plan amendments as well.

The process of implementing regulations has also been shortened by the new amendment. The Secretary must promulgate each regulation that is necessary to carry out a plan or amendment within 110 days after that plan or amendment was received by him for action.

8.5.8 Other Federal Acts and Executive Orders

The Paperwork Reduction Act, the Regulatory Flexibility Act and Executive Order 12291 also relate to the process of developing and implementing the action proposed in this framework amendment.

The major purposes of the Paperwork Reduction Act of 1980 are: (1) to minimize the federal paperwork burden for individuals, small businesses, state and local governments; (2) to minimize the cost to the federal government of collecting, maintaining, using and disseminating information; and (3) to ensure that the collection, maintenance, use and dissemination of information by the federal government is consistent with applicable laws relating to confidentiality. NMFS has determined that neither this amendment nor the regulations that will implement this amendment will involve any federal government collection of information that would violate the purposes and requirements of the Paperwork Reduction Act.

The major requirement of the Regulatory Flexibility Act of 1980 is for agencies to describe the impact(s) of a rulemaking action on small businesses. In particular, whenever an agency is required to publish a notice of proposed rulemaking (as NOAA will be when regulations are published to implement this amendment), the agency shall prepare and make available for public comments an initial regulatory flexibility analysis (IRFA). NOAA has issued guidelines to its agencies that describe the procedures to be followed for implementing the provisions of the Regulatory Flexibility Act and Executive Order 12291, which establishes procedures for review and oversight of existing regulations, regulations which have been issued in final form but are not yet effective, regulations to be issued in final form, and regulations that the agency wishes to propose. The basic purpose of the Order is to ensure that, to the extent permitted by law, administrative decisions are based on adequate information concerning the need for and consequences of government action, and that regulatory action is not undertaken unless the potential benefits to society from the regulation outweigh the potential costs to society. In order to implement the Executive Order, each agency is directed, in connection with every major rule, to prepare a regulatory impact analysis (RIA).

The NOAA guidelines provide that the IRFA and the RIA can be combined into one document if a rule is considered major for the purpose of Executive Order 12291. The NOAA guidelines also rename the IRFA and RIA (when combined) into a regulatory impact review/initial regulatory flexibility analysis (RIR/IRFA). For the purpose of the action proposed in this amendment, the RIR/IRFA is integrated with the draft revised FMP/EIS, and elements of the RIR/IRFA are indexed by section 1.3

Moreover, it is likely that the NOAA Administrator will determine that the rules that will implement this amendment will not be "major" rules under Executive Order 12291, thus not requiring the preparation of a regulatory impact analysis.

9.0 Regulatory Impact Review

The central subpopulation of Northern Anchovy (Engraulis mordax) is fished by a number of relatively small, independently operated vessels. Because current harvest rates affect future biomass and yield of this resource, any given rate of extraction will imply a tradeoff between present and future economic yields. In an unregulated open-access fishery, vessel owners individually cannot control the aggregate harvest rate and are inclined to seek more immediate economic rewards at the expense of a longer term aggregate yield and benefit.

Proper fishery management can increase long-term benefits by fostering a more conservative rate of harvest than would tend to occur in an unregulated setting. In the case of anchovy, an optimal harvest policy would incorporate additional considerations, namely:

1) Mitigation of potential conflict between two interest groups for whom anchovy represents a source of benefit (reduction and recreational fishermen).

2) Protection of marine mammals, birds, and fishes including some designated endangered species and highly valued recreational gamefish, all of which use anchovy as forage (see Table 4.2-4).

Implementation of these objectives requires that decisions be made regarding reduction and non-reduction optimal yields, area and season closures, gear restrictions and minimum fish size limits. The options considered within each of these broad categories in this FMP represent potential modifications to an existing management regime, which has evolved over the years under the auspices of the California Fish and Game Commission and later (since 1978/79) the Pacific Fishery Management Council. It is these options which are the subject of this Regulatory Impact Review (RIR), which has been prepared in accordance with E.O. 12291, the Regulatory Flexibility Act (RFA) and the Paperwork Reduction Act (PRA).

In order to fulfill the requirements of an RIR, a comparison of options will be made on the basis of the following criteria:

1) The biological impact on the northern anchovy population.

2) a. Economic impacts relating to competition, employment, investment, productivity, exports, innovation and the cost and price of goods and services, and
b. Social and other impacts on the potentially contentious relationship between commercial and recreational fishing interests.

3) Information collection costs incurred by the government in order to implement each option.

4) Monitoring and enforcement costs incurred by State governmental units that oversee compliance.

5) Compliance costs and recordkeeping requirements imposed on small

businessmen (i.e., vessel operators).

Because evaluation of the alternatives depends largely on marginal differences between options rather than their absolute impacts, this analysis also focuses on relative differences.

9.0.1 Factors Limiting Economic Impacts of FMP

Anchovy comprises a very modest portion of the aggregate amount of fishmeal traded in national and international markets. The ex-vessel anchovy price is calculated each season on the basis of the corresponding meal price, which in turn varies with domestic menhaden and imported fishmeal prices. Because the price of this commodity is based more on exogenous factors than conditions in the local fishery, fluctuations in anchovy yield are likely to have little significant impact on its own price or the price of fishmeal in general.

California's poultry industry, one of the largest in the nation, absorbs much of the locally produced anchovy meal. Because substitutes are generally available when anchovy is in short supply, conditions in this fishery are not likely to affect the cost of poultry feed or the supermarket price of table birds in any significant way.

All domestically produced fishmeals, including anchovy, are consumed almost exclusively in this country. In fact, the U.S. has historically been a net importer of fishmeal, often supplementing domestically produced supplies with imports from Peru and Canada. The already limited participation of anchovy harvesters and processors in export activities is not likely to vary much from current levels regardless of what regulations are imposed on the fishery.

In view of the modest market position held by anchovy with respect to other readily substitutable protein meals, the impact of fishery regulation on the market price of fishmeal, operating costs associated with poultry feed production and the level of fishmeal exports is likely to be insignificant. For all practical purposes the major economic impact of this FMP will be limited to the areas of productivity, employment, investment and operating costs incurred by local harvesters and processors of anchovy. All further discussion of economic impacts in this RIR will be limited to these areas.

9.0.2 Transboundary Management Considerations (U.S.-Mexico Allocation)

The MFCMA requires that a fishery resource be managed as a unit stock throughout its range, but gires little guidance regarding management of transboundary stocks. The northern anchovy central subpopulation is shared by the U.S. and Mexico, and as of 1983, no bilateral agreement for anchovy management has been established. Mexico harvests the resource independently of management regulations established under the MFCMA.

Given a necessarily unilateral management policy by the U.S., the important question remains: "What is the appropriate specification of OY for the U.S. segment of the fishery"? The answer to this question is a matter of defining the nature of the resource being managed, rather than a matter of establishing fishery regulations. The main considerations are biological and political. The biological consideration is the long-term geographic distribution of the resource, 67% of which has been in U.S. waters (section 4.1.2). The political considerations are the setting of precedents which may affect future negotiations with Mexico. The considerations in selecting options for addressing U.S.-Mexico allocation of OY (Section 8.3.1) are not economic in nature, and are not discussed further in this RIR.

To facilitate evaluation of the remaining management considerations, this RIR assumes that the U.S. allocation will be 70% of the total OY. This assumption reflects management under the previous FMP, and is the recommended option selected by the Pacific Fishery Management Council for this revised FMP.

9.1 Reduction Quota Formulas

Alternative reduction harvest formulas are described in Section 8.3.4 and fall into three basic categories: "Reserve with Slope" (options 2-6), "Reserve with Limit" (options 7-8) and "Compromise" formulas (options 9-11), combining features of the first two types of formulas. A dynamic model was used to simulate features of each option. The model is characterized by a variable rate of recruitment to the fishery and a constant natural mortality rate; it also assumes that fishermen utilize the entire optimal yield up to a maximum of 500,000 metric tons (the assumed maximum potential U.S.-Mexico harvesting capacity per season) for options 2-6 and 200,000-300,000 m tons (the actual specified limit) for options 7-11.

The simulation results are contained in Table 8.3-3 and are subject to the following qualifications:

1) To the extent that the relationship between optimum yield (OY) and actual fishing mortality assumed in the model diverges from reality, the catch and biomass statistics and the percent of years with no fishery will also diverge from their simulated values. Although U.S. fishermen have utilized only a fraction of their reduction quota in recent years, Mexico has taken substantial quantities over this same period (see Table 3.2-4). To the extent that combined U.S.-Mexico harvests fall below (above) the OY, actual fishing mortality will be less (more) and biomass values more (less) than the simulation results suggest. In addition, the percent of years with no fishery, which is based on the probability that the biomass level will fall below a specified reduction cut-off level, will tend to be higher the higher the level of fishing mortality.

2) The model incorporates the observed extent of natural variability, but does not incorporate the effects of abnormal environmental occurrences which severely affect anchovy abundance. These environmental factors could potentially affect the simulation results, although the nature and extent of such effects are not known.

These uncertainties suggest that evaluation of the alternative reduction harvest formulas in Table 8.3-3 are best made on the basis of relative rather than absolute differences among the options.

Table 9.1-1. Relative evaluation of reduction quota formula options. Biomass and catch have units of thousand metric tons. Option 1 is the present harvest formula based on the larva census method of estimating spawning biomass. All relative values are scaled to option 2.

Option:	1	2	3	4	5	6	7	8	9	10	11
Biomass at cut-off:	1000	200	300	300	300	400	300	400	200	300	200
Slope:	1/3	1/4	1/4	1/3	1/2	1/3	*	*	1/1	5/4	1/1
Maximum catch:	--	--	--	--	--	--	200	200	200	250	300
Mean biomass (relative scale)	--	1.00	1.05	.96	.85	1.01	1.03	1.09	1.03	.97	.83
Mean pelican reprod. success (relative scale)	--	.68	.70	.67	.61	.69	.68	.70	.67	.66	.59
Mean catch (relative scale)	--	1.00	.95	1.06	1.17	1.00	.85	.81	.85	.95	1.09
St dev of catch (relative scale)	--	1.00	1.03	1.11	1.20	1.14	.38	.45	.32	.57	.69
St dev/Mean catch	--	.73	.79	.77	.75	.83	.33	.41	.28	.44	.46
%years w/no fishery (relative scale)	--	1.00	2.18	3.23	4.91	5.41	4.45	6.59	1.36	4.68	3.36
Avg duration of fishery closure (relative scale)	--	1.00	1.00	1.08	1.17	1.08	1.00	1.08	.92	1.08	1.00
Freq of biomass est. 90.0% probability (relative scale)	--	1.00	1.00	1.00	1.00	1.00	.40	.45	.49	.58	.66
Reduc fishery profit** (relative scale)	--	1.00	1.00	1.01	.95	1.01	.88	.88	.89	.92	.85
Net monetary value*** (relative scale)	--	1.00	1.00	1.02	.94	1.02	.98	.98	.97	1.00	.90

*Quota increases from zero to the maximum at the cut-off level..

**Total Cost obtained by plugging U.S. OY (70% of mean catch) and mean biomass. figures (Table 8.3-3) into CPUE equation (Sectiion 6.4), solving for effort, and. multiplying effort by $160..

Total Revenue=U.S. OY x $45..

Reduction Fishery Profit=Total Revenue-Total Cost.

***Avg Annual Cost of Biomass Estimation=Freq of biomass est x $468,000.

Net Monetary Profit=Reduction Fishery Profit-Avg Annual Cost of Biomass Est..

NOTE: Absolute value of Reduction Fishery Profit and Net Monetary Value for. option 2 are $2,629,760. and $2,161,760 respectively. Absolute values for all other variables are contained in Table 8.3-3.

9.1.1 Biological Impacts

The relative biological impact of the harvest formulas is summarized in the mean spawning biomass values of Table 9.1-1. These values reflect average levels of abundance prevailing in the fishery and vary by approximately 21% between lowest and highest ranked options.

All of the optimal yield formulas also specify a reduction cut-off level of spawning biomass, below which reduction fishing is strictly prohibited. The biological rationale for this cut-off is to buffer the resource from depletion and to serve as a forage reserve for the numerous marine fishes, mammals and birds (see Table 4.2-4) which rely on anchovy as a food source. Implementation of any of the options does not guarantee that the spawning biomass will not fall below the "cut-off" level since large natural fluctuations in abundance can occur even if the resource is unfished. However, by eliminating fishing mortality as a source of depletion at low levels of abundance, the reduction cut-off gives the population maximum opportunity to rebound from these levels.

Because the dietary preferences and consumption of anchovies by natural predators are not well understood, historical data provide the best available clues to an appropriate cut-off level of spawning biomass. The years 1957-1960 were characterized by an exceptionally large influx of migratory predators which was sustained by an anchovy spawning biomass of approximately 200,000 m tons (and a sardine biomass of approximately 100,000 m tons). This historical evidence, plus the fact that the productivity of the anchovy population is seriously impaired at lower levels of abundance, suggest that a spawning biomass of 200,000 to 300,000 m tons would be an appropriate minimum cut off level, although higher levels could be justified by a conservative managment regime.

Strictly speaking, the cut-off level of spawning biomass (below which reduction fishing activity is prohibited) does not always coincide with the values specified in Table 8.3-3. In three exceptional cases, the formulas themselves allow the biomass to drop below its nominal cut-off value in the interim period between management decisions. For instance, because option 7 allows fishermen to take 200,000 m tons when the biomass exceeds a reserve level of 300,000 m tons, the actual biomass may drop as low as 100,000 m tons before a decision is made to close the fishery. Similarly, under option 8 cut-off actually occurs at 200,000 m tons--50% lower than the nominal cut-off level of 400,000 m tons. And while option 10 nominally provides for a cut-off of 300,000 m tons, terms of this option allowing incremental harvests of the stock to exceed incremental in biomass within a specified range of biomass may cause the biomass to fall as low as 250,000 m tons before the fishery is closed.

In all three cases the actual cut-off levels of spawning biomass are much closer to (even lower than) 200,000-300,000 m ton minimum recommended as forage reserve than the nominal levels specified in Table 8.3-3. However in interpreting the biological impact of these, in fact all, the options, it should be noted that implementation of the FMP is based on spawning biomass estimates made in winter-spring. By early summer, when reduction fishing activity is most intense, spawning biomass is likely to exceed this prior estimate. Moreover predators prey on non-spawners as well, including a new year class of anchovy which appears in late summer.

On the basis of mean biomass and the nominal cut-off level of biomass, option 8 is the most biologically conservative of the reduction harvest formulas.

9.1.2 Socioeconomic Impacts

9.1.2.1 Impact on Productivity

The economic impact of the alternative harvest formulas is partially reflected in mean catch, which is described on a relative scale in Table 9.1-1. The 31% difference between lowest and highest yield options suggests that this decision can have substantial impact on potential anchovy harvests. However, commercial fishing interests must be weighed against the interest of natural predators and recreational fishermen who depend on anchovy for live bait and as forage for recreational gamefish. This is demonstrated by the fact that yields are lowest for the most biologically conservative alternative (option 8).

Two factors tend to dilute the economic impacts associated with differences in mean catch.

1) Anchovy revenues are lower for the lower yield options but because biomass tends to be higher for these same options, catch-per-unit-effort is also likely to be higher (and operating costs moderately lower). Therefore relative differences in net revenue among the options are likely to be less than the differences in gross revenue.

2) Fishermen may be able to "make up" for the lower anchovy revenues generated under the lower yield options by diverting fishing effort to other species.

9.1.2.2 Impact on Risks Incurred by Vessel Operators

The standard deviation of landings is indicative of the long run variability of landings and, to some extent, the relative financial risks associated with the various options. The ability of vessel owners to bear such risks is reflected in the ratio of standard deviations to mean landings, since larger yields and revenues in busy years allow them to more easily absorb losses during less productive seasons. Both these statistics are included in Table 9.1-1, where they assume minimum values for options 7-10, largely because these alternatives impose an upper limit on landings which is not specified by the "Reserve with Slope" options.

The absolute risks associated with this variability in anchovy landings are lessened to the extent that vessel operators can occupy themselves with other species which are also seasonally available in the fishery. Such deversification is facilitated by the State of California's Pacific mackerel regulations. Currently a new mackerel quota is made available on July 1 of each year, coinciding with closure of the anchovy fishery (as required by the prevailing season closure regulation--option 1 in Section 8.3.7), and normally exhausted by spring or early summer when anchovy fishing activity reaches its peak.

9.1.2.3 Impact on Employment and Capital Utilization

The percent of years with no fishery and the average duration of fishery closure reflect a more extreme type of variability in which losses are likely to include unemployment and idle capital resources as well as foregone income. Losses of this type will be incurred only during those portions of the season when other species are largely unavailable for capture. Moreover such losses must be weighed against the potentially larger economic impacts which could occur if long term abundance is impaired by failure to close the fishery at low levels of spawning biomass.

According to Table 9.1-1, options 2 amd 9 do best on the basis of the fishery closure statistics. This outcome is not surprising given that both these alternatives provide for relatively low reduction cut-off levels of spawning biomass. This is another example of the trade-offs which must be made between commercial fishing interests and the interests of natural and recreational predators of anchovy.

The impact of fishery closure, as proscribed at low levels of spawning biomass, is unevenly distributed between geographic segments of the reduction fleet. Numerically speaking, the Northern area fleet consists of 35-40 small round haul vessels. In 1981 the composition of fleet landings was approximately 65% squid, 10% herring, 20% anchovy and 5% mackerel, although price differences caused the distribution of gross revenues from these species to be 65%, 25%, 5% and 5% respectively.

These aggregate figures obscure the fact that fewer than half a dozen vessels actually fish anchovy regularly in the Northern area. In order to cultivate ongoing cannery interest in anchovy these operators provide the Northern area reduction plant with some anchovy landings each season. However, because squid and herring fishing are more lucrative activities, these vessels tend to fish anchovy and mackerel only when opportunities in these other fisheries slack off. Assuming that their annual earning from squid and herring are comparable to average revenues generated by the rest of the fleet, these operators earned approximately 20-25% of their 1981 income from anchovy. For them fishery closure could represent short term dollar losses of this magnitude, although actual losses will vary depending upon the availability and market demand for other species during the season.

The Southern area fleet consists of approximately 25-30 "wetfish" vessels employing about 291 crewmen and half a dozen "combination" vessels employing about 43 crewmen. Table 3.5-4 shows that while these vessels derived over half their gross revenue from anchovy in the mid-1970s, this percentage for dwindled to less than 25% in recent years. Over this same period mackerel landings and revenues have steadily increased in both relative and absolute terms, and currently account for well over half of the Southern fleet's gross revenues. As with Northern area anchovy vessels, the impact of closure of the anchovy fishery on the Southern fleet will depend upon the availability and market demand for other target species during closed seasons.

9.1.2.4 Impact of Irregular Harvests on Long Term Demand

Most of the anchovy meal derived from the California fishery is marketed within the state. To the extent that local poultry feed mixers give preference to regular suppliers, large values for the standard deviation of catch and the frequency and duration of fishery closure may undermine the competitive position of domestically produced anchovy meal with respect to other protein meals used in poultry rations. In this respect the impact of large fluctuations in catch is not necessarily limited to those fishing seasons in which they occur but can also affect long-run demand for domestically produced anchovy meal.

9.1.3 Implementation Costs

Options 2-6 require that optimal yield be estimated on the basis of annual spawning biomass estimates. Options 7-11, however, specify an upper limit on landings which becomes effective when the spawning biomass exceeds a certain level. For seasons when abundance is high, the projected following season's spawning biomass may fall into the range of constant reduction quota, making subsequent biomass estimation unnecessary. Statistical analysis of simulation results was used to predict the probability of such an event, with results shown in Table 9.1-2. The table should be read as follows: For option 7 the current year spawning biomass must be at least 780,000 m tons in order for the projected spawning biomass to equal or exceed the critical level of 300,000 m tons and not require estimation the following year. This condition occurs with 90% certainty in 60% (100%-40%) of the years. Similar interpretations can be made for other options. On the basis of these estimates, the frequency of biomass estimation is expected to be considerable lower under options 7-11 than options 2-6.

Table 9.1-2. Frequency of Biomass Estimation (less than 10% probability of necessity) for Options 7-11. (Spawning biomass measured in thousand metric tons)

Option	Minimum Spawning Biomass in Previous Year	Critical Spawning Biomass in Current Year	Frequency %
7	780	300	40
8	923	400	45
9	923	400	49
10	1066	500	58
11	1066	500	66

The average annual cost of egg production biomass estimation is approximately $468,000. This includes vessel operation, labor and equipment aboard ship and in laboratories, and labor and computer time for data management and analysis. This dollar amount suggests that implementation costs are likely to be much less for those options requiring less frequent estimations of biomass. By contrast, the annual cost of biomass estimation by the previous larva census method--which is discontinued by this amendment--was considerably higher because of the increased amount of ship time required for data collection under this method. The average annual cost of a larva census endeavor is estimated to be $635,000-$915,000; the low estimate assumes that larva census data collection occurs free of cost under the auspices of CalCOFI (California Cooperative Oceanic Fishery Investigations) every three years, while the high estimate would apply if CalCOFI cruises were to be discontinued.

For spawning biomass values above the reduction cut-off levels specified in Table 8.3-3, the "Reserve with Slope" and "Compromise" options provide for gradual increases in the reduction quota as the spawning biomass increases. This behavior is not characteristic of the "Reserve with Limit" formulas (options 7 and 8), for which the reduction quota abruptly rises from zero to 200,000 m tons above cut-off values of 300,000 and 400,000 m tons respectively and remains constant at all higher levels of spawning biomass. Because even a very small change in spawning biomass from below to above the cut-off (or vice versa) could mean the difference between zero harvests and a potentially productive season to fishermen, and because of statistical imprecision inherent in the biomass estimate, options 7 and 8 could focus considerable and controversial attention upon the estimate itself--more so than the other options. The frequency with which such decisions must be made regarding closure and reopening of the fishery is indicated in Table 9.1-1, which shows that the percent of years with no fishery is quite large for options 7 and 8 relative to the other options.

9.1.4 Monitoring and Enforcement Costs

The monitoring activities required under the reduction harvest formulas are twofold: 1) tracking the amount of anchovy landed during periods when the fishery is open and 2) ensuring that no fishing takes place during closed portions of the season. Monitoring of anchovy reduction landings is currently conducted on the basis of landings receipts submitted by the canneries to the California Department of Fish and Game. These receipts are required by State law for all commercially harvested species. Because all the reduction harvest formulas require that such monitoring take place while the fishery is open, the costs associated with this activity are expected to be approximately the same regardless of the option chosen. Moreover such monitoring would continue even in the absence of a Federal fishery management plan, since the State of California collects a "use tax" on commercial landings on the basis of landings receipts. This FMP imposes no additional burden of cost on paperwork on monitoring the cumulative harvest.

California state law prohibits the reduction of whole fish without a permit. This permit can be rescinded if a cannery engages in anchovy or other unauthorized reduction during closed portions of the season. The supervision required to ensure compliance with this regulation is minimal and is conducted as an adjunct to other Fish and Game activities (e.g., sampling of other species) which take place at the cannery docks. Because these other activities will continue irrespective of what occurs in the anchovy fishery, the incremental costs associated with enforcing fishery closure are expected to be small regardless of the option chosen.

9.1.5 Compliance Costs and Recordkeeping Requirements

By state law, canneries and fishing vessels must obtain permits (free of charge) from the State of California in order to engage in reduction fishing activities. Fishermen are also required to provide landings-related information to the canneries, which is recorded on landings receipts and submitted to the California Department of Fish and Game. This recordkeeping requirement would continue even in the absence of the FMP in order to satisfy ongoing state interest in reduction fishing activities.

9.1.6 Net Benefits Associated with PFMC Recommendations

The PFMC recommends adoption of a reduction quota formula allowing harvest up to a maximum quota of 200,000 m tons of the spawning biomass in excess of 300,000 m tons. While this formula is not one of the eleven options originally considered and already analyzed in this RIR, its specification of biomass at cut-off, slope, and maximum catch fall well within the range of values considered in the original eleven options. The PFMC recommends this formula as the best method of ensuring both a stable and profitable commercial fishery and an adequate forage base for predators of anchovy.

For purposes of comparing the Council's recommended formula to the options described in Table 9.1-1, the statistics of that table are reproduced for the Council's recommended harvest strategy in Table 9.1-3.

Note from Tables 9.1-1 and 9.1-3 that, while potential economic profit from commercial fishing is greatest under the Reserve with Slope options (2-6), the relative differences between these and the remaining options become much smaller when net monetary benefit (that is, commercial profit minus average annual cost of biomass estimation) is considered. On the basis of this monetary criterion, the Council's preferred formula falls midway (.96) between the lowest (.90) and highest (1.02) ranked options.

Two non-monetary considerations strongly affected the Council's determination of a preferred harvest strategy. While it is possible to identify an option in Table 9.1-1 which best satisfies each of these concerns, the Council's preferred harvest strategy was devised to better address all of them simultaneously. More specifically:

1) The PFMC's interest in protecting the numerous marine mammals, birds and fishes (including some designated endangered species and highly valued recreational gamefish) which use anchovy as forage is best served by option 8, which exhibits maximum values for both mean biomass and pelican reproductive success.

2) The Council's interest in maintaining a stable commercial fishery is best served by option 9, which exhibits very low values for the standard deviation of catch, the ratio of standard deviation to mean catch, and the number of years and average duration of fishery closure.

3) The Council's recommended harvest formula (Table 9.1-3) retains the high mean biomass and pelican reproductive success of option 8. By all

Table 9.1-3. Description of PFMC Recommended Harvest Strategy. Biomass and catch have units of thousand metric tons. To facilitate comparison, all relative values are scaled to option 2 of Table 9.1-1.

Biomass at cut-off	300
Slope	1/1
Maximum catch	200
Mean biomass (relative scale)	1.09
Mean pelican reprod. success (rel. scale)	.70
Mean catch (rel. scale)	.81
Standard deviation of catch (rel. scale)	.40
Standard deviation/Mean catch	.36
% years with no fishery (rel. scale)	3.05
Avg duration of fishery closure (rel. scale)	1.00
Frequency of biomass estimation (rel. scale)	.52
Reduction fishery profit* (rel. scale)	.88
Net monetary value** (rel. scale)	.96

*Total Cost obtained by plugging U.S. OY (120,400 mtons) and mean biomass (1,277,000 mtons) into CPUE equation (section 6.4), solving for effort and multiplying effort by $160.
Total Revenue = U.S. OY x $45.
Reduction Fishery Profit=Total Revenue-Total Cost
**Avg Annual Cost of Biomass Estimation=Frequency of biomass estimation .52) x $468,000.
Net Monetary Value = Reduction Fishery Profit - Avg Annual Cost of Biomass Estimation

measures of stability, it also provides for a more stable commercial fishery than would be possible under option 9.

9.2 Reduction Quota Reserve

The Reduction Quota Reserve is discussed in Section 8.3.5. Option 1 requires that half of the reduction quota be made available for harvest at the beginning of the season and that the second half (the quota reserve) be considered for release when 25% of the total quota has been landed but no later than February 1. This reserve will be withheld if it is determined that continued U.S. harvests would cause the spawning biomass to fall below the cutoff level specified by the reduction harvest formula. Option 2 establishes no reduction quota reserve.

9.2.1 Biological Impact

A pre-season estimation of spawning biomass is currently required in order to implement any of the reduction harvest formulas discussed in Sections 8.3.4 and 9.1. The biological impact of option 1, which provides for a smaller-scale in-season reassessment of anchovy abundance, depends upon:

1) the frequency with which an in-season reassessment of abundance could warrant action to withhold the quota reserve, and

2) the extent to which the reproductive capability of the population would be impaired if in-season closure were warranted but did not take place (as could occur under option 2).

Larva census equivalent estimates of spawning biomass used in the previous FMP are considerably larger than the estimates obtained by egg production and acoustic methods. Therefore the changeover to egg production method anticipated for the 1983/84 season will introduce more conservative levels of optimum yield than were established by the previous FMP, regardless of the reduction harvest formula chosen. To the extent that fishing mortality influences factors 1) and 2) above, use of egg production estimates will dilute the biological impact of the quota reserve.

9.2.1.1 Impact of Reduction Harvest Formulas on Biological Assessment of Reduction Quota Reserve

The biological impact of the quota reserve is also influenced by the type of reduction harvest formula chosen. In general, any benefit accruing from option 1 is likely to be less if the accompanying optimal yield formula is a "Reserve with Limit" or "Compromise" option. This is because, unlike the "Reserve with Slope" formulas, these other alternative formulas place an upper limit on reduction landings and decrease the risk of resource depletion.

9.2.2 Socioeconomic Impacts

The immediate economic impact of option 1 will be felt in those seasons when the decision is made to withhold the second half of the quota, an action which is not expected to occur often. In this rare situation fishery closure could conceivably result in short term losses of revenue and employment, which could be recouped in the long run to the extent that these closures favorably affect abundance in later years. Conversely while fishermen would not be faced with in-season closures of this type under option 2, they could face longer term losses to the extent that anchovy abundance in later years is adversely affected by this option. A more precise evaluation of the trade-offs between short and long term yields implied by the options is not possible, since even their relative biological impacts are not known to be significant.

9.2.3 Implementation Costs

Option 1 requires that an in-season reassessment of anchovy abundance be made. The administrative costs incurred in order to fulfill this requirement will vary from season to season, depending upon:

1) whether or not sufficient biological evidence exists to warrant a serious reassessment, and

2) the controversy surrounding such assessment and the extent to which such controversy complicates the decisionmaking process.

The procedures for calculating allowable harvests for Joint Venture Processing (JVP) and the Total Allowable Level of Foreign Fishing (TALFF) are discussed in Sections 5.3 and 7.0 respectively. Because the levels of JVP and TALFF are constrained by domestic processing activity and by the quota itself, release of the quota in two stages (as specified by option 1) would complicate calculation of these other quantities--particularly JVP, which is already subject to in-season modification on a timetable which does not necessarily coincide with release of the quota reserve.

None of the direct and indirect costs associated with implementing option 1 will be incurred under option 2.

9.2.4 Monitoring, Enforcement and Compliance Costs

The California Department of Fish and Game enforces terms of the reduction harvest formulas by monitoring anchovy landings when the fishery is open and conducting dockside surveillance to ensure that no fishing occurs during closed portions of the season. These same activities also allow the agency to enforce the terms of option 1. As described in Section 9.1.4, surveillance of this type is not costly and would continue even in the absence of a reduction quota reserve. Also compliance of fishermen and processors with option 1 is subsumed by their compliance with terms of the reduction harvest formula. Thus monitoring, enforcement and compliance costs associated with option 1 are expected to be minimal.

9.2.5 Net Benefits Associated with PFMC Recommendation

The conversion to the more accurate egg production method of biomass estimation and the PFMC's recommended reduction harvest formula (section 9.1.6) both minimize the risk of inadvertent overfishing. Under these circumstances a quota reserve (as specified by option 1) is not needed. In the interest of reducing unnecessary regulation, the PFMC recommends that the quota reserve be abandoned (option 2).

9.3 Non-Reduction Harvest Formulas

In the interest of maximizing long-term benefit from the resource, two types of non-reduction fishing regulations are considered in this FMP:

1) Allocations for non-reduction use, the options considered being:

a) a constant non-reduction allocation of 16,330 m tons, and
b) a non-numeric live bait yield coupled with a 7000 m ton allocation for other non-reduction uses

The numeric allocations considered in (a) and (b) are amounts reserved from the total OY. Non-reduction fishermen have exclusive access to these non-reduction allocations and are permitted to dip into whatever remains of the reduction quota once these allocations are exhausted. The non-numeric live bait yield considered in (b) allows live bait fishermen to catch unlimited amounts of anchovy, regardless of whether and when the numeric OY is reached.

2) Cessation of all non-reduction fishing activity when the spawning biomass falls below a specified level. The non-reduction cut off levels of biomass considered are:

a) 90,700 m tons
b) 20,000 m tons
c) No cut-off level specified

Only non-reduction fishing activity is possible at levels of biomass this low, since each of the reduction harvest formulas considered in this FMP specifies a cut-off level of spawning biomass of 200,000 m tons or higher for the reduction fishery.

The options considered under 1) and 2) are described in greater detail in Sections 8.3.2 and 8.3.3.

Table 9.3-1 illustrates all possible combinations of type 1) and 2) options being considered and identifies the most and least restrictive among them.

Table 9.3-1. Alternative Non-Reduction Harvest Formulas

	Spawning biomass level below which non-reduction fishing activity strictly prohibited: 2a. 90,700 m tons	2b. 20,000 m tons	2c. No limit
1a. Non-reduction quota = 16,330 m tons	Most restrictive	Moderate	Moderate
1b. Non-numeric live bait quota + 7,000 m ton limit on other non-reduction uses	Moderate	Moderate	Least restrictive

9.3.1 Biological Impact

9.3.1.1 Non-Reduction Cut-Off Level of Spawning Biomass

Options 2a and 2b of Table 9.3-1 specify a numerical level of spawning biomass below which non-reduction fishing activities would be prohibited. In both cases this biomass level is based on historical time series data showing the ability of the population to rebound from levels of abundance as low as the limit specified by the particular option. However option 2a is based on the previous larva census method of biomass estimation which is being discontinued by this FMP. Option 2b is based on the egg production method, the new technique utilized in this FMP (see Sections 4.3.1 and 4.3.2 for further description of these techniques).

The same historical data which support 2b also provide some justification for the least restrictive option (2c). A time series of spawning biomass estimates, scaled to egg production estimates for 1980-1982, shows that the resource languished at low levels of abundance during the 1950s (MacCall, 1982b, p. 14) at the same time that commercial yields of up to 38,935 m tons were being taken from the fishery (see Table 3.2-1). Substantial increases in biomass in subsequent years demonstrate the ability of the resource to rebound from the low levels of abundance prevalent during the 1950s despite harvests which were approximately five times greater than current non-reduction yields and much greater than future yields are likely to be.

9.3.1.2 Non-Reduction Allocations

Option 1a specifies a numeric non-reduction allocation which is reserved from the over-all optimum yield. The non-numeric live bait yield specified by option 1b is not reserved from the numeric OY, and represents an additional potential harvest (which would be returned to the ocean as bait). Live bait yields have averaged approximately 5500 m tons and peaked at 6400 m tons in the last six years (see Table 3.2-3), and thus represent only modest additions to the harvests permitted under the numeric OY. In fact live bait yields will cause the numeric OY to be exceeded only to the extent that (1) other non-reduction fishermen (who have landed a maximum of 1200 m tons in recent years) utilize the entire U.S. portion of the 7000 m ton reserve made available to them under option 1b and (2) the entire reduction quota is also utilized. The fact that live bait, unlike reduction yields, is returned to the ecosystem after it is caught also suggests that the biological impact of allowing unrestricted live bait fishing is likely to be insignificant.

9.3.2 Socioeconomic Impacts

9.3.2.1 Impact on Productivity

The extent to which live bait yields are constrained under option 1a depends upon what portion of the non-reduction reserve is made available in the U.S. FCZ. Under the 70% allocation used in the previous FMP, the U.S. portion of the non-reduction reserve would amount to 11,431 m tons--providing a comfortable margin for increases in non-reduction yield above the 7600 m ton maximum experienced in recent years. An approximate "breakeven" point, accommodating but not allowing for significant increases in non-reduction yield, would be a 50% U.S. allocation, or 8165 m tons. However even this allocation will not necessarily constrain non-reduction harvests, which can still be augmented if some portion of the reduction quota remains when the non-reduction reserve is exhausted.

Option 1b places no limit on live bait yields and reserve 7000 m tons (as modified by U.S.-Mexico allocation) for other non-reduction uses. Long term yields are potentially higher under option 1b than option 1a. However, assuming that at least 50% of the non-reduction reserve is allocated to the U.S. FCZ under option 1a, non-reduction yields are not likely to be constrained by either set of options in the foreseeable future--at least in those seasons when the fishery is open for non-reduction use.

9.3.2.2 Impact on Employment and Capital Utilization by Live Bait Fleet

Closure of the non-reduction fishery will occur with greater frequency under those options specifying higher cut-off levels of spawning biomass; that is, fishery closure is more likely under option 2a, less likely under 2b and does not occur under 2c. The economic consequences of closure would be borne by the live bait fishing fleet, consisting of approximately twelve vessels and employing a maximum of 70 people during busiest periods of the season. Although this fleet is modest in size, it catches approximately 5500 m tons of anchovy each year (see Table 3.2-3), representing ex-vessel revenues of $2,200,000, and supports the large recreational partyboat industry in California. According to Table 3.5-5, approximately 750,000 angler trips are made each year aboard commercial partyboats, generating revenues from fares of approximately $22,500,000.

While the decision to close the non-reduction fishery at low levels of abundance is made at the beginning of a season and remains in effect throughout the season, closure can also occur if both the numeric non-reduction allocation specified by option 1a and the reduction quota are depleted prior to the end of the season. Closure of this type is likely to occur late in the season--which officially extends from August 1 to July 31. This is the period of highest demand for live bait (highest recreational fishing activity), and the impact of fishery closure at this time would be most severe. Such losses would not occur under option 1b.

The short term economic losses resulting from fishery closure must be weighed against the impact of such closure on longer term population abundance. However, as suggested in Section 9.3.1.1, the long term biological benefits associated with higher cut-off levels of spawning biomass may actually be negligible.

9.3.3 Implementation Costs

Biomass estimation is not necessary in order to implement option 2c since fishery closure is not required at low levels of abundance under these options. However fishery closure is possible under options 2a and 2b and is based on the levels of spawning biomass.

Closure of the fishery at low levels of abundance is also a feature of the reduction harvest formulas being considered in this FMP. As discussed in Section 9.1.3 with regard to some of the reduction formulas, when the resource is particularly abundant in one season, biomass estimation may not be necessary in order to implement the formula in the following season. However, when spawning biomass approaches the reduction cut-off level, annual estimation becomes necessary under all the options in order to determine when the reduction fishery should be closed and reopened. Therefore the costs associated with implementing non-reduction options 2a and 2b at low levels of abundance will already be incurred in the course of implementing any of the reduction harvest formulas. The additional cost of implementing any of the non-reduction options is expected to be negligible.

9.3.4 Monitoring, Enforcement and Recordkeeping

Because live bait catches are offloaded onto recreational fishing vessels or temporary holding tanks, and never "landed", monitoring of catch cannot be done at dockside. Instead the California Department of Fish and Game relies upon vessel operators to submit logbooks summarizing catch, effort and other information relevant to their participation in the fishery. For other informational purposes, this data collection effect is likely to continue even if a non-numeric live bait policy (1b) is adopted. Technically speaking, however, compliance would be voluntary under 1b and mandatory under 1a although the rate of compliance is expected to be the same under both options. Thus option 1b relieves the live-bait fishermen of an existing mandatory paperwork burden.

9.3.5 Net Benefits Associated with PFMC Recommendation

Because the quota imposed by option 1a is more than sufficient to accommodate current and projected levels of non-reduction fishing, non-reduction harvests are likely to be the same under 1a and 1b. Given no difference in net economic benefits between these options, the Council's choice of 1b was made in the interest of minimizing unnecessary regulation of the live bait fishery.

With regards to a total fishery cut-off level of spawning biomass, the opportunity cost associated with options 2a and 2b is the income foregone when the fishery is closed due to low resource abundance or to exhaustion of the numeric OY. Such cost would not be incurred under the PFMC's preferred option 2c; moreover the biological risks to the population are minimal under even this least restrictive of options.

The Council's recommendation of options 1b and 2c thus represents the least restrictive, most economically beneficial non-reduction harvest strategy being considered.

9.4 Geographic Allocation of Reduction Quota

A geographic allocation scheme has existed in the northern anchovy fishery even prior to establishment of the first Anchovy FMP in 1978/79. As currently formulated this provision stipulates that 10% or 9070 m tons, whichever is less, be reserved from the reduction quota for fishermen in the Northern regulatory area. Such an allocation was originally devised to preclude the possibility that the larger-capacity Southern fleet would exhaust the quota before Northern area fishermen had an adequate chance to fish.

Management alternatives pertaining to geographic allocation are described in Section 8.3.6. Option 1 stipulates that, if necessary the initial Northern allocation be modified on June 1 to reflect expected Northern area landings between then and the end of the season and that any positive excess of the initial allocation over expected landings be made available at that time to Northern and Southern area fishermen on a competitive basis. Option 2 stipulates that any portion of the original Northern allocation remaining on June 1 be made available to fishermen in both areas between then and the end of the season. Option 3 is the no allocation alternative.

9.4.1 Biological Impact

The distribution of yields between Northern and Southern permit areas is not expected to have any significant biological impact on the resource.

9.4.2 Socioeconomic Impacts

Both options 1 and 2 give the Northern area fishing fleet exclusive access to a designated portion of the quota for most of the season and allow them to make additional harvests over and above this allocation in competition with the Southern area fleet (within the constraints imposed by the over-all quota). Both these options are disadvantageous to the Southern fleet, which may have to forego revenues represented by (1) that portion of the Northern allocation which is not utilized by the Northern fleet but not made available to the Southern fleet for harvest and (2) that portion of actual Northern harvests which might have gone to the Southern fleet in the absence of a geographic allocation. While the impact of (1) is felt solely by the Southern fleet, (2) represents a distributional effect which favors one fleet at the expense of the other. Comparison of the economic impacts of the three options being considered will focus on these two areas.

Note that although the fishing season officially extends from August 1 through July 31, it effectively ends on June 30 since a separate season closure regulation (option 1 in Section 9.5) currently prohibits reduction fishing during the month of July. Since a Northern allocation would be operational for the entire season under option 1 and from the beginning of the season to June 1 under option 2, the difference between these alternatives depends upon the level of fishing activity between June 1 and the end of the season (i.e., during the month of June) in both Northern and Southern permit areas. More specifically, the potential economic impact associated with choosing option 1 over option 2 depends upon:

1) the extent (if any) to which the June allocation overestimates actual June harvests, and

2) the extent to which June harvests made by the Northern fleet would have gone to the Southern fleet instead under the competitive conditions stipulated by option 2.

June anchovy landings in the Northern area have historically been quite small--numbering only 510 m tons in 1981/82 and zero in the three prior seasons--largely because the fishermen are preoccupied with squid at this time. This historical pattern of behavior suggests that 1) a modest June allocation would be sufficient to reflect the modest harvests normally made in June, with any difference between predicted and actual harvests likely to be quite small, and 2) even if the Southern fleet were to take all of the North's June landings under option 2, the amounts involved are likely to be too small to make any sizeable distributional impact. In terms of these factors, there is likely to be little significant difference between options 1 and 2.

The potential increase in yield to the Southern fleet associated with choosing option 3 over options 1 or 2 consists of

1) that portion of the initial Northern allocation which is made available to Southern area fishermen on June 1 but not utilized between June 1 and the end of the season, and

2) that portion of Northern area landings which Southern fishermen might have caught if allowed to compete freely with their Northern neighbors from the beginning of the season to June 1.

Since the inception of the FMP in 1978/79, the Northern fleet has never fully utilized its initial allocation while the Southern fleet has exhausted its share of the quota only once. Comparison of the unused portion of the initial Northern allocation to Southern area June harvests in Table 9.4-1 indicates that the Southern fleet (had it exhausted its own share of the quota prior to June) could have harvested all of the unused Northern allocation during June in all four seasons.

Table 9.4-1. Amounts of Anchovy Allocated to Northern Area and Landed in Northern and Southern Areas (metric tons).

Season	Initial Nor. Alloc.	Nor. Landings Season Total	Unused Portion of Nor. Alloc.	So. Area June Landings	So. Landings Season Total
1978/79	5292	1065	4227	5900[1]	47,688
1979/80	9072	2113	6959	7344	30,016
1980/81	9072	4296	4776	5059	56,254
1981/82	9072	4493	4579	19,244	43,500
Average		2992			44,365

[1]Southern Area June landings might have been higher if the portion of the quota available to Southern fishermen had not been exhausted prior to the end of June.

Table 9.4-1 also illustrates the distributional impact of option 3. While Northern landings have averaged 2992 m tons over the past four seasons and reached 4493 m tons in 1981/82, comparable Southern yields for these same periods have been 44,365 m tons and 43,500 m tons respectively. Assuming that the Southern fleet could deprive the Northern fleet of all of its anchovy landings under the competitive conditions of option 3, this alternative represents a potential 7-10% increase in anchovy landings and revenues for the Southern fleet and an associated 3-5% increase in aggregate gross revenues from all species. For the fewer than half dozen vessels which fish anchovy regularly in the Northern area, loss of all anchovy yields would represent a 20-25% decrease in aggregate gross revenue (from all species); for the other round haul vessels in the Northern area which fish anchovy only sporadically and in relatively small quantities, losses would be negligible.

While the options discussed here provide varying harvest opportunities to Northern and Southern area fleets, these opportunities are realized only to the extent allowed by market demand and species availability. However, even if the potential anchovy yields associated with each option are not diluted by these factors, the relative economic impacts tend to be of minor importance--reflecting the fact that revenues generated from anchovy harvests in the Northern area are normally quite small relative to aggregate revenues from all species in either Northern or Southern regulatory areas.

9.4.2.1 Impact of Season Closure Regulation on Productivity

Option 2 pertaining to season closure (Section 9.5) requires that closure of the Southern reduction fishery commence on May 15 rather than July 1. Implementation of this option in conjunction with geographic allocation options 1 or 2 would make redistribution of the Northern allocation on June 1 inoperative. In this situation underutilization of the Northern allocation could represent a greater loss of yield to Southern area fishermen than if either of these geographic allocation options 1 or 2 were accompanied by the prevailing season closure option 1.

A historic precedent for this occurred in the 1978/79 season, when Southern area fishermen exhausted their share of the quota prior to the end of the season while Northern area fishermen left 4227 m tons of their allocation untouched. This 4227 m tons, valued at $190,215, represented a potential 9% increase in anchovy yield to Southern operation which could not be realized because redistribution of the initial Northern allocation was not a provision of the FMP at that time.

9.4.3 Implementation Costs

Because option 2 requires geographic allocation of the reduction quota according to a prescribed formula (with the lesser of 10% of the quota or 9% m tons reserved for the Northern permit area) and option 3 involves no allocation at all, the cost of implementing these options is virtually zero. Option 1, however, requires that the initial Northern allocation be modified on June 1 to reflect expected June harvests in the area. The cost of implementing this option will be higher, though not by much, particularly since this requirement is operational only in those seasons when the Southern fleet has depleted enough of its share of the quota by June 1 to take advantages of a reallocation.

9.4.4 Monitoring, Enforcement and Compliance Costs

Recalling Sections 9.1.4 and 9.1.5, terms of the reduction harvest formulas require that reduction landings be monitored when the fishery is open and surveillance conducted to ensure that no landings are made during periods of closure in both Northern and Southern regulatory areas. Enforcement of and compliance with terms of geographic allocation options 1 and 2 are subsumed by these activities, since the costs of enforcement and the recordkeeping requirements imposed on fishermen and processors by a geographic allocation scheme must already be incurred in order to implement any of the reduction harvest formulas. These costs are largely unaffected by the presence (options 1 and 2) or absence (option 3) of a geographic allocation scheme.

9.4.5 Net Benefits Associated with PFMC Recommendation

In order to "equalize" fishing opportunities between the Northern area fleet and the larger Southern fleet, the PFMC recommends retention of the Northern allocation (as per option 1). Elimination of this allocation could result in redistribution of Northern area anchovy revenues (valued at $200,000 in a very good season) to Southern fishermen. Because the relative impact of such redistribution would be to decrease Northern revenues from all species by 20-25% and increase Southern revenues by a much smaller 3-5%, the monetary distributional benefits were felt to justify retention of this option. The June 1 modification of the Northern allocation (made possible only under the Council's recommended option 1) is also economically beneficial since it gives Southern area fishermen the opportunity to utilize unused portions of the Northern allocation.

9.5 Season Closure

Under the current anchovy management plan, reduction fishing is prohibited in both Northern and Southern areas during the spawning period February 1 - March 31. Fishing is also prohibited July 1 - July 31 in the Northern area and July 1 - September 15 in the Southern area, largely for the purpose of mitigating social conflict between commercial and recreational fishermen during the busy recreational summer season. At the root of this conflict is the belief strongly held by recreational interests that the presence of commercial fishermen, even in offshore fishing grounds, adversely impacts the availability of live bait in nearshore areas. The presence of such a tradeoff between commercial and recreational yield cannot be verified, but the conflict arising thereof remain a problem in any case. The season closure options represent attempts to deal with this problem.

All season closure options are described in Section 8.3.7. The difference between the current regulation (option 1) and option 2 is that the latter specifies that the entire fishery be closed for an additional period May 15-June 30 and opened February 1 - March 31. Option 3 requires that reduction fishing be halted only when a quota is reached.

9.5.1 Biological Impact

Under option 1 both Northern and Southern regulatory areas are closed during the spawning period February 1 - March 31. This condition is not stipulated by options 2 and 3, but because reduction fishing activity is normally low at this time anyway, none of the options is likely to affect fishing mortality of pre-spawners to any significant extent.

9.5.2 Socioeconomic Impacts

The February-March closure is not likely to be a significant factor in assessing the relative socioeconomic merits of the options. Because of the seasonal lull in fishing activity by both recreational and commercial fishermen at this time, potential conflict between these groups and potential productivity of the commercial fishery are likely to be minimal with or without this closure. Also since Northern area anchovy landings are usually minimal from May 15 to June 30, and are likely to continue at these levels in July due to fishermen's preoccupation with squid, the major impact of the closure options will be felt in the Southern regulatory area. The remainder of this analysis of closure options will therefore examine impacts in the Southern area of the summer closure only.

9.5.2.1 Impact on Productivity, Employment and Capital Utilization

Comparison of closure dates for the Southern area reduction fishery specified by the three options shows that option 1 forbids mid- to late summer fishing, option 2 forbids early to late summer fishing and option 3 allows unrestricted fishing throughout the summer months. In order to compare the economic impacts of these options, yields and revenues associated with reduction fishery activities during the summer months will be projected. Recreational yields and revenues for these same months will also be provided, although no valid statistical relationship between the level of reduction fishing and the availability of live bait has been established. This information regarding commercial and recreational fishing activities will also be useful in interpreting the relative impact of the options on potential social conflict between these two groups, as discussed in Section 9.5.2.2.

1) May 15-June 30:

a) Over the most recent four seasons, reduction fishermen landed an average of 19,213 m tons--approximately 46% of the total season's yield with an ex-vessel value of $864,585--during the May 15-June 30 period. Because target species other than anchovy (e.g., bonito and mackerel) are not readily available to fishermen at this time, an early summer closure could idle much of the Southern California wetfish fleet, which has depended upon anchovy for as much as 25% of its gross revenues in recent years (see Table 3.5.4). This fleet numbers approximately 30 vessels and employs close to 300 fishermen.

b) In recent years, live bait fishermen in Southern California have harvested an average of 787 m tons during the May 15 - June 30 period--17% of the season's catch with an ex-vessel value of $314,800. In 1980, 85,150 angler trips--16% of the year's total--were made aboard Southern California partyboats over this same period (see Table 3.5-6), with associated gross revenues to partyboat operators of approximately $2,554,500.

2) July 1 - September 15:

a) Legal restrictions on fishing activity have historically precluded reduction landings in the mid- to late summer period. However the large amounts harvested by the Mexican fishing fleet over this same period suggest the possibility of large yields from the U.S. fishery as well. June landings in the Southern permit area have averaged 6100 m tons over 1979-1981. Assuming that this rate of harvest can be continued through the entire summer, projected Southern landings during July 1 - September 15 are 15,250 m tons (ex-vessel value $686,250). A downward adjustment to this figure of unknown amount may be required since bonito and jack mackerel are also more available later in the summer and may divert cannery interest and fishing effort away from anchovy.

b) Over this same period July 1 - September 15 recreational fishing activity normally becomes very intense in Southern California. In recent years bait haulers in this area have harvested 40% of the season's catch--an average of 1855 m tons with an ex-vessel value of $742,000--during this time. A corresponding increase in partyboat fishing activity also occurs; in 1980 approximately 208,250 angler trips--generating revenues of $6,247,500 and comprising 40% of total passenger volume for that year--were made over this 2-1/2 month period.

These estimates suggest the magnitude of foregone yields and revenues to the Southern area reduction fleet imposed by option 2, and the lesser magnitudes imposed by option 1. They may overestimate the impact of these options, since the level of cannery orders (which is based on market demand) is likely to impose separate additional constraints on the level of harvests.

9.5.2.2 Impact on Commercial-Recreational Conflict

The high levels of reduction and recreational fishing activity projected for the summer months in Section 9.5.2.1 suggest that the potential for social conflict between commercial and recreational fishermen would be very great under option 3, which allows for no closure of the reduction fishery prior to exhaustion of the quota. Conversely, this same information shows that such conflict is likely to be greatly diminished by option 1, which forbids reduction fishing from mid- to late summer and even further diminished by the early to late summer closure specified by option 2.

9.5.3 Implementation Costs

The only difference among the options is that they specify different periods of closure. Because no contingencies are attached to any of these closures, implementation costs are expected to be zero regardless of the option chosen.

9.5.4 Monitoring and Enforcement Cost

The monitoring activities conducted by the California Department of Fish and Game to ensure that no reduction fishing takes place during closed portions of the year (as specified by options 1 and 2) represents an additional task over and above what is required by the reduction optimal yield regulation (which closes the fishery when the quota is exhausted) or the geographic allocation regulation (which closes Northern and Southern areas of the fishery when their respective shares of the quota are exhausted). As with these other regulations, however, monitoring takes place at the cannery docks as an adjunct to other Fish and Game activities which occur in an ongoing basis irrespective of the regulations imposed on the anchovy fishery. Therefore the monitoring costs directly attributable to season closure option 1 or 2 are expected to be negligible.

In the past, violations of the season closure regulation have been rare; therefore enforcement costs associated with legal follow-up of such violations are also expected to be minimal.

9.5.5 Net Benefits Associated with PFMC Recommendation

Because of the seasonal lull in commercial and recreational fishery activity during the peak spawning months of February and March, fishery impact on the resource and economic yield are likely to be minimal at this time, whether or not fishing is prohibited. In the interest of eliminating unnecessary regulation, the PFMC recommends that the currently operational season closure regulation (option 1) be modified by elimination of the February-March closure and that all other terms of this option remain in force.

In recommending retention of the mid- to late- summer closure specified by option 1, the Council weighed the potential cost of season closure to the commercial fleet against the necessity of dealing with potential social conflict between commercial and recreational fishermen. While a potential $293,930 in anchovy profit may be foregone if the reduction fishery is closed over the July 1 - September 15 period, target species other than anchovy (e.g., highly valued tuna and mackerel) become available to and are generally preferred by the fleet at this time. Thus relatively little of the potential revenue loss would actually be realized. Because such alternative target species are not normally available in early summer, estimated foregone profits of $370,185 arising from a May 15-June 30 closure (as specified by option 2) could not be similarly recouped. Given the amount of monetary losses and the prospect of idle fishing resources resulting from a May 15-June 30 closure, the level of recreational fishing activity and the potential for conflict in early summer do no warrant the lengthy period of closure specified by option 2. The PFMC, however, feels that such closure is warranted mid- to late- summer, when recreational fishing activity reaches a seasonal high.

9.6 Nearshore Closures

The state of California currently forbids reduction fishing activity in specified nearshore areas. This FMP broadens this restriction to include additional nearshore areas which extend more than three miles from shore and therefore fall outside state jurisdiction (exact boundaries of the closed areas described in Section 8.3.8). The purpose of this nearshore closure is twofold:

1) Nearshore areas are the major habitat of more than half of all pre-spawning anchovies. Closure of these areas, in conjunction with the fish/mesh size regulation (considered separately in Section 9.7) reduces the fishing mortality on this segment of the population.

2) The effective range of live bait vessels is limited to nearshore areas since the lampara nets they use require a shallow ocean bottom to work effectively. By physically separating these vessels from the reduction fleet, the nearshore closure mitigates potential conflict between these two groups.

The exact boundaries of the six separate areas designated for closure are described in Section 8.3.8. Option 1 requires that all six areas be closed, option 2 that each area designated for closure be considered separately; in the extreme case complete abolition of the nearshore closure is possible under option 2.

9.6.1 Biological Impact

Sea surveys conducted by the California Department of Fish and Game show that juvenile anchovies typically are found primarily in inshore areas, while larger older fish tend to congregate offshore. This geographic distribution of the population indicates that the nearshore closure specified by option 1, combined with a fish/mesh size limit in offshore areas (see Section 9.7) can be an effective tool for reducing fishing mortality on these pre-spawners.

The biological impact of closing some nearshore areas but not others is more difficult to determine since the spatial distribution of the population varies both seasonally and annually. Because of these uncertainties it is likely that the more selective closures permitted under option 2 will dilute the biological protection afforded by option 1.

9.6.2 Socioeconomic Impacts

9.6.2.1 Impact on Social Conflict Between Commercial and Recreational Fishermen

Although reduction fishing vessels use purse seine nets to harvest anchovy, live bait fishermen claim that the injury inflicted on live bait by this method of capture reduces the survival rate in bait wells to unacceptable levels. To ensure greater survivability live bait vessels use lampara nets which do not close or "purse" at the bottom. Because these nets must be positioned on a shallow ocean bottom to prevent anchovies from escaping, the effective range of these vessels is limited to nearshore areas. Reduction fishing vessels, by contrast, can range much farther offshore. Considerable conflict can occur if reduction fishermen are allowed to operate in nearshore areas.

While option 1 neutralizes much of this conflict by physically separating the two groups, the impact of option 2 is less clear. Because both live bait and reduction fishing activity is concentrated in southern California, nearshore closure in the Southern permit area (particularly San Diego and Los Angeles) is more critical to managing commercial-recreational conflicts than Northern area closures. Beyond this, the marginal effect of closing some but not all nearshore areas, as allowed by option 2, is difficult to determine.

9.6.2.2 Impact on Productivity

Although fish size limits have not historically been imposed on the live bait fishing fleet, bait haulers prefer to avoid small juvenile fish because of their size and avoid larger adult fish because they are sluggish and difficult to maintain in captivity. Recruitment to the reduction fishery generally occurs at a somewhat older age, and interest in adult fish is not diminished as it is for the live bait fishery. Despite these differences there can be considerable overlap in the catchable stocks available to these two fleets in nearshore fishing areas.

For this reason option 1 may cause reduction fishing vessels to forego income they could have earned from nearshore fishing. The extent of such losses cannot be determined from historical data, which reflect the consequences of prevailing closure restrictions. In general these losses will vary from season to season, depending upon (a) the distribution of potential recruits to the reduction fishery between nearshore and offshore areas and (b) the extent to which market demand can absorb yields over and above what the reduction fleet can catch in offshore areas. Even if the market situation does not allow for appreciable increases in yield, closure of nearshore areas when fish are not readily available offshore will result in a decrease in catch-per-unit-effort and a commensurate increase in operating costs for the reduction fishing fleet.

To the extent that option 2 dilutes the nearshore closure specified by option 1, the live bait fleet may suffer losses in yield and/or decreases in catch-per-unit-effort as a result of direct competition with the reduction fleet. Live bait losses will also be felt by partyboats and some private fishing vessels, since live anchovy is the preferred bait for many recreationally valuable species.

Since much of the recreational fishing activity in southern California takes place off San Diego, Orange and Los Angeles counties, failure to close these areas to reduction fishing, as allowed by option 2, could be particularly detrimental to the recreational fishing industry. Also, to some extent failure to close one particular area can have repercussions in other areas, since bait haulers are willing to travel considerable distances if necessary to meet their commitments, particularly in the summer months. The notable historic precedent for this occurred over the period 1956-1966, when bait boats from as far away as San Diego frequently travelled to Los

Angeles/Long Beach Harbor in search of bait.

9.6.2.3 Impact of Fish/Mesh Size Limit on Productivity

The fish/mesh size regulation discussed in Section 9.7 may have an indirect impact on relative productivity associated with the two nearshore closure options. For a given spatial distribution of biomass within the fishery, the catchable portion of biomass is greater in both near and offshore areas if the mesh size restriction is chosen over any of the fish size limit options. To the extent that reduction fishermen benefit from the increased availability of anchovies in their customary fishing grounds, they are less likely to sustain losses in productivity from the nearshore closure.

9.6.2.4 Impact on Incentive to Invest in Innovative Gear

Even under the "protection" of option 1, which grants exclusive fishing rights to live bait vessels in nearshore areas, these boats are frequently plagued by inadequacies in the quantity and/or quality of bait. For this reason this option is not likely to discourage innovation in fishing gear (e.g., a modified purse seine net) which might expand the effective operating range of these vessels while ensuring the survivability of their catch in captivity.

9.6.3 Implementation Costs

No contingencies are attached to the closure of nearshore areas under options 1 and 2 and no costs need be incurred in order to implement these options.

9.6.4 Monitoring and Enforcement Costs

Surveillance of nearshore waters to ensure compliance with the nearshore closure is conducted as part of a regular patrol by the California Department of Fish and Game. This patrol would continue even in the absence of a nearshore closure since it involves monitoring of miscellaneous other fishing activities not related to this regulation. The variable costs associated with this patrol and attributable to option 1 of the nearshore closure were approximately $25,000 in the 1981/82 fishing season. Monitoring costs incurred under option 2 will be at least this small and possibly zero, depending upon which nearshore areas are designated for closure.

9.6.5 Compliance Cost

The nearshore closure specified by option 1 requires that reduction fishing vessels move to offshore areas in order to participate in the commercial fishery. Because the distances travelled in order to comply with the regulation (3-6 miles) are considerably less than the distances routinely travelled in the normal course of fishing operation, the associated costs are expected to be very small. Compliance costs under option 2 will be at least as small as option 1 and possibly zero, depending upon which areas are designed for closure.

9.6.6 Net Benefits Associated with PFMC Recommendation

The PFMC's recommendation regarding nearshore closures reflects its consideration of the potential economic benefit of nearshore access to both commercial and live bait fishermen. Because reduction fishing activity has historically been disallowed in nearshore areas, there is no precedent for determining the absolute monetary impact of such closure on the commercial fleet. However the monetary importance of nearshore access to the live bait fleet is know to be substantial, since gear limitations prevent them from expanding their operations offshore. Because market value per unit harvest is 8-10 times greater for live bait than for reduction landings, reduction fishermen would have to land 8-10 units of anchovy (that they could not have otherwise caught offshore) for each unit of harvest lost by live bait fishermen as a result of direct competition in nearshore areas (for any given level of aggregate revenue). It should also be noted that the PFMC's adoption of a mesh size limit in place of a fish size limit (Section 9.7) diminishes the importance of nearshore access to the reduction fleet by increasing their ability to obtain harvests offshore.

Because of the economic tradeoffs involved and because nearshore closures also: (1) protect pre-spawners (which tend to congregate on these areas) from excessive fishing mortality and, (2) reduce social conflict by physically separating commercial and recreational fishermen at sea, the PFMC recommends retention of all nearshore closures (option 1).

9.7 Mesh and Fish Size Limits

Regulatory options pertaining to minimum fish/mesh size limits are described in Section 8.3.9. Until very recently reduction fishermen have operated under a five-inch size limit coupled with a 15% incidental catch allowance (option 2). This regulation, in conjunction with the nearshore closure (a separate regulation discussed in Section 9.6) was initially promulgated to reduce fishing mortality on the pre-recruit segment of the population.

9.7.1 Biological Impact

Evidence now suggests that anchovies in recent years have reached sexual maturity at younger ages and sizes closer to 4 inches, and that this early maturation may be related to the decreased levels of abundance observed in these same years. In view of the current maturation patterns of the population, size limits of 4-1/2 to 5 inches (options 2-5) are not likely to protect pre-spawners to any significantly greater extent than option 1, which specifies mesh sizes consistent with a four inch size limit. Moreover, option 1 would not be made obsolete by any foreseeable increases in age-at-maturity, since the increase in abundance accompanying such a change would "offset" the increase in fishing mortality among pre-spawners. It should also be noted that the vast majority of nets used by anchovy purse seiners already comply with option 1; therefore current fishing practices in the absence of regulation already protect pre-spawners in reduction fishing areas. The purpose of option 1 is to ensure that such practices continue in the future.

9.7.2 Socioeconomic Impacts

9.7.2.1 Impact on Productivity

The impact of the five fish/mesh size options on potential harvests and catch-per-unit-effort is described by (1) the extent to which entanglement of small fish in purse seine meshes hampers fishing operations, and (2) the extent to which inadvertent size limit violations result in "dumping" of loads containing excessive undersized fish and the impact of this practice on catch-per-unit-effort. These issues can be further elaborated as follows:

(1) The mesh size requirements associated with option 1 allow immature fish to become entangled (gilled) in the nets. Removal of gilled fish is sufficiently tedious and time-consuming to discourage fishermen from knowingly setting on schools of small fish. Because fishermen can misjudge the size composition of an anchovy school prior to capture, option 1 does not preclude all mortality from gilling.

(2) Options 2-5 impose additional mortality on the population since misjudgments regarding the size composition of an anchovy school can result in the catch of significant numbers of fish large enough to avoid mesh entanglement but small enough to violate size limits. Such catches are either dumped at sea, by which time considerable mortality may have already occurred, or seized by wardens at the cannery docks. "Waste" of this type would be greater under option 2 than the remaining size limit options, which provide for a larger incidental catch (option 3), a smaller size limit (option 4) or a lesser period of enforcement (option 5) than the second option.

The actual incidence of gilling and dumping of illegal size fish and the impact on fishing mortality and catch-per-unit-effort are not known. However available information on growth patterns of the fish population and behavioral patterns of participants on the fishery allow one to estimate the relative frequency of gilling and dumping under the various options.

Because the Anchovy FMP has not imposed gear restriction in past years, the fishermen have been free to reduce the incidence of gilling by investing in smaller meshed nets. They have not done so, possibly because

a) the low oil content of the smaller fish which could be caught with finer mesh makes them undesirable to canneries, and

b) smaller meshed nets are heavier and increase the chance of capsizing when harvesting large schools of fish.

The fishermen's apparent preference for prevailing mesh sizes suggest that species mortality related to gilling is likely to be the same regardless of whether a mesh size limit (option 1) or a fish size limit (options 2-5) is chosen.

Table 9.7-1 illustrates the relative distribution of the biomass by length of fish in the fall, winter and spring seasons.

Table 9.7-1. Percent of anchovy biomass falling into various length categories.

Length Category	Percent of Biomass Fall	Winter	Spring
<4"	.10	.04	0
4"-4.5"	.19	.14	.02
4.5"-5"	.25	.24	.17
>5"	.46	.57	.81

According to the table, fish in the smallest length category--the prime candidates for gilling--constitute 10% of the biomass in the fall, with this percentage declining to virtually zero by spring. Note also that the percent of total landings made during the fall and winter periods has ranged from 19% to 45% and averaged 28% over the most recent four seasons. Assuming that fishing effort is proportional to landings, participation in the fishery tends to be lower in those months when the chances of encountering very small fish are greatest--suggesting that mortality related to gilling is of small significance.

Note also from Table 9.7-1 that a large percent of the biomass falls into the 4-5 inch category, the proportions being 44%, 38% and 19% in fall, winter and spring respectively. It is these fish which are ineligible for capture if a 5 inch size limit is chosen over the mesh size restrictions imposed by option 1. The percent of the biomass ineligible under a 4-1/2 inch limit is 19%, 14% and 2% over these same seasons. These percentages do not directly translate into probabilities associated with size limit violations, which are also affected by the geographic distribution and schooling behavior of the population, particularly in heavily fished areas. On a relative scale, however, the table does show that for a given incidental catch rate and a given period of enforcement, a considerably larger proportion of the biomass is eligible for capture under a 4-1/2 inch limit (option 4) than a 5 inch limit (option 2)--particularly in the spring when fishing effort begins to intensify.

Increases in potential yield and catch-per-unit-effort and fewer incidents of dumping are also expected if the remaining 5 inch options, which permit a larger incidental catch (option 3) or a shorter period of enforcement (option 5) are chosen over option 2. A similar relative evaluation of options 3-5 among themselves cannot be made with available information.

9.7.3 Implementation Cost

No special costs are involved in implementing any of the fish/mesh size options.

9.7.4 Monitoring and Enforcement Costs

Monitoring costs associated with option 2 are estimated at $40,000 for the 1981/82 season and include the activities of wardens who sample landings at the cannery docks for size limit violations. Monitoring costs of comparable amount are expected for options 3 and 4. Under option 5, however, size limit restrictions are imposed only during the fall and winter; an average of 28% of all anchovy landings have been made in these months over the past four seasons--suggesting that monitoring costs would be considerably lower under option 5 than options 2-4.

Nine of the eleven citations issued by the California Department of Fish and Game over the past two years (1981 and 1982) for alleged violation of FMP regulations pertained to the size limit restrictions mandated by option 2. This evidence suggests that enforcement costs associated with legal pursuit of violators can be considerable under this option. These costs are likely to be lower for the less restrictive size limit options 3-5, since the incidence of violation is likely to be less under these options than under option 2 in any given fishing season.

Option 1 must be enforced at sea since violations can be legally proven only if fishermen are caught in the act of fishing with an illegal net. In order for enforcement to be cost effective, monitoring of vessels at sea is likely to occur only on the basis of prior suspicion that a vessel carries an illegal net. The enforcement agency will rarely be called upon to perform this task since:

a) By their own preference, nearly all reduction fishing vessels already utilize purse seine nets which comply with option 1.

b) Most if not all of the fleet orders new nets from the same supplier (using the Fishermen's Cooperative of San Pedro as an intermediary), whose manufacturing specifications comply with the mesh sizes designated by option 1. Therefore this option will not require fishermen to deviate from previously established sources of supply.

c) Penalties for mesh size violations include confiscation of the net, which has an estimated replacement value of $60,000.

These factors a) to c) suggest that monitoring and enforcement costs associated with option 1 are likely to be minimal.

9.7.5 Compliance Costs

Dockside sampling of purse seine nets (see Figure 8.3-2) indicates that at least one and at most two vessels in the wetfish fleet use nets which do not comply with the mesh size restrictions specified by option 1. It is these vessel(s) which will bear the entire cost of compliance if option 1 is chosen over any of the size limit options.

The current market value of a new net is $60,000; assuming a useful life of fifteen years this net will depreciate at a rate of $4000/year--a cost which will be incurred irrespective of the fish/mesh size limit chosen. Assuming that fishermen distribute the portion of net replacement costs attributable to option 1 equally over the three year grace period and assuming a discount rate of 10%, the present value of first, second and third year costs will be $16,000, $14,545 and $13,223 respectively. The average of these values--$14,589--represents approximately 3% of the average vessel's gross revenues in 1981. These estimates represent an upper limit on compliance costs, since they are based on the assumption that all of the netting in the 1-2 purse seines in question fails to comply with option 1.

The cost of complying with options 2-5 consists of the decrease in catch-per-unit-effort and associated increase in operating costs which are incurred by fishermen who must bypass illegal schools of fish in search of legal size catch.

9.7.6 Net Benefits Associated with PFMC Recommendation

Economic benefits for commercial fishermen will be greatest under the PFMC's preferred option 1. As elaborated in Section 9.7.2.1, both landings and catch-per-unit-effort are expected to be maximized under this option, since a larger percentage of the population is eligible for capture under the mesh size limit than under any of the fish size limits specified by the remaining options.

9.8 Foreign Fishing Management Measures

Both options 1 and 2 of the foreign fishing management measures described in Section 8.4 were written in anticipation of possible future joint venture and foreign participation in the fishery. There is no historical precedent for foreign participation in the anchovy fishery. Foreign parties are required to observe all regulations imposed on domestic harvesters and processors. While these parties would not be subjected to any additional regulations under option 1, option 2 would bar foreign fishing and processing vessels from specific areas (as described in Section 8.4).

9.8.1 Biological Impact

Allowable harvests for Joint Venture Processing (JVP) and the Total Allowable Level of Foreign Fishing (TALFF) are calculated according to procedures described in Sections 5.3 and 7.0 respectively. These procedures ensure (1) that total potential harvests in the U.S. FCZ (including JVP) do not exceed the U.S. portion of the option yield and (2) that combined U.S. harvests (including TALFF) and Mexican harvests do not exceed the over-all optimum yield due to TALFF allowed in the U.S. FCZ. With potential joint venture and foreign yields calculated in this manner, overfishing of the resource by foreign parties is unlikely regardless of the option chosen.

9.8.2 Socioeconomic Impacts

9.8.2.1 Economic Impacts

According to the procedures described in Sections 5.3 and 7.0, preference is given to domestic processors in the calculation of JVP, and to domestic U.S and Mexican fisheries in the calculation of TALFF. These procedures limit but do not necessarily eliminate the economic impact of foreign participation on these segments of the industry. The differences between options 1 and 2 depend to some extent on the type of foreign involvement which occurs.

1) In the case of joint venture participation, option 2 would prohibit foreign processing vessels from entering selected areas of the fishery. The U.S. fishermen who would provide these vessels with fish could make harvests in these restricted areas but may have to travel longer distances under option 2 than option 1 to deliver their catch to joint venture processors. Fishing vessels must normally travel some distance even to land their catch at U.S. cannery docks, and the extra travel which may be necessary under option 2 would pose no particular additional hardship relative to normal domestic fishing.

2) Competition from foreign fishing vessels can reduce potential yields and/or catch-per-unit-effort for U.S. fishermen. Therefore the restrictions on foreign fishing imposed by option 2 may benefit U.S. fishermen, depending upon a) the amount of foreign fishing which would have occurred in those areas closed to them by option 2, b) whether foreign participation would be displaced to other areas, and c) the impact of such participation in these other areas.

9.8.2.2 Social Impacts

Unlike the economic impacts, the relative social impacts of the two options are less likely to depend upon the type of foreign vessels involved. Because option 2 keeps both foreign fishing and processing vessels away from selected areas of intense recreational fishery activity, it reduces the visibility of these vessels to U.S. fishermen, thereby reducing potential social discontent. No such physical separation would take place under option 1.

9.8.3 Implementation Costs

The only difference between options 1 and 2 is that the latter restricts foreign participation in selected areas of the fishery. Additional costs associated with implementing option 2 over option 1 are expected to be negligible.

9.8.4 Monitoring and Enforcement Costs

Monitoring and enforcement of option 2 would require surveillance of foreign vessels to ensure that they do not enter restricted areas. This activity would probably be included as part of a regular patrol which is already routinely conducted in U.S. waters to ensure compliance with a variety of domestic fishery regulations (including many which are unrelated to anchovy).

9.8.5 Compliance Costs

Compliance of foreign joint venture processing vessels with option 2 is likely to create little economic hardshop for these participants, since their yields would be obtained from U.S. vessels, who are not bound by the terms of this option.

9.8.6 Net Benefits Associated with PFMC Recommendation

Any potential foreign participants in the anchovy fishery would be bound by the same regulations imposed on domestic harvesters and processors. To impose additional restrictions on foreign vessels (as per option 2) would be inconsequential at this time, since there is no history of foreign entry nor is such entry anticipated for the foreseeable future. In the interest of reducing unnecessary regulation, the PFMC recommends retention of option 1.

9.9 Summary Tables

The following tables qualitatively summarize the relative impacts of alternative management options. These tables include analyses presented in sections 8.3 and 9.0, and are referred to in the Executive Summary.

Table 9.9-1. Evaluation of options regarding the U.S.-Mexico allocation of the reduction OY (Section 8.3.1).

	U.S.-Mexico OY Allocation Option				
	1	2	3	4	5
Specification of U.S. allocation:	70% of total OY	50% of total OY	Remainder of total after subtracting expected Mexican catch	100% of adjusted total OY (expected Mexican catch subtracted from biomass)	100% of total OY*
Consistent with FCMA OY definition:	YES	YES	NO	YES	??
TALFF recognizes Mex. harvest:	YES	YES	YES	YES	NO
Impact of fishery on the stock:	VAR.	VAR.	LEAST	OK	MOST
Change in percentage of years with no U.S. fishery:	NONE	NONE	LARGE INCREASE**	INCREASE	NONE

*Mexican catch is considered implicitly as an external source of mortality that affects the biomass and future OY levels based on that biomass.

**Amount of increase is dependent on which harvest formula option is selected. With harvest formula options 7-9, the U.S. reduction quota would be zero in more than 90% of the years.

Table 9.9-2. Evaluation of options regarding harvest quotas (Section 8.3.4). Biomass and catch have units of thousand metric tons. Option 1 is the present harvest formula which was originally based on the larva census method of estimating spawning biomass.

Option:	1	2	3	4	5	6	7	8	9	10	11
Harvest Quota Formula:											
Biomass at cut-off:	1000	200	300	300	300	400	300	400	200	300	200
Slope:	1/3	1/4	1/4	1/3	1/2	1/3	*	*	1/1	5/4	1/1
Maximum catch:	--	--	--	--	--	--	200	200	200	250	300
Maximum expected catch:	500	500	500	500	500	500	200	200	200	250	300
Biological Response:											
Mean spawning biomass:	1429	1178	1233	1131	996	1192	1215	1281	1216	1146	973
Mean pelican reproduction:	0.76	0.68	0.70	0.67	0.61	0.69	0.68	0.70	0.67	0.66	0.59
Fishery Characteristics:											
Mean catch:	156	212	202	224	248	212	180	171	181	202	232
Percent years with no fishery:	37.0	2.2	4.8	7.1	10.8	11.9	9.8	14.5	3.0	10.3	7.4
Sensitivity of quota to biomass estimates near cut-off:	LO	LO	LO	LO	LO	LO	HI	HI	MID	MID	MID
Cost of implementation (freq. of biomass est.):	HI	HI	HI	HI	HI	HI	LO	LO	MID	MID	MID

*Quota increases from zero to the maximum at the cut-off level.

Table 9.9-3. Evaluation of options for the reduction quota reserve (Section 8.3.5).

Option:	1	2
Level of reserve:	1/2 of U.S. reduction quota	NONE
Effect on implementation of TALFF and JVP:	COMPLICATES	NONE
Change in paperwork and cost:	INCREASES	NONE
Change in chance of overexploitation by the U.S. fishery:*	REDUCES	NONE
Effect on forecasting by the fishing industry:	SLIGHT ADDED UNCERTAINTY	NONE

*Due to the magnitude of recent unregulated Mexican harvests, adjustment to U.S. reduction quota will have little effect on overall chance of overexploitation. With implementation of the new method of estimating spawning biomass and the new harvest formula, the probability of a need to adjust the quota is greatly reduced.

Table 9.9-4. Evaluation of options regarding the minimum biomass allowing a non-reduction harvest (Section 8.3.2).

Option:	1	2	3
Minimum biomass allowing a harvest:	90,720 mtons	20,000	NONE
Number of years since 1951 with biomass below minimum:*	7	3	0
Increase in probability of U.S. fishery closure with selection of specified U.S.-Mexico OY allocation (Section 8.3.1):			
1. Option 4:	SOME	SLIGHT	NONE
2. Options 1,2,3,5:	NONE	NONE	NONE

*Low biomasses occurred prior to 1958; a significant fishery existed in most of those years.

Table 9.9-5. Evaluation of options regarding the allocation for non-reduction use (Section 8.8.3).

Option:	1	2
Non-reduction allocation:	16,330 mtons (includes live bait)	7,000 mtons (live bait not included)
Possibility of closing live bait fishery due to substantial non-reduction harvest:	SMALL	NONE
Necessity of live bait catch reports:	REQUIRED	VOLUNTARY

Table 9.9-6. Evaluation of options regarding geographic allocation of the reduction quota (Section 8.3.6).

Option:	1	2	3
Maximum initial allocation to northern fishery:	10% of total or 9072 mtons	10% of total or 9072 mtons	NONE
Action on June 1:	Reallocate if requested	End allocation	NONE
Opportunity for northern fishery:	Maximum	Nearly max.	Possible preemption by south
Opportunity for southern fishery:	Nearly maximum	Nearly maximum	Maximum
Paperwork and cost:	SLIGHT	SLIGHT	NONE

Table 9.9-7. Evaluation of options regarding fishing seasons (Section 8.3.7).

Option:	1	2	3
Northern season:	Aug 1-Jan 31 Apr 1-Jun 30	Aug 1-May 15	All year
Southern season:	Sep 15-Jan 31 Apr 1 -Jun 30	Sep 15-May 15	All year
Opportunity for reduction fishery:	OK	OK	MAX.
Possible conflict with recreational and live bait fishery:	SOME	REDUCED	SOME
Possible conflict with pelicans during nesting season:	REDUCED	REDUCED	SOME
Possible disturbance and harvest of spawning anchovy:	REDUCED	SOME	SOME

Table 9.9-8. Evaluation of area closure options (Section 8.3.8).

Option:	1	2
Closed areas outside 3 miles:	Gulf of the Farallons Oxnard Santa Monica Bay Los Angeles Harbor San Diego County	NONE
Potential direct conflict between commercial and recreational fishermen:	SLIGHT	SOME
Protection of pre-recruit fish outside 3 miles:	SOME	NONE*
Area open to commercial fishing outside 3 miles:	SLIGHTLY REDUCED	ALL

*Pre-recruit fish also are protected by size limits and/or mesh size restrictions (Section 8.3.9).

Table 9.9-9. Evaluation of options regarding fish size limits and mesh restrictions (Section 8.3.9).

Option:	1	2	3	4	5
Minimum fish length:	NONE	5"	5"	4.5"	5"
Allowance for undersized fish:	N.A.	15%	40%	15%	15%
Season for size limit:	N.A.	all yr.	all yr.	all yr.	August-March
Minimum mesh size:	10/16"	N.A.	N.A.	N.A.	N.A.
Wasted catch:	NONE	SOME	SLIGHT	SOME	SLIGHT
Direct protection of pre-recruits:*	LEAST	MOST	SOME	SOME	MOST
Enforcement cost:	LEAST	MOST	MOST	MOST	SOME

*Other protection provided by nearshore area closures and low economic value.

Table 9.9-10. Evaluation of options for area restrictions on foreign vessels (Section 8.4).

Option:	1	2
Closed areas outside 3 miles:	Catalina Channel and 3-6 miles from shore	NONE
Visibility of foreign vessels (social conflict):	REDUCED	SOME
Local competition with domestic fishing by vessels fishing under TALFF:	REDUCED	SOME

9.10 Compliance of FMP with RFA

In accordance with the Regulatory Flexibility Act (RFA), this section identifies the number and type of small entities affected by this FMP and summarizes the record keeping requirements and financial impacts resulting from such regulation. Previous portions of Section 9.0, which fulfill other RFA (as well as RIR) requirements regarding benefit-cost analysis of management options, will be referenced here where appropriate.

Although the PFMC recommends that no restrictions be directly placed on live bait fishing activity (Section 9.3.5), live bait and commercial recreational (partyboat) operators are indirectly affected by regulations imposed on the commercial reduction harvest of anchovy. This is because all the reduction harvest options considered by the Council implicitly involve a trade-off between commercial and recreational fishing interests. The commercial vessels affected by this FMP include 25-30 "wetfish" vessels and six "combination" vessels in the Southern permit area and an additional four vessels in the Northern area. On the recreational side, approximately 21 bait boats and 198 partyboats actively participate in Southern California's recreational fishery, which relies on anchovy for live bait (Gruen <u>et</u>.al., 1979, pp. 41 and 78).

The estimated mean biommass resulting from the PFMC's preferred harvest strategy (Section 9.1.6) provides for high availability of anchovy as live bait and as a forage base for recreationally valued species of fish--thereby benefitting the 200 plus small businesses which operate in the recreational fishery. Note also that the relatively low value for mean catch associated with this strategy is not necessarily detrimental to the commercial fleet, which: (1) benefits from a harvest policy promoting long-run availability of the resource and relatively stable harvests from season to season and, (2) suffers short-run losses only in those seasons when potential commercial landings would exceed the allowable harvest. In all but one of the most recent five seasons, the 35-40 commercial fishing vessels affected by this FMP have landed only a small fraction of the quota, for reasons largely unrelated to resource availability. Although the proposed quota formula restricts the U.S. reduction quota to 140,000 mtons, even at high levels of biomass, reduction landings have never exceeded this amount even when quotas larger than this were made available to the fishery (see Table 3.2-2).

Record keeping requirements and financial impacts associated with this FMP are as follows:

1) The state of California requires that landings of all commercially harvested species be monitored for tax collection purposes (see Section 9.1.5). This FMP does not impose any additional record keeping requirements on live bait or reduction fishermen and relies on state data collection efforts to monitor the commercial catch.

2) By regulating the rate of resource extraction, this FMP enhances the stability and long-run profitability of the fishery. As such it affects the timing of revenues and expenses, resulting in larger future and smaller current cash flows than would occur in an unregulated setting.

3) In the interest of equity, the PFMC recommends continuation of the Northern allocation, which enhances fishing opportunites for the small Northern fleet at little cost to the much larger Southern fleet (see Section 9.4). No other differential treatment is proscribed by the FMP which has minimal impact on the relative competitive positions of commercial vessel operators.

10.0 Management Regime

This section describes the management regime implemented by this amendment.

10.1 Preferred Options

As an aid to reviewers of this draft FMP, the Pacific Fishery Management Council, at its meeting on July 20, 1983, identified options which were likely to be recommended following review. The Council was not committed to these choices, but wished to focus review and comment in the areas of likely action. These preferred options are as follows (also see Tables ES-1 or 8.3-1):

U.S.-MEXICO OY ALLOCATION -- OPTION 1

MINIMUM SPAWNING BIOMASS ALLOWING HARVEST -- OPTION 2

NON-REDUCTION ALLOCATION -- OPTION 2

REDUCTION QUOTA FORMULA -- OPTIONS 2,9 and 11 were chosen as being representative of the Council's range of preferences

REDUCTION QUOTA RESERVE -- OPTION 2

GEOGRAPHIC ALLOCATION OF REDUCTION QUOTA -- OPTION 1

FISHING SEASONS -- OPTION 1

AREA CLOSURES -- OPTION 1

SIZE LIMIT/MESH RESTRICTIONS -- OPTION 1

FOREIGN VESSEL AREA RESTRICTION -- OPTION 1

10.2 Management Measures Adopted

This section contains the set of management measures recommended to the Secretary of Commerce by the PFMC on Sept. 29, 1983 in San Diego, CA. The recommendations are based on the preferred options specified by the PFMC on July 20, 1983 (Section 10.1) and on public comments and discussions during the subsequent review period and public hearings. In some cases the recommended option differs from the earlier preferred option. A brief discussion of the rationale for each difference is included in this section.

10.2.1 U.S.-Mexico OY Allocation

Option 1: The OY in the U.S. FCZ is 70% of the total OY.

10.2.2 Minimum Spawning Biomass Allowing Harvest

Option 3: No lower limit is specified.

The preferred option had been #1: 20,000 mton minimum. This preference was reconsidered after discussions indicated that 1) such low levels of abundance are difficult to measure, 2) specification of incidental catch allowances in other fisheries would have become necessary, and 3) the stock has recovered from such low levels in the early 1950s despite a small fishery at the time.

10.2.3 Non-Reduction Allocation

Option 2: Non-numeric OY for live bait and 7,000 mtons for other non-reduction fisheries.

10.2.4 Reduction Quota Formula

Modified Option: The reduction quota for the total fishery will be 1.0 of the excess over 300,000 mtons spawning biomass with a limit of 200,000 mtons.

This formula is similar to the range of options preferred by the PFMC in July 1983 (Options 2,9, and 11). The biological and economic consequences of this recommended formula are similar to those of options analyzed in Sections 8.3.4 and 9.1. The PFMC recommends this particular formula as the best means to achieve the dual objectives of harvesting available production and maintaining an adequate forage base for predators.

10.2.5 Reduction Quota Reserve

Option 2: No reduction quota reserve for in-season management.

10.2.6 Geographic Allocation of Reduction Quota

Option 1: 10% or 9072 mtons, whichever is smaller, is allocated to the northern area fishery and may be reallocated on June 1 if necessary.

10.2.7 Fishing Seasons

Modified Option 1: The seasons will be Aug. 1-June 30 in the northern area and Sept. 15-June 30 in the southern area.

This recommendation is a modification of the preferred option in that the February-March reduction fishery closure has been eliminated. Discussions indicated that there is no biological necessity for closing the fishery during the typically peak months of the spawning season.

10.2.8 Area Closures

Option 1: Maintain existing closures.

10.2.9 Size Limit/Mesh Restrictions

Option 1: No minimum fish size but nets are restricted to 10/16" mesh size.

10.2.10 Foreign Vessel Area Restriction

Option 1: No special restrictions were applied.

10.2.11 Example Quotas and Allocations

The following examples are based on the set of management measures recommended by the PFMC on Sept. 29, 1983. To calculate TALFF in these examples, two values need to be estimated: domestic capacity (DAH) and the expected level of Mexican harvest. DAH is taken as the maximum level of reduction plus non-reduction processing experienced during the past three years plus anticipated JVP harvest (Section 5.3). On July 1, 1983, DAH would equal 65,937 mtons. The expected level of Mexican harvest is estimated to be 250,000 mtons, a level which exceeds 30% of the total OY in all of the examples below. The OY for live bait is non-numeric so the harvesting of anchovies for live bait is not restricted by any quota. The OY and quota values in the following examples are exclusive of the non-numeric OY for live bait.

EXAMPLE 1: SPAWNING BIOMASS LESS THAN 300,000 MTONS
TOTAL OY = 7,000 MTONS
U.S. OY = 4,900 MTONS
U.S. NON-REDUCTION QUOTA = 4,900 mtons
U.S. REDUCTION QUOTA = 0
NORTHERN ALLOCATION = 0
INITIAL SOUTHERN QUOTA = 0
TALFF = 0

EXAMPLE 2: SPAWNING BIOMASS = 350,000 MTONS
TOTAL OY = 57,000 MTONS
U.S. OY = 39,900 MTONS
U.S. NON-REDUCTION QUOTA = 4,900 MTONS
U.S. REDUCTION QUOTA = 35,000 MTONS
NORTHERN ALLOCATION = 3,500 MTONS
INITIAL SOUTHERN QUOTA = 31,500 MTONS
TALFF = 0

EXAMPLE 3: SPAWNING BIOMASS = 450,000 MTONS
TOTAL OY = 157,000 MTONS
U.S. OY = 109,900 MTONS
U.S. NON-REDUCTION QUOTA = 4,900 MTONS
U.S. REDUCTION QUOTA = 105,000 MTONS
NORTHERN ALLOCATION = 9,072 MTONS
INITIAL SOUTHERN QUOTA = 95,928 MTONS
TALFF = 0

EXAMPLE 4: SPAWNING BIOMASS GREATER THAN OR EQUAL 500,000 MTONS
TOTAL OY = 207,000 MTONS
U.S. OY = 144,900 MTONS
U.S. NON-REDUCTION QUOTA = 4,900 MTONS
U.S. REDUCTION QUOTA = 140,000 MTONS
NORTHERN ALLOCATION = 9,072 MTONS
INITIAL SOUTHERN QUOTA = 130,928 MTONS
TALFF = 0

10.3 Data Reporting Requirements

In order to monitor the fishery and evaluate the performance of the management system under this Plan, it is necessary to collect data regarding the catching and processing of anchovies. The data to be collected from the domestic fishery are:

a. Date, location, quantity and area of catch for every landing of anchovy from the central subpopulation;
b. The quantities of landed anchovies going into:
   (i) fresh market
   (ii) frozen bait
   (iii) canned pack
   (iv) reduction to meal, oil and solubles.

Data regarding fishing vessels, fishing activities, landings, and processing activities required by the Plan for the reduction and nonreduction fisheries are collected by the State of California under existing State data collection provisions. No additional reports will be required of fishermen or processors as long as the data collection and reporting systems operated by the State of California continue to provide the Secretary with statistical information adequate for management. Reporting requirements may be promulgated by emergency regulations if this reporting system becomes inadequate for management purposes.

Domestic fishermen are not required to obtain any permits from the Secretary of Commerce in order to participate in the anchovy fishery. State laws regarding vessel registration, identification and reporting are not modified by this Plan.

Foreign fishing vessels wishing to fish for northern anchovies in the U.S. Fishery Conservation Zone must obtain the appropriate permits and follow reporting requirements specified in regulations implementing the MFCMA.

11.0 List of Agencies and Organizations to Whom Copies of the Draft Amendment are Sent

The PFMC mailed the draft revised FMP/EIS/RIR to over 400 individuals who had requested copies of the document, including representatives of the agencies and organizations listed here. The list may not include all the agencies and organizations that received copies.

Federal Agencies:

American Embassy, Tokyo, Regional Fisheries Attache
American Embassy, Mexico, Regional Fisheries Attache
Caribbean Fishery Management Council
Commercial Fisheries Entry Commission
Congressional Information Service
Council on Environmental Quality
Environmental Protection Agency
Fisheries, Wildlife Conservation and Environment Subcommittee
 (U.S. House of Representatives)
Gulf of Mexico Fishery Management Council
Office of the General Counsel
Mid-Atlantic Regional Fishery Management Council
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
New England Fishery Management Council
NOAA General Council
North Pacific Fishery Management Council
Office of Ocean Management
Subcommittee on Oceanography, U.S. House of Representatives
Pacific Environmental Group
South Atlantic Fishery Management Council
U.S. Coast Guard
U.S. Army Corps of Engineers
U.S. Department of State
U.S. Department of Interior, Bureau of Land Management
U.S. Department of Interior, Environmental Project Review
U.S. Department of Transportation, Office of Environmental Quality
U.S. Department of Energy
U.S. Fish and Wildlife Service, Editorial Office
U.S. Fish and Wildlife Service, Endangered Species Program
Western Pacific Fishery Management Council

State and Other Governmental Agencies:

University of Alaska
Alaska Department of Fish and Game
Atlantic States Marine Fisheries Commission
University of British Columbia
University of California, Davis

University of California, Marine Advisory Program, Sea Grant:
- Eureka
- Davis
- San Diego
- Santa Barbara
- Watsonville

California Department of Fish and Game
California State University, Long Beach
California Resources Agency
University of California, Santa Cruz, Crown College
Embassy of Canada
Canadian Consulate General
Embassy of Cuba (c/o Embassy of Czechoslovakia)
Environment Canada, Fisheries and Marine Services
Eureka Chamber of Commerce
Idaho Department of Fish and Game
International North Pacific Fisheries Commission
Embassy of Italy
Kodiak Community College
Embassy of Korea
Lane County General Administration, Oregon
Los Angeles County Department of Consumer Affairs
Los Angeles Harbor Department
Marine Resources Commission
Moss Landing Marine Laboratory
Northwest Indian Fisheries Commission
University of Oregon
State of Oregon, Joint Committee on Trade
Oregon Department of Fish and Wildlife
Oregon Department of Energy
Oregon Land Conservation and Development Commission
Oregon State University
Oregon State University, Sea Grant
Pacific Marine Fisheries Commission
University of Rhode Island, Center for Ocean Management Studies
San Diego Unified Port District
San Diego State University, Center for Marine Studies
Scripps Institution of Oceanography, University of California
University of Southern California, Law Center
University of Washington
Washington Sea Grant Program
Washington Department of Fisheries

Other Agencies and Organizations

Alaska Packers Association
American Tunaboat Association
Aquatic Research Institute
Associated Sportsmen of California
British Columbia Packers
California Aquaculture Association
California Seafood Institute
Commercial Fishermen of California
Economic Development Council, Fisheries Development
Environmental Defense Fund

Fisherman and Allied Works Union, San Pedro
Fishermans Union of America, San Pedro
Fishermens Co-operative Association, San Pedro
Golden State Trollers, Inc.
Grays Harbor Gillnetters
Halfmoon Bay Fishermens Marketing Association
Halibut Association of North America
International Gamefish Association
Japan Trade Center
Klamath River/Trinity River Coalition, Inc.
Living Marine Resources, Inc.
Mission Bay Marlin Club
Moss Landing Fishing Association
National Coalition for Marine Conservation
National Fisheries Institute
National Wildlife Federation
Northern California Council of Fly Fishing Clubs
Oregon Coastal Zone Management Association, Inc.
Oregon Shores Conservation Coalition
Oregon Wildlife Federation
Otter Trawl Commission of Oregon
Pacific Biological Marine Labs
Pacific Coast Federation of Fishermens Associations, Inc.
Pacific Gas and Electric Co.
Pan-Pacific Fisheries
Peter Pan Seafood
Purse Seine Vessel Owners Association
Quinault Tribal Office
Redwood Region Economic Development Commission
Salmon Trollers Marketing Association, Inc.
San Diego Sportfishing Association
South Carolina Marine Resources Center
Sportfishing Association of California
Sportsmen's Council of Central California
Star-Kist Foods, Inc.
Washington Trollers Association
West Coast Professional Fishermans Union

11.1 List of Preparers

NAME	QUALIFICATION	SECTION OF DOCUMENT
Herbert Frey (CDFG)	M.A. Biology	FMP
Jay Ginter (NMFS)	M.S. Marine Biology	EIS,RIR
Daniel Huppert (NMFS)	Ph.D. Economics	All
Alec MacCall (NMFS, CDFG prior to 10/82)	M.A. Biology	All
Richard Methot (NMFS)	Ph.D. Oceanography	All
Gary Stauffer (NMFS)	Ph.D. Fishery Biology	FMP
Cindy Thomson (NMFS)	M.A. Economics	EIS,RIR

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