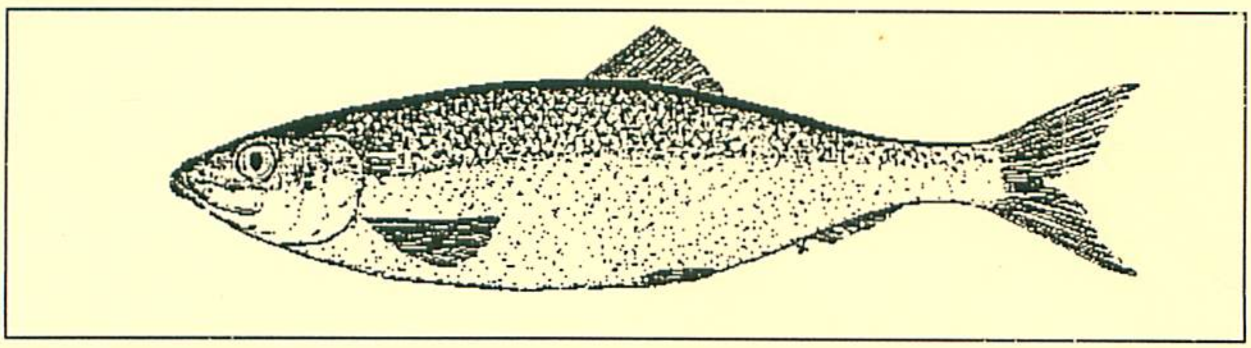
OTA

FINAL

ENVIRONMENTAL DOCUMENT

PACIFIC HERRING COMMERCIAL FISHING REGULATIONS

(Sections 163, 163.5, and 164, Title 14, California Code of Regulations)



1998
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF FISH AND GAME

ENVIRONMENTAL DOCUMENT
COMMERCIAL HERRING FISHERIES
TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SUMMARY

S.1 Introduction

This draft environmental document (DED) provides the review and analysis required by California Environmental Quality Act (CEQA) Guidelines to assist the State's Fish and Game Commission in regulating the commercial harvest of Pacific herring throughout ocean and estuarine waters. Specifically, the DED reviews and evaluates proposed regulations and selected alternatives for the 1998-99 fishing season. A Notice of Preparation (NOP) was used to identify and incorporate concerns and recommendations of the public into the review and analysis of commercial herring regulation options.

The DED, a functional equivalent of an Environmental Impact Report, includes seven chapters. Chapter 1 discusses the authorities and responsibilities under which the DED was developed and describes its intended use. Chapter 2 describes the proposed project and alternatives for regulating the commercial harvest of herring. The existing environment is described in Chapter 3. The impacts of the proposed project are described in Chapter 4. Cumulative impacts are considered separately in Chapter 5. The alternatives to the proposed project including the "no project" alternative are assessed in Chapter 6. Chapter 7 identifies consultations. References used throughout the DED are listed in the Literature Cited section.

Based on the analysis in this DED, the proposed project is identified as the preferred alternative because it provides a set of regulations most likely to achieve the State's policy with respect to the conservation, maintenance and utilization of the Pacific herring resource.

S-2 Proposed Project

The proposed project is a body of recommended regulations governing the commercial harvest of herring for roe products, the harvest of herring eggs-on-kelp, and the harvest of herring for fresh food, bait, and pet food. The proposed project takes the form of recommendations for continuation, amendment, or change to an existing body of regulations in effect since 1997 (Sections 163 and 164, Title 14, California Code of Regulations (CCR)).

The commercial harvest of herring in California has been provided for by either Legislative or Fish and Game Commission regulatory action for over 100 years. The dominant product from the fishery has changed considerably over time with herring roe providing the dominant product at present. The herring roe fishery has been intensively regulated since its inception in the early 1970's. The proposed project has evolved, in large part, as a consequence of prior regulatory action.

The proposed project will establish fishing quotas by area and permit type for the 1998-99 herring fishing season, based on the most recent assessments of the spawning populations of herring in San Francisco and Tomales bays. Other changes relating to seasons, permittee qualifications, permit applications, the use of round haul gear, notice of kelp suspension, herring buyer's permits and penalties are recommended to improve the clarity of the regulations or provide for the efficient harvest and orderly conduct of the fishery and for the protection of the resource.

The specific changes recommended for the 1998-99 season will: provide three alternative fishing quotas for San Francisco Bay: 4,000 tons, 3,000 tons, and no fishery (20 percent, 15 percent, and zero percent of the estimated spawning biomass for the 1997-98 season); provide an initial 90-ton fishing quota for Tomales Bay with provisions to increase the quota in season if escapement goals are achieved by February 15, 1999; delete the requirement to validate permits each season, and delete penalties for not validating a permit; set the dates of the roe herring fishery in Tomales Bay from 5:00 p.m. on Sunday, January 3, 1999 to noon on Friday, March 12, 1999; set the dates of the roe herring fisheries in San Francisco Bay from noon on Wednesday, December 2, 1998 to noon on Tuesday, December 22, 1998 ("DH" gill net platoon only), and from 5:00 p.m. on Sunday, January 3, 1999 to noon on Friday, March 12, 1999; remove all subsections of the regulations related to the use of round haul gear to take herring in San Francisco Bay, and all penalties specific to the use of round haul gear in the roe herring fishery; remove herring eggs on kelp quotas for individuals possessing round haul permits, since existing regulations provide that all San Francisco Bay round haul permits will be converted to gill net permits prior to the 1998-99 season; provide a means for changing the information given during a notice of kelp suspension if conditions change after notice has been given; delete the word "primary" from the listing of the type of license required for a herring buyer's permit, so that the name of the license is consistent with the name in the Fish and Game Code; and modify Section 163.5 to make the list of fish that cannot be taken while herring fishing consistent with the list in Section 163.

Other aspects of the regulations will remain unchanged. The regulations govern commercial herring activity in five geographically distinct areas. Withing these areas, several types of fishing activity can occur that produce distinctive products.

S.3 Project Alternatives

Three alternatives are considered; however, most take the form of additional proposals for modification of existing regulations. These alternatives include: 1) a no project alternative; 2) using existing regulations; and 3) establishing individual vessel quotas for gill net vessels in the herring roe fishery.

S.4 Existing Environment

The existing environment potentially affected by the proposed project and alternatives include the open ocean and bays in which herring occur. However, the environments most likely to be affected are the five geographically separate areas that actually support commercial herring fishing activity.

The open ocean harvest of herring for bait and pet food occurs primarily within Monterey Bay; however, harvest is permitted from the Monterey Bay area north to the California-Oregon border. The open ocean off-bottom (pelagic) habitat used by herring is characterized by complex alongshore currents that show marked seasonal phases. The animals and plants in this habitat also show marked seasonal changes in distribution and abundance. The herring landed in the Monterey Bay (open ocean) fishery account for only a small proportion (<2%) of the total herring commercial harvest.

Most commercial harvest of herring occurs in four isolated bays and estuaries in California and ultimately provides sac-roe as food. Herring use these bays and estuaries as spawning grounds. Landing herring taken from the spawning grounds provides the highest quality product, most of which is exported to Japan.

Bays and estuaries, in general, share factors and processes that provide for a highly variable environment. For example, two current systems, fresh water outflow and oscillating tidal current, meet and exert variable effects upon sedimentation and water mixing. Animal and plant distribution and abundance are, as a consequence, also highly variable.

San Francisco Bay has supported the largest of these fisheries. The Tomales Bay area supports a moderate herring roe fishery, while both Humboldt Bay and the Crescent City area support small herring roe fisheries. A very diverse assemblage of organisms utilize both the estuarine environment and the herring resource, including marine mammals, birds, and some fish species.

S.5 Environmental Impacts

S.5.1 Proposed Project

A preliminary assessment by the California Department of Fish and Game of potential impacts from existing commercial harvest of herring in each geographical area identified several areas of potential concern. The potential impacts varied with fishing intensity and geographical area. The area with the highest potential for impacts was the highly urbanized San Francisco Bay area that, coincidentally, supports the largest herring roe fishery in the State. Environmental impact assessment focused on this area.

Localized, short-term, and less than significant impacts were identified for several areas of potential concern including: boat and vehicle traffic circulation, water quality, air quality, housing and utilities, geology, scenic quality, recreation, and noise.

The greatest potential for significant environmental impact was deemed to be in the area of biology. Potential biological impacts were divided into two types: 1) direct harvest impacts and 2) trophic level (food web) impacts.

Potential direct harvest impacts included: 1) the effect of incidental take of other fish species, 2) the effect on fish resources from "ghost" net fishing, 3) the effect on herring stocks from regulating fisheries without stock assessment efforts, 4) the effect on all herring resources if non-harvest mortality (illegal and unreported harvest and natural mortality) exceeded assumed high natural mortality rates used in computer simulations.

Direct harvest impacts were considered to be localized, short-term, and less than significant. Mitigation of the potential long-term impacts on the herring resource from stock collapse is provided by the implementation of current management strategies and assessment techniques. Current management strategy sets harvest quotas (less than 20% of spawning population size) at a level that modeling indicates will provide for a sustained harvest. Use of spawn escapement and hydroacoustic assessment techniques provides data on trends in population size. Data obtained from these stock assessment techniques should herald any decline before the potential for a significant impact can be realized.

The harvest of herring also has the potential to affect a wide variety of species connected to herring through food web relationships. The abundance of herring, the relative abundance of predators, their proximity, predator food preferences, and competitive interactions all play a role in determining the importance of herring as prey. Generally, predator-prey systems in the marine environment that include top carnivores are stable because the system is relatively complex, the prey base is relatively broad, and the carnivores are capable of searching large areas.

No significant or long-term impacts to marine mammal, bird, or fish populations were identified associated with the commercial harvest of herring. The recognized herring predator populations were either increasing in size or have been found to be limited by factors other than food availability. However, individual predators may be affected to the extent that reduced herring availability influences search effort, prey selection, or capture effectiveness. These potential short-term, localized impacts to individuals are expected to be less than significant when considering impacts to populations.

S.5.2 Alternatives

Alternative 1 (no fishery)

Localized, short-term, and less than significant impacts to vessel and vehicle traffic circulation, water quality, air quality, housing and utilities, scenic quality, recreational opportunities, and noise levels identified for the proposed project would be eliminated or redistributed in an unpredictable manner.

Potential biological impacts associated with a no project alternative include an increased rate of natural mortality, the potential for deterioration in the condition of the herring population as it reaches carrying capacity, and potential impacts to other species that compete with herring for food resources.

Alternative 2 (existing regulations)

In most regards, the environmental impacts will be comparable to those of the proposed project. However, existing regulations do not address certain fishery-related problems considered in amendments or changes to existing regulations. For example, if the San Francisco Bay quotas were not reduced, fishing mortality would be incrementally higher and the potential impact to the resource greater.

Alternative 3 (individual vessel quota)

Individual vessel quotas, rather than the platoon-based quota system currently used in the herring roe gill net fishery, would add incrementally to most impacts due to longer actual fishing seasons. The operating incentive would direct effort toward higher quality (e.g. higher percentage roe content) rather than quantity. However, these impacts are still expected to be short-term, localized, and less than significant for most environmental categories.

Wastage of resource could result from sorting to remove males from the catch to achieve higher roe content (and higher prices). However, fewer illegal nets are likely to be lost, reducing impacts from "ghost" net fishing.

S.5.3 Cumulative

A variety of factors have the capacity to influence Pacific herring population status in California in addition to the proposed project including: 1) biological events, 2) competitive interactions with other pelagic fish and fisheries, 3) oceanographic events, 4) habitat loss, and 5) water quality.

The potential for overfishing with concomitant stock reduction (stock collapse) associated with the on-going commercial harvest of herring was assessed using a computer simulation model. The model assumed a relatively high natural mortality rate ($M = 0.4$) for most simulations. If actual natural mortality exceeds the assumed rate, the assessment of the potential long-term impacts from use of the selected harvest strategy may not be valid. Several of the factors mentioned above can elevate natural mortality. Whether these factors could actually occur and what impact they might have on natural mortality rates is largely conjectural. However, as with potential impacts from the on-going commercial harvest of herring, continued monitoring of the herring resource should herald any directional trends long before the stocks reproductive potential would be jeopardized.

S.6 Areas of Controversy

The following areas of controversy have been identified regarding commercial herring fishing:

1. Potential interactions between marine mammals and commercial fishing activities;
2. Importance of herring as a forage species for sea birds, marine mammals, and

other fishes;

3. Inadequate knowledge of the resource;

4. Errors in stock assessment;

5. Insufficient management resources;

6. Potential impact of unforeseen events or catastrophes (e.g. oil spills; chemical spills).

S.7 Issues to be Resolved

At issue is whether or not to provide for commercial fishing as an element of herring management in California. If commercial fishing is authorized, decisions are needed to specify the areas, seasons, fishing quotas and other appropriate special conditions under which fishing operations may be conducted. This document includes a review and discussion of the proposed project as well as alternatives.

Chapter 1. INTRODUCTION

1.1 Background

Existing commercial fishing regulations enacted by the State Legislature and Fish and Game Commission (Commission) provide for the harvest of Pacific herring (herring) and their eggs (roe). Herring have been harvested in California for a variety of commercial purposes since at least the mid-1800's (Spratt 1981 [1]). Early commercial harvest (prior to 1916) was minor and directed toward human consumption. From 1916 through 1919 herring were also harvested for their oil and reduced to meal (Scofield 1918). This use was prohibited in 1919 and the fishery for human consumption and bait has continued. [1]

In 1965, a new use for California herring products developed when Japan began importing herring eggs attached to seaweed for human consumption. In 1973, Japan began importing herring roe from California. Both products are Japanese delicacies. Regulated harvest of herring eggs on seaweed and herring roe has occurred every year since 1973.

The environmental document presented here provides the review and analysis necessary to aid the Commission in taking action to regulate the commercial harvest of herring in California and was prepared using the California Environmental Quality Act (CEQA) Guidelines. The project to be considered is the proposed regulations and selected alternatives for the 1998-99 herring fishing season.

The Department and Commission hold the public trust for managing the State's wildlife populations, including herring. That responsibility is fulfilled by a staff of experts including

[1]The author(s) and the year or publication cited in text can be used to locate complete reference in Literature Cited found in pp L1-15 following text.

experts in marine resource management and enforcement issues related to California's herring resource. The knowledge and training represented by that expertise qualifies them to perform the review and analysis of proposed commercial herring harvest regulations contained in this document.

1.2 The Functional Equivalent

CEQA requires all public agencies in the State to evaluate the environmental impacts of projects that they approve or carry out. Most agencies satisfy this requirement by preparing an Environmental Impact Report (EIR) if there are potentially significant environmental impacts. If no potentially significant impacts exist, a Negative Declaration (ND) is prepared. However, an alternative to the EIR/ND requirement exists for State agencies with activities that include protection of the environment as part of their regulatory program. Under this alternative, an agency may request certification of its regulatory program from the Secretary for Resources. With certification, an agency may prepare functional equivalent environmental documents in lieu of EIRs or NDs. The regulatory program of the Fish and Game Commission has been certified by the Secretary for Resources. Therefore, the Commission is eligible to submit an environmental document in lieu of an EIR (CEQA Guidelines Section 15252).

1.3 Scope of Environmental Document

This environmental document contains a description of the proposed project and its environmental setting, potential effects of the proposed project, and reasonable alternatives to the project. It also addresses cumulative impacts and provides a discussion of mitigation of adverse environmental effects related to the proposed project and alternatives. In addition, it considers relevant policies of the Legislature and Commission. This environmental document presents information to allow a comparison of the potential effects of reasonable alternatives. All alternatives may not achieve the project's objectives equally well. They are presented to provide the Commission and the public with additional information related to the options available. Both harvest and non-harvest alternatives are considered.

The Department prepared and distributed a notice of preparation (NOP). Specific alternatives to the proposed project and additional information were developed to address the issues raised in response to the NOP.

1.4 Intended Use of the Environmental Document

This environmental document has been prepared to assess the potential impacts of the commercial harvest of herring in California. It has been prepared pursuant to the California Environmental Quality Act (CEQA, Public Resource Code Section 21080.5) and the CEQA Guidelines (Title 14, California Code of Regulations, Section 15250). The document fully discloses potential impacts of the proposed project to aid the Commission in the decision-making process and to inform the public. Although a wide range of issues are addressed, this document is intended to be the environmental document analyzing the potential effects of the proposed and alternative actions related to the commercial harvest of herring.

Analysis of commercial herring harvest projects in future seasons may refer to and incorporate by reference information contained in this document. That analysis may not involve the preparation of environment documents similar to this; but, may include updates to this document. If substantial changes occur in the project itself or in the environmental conditions affected by the regulations, a supplemental or subsequent environmental document would be prepared (Wildlife Alive et al. v. Chickering et al. (1976) 18 Cal.3d 190 [132 Cal. Rptr. 377, 553 p.2d 537]).

1.5 Authorities and Responsibilities

The Legislature formulates the laws and policies regulating the management of fish and wildlife in California. The State's policy with respect to aquatic resources is to encourage the conservation, maintenance and utilization of the living resources of the ocean and other waters under the jurisdiction and in-fluence of the State for the benefit of all the citizens of the state. It is also the State's policy to promote the development of local fisheries and distant-water fisheries based in California in harmony with international law respecting fishing and the conservation of the living resources of the oceans and other waters under the jurisdiction and influence of the State (Section 1700, Fish and Game Code, Appendix 1). This policy includes the following objectives:

The maintenance of sufficient populations of all species of aquatic organisms to insure their continued existence;

- The recognition of the importance of the aesthetic, educational, scientific, and nonextractive recreational uses of the living resources of the California Current;
- The maintenance of a sufficient resource to support a reasonable sport use, where a species is the object of sport fishing, taking into consideration the necessity of regulating individual sport fishery bag limits to the quantity that is sufficient to provide a satisfying sport;
- The growth of local commercial fisheries, consistent with aesthetic, educational, scientific, and recreational uses of such living resources, the utilization of unused resources, taking into consideration the necessity of regulating the catch within the limits of maximum

sustainable yields, and the development of distant-water and overseas fishery enterprises;

- The management, on a basis of adequate scientific information promptly promulgated for public scrutiny, of the fisheries under the state's jurisdiction, and the participation in the management of other fisheries in which California fishermen are engaged, with the objective of maximizing the sustained harvest; and

- The development of commercial aquaculture.

The Legislature provides further policy direction regarding herring management in sections 8550 through 8559, Fish and Game Code (Appendix 1). The Legislature delegated authority to the Commission, whose members are appointed by the Governor, to regulate the commercial harvest and possession of herring (section 8553). The remaining code sections provide for a limited entry fishery and require periodic review of regulations and policies. The Commission holds public meetings at its discretion to consider and adopt revisions to these regulations. Recommendations and comments from the Department, other agencies and the public are received typically at two public meetings each year (June and August).

Chapter 2. PROJECT DESCRIPTION

2.1 Project Objectives

The proposed project is the regulation of Pacific herring fisheries under the State's jurisdiction. The regulations are considered for inclusion in the California Code of Regulations (CCR) to implement the State's policies for managing the commercial use of Pacific herring [Sec 1.5 [2]]. The proposed project and alternatives take the form of recommendations for continuation, amendment, or change to an existing body of regulations (Sections 163, 163.5, and 164, Title 14, CCR). The recommendations and alternatives are based on biological assessments of existing stock conditions and comments received from interested individuals, commercial fishermen, and from the Director's Herring Advisory Committee. The California Fish and Game Commission, whose members are appointed by the Governor, has legislatively delegated authority to act on these recommendations.

Project objectives include:[2]

- maintaining healthy Pacific herring stocks in California;
- controlling commercial use of Pacific herring at optimal levels;
- providing sufficient Pacific herring to support recreational uses; and
- providing sufficient Pacific herring to conserve living resources of the ocean that use herring.

Under existing law, herring may be taken for commercial purposes only under a revocable permit, subject to such regulations as the Commission shall prescribe. Current regulations

---

[2] In the sections to follow, references will be provided linking pertinent points in this document. The linking will reference appropriate subsection numbers within brackets ([#,#,#,]).

specify: permit qualifications, permit validation requirements, permit limitations, permit areas, seasons, fishing quotas, gear restrictions, and landing and monitoring requirements.

In addition to these regulations, the proposed project includes recommendations for amendments to existing regulations to establish fishing quotas by area and gear type for the 1998-99 herring fishing season. Quota recommendations for San Francisco Bay and Tomales Bay are based on the most recent assessments of the size of the spawning populations of herring in those areas. Other recommendations suggest new regulations to improve the efficient and orderly conduct of herring fisheries.

2.2 Project Locations

Permits have been issued for commercial herring fishing in five geographically distinct areas of the ocean and estuarine waters under the jurisdiction of the state of California (Figure 2.1). Many of the regulations considered by this document are specific to an area and type of fishing operation. Within each broad geographical fishing area, additional regulations may further limit the area fished. This section describes each area, including current commercial uses for herring, proposed seasons and quotas for those uses, and any geographical restrictions on those uses. A more complete description of the environmental setting for each geographical fishing area is provided in Section 3.3. (Specific Biological and Environmental Descriptions).

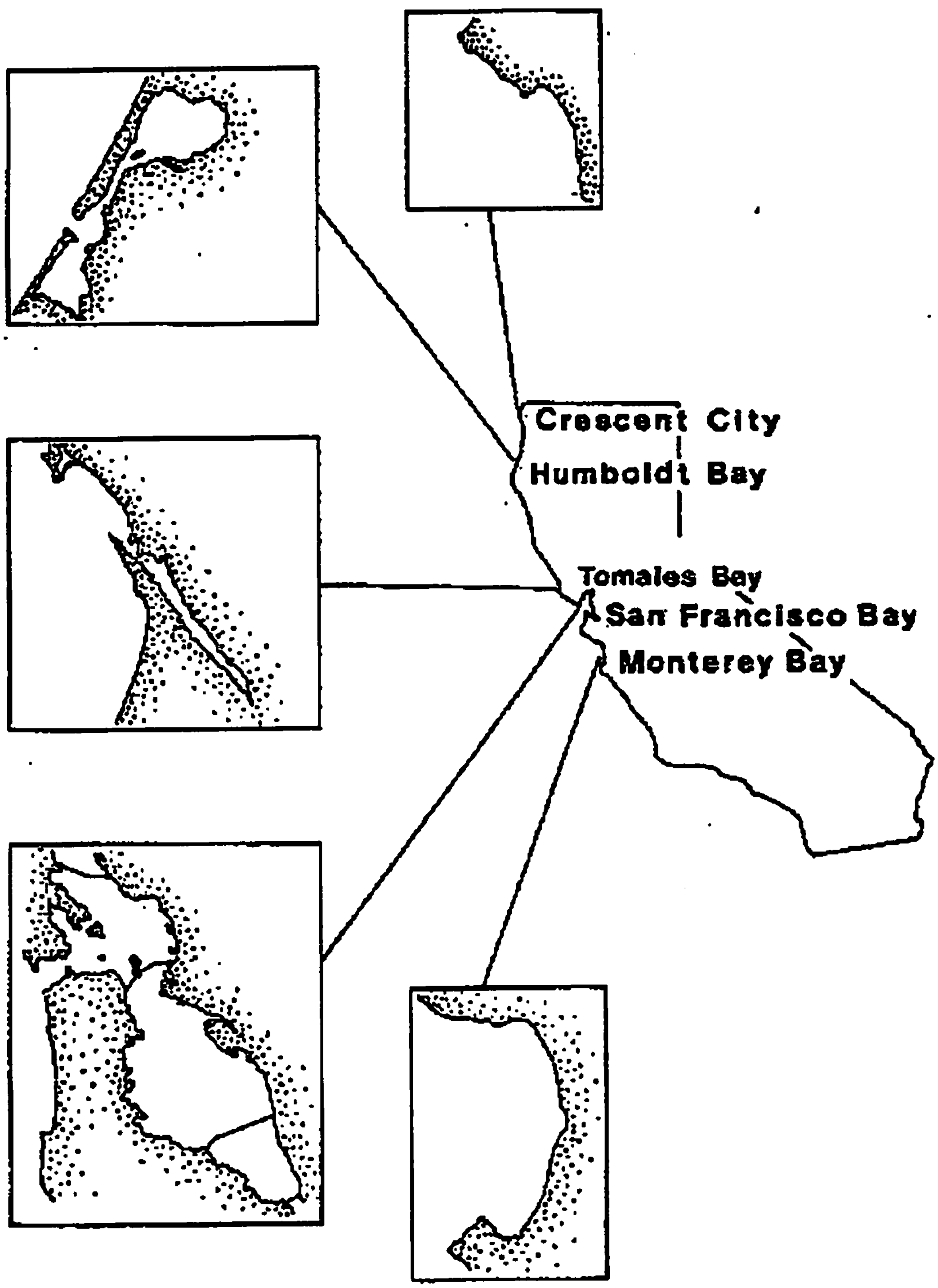


Figure 2.1. Locations of commercial herring fisheries

2.2.1 Ocean Waters

Use: bait and animal food

Season: April 1 to November 30 (Pigeon Point, San Mateo County south to Yankee Point, Monterey County)

April 1 to October 31 (Pigeon Point, San Mateo County north to the California-Oregon boarder)

Quota: no limit

Area: ocean waters of District 6 (excluding the Crescent City area), 7, 10 (excluding Tomales Bay), 16, and 17

note: see District descriptions in Appendix 2

2.2.2 San Francisco Bay

2.2.2.1 Herring Roe Fishery

Season: noon on December 2 until noon on December 22, and 5:00 p.m. on January 3 until noon on March 12.

note: herring fishing is not permitted from noon Friday through 5:00 p.m. Sunday.

Gill net permittees (DH) December 2-4, December 6-11, December 13-18, December 20-22, and, if necessary, after other platoons have reached their quotas until DH quota is reached or last day of season.

Gill net permittees (Even #) January 3-8, January 17-22, January 31-February 5, February 14-19, February 28- March 5.

Gill net permittees (Odd #) January 10-15, January 24-29, February 7-12, February 21-26, March 7-12.

Quota: 20 percent exploitation rate 3,980 tons for gill net permittees.

15 percent exploitation rate 2,980 tons for gill net permittees.

Zero percent exploitation rate No fishery.

note: the overall quota for the roe fishery will be reduced by transfers to the eggs-on-kelp fishery.

Area: Waters of Districts 12 and 13 and that portion of District 11 lying south of a line extending from Peninsula Point (the most southerly extremity of Belvedere Island) to the easternmost point of the Sausalito ferry dock.

1) Regulations prohibit the setting or operating of nets within 300 feet of the following piers and recreation areas: Berkeley Pier, Paradise Pier, San Francisco Municipal Pier between the foot of Hyde Street and Van Ness Avenue, Pier 7 (San Francisco), Candlestick Point State Recreation Area, the jetties in Horseshoe Bay, and the fishing pier at Fort Baker. Regulations also prohibit the setting or operating of nets within 70 feet of Mission Rock Pier.

2) Regulations prohibit the setting or operating of nets in Belvedere Cove north of a line drawn from the tip of Peninsula Point to the tip of Elephant Rock. Regulations also prohibit the setting or operating of gill nets from November 30 through February 15 in the area bounded by a line drawn from the middle anchorage of the western section of the Oakland Bay Bridge (Tower C) to the Lash Terminal buoy #5 to the easternmost point at Hunter's Point (Point Avisadero), from Point Avisadero to the Y"A" buoy, from the Y"A" buoy to Alameda NAS entrance buoy #1 (entrance to Alameda Carrier Channel) to the Oakland Harbor Bar Channel buoy #1, and then to from the first Bar Channel buoy to Tower C of the Bay Bridge.

2.2.2.2 Herring Eggs-On-Kelp Fishery

Season: December 1 to March 31

Quota: 20 percent exploitation rate an individual quota of 7.0 tons for transferred "CH" permits, an individual quota of 1.9 tons for transferred gill net permits.

15 percent exploitation rate an individual quota of 5.3 tons for transferred "CH" permits, an individual quota of 1.4 tons for transferred gill net permits.

Zero percent exploitation rate No fishery.

note: the combined quota for harvest of herring eggs-on-kelp depends on the number of "CH" and gill net permits transferred to the herring eggs-on-kelp fishery.

Area: Waters of Districts 11, 12, and 13, and that portion of District 2 known as Richardson Bay.

note: the area open to the herring eggs-on-kelp fishery is further restricted. Rafts and lines may not be placed in any waters or areas otherwise closed or restricted to the use of herring gill net operations, except the areas known as Belvedere Cove and Richardson Bay or except where written permission is granted by the owners or controlling agency (e.g., Navy, Coast Guard). When rafts or lines are placed in Belvedere Cove or Richardson Bay, they must be tied to a permanent structure (e.g. pier, dock).

2.2.2.3 Fresh Food Fishery (not for roe purposes)

Season: November 2 through November 29 and April 1 through October 31.

Quota: 20 tons

note: no permittee may take or possess herring except in the amount specified on a current daily market order, not to exceed 500 pounds, from a licensed fish dealer.

Area: Same as herring roe fishery

2.2.3 Tomales Bay

2.2.3.1 Herring Roe Fishery

Season: 5:00 p.m. on January 3 until noon on March 12.

note: herring fishing is not permitted from noon Friday through 5:00 p.m. Sunday.

Quota: The total take of herring for roe purposes shall not exceed 90 tons for the season. However, if spawning escapement, as determined by the Department, reaches or exceeds 1,590 tons prior to February 15, the quota shall be increased as follows: 1) if spawning escapement is more than 1,590 tons, the total take of herring shall not exceed 190 tons for the season; 2) if spawning escapement is more than 2,590 tons, the total take of herring shall not exceed 290 tons for the season; 3) if spawning escapement is more than 3,590 tons, the total take of herring shall not exceed 390 tons for the season; and 4) if spawning escapement is more than 4,590 tons, the total take of herring shall not exceed 490 tons for the season. The total take of herring for the fresh fish market shall not exceed 10 tons per season.

Area: Tomales Bay includes the waters of District 10 lying south of a line drawn west, 252° magnetic, from the western tip of Tom's Point to the opposite shore.

2.2.3.2 Fresh Food Fishery (not for roe purposes)

Season: November 2 through November 29 and April 1 through October 31.

Quota: 10 tons

note: no permittee may take or possess herring except in the amount specified on a current daily market order, not to exceed 500 pounds, from a licensed fish dealer.

Area: Same as herring roe fishery.

2.2.4 Humboldt Bay

Use: herring roe

Season: noon January 2 until noon March 10.

Quota: 60 tons

Area: waters of Districts 8 and 9.

2.2.5 Crescent City Area

Use: herring roe

Season: noon January 15 until noon March 24.

Quota: 30 tons

Area: Crescent City Harbor and waters of District 6 less than 20 fathoms in depth between two nautical measure lines drawn due east and west true from Point Saint George and Sister Rocks.

2.3 Project Characteristics

Pacific herring are schooling fish that are generally captured for commercial purposes by using entangling or encircling nets. The proposed project recommends continuation of the existing regulations as modified by those changes discussed below to control the commercial harvest of herring to a level that meets the state's policy with respect to the use of aquatic resources. This section states the specific purpose of the regulations and summarizes the factual basis for the regulation.

The commercial herring roe and eggs-on-kelp fisheries are closely regulated through a catch quota system to provide for adequate protection and utilization of the herring resource. The Department conducts annual assessments of the size of the spawning population of herring in San Francisco and Tomales Bays [Sec 3.2.2.1]. These data serve as the basis for establishing fishing quotas for the next season. In addition, annual management recommendations to improve or provide for the efficient harvest and orderly conduct of the herring fisheries are solicited from interested fishermen and individuals at public meetings and from the Director's Herring Advisory Committee, which is composed of various representatives from the commercial herring fishing industry. The following proposed amendments to Section 163, 163.5 and 164, Title 14, CCR, reflect both Department and public recommendations.

Annual assessments of the size of the herring spawning populations in San Francisco and Tomales Bays are conducted by the Department, using both hydroacoustic and spawning ground surveys. Hydroacoustic surveys use sound transmitted from a transducer on a boat and record returning echoes to determine the size and density of fish schools [Sec 3.2.2.1.2]. Spawning ground surveys assess the total number of eggs spawned and back calculate the parental population size [Sec 3.2.2.1.1]. Annual fishing quotas are conservative and limit the total commercial catch to no more than 20% (exploitation rate) of the previous season's spawning biomass. This exploitation level was selected, based on computer simulations [Sec 3.2.4], to help ensure adequate protection for the herring resource and to provide for the long-term yield of the fishery. However, quotas are not determined by a fixed mathematical formula, but are modified based on additional biological and fishery data collected each season, such as growth rates, strength and importance of individual year-classes, and recruitment of incoming year-classes.

The 1997-98 El Niño is one of the strongest on record, and strongly affected California's herring stocks. El Niño events are generally characterized by elevated water temperatures and nutrient-depleted water masses which result in reduced ocean productivity and prey availability. El Niño conditions can result in reduced survival rates, growth rates, and condition factor of herring. In addition, the warm water temperatures associated with El Niño events can cause the distribution of herring stocks to temporarily shift north of their normal spawning grounds.

By late October 1997, upwelling had declined off central California and temperatures had increased in nearshore waters. This change in oceanographic conditions had a significant effect on the San Francisco Bay herring stock: (1) the 1997-98 spawning biomass estimate for San Francisco Bay was 20,000 tons (including catch), 22 percent of last season's estimate of 89,570 tons and far below anticipated levels; (2) the weight of the herring at any given length was below normal; (3) many of the herring that entered the bay were not in spawning condition; and (4) many females were reabsorbing their eggs.

At present, El Niño conditions are subsiding at the equator. However, at this time, it is not clear how quickly waters off California will change when the El Niño event ends. A clearer picture should be available by August.

Due to the uncertainty that currently exists regarding the continuing effects of the 1997-98 El Niño event, three alternative fishing quotas are proposed for San Francisco Bay: (1) 4,000 tons, which is 20 percent of the 1997-98 spawning biomass estimate; (2) 3,000 tons, which is 15 percent of the 1997-98 spawning biomass estimate; and (3) no fishery. The 4,000-ton quota alternative takes into account the extremely low biomass estimate, and yet recognizes the strength of the 1992, 1993, 1994, and 1995 year-classes. It would be most appropriate if local effects of the El Niño event subside rapidly and ocean productivity is good through the spring and summer. The 3,000-ton quota alternative takes into account the extremely low spawning biomass estimate, and it would be most appropriate if the local effects of the El Niño event don't subside until the summer. The no-fishery alternative would be most appropriate if local effects of the El Niño event continue unabated. This alternative recognizes the potential for increased natural mortality and displacement due to El Niño conditions which may result in a significant decline in the size of the spawning biomass.

Within the overall quota in San Francisco Bay, separate quotas are established for each gill net platoon (i.e., fishing groups). The overall quota is divided among the three platoons in proportion to the number of permits in each platoon. Slight annual adjustments in the quota assignments for each gill net platoon are needed to account for attrition of permittees and the use of herring permits in the herring eggs on kelp fishery.

The 1997-98 spawning biomass estimate for Tomales Bay is 586 tons, down 60 percent from last season's estimate of 1,469 and well below the 5-year average of 2,820 tons. No clear trend is evident for spawning biomass since the reopening of the Tomales Bay herring fishery in the 1992-93 season. Heavy rains during the 1997-98 season drastically reduced salinity levels in the Bay and most likely inhibited spawning. The Department recommends continuing the existing conservative management regime and proposes an initial fishing quota of 90 tons (15 percent of the 1997-09 spawning biomass estimate). The proposed regulations also contain provisions to increase the quota based on in-season estimates of spawning escapement. If escapement goals are achieved prior to February 15, 1999, then the quota would be increased with the amount of the increase dependant on the level of escapement. If spawning escapement does not exceed 1,590 tons prior to February 15, 1999, then no additional fishing quota would be provided.

Season opening and closing dates for San Francisco and Tomales bays, as well as the dates of various provisions of the regulations, are adjusted each year to account for annual changes in the calendar. The consensus of the Director's Herring Advisory Committee was to set the dates of the roe herring fisheries in San Francisco Bay from noon on Wednesday, December 2, 1998 to noon on Tuesday, December 22, 1998 ("DH" gill net platoon only), and from 5:00 p.m. on Sunday, January 3, 1999 to noon on Friday, March 12, 1999. This season the consensus among Tomales Bay permittees was to recommend opening at 5:00 p.m. on Sunday, January 3, 1999 and closing at noon on Friday, March 12, 1999.

Existing regulations require that permittees validate their roe herring permits each year by landing herring or by demonstrating intent to fish during the next season. This requires permittees to fish when biomass and quotas are low and when prices are low. The proposed amendments remove validation requirements and penalties for not validating a permit.

Existing regulations provide that all San Francisco Bay round haul permits will be converted to gill net permits prior to the 1998-99 season. Therefore, the proposed amendments remove all subsections of the regulations related to the use of round haul gear for herring in San Francisco Bay, and all penalties specific to the use of round haul gear in the roe herring fishery. Subsection 163(f)(2) provides gear specifications and limits where gill nets and round haul nets can be used. The proposed amendment prohibits the use of round haul nets to take herring in San Francisco Bay and clarifies that round haul nets may be used to take herring in ocean waters with an ocean waters permit. Existing regulations specify that herring taken with an ocean waters permit may not be sold for roe purposes; this remains unchanged.

Under subsection 163(j), a current "primary fish receiver's license" is needed to obtain a herring buyer's permit. The correct name for the license is a fish receiver's license (Fish and Game Code Section 8033). This amendment makes the name in the regulations consistent with the name in the code and clarifies the type of license that is needed.

Subsection 163.5(f)(2)(B)6 refers to a violation of subsection 163(e)(6) regarding the incidental take of fish other than herring. The proposed amendment makes subsection 163.5(f)(2)(B)6 consistent with subsection 163(e)(6):

Subsection 164(j)(3) specifies that a herring eggs on kelp permittee must notify the Department at least 12 hours prior to harvesting herring eggs on kelp on a weekday and give the following information: a description and point of departure of the vessel that will be used, the location of each raft and line, an estimated time for beginning each operation, and the time and location of off-loading product. Herring eggs on kelp permittees have stated that the herring school may move or weather may change during the 12 hours after they have notified the Department, and thus they may want to move a raft or change the time of harvesting or change the off-loading location. The permittees have requested that the regulations provide a means for changing the information provided if conditions change after notice has been given. The proposed modifications to the subsection are an effort to fulfill this request.

2.4 Project Alternatives

Three alternatives are considered in addition to the preferred alternative (proposed project). Although considered as separate alternatives, most alternatives take the form of additional proposed changes to the existing regulations that could feasibly be joined. In evaluating alternatives, the comparative merits and impacts of individual alternatives that could be logically and feasibly joined should be considered as so joined unless otherwise stated. The alternatives to be considered are as follows:

- Alternative 1 (no project alternative). Under this alternative, the commercial harvest of herring would be prohibited.
- Alternative 2 (existing regulations). Under this alternative, existing regulations would be modified only by adjusting quotas to reflect current biomass estimatesand by adjusting dates to reflect changes in the calendar.
- Alternative 3 (individual vessel quota for gill net vessels in herring roe fishery). Under this alternative the proposed regulations would be modified by establishing an individual vessel quota for all gill net vessels. The proposed individual gill net vessel quota would equal the overall gill net quota divided by the number of permittees using gill net gear.

The following section states the specific purpose of the alternatives and summarizes the factual basis for determining that the alternatives are reasonably necessary.

2.4.1 Alternative 1 (no project)

This is a CEQA required alternative.

2.4.2 Alternative 2 (existing regulations)

The only amendment or change suggested relates to adjusting quotas to reflect current biomass estimates and adjusting dates to reflect annual changes in the calendar.

2.4.3 Alternative 3 (individual vessel quota)

This alternative would establish an individual herring quota for all San Francisco Bay gill net permittees. Under existing regulations [Section 163(g)(4)(C), Title 14, CCR] an overall herring quota is established for each of three gill net groups (platoons) in San Francisco Bay.

However, individual permittees may take and land as much fish (tonnage) as they are capable of until the overall quota for their respective group is reached. This amendment has been suggested each season for the past several years. However, there has never been a clear consensus of support or opposition among gill net fishermen about this issue. Those fishermen favoring an individual vessel quota argue that: it would encourage the use of larger-mesh gill nets which would increase the roe percentage/quality of fish; it would eliminate gear conflicts; it would allow permittees to "stack" more than one permit on a vessel and share overall operating and gear costs; it would remove the incentive to use an illegal number of nets; it would allow smaller boats to compete on an equal basis with larger or more efficient boats; it would eliminate all cheating; it would reduce enforcement needs and result in less gear damage and lost/abandoned nets.

Those fishermen opposed to an individual boat limit argue that: it is an unfair and unnecessary restriction of the free enterprise system; it would result in illegal and unreported landings; it would unnecessarily extend the herring season, resulting in higher operating costs; it would encourage the "sorting" of fish (discard of males) to increase the roe percentage; it is unenforceable; "non-competitive" fishermen would continue to have problems in spite of a vessel quota; it would not work with odd/even platoons fishing on alternate weeks because major spawning activity tends to occur on a bi-weekly basis. Also, the Department is concerned about the level of enforcement effort that would be necessary to effectively monitor and enforce such a provision.

Chapter 3. ENVIRONMENTAL SETTING

3.1 General

Herring are recognized as a fish species of worldwide importance (Blaxter 1985) and have been the subject of more research than any other fish (Blaxter and Holliday 1963). A brief overview is provided to delineate differences and similarities among herring groups found worldwide.

Historically, herring have been divided into five subgroups (Figure 3.1), generally considered to be five subspecies separated primarily by geography (Blaxter 1985). However, recent taxonomic literature has designated the Pacific herring a separate species (Robins et al. 1991, Grant 1986). The subgroups have different body characters (body dimension, size at first maturity, longest length, vertebral and other structure counts). The species subject to the proposed project is the Pacific herring (*Clupea pallasi*).

Pacific herring lay adhesive eggs on substrate (shell rubble, pier pilings) and vegetation in a wide range of open ocean environments (shallow subtidal to the intertidal zone) and in estuarine subtidal and intertidal zones. The other herring species to lay eggs on substrate in the open ocean is the Atlantic herring (*Clupea harengus*) (Blaxter and Hunter 1982).

All five subgroups of herring share a number of characters in common. For example, they all have the same silvery color pattern (blue-green above fading to silvery white below) which provides countershading and camouflage in mid-water; they exhibit a strong schooling behavior; and all can switch from particulate (biting) feeding to filter-feeding.

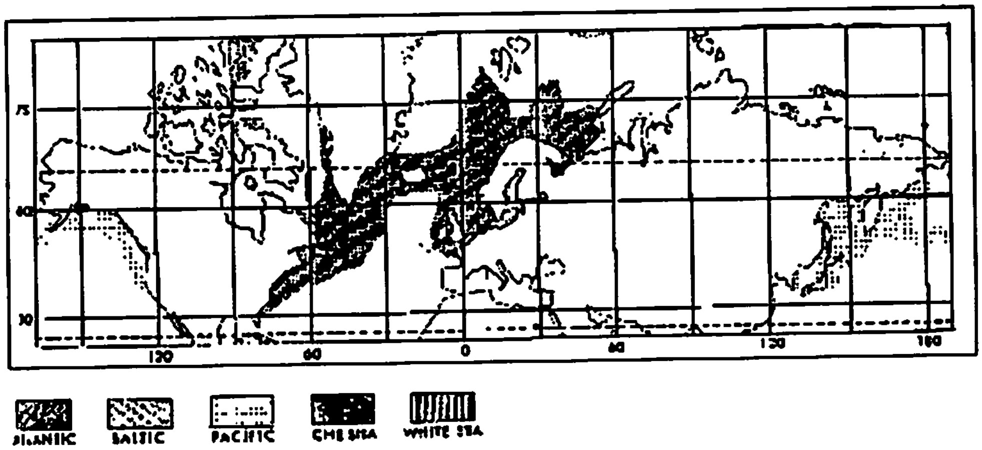


Figure 3.1. Geographical distribution of herring divided into five main groups. (From Blaxter 1985)

The herring family (Clupeidae) includes such closely related Pacific coast species as the Pacific sardine (*Sardinops sagax*) and the American shad (*Alosa sapidissima*).

3.2 General Biological and Environmental Descriptions

3.2.1 Life History

3.2.1.1 Taxonomy and Morphology

Scientific name .... *Clupea pallasi*
Class .... Osteichthyes
Order .... Clupeiformes
Family .... Clupeidae

Preferred common name .. Pacific herring
Other common name ...... Herring

Pacific herring are moderately compressed silvery fish with unspined fins (Barnhart 1988)(Figure 3.2). Their body color is dark bluish green to olive on the upper surface, shading to

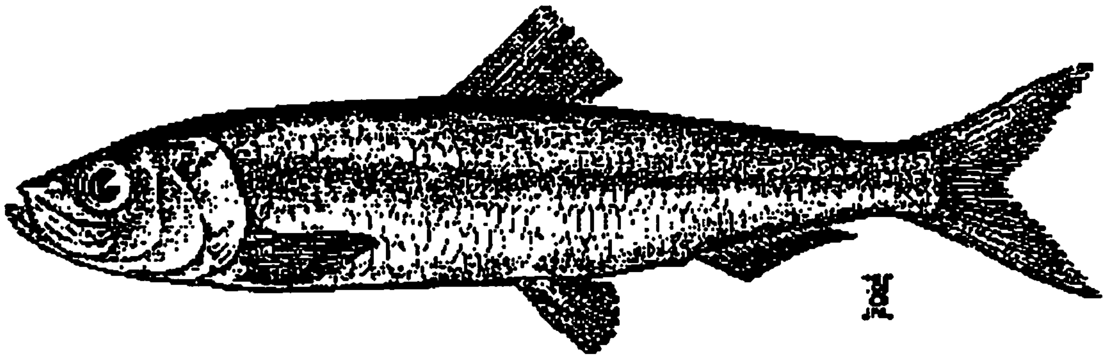


Figure 3.2. Pacific herring. (From Hart 1973)

silver on the sides and belly. They have a short dorsal fin near the middle of the back, abdominal pelvic fins beneath the dorsal fin, and a deeply forked tail fin. They lack scales and striations on the head or gill covers, spots on the sides, lateral line canal, modified scales or flaps on the side of the tail fin, and teeth on the jaw (Eschmeyer et. al. 1983, Hart 1973).

3.2.1.2 Distribution and Migration

Herring, in general, are adapted to an open ocean pelagic habitat (Blaxter and Holliday 1963). Schooling behavior in Pacific herring develops well before metamorphosis from the larval to adult forms (Marliave 1980). Because Pacific herring schools use open ocean areas inshore of the continental shelf (coastal or neritic zone) for much of their life cycle and spawn in shallow inshore areas, migrations are extensive (Outram and Humphreys 1974).

Pacific herring can be found throughout the relatively narrow coastal zone from northern Baja California on the North American coast, around the rim of the North Pacific Basin to Korea on the Asian coast (Outram and Humphreys 1974, Hart 1973). Within this range, herring abundance increases to the north (Figure 3.3), with the largest populations off Canada and Alaska (Spratt 1981)

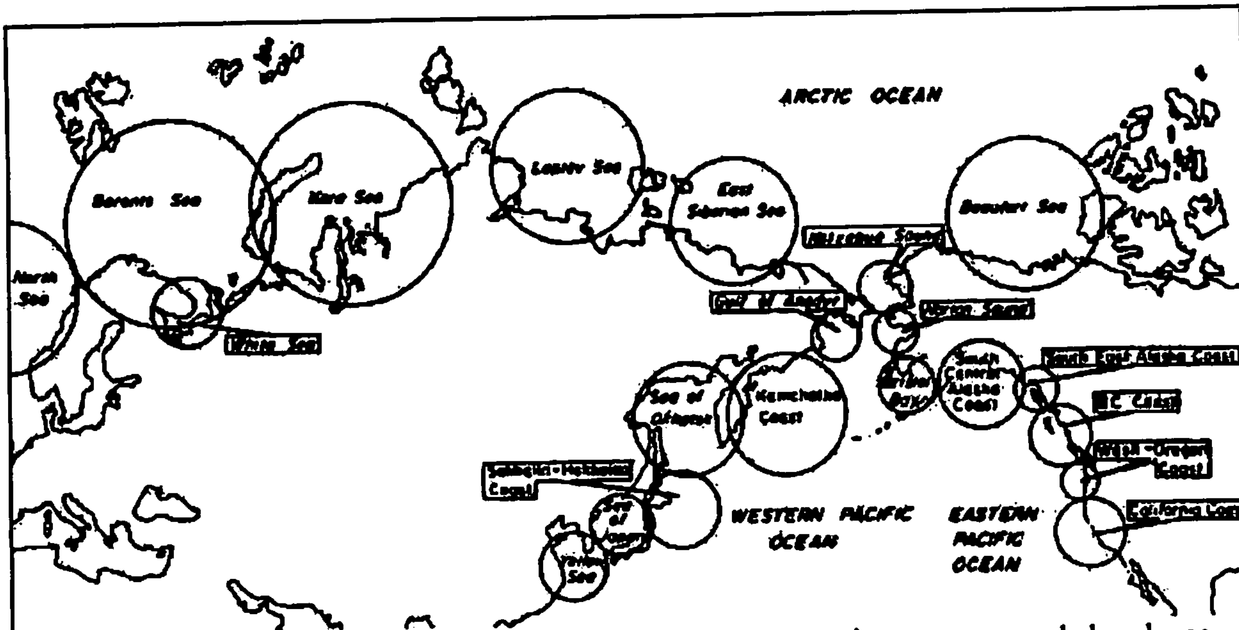


Figure 3.3. Distribution of Pacific herring. Size of circle approximates range and abundance.

Open ocean surveys along the coast indicate that different age or size groups of Pacific herring tend to school separately (Hay 1985). Schooling by size may be due to size-related differences in swimming rates (Lambert 1987). Large schools may also segregate internally by size (Breder 1976).

Pacific herring aggregate in open ocean feeding grounds from late spring to early autumn. Some stocks (defined as a race using a discrete spawning area) of Pacific herring mingle on feeding grounds while others remain isolated (Carlson 1980, Barton and Wespestad 1980). Using parasites as biological tags, Moser and Hsieh (1992) suggest that Tomales Bay and San Francisco Bay herring are separate stocks that do not mingle in the open ocean [Sec 4.2.6.1].

A tagging study by Hourston (1982) of Canadian stocks of Pacific herring found that fish homed to specific spawning areas (Hourston 1982). The extent of homing varied between 66 and 96 percent and seemed to be related more to previous spawning experience than to where the fish themselves hatched. Harden-Jones (1968) obtained comparable results and identified a tendency for older fish to stray [Sec 4.2.6.1]. All, or nearly all, herring-like fish reduce their feeding and spawning range as the population declines (Murphy 1977)[Sec 4.2.6.1].

In California, herring have been found during the summer near Monterey and Morro Bays and offshore of the Farallon Islands (Miller and Schmidtke 1956). The herring found near Monterey Bay were not produced locally (Phillips et al. 1986) and may have originated from San Francisco Bay spawning grounds (Moser and Hsieh 1992, Moser 1983).

In early autumn, Pacific herring migrate inshore to holding areas and spawning grounds. Holding areas tend to be close to the spawning grounds (Ware and Tanasichuk 1989). Herring can arrive at least three months before spawning but arrival varies from year to year depending upon such factors as weather and food availability (Blaxter and Hunter 1982). Prokhorov (1968) found that maturation and migration to spawning grounds occurred earlier in warmer years.

Herring are known to spawn at many locations along the California coast (Figure 3.4)(Spratt 1981). Historic spawning areas in California are: San Diego Bay, San Luis River, Morro Bay, Elkhorn Slough, San Francisco Bay, Tomales Bay, Bodega Bay, Russian River, Noyo River, Shelter Cove, Humboldt Bay, and Crescent City (Miller and Schmidtke 1956, Spratt 1981). Spawning areas south of San Francisco Bay are minor and may not support spawning every year. Spawning areas from San Francisco Bay north to Crescent City (except for the Russian River and Shelter Cove areas) are considered to be regular spawning areas. Those spawning areas with established commercial herring roe fisheries are described in greater detail [Sec 3.3].

3.2.1.3 Spawning

Pacific herring and Atlantic herring are the only two marine fish in the herring family to lay

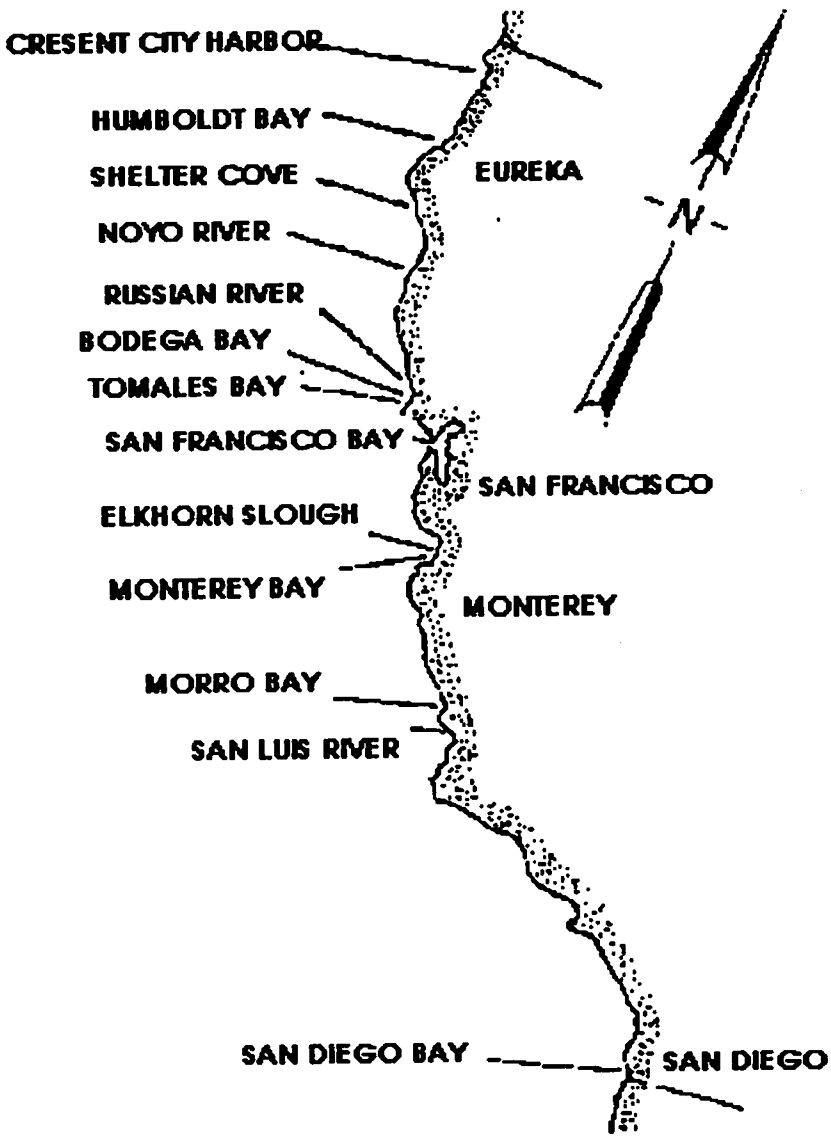


Figure 3.4. Known Pacific herring spawning areas in California.

their eggs on the bottom (demersal eggs)(Blaxter and Hunter 1982). Pacific herring typically spawn in the intertidal or shallow subtidal areas of open ocean or protected bays and estuaries (Spratt 1981, Alderdice and Hourston 1985). However, due to their ability to adapt to a wide range of temperatures and salinities they may also spawn in the tidal portions of rivers and brackish lakes and lagoons (Alderdice and Hourston 1985). The system of site selection and reproductive behavior is designed to maximize the potential for egg and larval survival. Many locations with these general characteristics are not used, indicating that spawning habitat may not be a limiting factor in determining population size.

The timing of spawning is believed to coincide with the peak in plankton production in order to insure an adequate food source for larval fish (Cushing 1975) [Sec 3.2.1.9]. In higher latitudes, where plankton production cycles are short, the timing of spawning of Pacific herring can be more precise. In lower latitudes, plankton production cycles are more variable, resulting in longer spawning seasons (Blaxter and Hunter 1982, Hay 1985, Haegele and Schweigert 1985)(Figure 3.5). Spawning in California typically begins in early November, peaks in January, and may extend through March (Rabin and Barnhart 1986, Spratt 1981, Reilly, Oda and Wendell 1989).

Within a spawning season, temperature and fish size play important roles in the exact timing of spawning, by affecting the timing of gonad maturation (Ware and Tanasichuk 1989). As a result, Pacific herring generally enter and use spawning grounds in a succession of spawning waves, rather than all fish spawning at a single time (Reilly and Moore 1983, Lambert 1987, Hay 1986, Barton and Wespestad 1980).

In San Francisco Bay, the number and size of spawning waves is related to the age structure of the spawning population, with older age-classes tending to spawn early in the season,

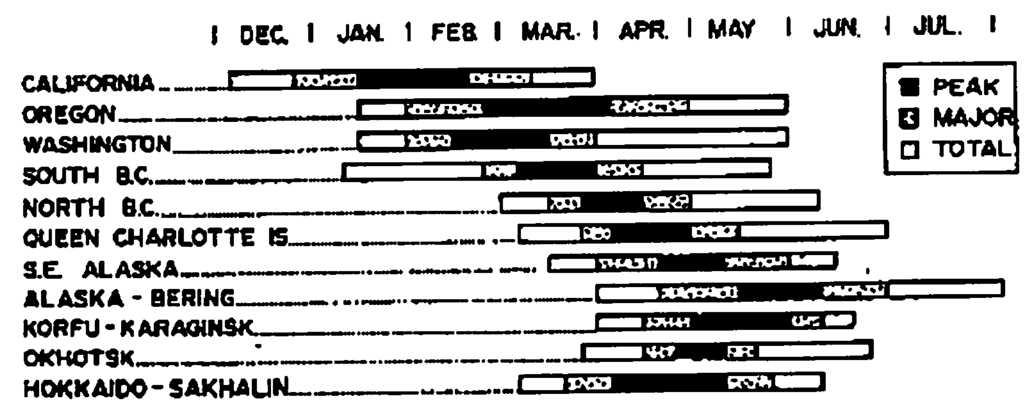


Figure 3.5. Timing of Pacific herring spawnings by major stock group. (From Hay 1985)

and younger age-classes spawning later in the season (Oda 1994). Pacific herring in California begin reaching sexual maturity at age two, and are fully recruited to the spawning population at age three (Spratt 1981, Reilly and Moore 1984). During years of poor recruitment, when two- and three-year-old fish appear in low numbers, spawning may only continue into February. When recruitment of two- and three-year-old fish is high, spawning may continue well through March. A broad age structure will tend to promote resilience or stability in a population by averaging out the effects of age on reproduction (Lambert 1987).

Little is known about which factors act as stimuli to initiate spawning for California herring, but salinity may play an important role (Barnhart 1988). When the right conditions exist, herring move into intertidal and shallow subtidal areas and spawn on any suitable substrate, such as vegetation, rocks, shell fragments, or other hard surfaces such as pier pilings.

The number of eggs laid per unit of body weight (fecundity) by Pacific herring is lower than many other fish species, but numbers of individual herring are high (Blaxter and Holliday 1963). However, the fecundity in Pacific herring is variable. For example, the fecundity of herring in California is higher than for herring in Canada and Alaska (Hay 1985, Tanasichuk and Ware 1987). The average fecundity of female herring in California is approximately 220 eggs per gram of body weight compared to 200 for herring in British Columbia (Hardwick 1973, Rabin and Barnhart 1977, Reilly and Moore 1986, Tanasichuk and Ware 1987).

A few sperm-releasing males can induce spawning behavior in a large number of fish (Stacy and Hourston 1982, Hay 1985). Rounsefell (1930) described Pacific herring spawning as coordinated sexual behavior. The substrate can be tested by spawners and sediment on the substrate may inhibit spawning (Stacy and Hourston 1982) [Sec 4.2.2]. Eggs are laid in varying numbers of layers. Spawn density varies from an egg or two per square meter of substrate to complete coverage in layers six to eight eggs thick (Spratt 1981).

Survival of the embryo (fertilized egg) is dependent on a number of variables. Egg density and water transport through the egg mass significantly influences embryo survival (Galkina 1971, Alderdice and Hourston 1985, Haegele and Schweigert 1985). Exposure to air can also contribute to losses through hypoxia, desiccation, and temperature differences (Jones 1972, Purcell, and Grover 1990). Jones (1972) found that the smaller eggs produced by smaller herring were less likely to survive air exposure than larger eggs. From this, Jones (1972) postulated that the reduction in average size of herring caused by harvest could result in lower survival of eggs exposed to air. Taylor (1971) and Jones (1972) examined the effect of egg density on survival. Taylor (1971) found hatching success to decrease with increased egg mass thickness, with optimal thickness at two to four egg layers for subtidal spawn. Jones (1972), who examined intertidal spawns, reported optimal survival from seven layers of eggs.

Other significant factors influencing egg survival include predation by birds, fish and invertebrates, cannibalism, storm loss, and siltation. Estimates of total predation vary significantly (Lough et al. 1985). Losses from predation and storms have been reported as low as 10 percent (Haegele et al. 1981) and as high as 90 percent (Hardwick 1973). Bird predation is considered to be a significant source of loss (Outram 1958, Spratt 1981, Bayer 1980, Barton and Wespestad 1980) [Sec 3.2.1.8]. However, at lower spawn densities, bird predation may not be a significant source of egg loss (Rabin and Barnhart 1986). Storms and wave action can also contribute significantly to egg loss on occasion (Hay and Miller 1982, Taylor 1964, Haegele and Schweigert 1985) as can siltation (Galkina 1971, Haegele and Schweigert 1985) [Sec 5.2].

The incubation period is temperature and egg size dependent. Warmer temperatures will lead to earlier hatches as will smaller egg size. Incubation time was 6-10 days in water temperatures of 8-10°C in Tomales Bay (Miller and Schmidtke 1956) and 10.5 days at an average water temperature of 10°C in San Francisco Bay (Eldridge and Kaill 1973).

3.2.1.4 Larval Stage

At hatching, Pacific herring are approximately 6 to 8 mm in length (Barnhart 1988). Immediately after hatching, the larvae have a yolksac and no swimming ability. Their distribution is clumped, controlled largely by tidal factors (Henri et al. 1985). The duration of the yolksac stage is dependent on the amount of yolk present and temperature (Fossum 1986). The time from exhaustion of yolk to the point where irreversible starvation occurs is also temperature dependent (McGurk 1984). With absorption of the yolksac and active swimming and foraging, larval distribution becomes patchy (McGurk 1987).

Larval starvation may be a critical factor in determining year-class strength (Hay 1983, Cushing 1975, Kiorboe et al. 1985). The period between exhaustion of yolk and irreversible starvation is, thus, a critical period in the herring life cycle (Anthony and Fogarty 1985, Blaxter and Holliday 1963, Hay 1983) [Sec 3.2.1.9].

Other factors that affect larval survival are competition, predation (Lasker and MacCall 1983), cannibalism (MacCall 1980), and larval drift (Parrish et al. 1981, Nelson et al. 1977). Variation in egg survival (Lo 1985), changes in fish fecundity (Picquelle and Hewitt 1983), and the effect of localized oceanographic events (storms and upwellings)(Lasker 1975, 1978) or widespread oceanographic events (unusual warming of the ocean - El Niño) also affect larval survival.

Larval herring develop swimming powers when they are 20 mm long (6 weeks old). With mobility, Atlantic herring avoid the surface during fast moving flood and ebb tides and use the surface waters during slack tides. This vertical migration promotes estuary residency (Henderson 1987). Metamorphosis from the slender, nearly transparent larval form to the green/silver adult form occurs at approximately 30 mm (10-12 weeks old).

3.2.1.5 Juvenile Stage

Upon completion of metamorphosis, juvenile Pacific herring are free swimming and form shoreline oriented schools. The schools enlarge and move out of the bays as summer progresses (Taylor 1964, Reilly and Moore 1983). Very little is known about the juvenile stage from the time they leave inshore waters in their first summer until they are recruited into the adult population at age two or three.

Data suggest that one- and two-year-old herring do not associate with adults offshore. Two-year-olds may be found in the same area as adults, but appear to maintain discrete schools (Taylor 1964).

3.2.1.6 Offshore Life History

Little information is available regarding the abundance, behavior, and ecological relationships of Pacific herring once they arrive in offshore feeding areas. Atlantic herring typically undergo vertical migrations to feed, rising toward the surface as light decreases and descending as light increases (Wales 1984). Vertical migration may help Atlantic herring find plankton near the surface in light intensities where they are less vulnerable to predation (Blaxter and Parrish 1965). The heaviest feeding periods, then, are dusk and dawn.

Herring schools in general occupy a small proportion of offshore feeding areas at any given time, but their presence can have a strong local affect on the community. They can reduce zooplankton populations through predation, and increase phytoplankton growth by introducing concentrations of nutrients found in their waste products (Blaxter and Hunter 1982).

Herring predation and availability as prey may have other effects in the offshore ecosystem. Predation by Atlantic herring on fish eggs has had area-specific impacts on fish populations (Daan et al. 1985). Under the right conditions, Pacific herring foraging in Puget Sound may cause salmon to switch prey to less suitable forms, potentially affecting growth and survival of salmon (Fresh 1983). Offshore populations of Pacific herring have declined in relation to increases in Pacific hake, *Merluccius productus*, populations (Day 1987). The paleosedimentary record of anaerobic basins (quantity of identifiable fish scales laid down through time) shows large fluctuations in offshore clupeoid biomass (Lasker 1985).

A number of physical features can have profound effects on the offshore community, and herring offshore life history. Changes in ocean currents, for example, affect many different organisms (phytoplankton, zooplankton, sockeye salmon)(McLain and Thomas 1983) [Sec 5.4].

The invasion of warm nutrient-depleted water (El Niño) affects the movement, distribution, growth and survival of a number of species (Spratt 1987, Lasker 1985).

3.2.1.7 Age and Growth

A number of age determination methods have been developed to provide the population age structure information used in fisheries management (Chilton and Beamish 1982, Nielsen and Johnson 1983). Pacific herring scales and otoliths (ear bones) show zones of growth which are used to determine age (Rounsefell 1930, Spratt 1981, Chilton and Stocker 1987).

Pacific herring have been found to attain an age of 15 years (Barton 1978). They occur in California fisheries from age 2 through 11 (Spratt 1981, Reilly, Oda and Wendell 1989, Rabin and Barnhart 1986). The age composition of spawning populations is influenced by dominant year-classes and can vary considerably (Reilly, Oda and Wendell 1989).

Pacific herring in the San Francisco Bay spawning population range in size from approximately 110 to 240 mm in body length (BL). The average size of herring within the population on the spawning grounds changes in a consistent manner through the spawning season. Larger herring spawn earlier in the season. Successive waves of spawners have smaller average size as younger fish move onto the grounds (Figure 3.6)(Reilly, Oda and Wendell 1989, Spratt 1981).

A few 1-year-old herring have been found on the spawning grounds in a mature state. Typically 2-year olds are the youngest herring found in the San Francisco Bay spawning population (Reilly and Moore 1983, Oda and Wendell 1990). However, not all 2-year olds join the population as first time spawners (Reilly and Moore 1987, Spratt 1981). Three-year old

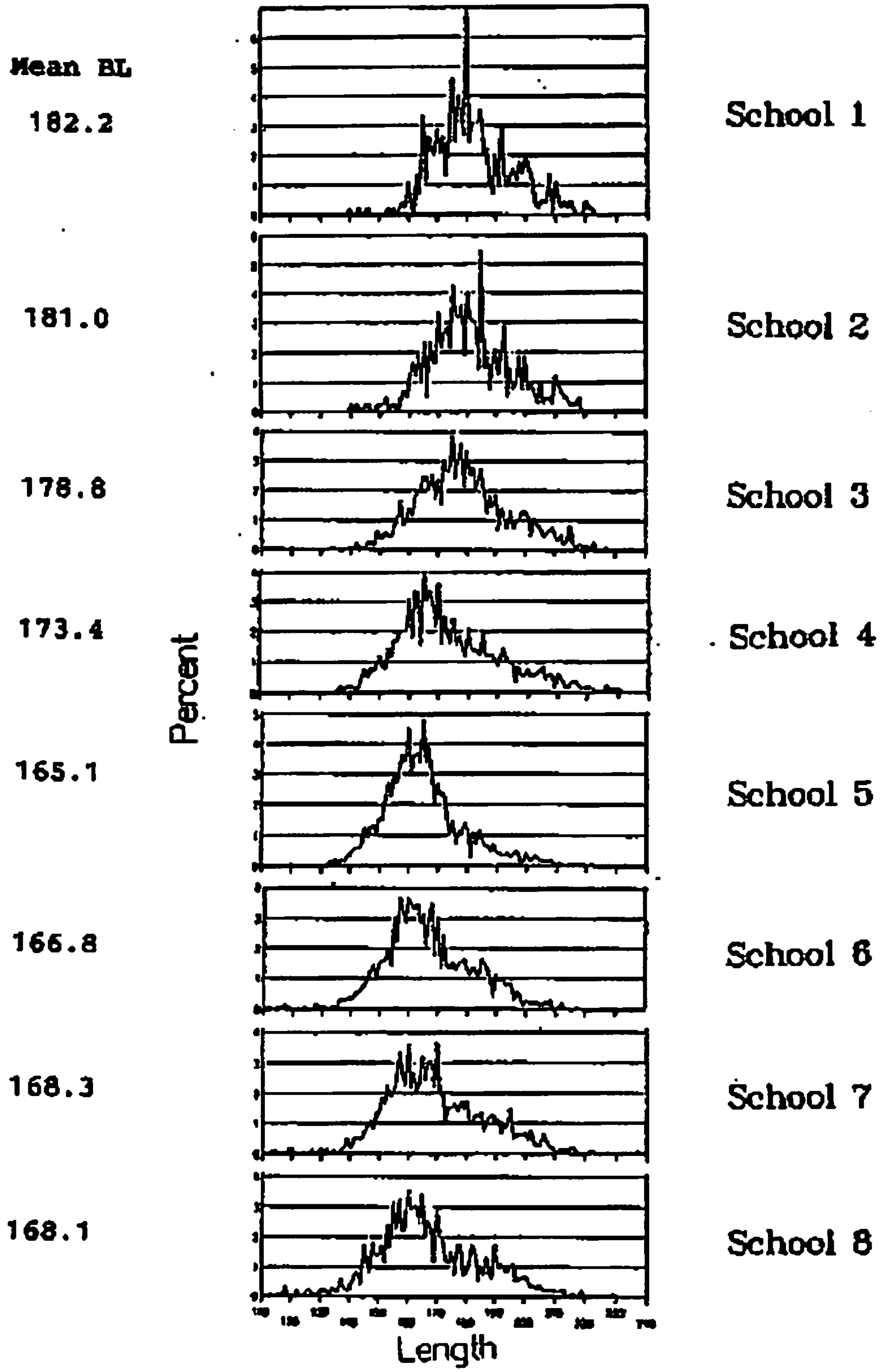


Figure 3.6. Size distribution of Pacific herring by school in San Francisco Bay during the 1989-90 spawning season. (from Oda and Wendell 1990)

herring are considered fully recruited to the spawning population (Reilly and Moore 1984, Spratt 1981).

Growth of immature Atlantic and Pacific herring differs among areas and between year-classes (Anthony 1971, Gonyea and Trumble 1983, Haist and Stocker 1985, Iles 1967, Levings 1983, Reilly 1988). Variation in growth is generally attributed to environmental factors and the abundance of young herring. Environmental factors are the primary cause of differences in adult herring growth (Murphy 1977, Reilly and Moore 1984, Spratt 1987). Differences in age-specific size between Tomales and San Francisco Bay spawning populations have been consistent and suggest different stock origins (Figure 3.7)(Spratt 1981). The maximum size of Pacific herring increases with latitude throughout its range (Gonyea and Trumble 1983).

3.2.1.8 Natural Mortality

There are many causes of death (mortality) among the fish in a population; removals by humans (fishing), predation, and disease are examples. In practice, causes of death are divided into two categories: fishing and natural mortality (which includes everything else)(Ricker 1975). Massive mortality caused by epidemics has devastated some populations of Atlantic herring (Sissenwine et al. 1984). Toxic substances produced by algae used as a spawning substrate by the Baltic herring, *Clupea harengus membras*, have also been identified as a source of natural mortality (Aneer 1987). Adult Atlantic herring have on several occasions died during blooms of a toxic species of plankton (*Gonyaulax excavata*)(White 1980). Predation, however, is widely recognized as a more significant source of natural mortality.

Causes of natural mortality and mortality rates typically vary with the age of fish within a population (Gulland 1988). This is particularly true when all life stages are considered (egg,

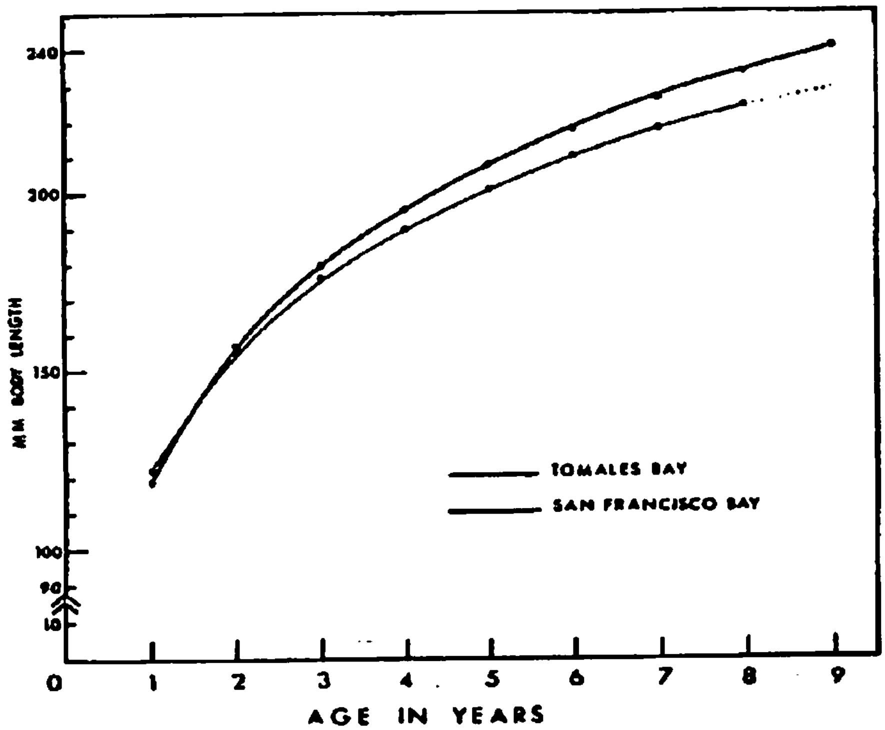


Figure 3.7. Herring growth curves for Tomales and San Francisco Bays. (From Spratt 1981)

larvae, juvenile, and adult). The causes of mortality at the egg stage vary to a greater extent than they do in subsequent stages in the herring life cycle, and have been reviewed in a prior section [3.2.1.3]. However, predation is considered to be the primary cause of natural mortality in juvenile and adult herring populations (Ware and Tanasichuk 1988, Walters et al. 1986, Outram 1958, Lasker 1985, Day 1987, Daan et al. 1985, Bayer 1980).

3.2.1.8.1 Predation

Predation during the egg stage of Pacific herring is recognized as a significant cause of natural mortality. At least 20 species of birds alone are known to feed upon Pacific herring eggs (Table 3.1)(Bayer 1980). In many cases, bird predation has been identified as the primary source

Table 3.1. Birds Observed Eating Pacific Herring Eggs.		
Black Brant	White-fronted Goose	Redhead
American Wigeon	Greater Scaup	Canvasback
Lesser Scaup	Common Goldeneye	Bufflehead
Harlequin Duck	Black Scoter	Oldsquaw
Surf Scoter	White-winged Scoter	Western Gull
American Coot	Glaucous-winged Gull	Mew Gull
Ring-billed Gull	Bonaparte's Gull	

of mortality (Outram 1958, Hardwick 1973, Bayer 1980, Haegele and Schweigert 1985). The species composition and abundance of the bird predator population is determined by migrations, immigrations to feeding areas, and competition (Bayer 1980, Norton et al. 1990). Glaucous-winged gulls appear to be dominant bird predators on eggs deposited within the intertidal zone in some areas (Norton et al. 1990). They also obtain herring eggs by piracy (stealing from other birds) as do some diving birds.

Non-avian predators on Pacific herring eggs include sturgeon, surfperch, smelt and crabs (Hardwick 1973). Pacific herring are also known to cannibalize herring eggs (Hay 1985). Spent (just spawned) Pacific herring were found on spawning grounds with their stomachs filled with herring eggs. Cannibalism has also been noted in the Atlantic herring (Blaxter and Holliday 1963).

Herring larvae are preyed upon primarily by invertebrates (animals without backbones) (Arai and Hay 1982, Blaxter and Holliday 1963, Hourston et al. 1981, Moller 1984, Purcell et al. 1987). Chief among the invertebrate predators are various species of jellyfish and comb jellies. *Sarsia tubulosa* and *Aequorea victoria* (jellyfish) have been identified as potentially significant predators on Pacific herring larvae (Arai and Hay 1982, Purcell et al. 1987). *A. victoria* is a significant predator for a short period after a hatch, consuming yolksac larvae (12 mm) with limited swimming ability. The ability of larvae to escape contact increases dramatically beyond that size. Small perch, young salmon, amphipod crustaceans and arrowworms (chaetognaths) have also been identified as predators on larval Pacific herring (Stevenson 1962).

Information on the importance of juvenile and adult Pacific herring as prey is limited. As consumers of zooplankton (secondary consumers), herring have an important role in transferring energy from lower feeding strata (phytoplankton and primary consumers) to upper strata when they, in turn, are consumed (Figure 3.8)(Fresh 1983). A number of piscivorous (fish-eating) fish, birds, and marine mammals have been identified as predators of Pacific herring juveniles and adults.

Predation by Pacific whiting may have a significant effect on herring biomass in offshore areas (Day 1987, Walters et al. 1986, Ware and McFarlane 1986, Ware and Tanasichuk 1988). A correlation has been noted between increasing whiting abundance and decreasing herring abundance in studies off British Columbia and northern Washington. Rexstad and Pikitch (1986) estimated that Pacific whiting consumed 120 tons per day of Pacific herring in the area between central Oregon and northern Washington. However, the seasonal migration pattern of whiting along the Pacific coast and its latitudinal stratification by size class complicates application of feeding study results to other areas (Rexstad and Pikitch 1986). Other potentially significant fish predators of herring include salmon (chinook and coho), sharks (particularly dogfish), sablefish striped bass, steelhead trout, Pacific cod, and walleye pollock. Other fish predators include lingcod, several species of rockfish (black, yelloweye, quillback and tiger rockfish), northern anchovy, pink salmon, cutthroat trout, buffalo sculpin, staghorn sculpin, and sand sole. Most of

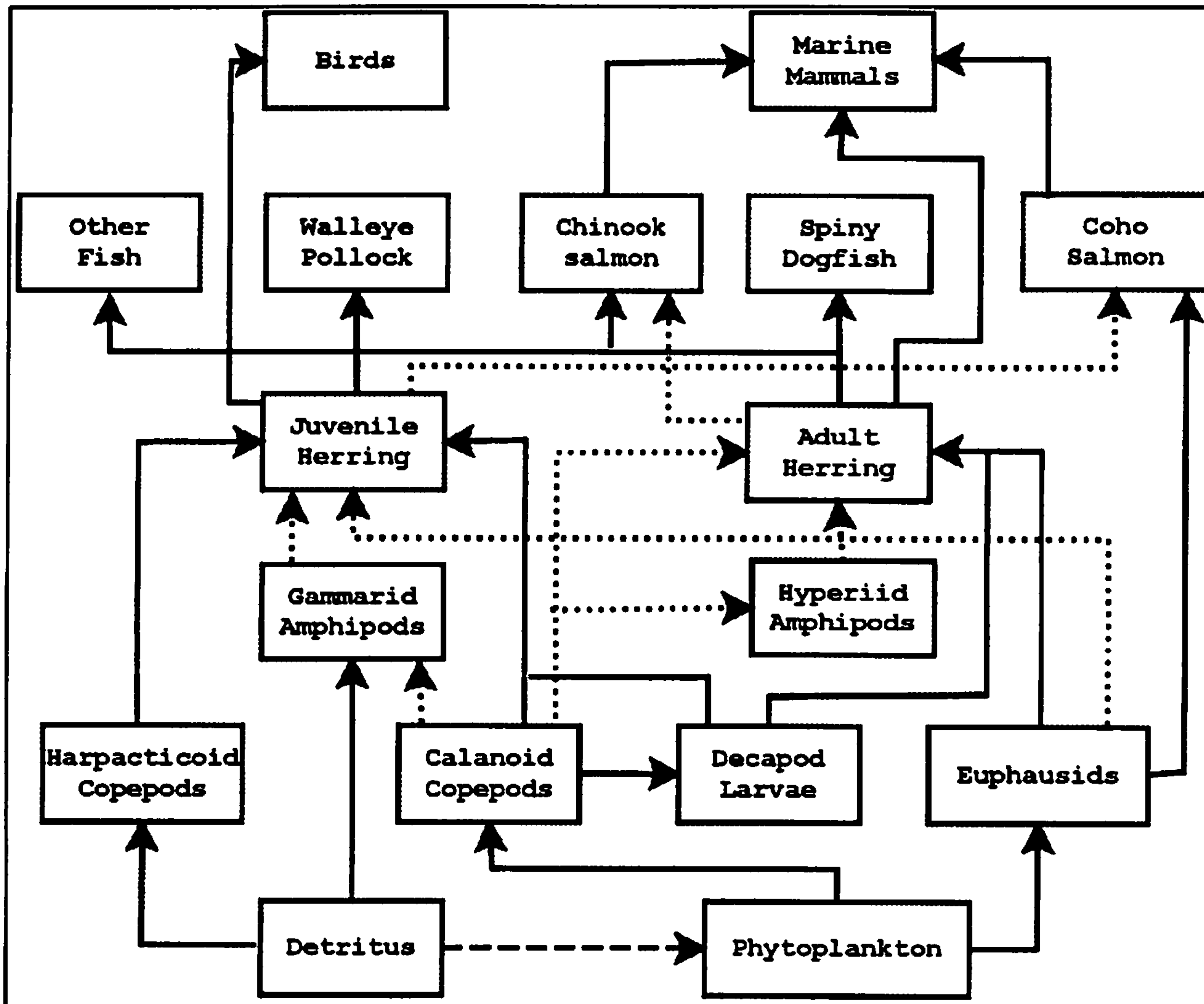


Figure 3.8. Puget Sound food web involving herring. Solid lines indicate primary linkages and dashed lines indicate secondary linkages (from Fresh 1973.

these fish predators can be categorized as opportunistic feeders, capitalizing on accessible prey (Rosenthal et al. 1988, Emmett et al. 1986).

Fresh (1983) reported herring as a major diet item of chinook salmon in the Puget Sound area, particularly in the winter and spring. The typical length of herring from chinook stomachs was 110 mm, indicating they were juveniles less than 2 years old. Chinook salmon off the San

Francisco area, on the other hand, tended to utilize larger herring (Merkel 1957). A marked seasonal change in the composition of the food used was related, to a certain extent, to shifts in the site of capture and prey availability (Figure 3.9). When Pacific herring were identified as the main food item for chinook salmon in Merkel's (1957) study, the salmon were taken in offshore herring holding areas near San Francisco Bay.

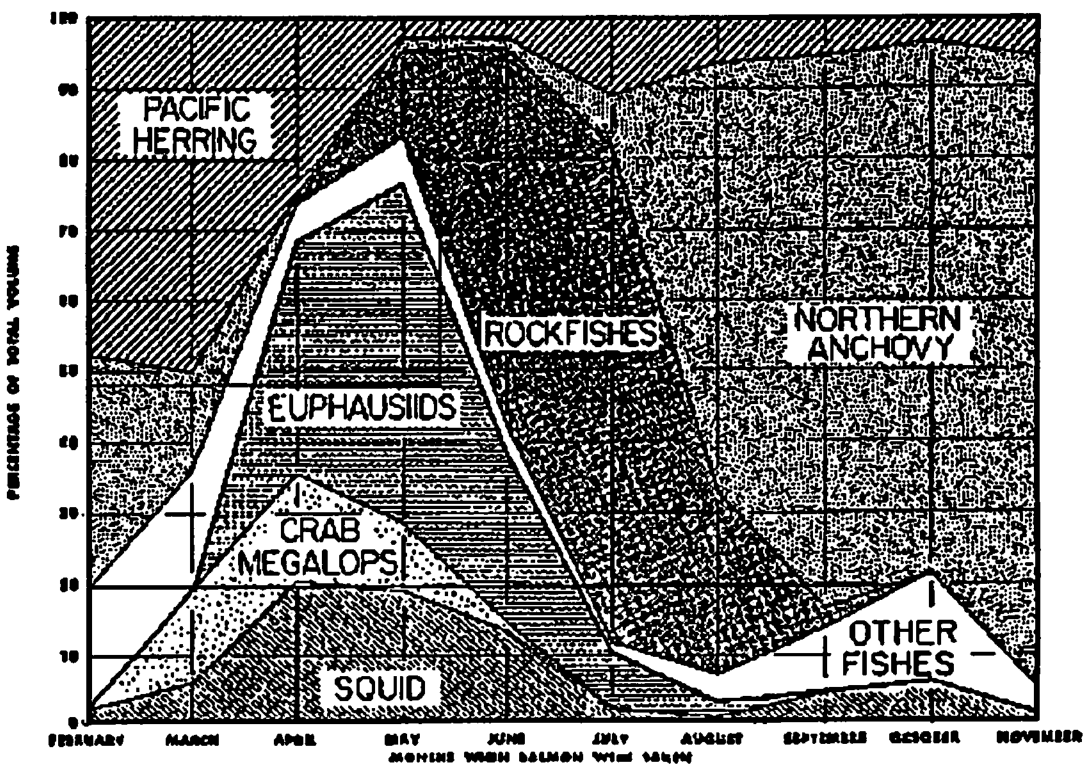


Figure 3.9. Occurrence of Pacific herring in the diet of King salmon in the vicinity of San Francisco Bay. (From Merkel 1957)

Juvenile and adult Pacific herring are also preyed upon by marine birds. Seabirds are important members of upper trophic levels (Furness and Ainley 1984). The extent of predation by seabirds on Pacific herring is relatively unknown. Ainley and Boekelheide (1990) found that of eight seabird species in the Farallon Island area capable of reaching depths of at least 50 m, none included Pacific herring in their diet during the summertime breeding season. Availability may be limited in offshore areas by changes in herring depth distribution associated with daily vertical migrations; however, several central California seabirds are known to forage regularly to 100 m (Ainley and Boekelheide 1990).

Herring may be more vulnerable to seabird predation in the shallow water embayments typical of most spawning grounds. Flocks of Brandt's and double-crested cormorants, brown pelicans, western grebes, gulls, and loons are often observed diving on adult herring schools during spawning season within Tomales Bay and San Francisco Bay. Terns are likely consumers of herring young-of-the-year in the summer.

Pacific herring are consumed by a number of marine mammals including harbor seals, northern fur seals, California sea lions, Steller sea lions, harbor porpoises, Dall's porpoises, Pacific white-sided dolphins (Jones 1981) and whales (Hart 1973). The extent that California herring stocks are used by these marine mammals has not been well documented. Pacific herring are an intermediate host for several parasites with definitive hosts among marine mammals (cetacean, pinnipeds)(M. Moser, UCSC, pers. comm.). This fact and the relative position of herring in the trophic ecology of the region suggest their use is prevalent. Since California sea lions specialize on schooling, open water fishes, they may be one of the most significant of the mammalian predators of herring in California.

3.2.1.9 Food Habits

Early post-yolksac Pacific herring feed on a variety of micro-plankton (diatoms, protozoans, bivalve veligers, and copepod eggs, nauplii, and copepodites) (Purcell and Grover 1990). Larval copepods (shrimp-like crustaceans) predominated in the environment and in the stomach contents of the larval herring at the time of Purcell and Grover's study. Larval Atlantic herring growth rates were shown to increase with increased concentrations of copepod larvae (Kiorboe and Munk 1986) and the food size selected increased with larval size (Blaxter and Holliday 1963, Jones and Hall 1974).

Herring continue to feed on plankton throughout their life cycle, relying heavily on visual cues in feeding (Blaxter and Holliday 1963). Adults will switch feeding forms (filter or particulate feeding) based on food concentration and size to maximize number of prey (Boehlert and Yoklavich 1984, Gibson and Ezzi 1985, Blaxter 1985).

Feeding tends to occur at dawn and dusk (Fresh 1983, Blaxter and Parrish 1965). Both herring and their potential prey undergo vertical migrations. This behavior may maximize foraging opportunities during relatively restricted foraging times by helping to reduce search effort.

Foraging can have strong local effects on zooplankton community structure (Blaxter and Hunter 1982). Young Atlantic herring, for example, may have affected plaice recruitment by feeding on their eggs. However, their impact was felt to be area specific and related to availability (Daan et al. 1985). Prey items selected by Pacific herring change with their growth and geographic distribution.

Juvenile Pacific herring in shallow subtidal areas fed primarily on zooplankton (copepods and crab larvae)(Fresh 1983). All of the prey utilized eelgrass beds as habitat. Herring diet changed as a function of fish size, time of year, and habitat, all of which influenced prey availability. Euphausiids (shrimp-like crustaceans) became the primary food item when herring reached adult size and moved into offshore pelagic habitats.

3.2.1.10 Competition

Herring obviously compete with a number of organisms for food during their life cycle. Although not extensively studied, some data are available. Herring, for example, compete with juvenile and subadult coho salmon for food in the shallow sublittoral habitat (Fresh 1983) or for euphausiids in the offshore pelagic habitat (Fresh et al. 1981). Herring larvae compete with some of the soft-bodied zooplankton (medusae) for microplankton (Purcell and Grover 1990).

3.2.1.11 Habitat

The general distribution of fish, including herring, is influenced by water movement and properties of water, principally currents, upwelling, temperature, and salinity. Pacific herring complete their entire life cycle within one portion of the North Pacific water-mass known as the coastal zone. The coastal zone is characterized by waters of reduced salinity (due to freshwater run-off from land) and low temperature (0-13°C). It includes sheltered bays used for spawning, and localized, nutrient-rich, plankton-producing areas of higher salinity associated with upwelling (Outram and Humphreys 1974).

Certain temperatures and salinities have been identified as optimal for Pacific herring spawning (3-9°C and 8-22 ppt) and for egg and larval survival (5-9°C and 13-19 ppt)(Alderdice and Velsen 1971, Prokhorov 1968). Adults have a much wider range of tolerance (Brawm 1960). California is near the southern limit of the North American distribution of Pacific herring. As a consequence, temperature and salinities are not typically within the optimal range; however, they do fall within the tolerance range (Alderdice and Velsen 1971).

Other characteristics of spawning habitat have also been identified as important factors in herring survival. Adequate spawning substrate, free of sediment and filamentous algae, is one such requirement (Graham and Townsend 1985, Aneer 1987, Blaxter and Holliday 1963). Pacific herring are capable of using a wide variety of substrates for spawning (Spratt 1981). A number of factors influence the distribution and availability of vegetation including agricultural herbicides in runoff, erosion input of fine grain sediments and nutrient enrichment (Kemp et al. 1983). Eelgrass distribution has been limited by its tolerance to exposure, turbidity, and by waterfowl grazing (Harrison 1982). The reduced rate of growth in winter could slow eelgrass recovery from grazing (Aioi et al. 1981).

Water transport through the spawning grounds has a number of effects. It influences egg survival (Alderdice and Hourston 1985, Galkina 1971), larval and juvenile food production (Stocker et al. 1985, Cloern et al. 1983), and larval and juvenile distribution (Blaxter and Hunter 1982, Corten, 1985, Graham and Townsend 1985). Currents can limit competition for food or remove larvae from favorable nursery areas. They can also influence the abundance of competing or predatory forms. Weather conditions, particularly storm waves, can lead to significant mortality of eggs.

Water temperature determines the rate of development. It also influences larval survival and year class strength (Anthony and Fogarty 1985, McGurk 1984, Sissenwine et al. 1984). It influences the rate of yolksac absorption (Fossum 1986) that, in turn, can influence survival through first feeding. In offshore areas, temperature can influence growth rates and the onset and rate of sexual maturation (Barton and Wespestad 1980, Lambert 1987).

3.2.2 Population Status

The Pacific herring roe fishery in California has been intensively regulated since its inception in 1973. Estimates of the size of the spawning population have provided the major source of information used to modify the regulations, as necessary, to insure long-term productivity of the herring resource.

Wide fluctuations in population abundance, due primarily to variable recruitment (fluctuations in the size of the youngest age class in the fishery), are a normal feature of short-lived pelagic fish populations (Appendix 3). As a result, frequent short-term assessments are necessary to update information databases used in developing fishery regulations. The information necessary to determine the annual status of California's Pacific herring population include: 1) current stock size, 2) current age structure, 3) fishery landings history, and 4) potential recruitment level.

The principle assessment methods used for monitoring the population abundance of herring are the egg deposition or spawn escapement surveys and hydroacoustic surveys (Spratt 1981, Rabin and Barnhart 1986, Reilly and Moore 1983, Miller and Schmidtke 1956, and Hardwick 1973) [Sec 3.2.2.1]. A variety of other indirect assessment methods have been used by resource managers worldwide to assess herring abundance. These methods include cohort analysis (analysis of age structured fisheries data), ecosystem modeling, and forecasting year class strength (Pope 1972, Ricker 1975, and Stocker et al. 1985).

The usefulness of these stock assessment methods is dependent on how the data are collected (data quality). Data must be sensitive (precise and accurate) enough to detect the extent of short-term changes in stock structure and abundance (Hourston 1980, Doubleday 1985). The use of several independent assessment procedures can reduce the strong dependency on precision and accuracy required of a single procedure (Schweigert and Stocker 1988).

Commercial catch samples and fishery independent midwater trawl samples have been used to assess population age structure (Spratt 1981, and Reilly, Oda, and Wendell 1989). A forecasting procedure is being used to predict future recruitment (projecting recruitment levels prior to their occurrence)(Oda and Wendell 1990). A description of each of these procedures and summaries of the data they have provided follows.

3.2.2.1 Biological Procedures

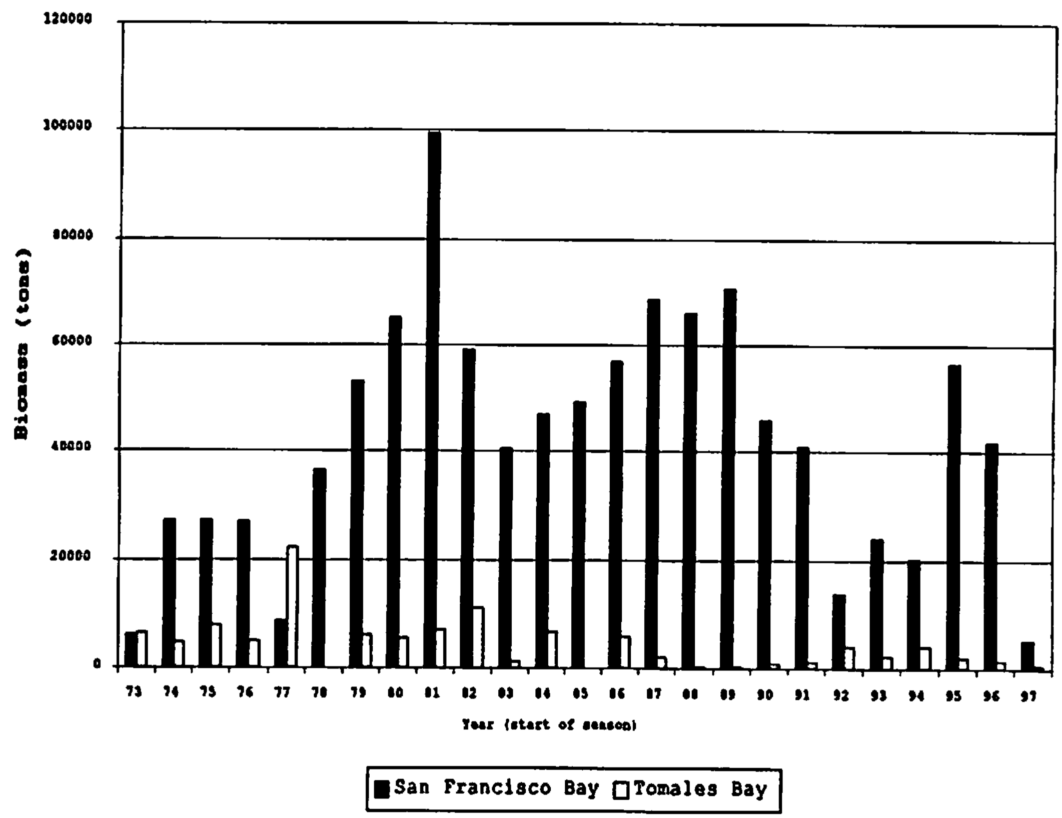
3.2.2.1.1 Spawn Escapement Surveys

Spawn escapement surveys have been used to assess Pacific herring abundance (biomass) in California at Elkhorn Slough, San Francisco Bay, Tomales Bay, and Humboldt Bay (Phillips et al. 1986, Spratt 1981 and 1991, Miller and Schmidtke 1956, Hardwick 1973, and Rabin and Barnhart 1986). The frequency of these surveys and exact methodology have varied. Tomales Bay and San Francisco Bay (sites of the largest spawning aggregations and fisheries) are surveyed annually and thus have a long time series of data with little change in data collection procedures (Spratt 1990). The remaining areas have been surveyed infrequently.

Spawn escapement surveys estimate biomass by measuring the area and density of eggs. Estimates of total egg production are converted to tons of fish that have spawned (biomass) by dividing by the average number of eggs laid per weight of female herring (fecundity). The procedure used by the Department is described in greater detail in Spratt (1981). Procedures used by other researchers conducting spawn escapement surveys in California have varied slightly.

Biomass estimates for the San Francisco Bay spawning stock, based on Department spawn escapement surveys, have been cyclical through time (Figure 3.10). The increase during the 1978-79 spawning season was due to expansion of the survey area to include assessment of subtidal spawning. Other Department assessment data (hydroacoustic and cohort analysis) follows the same general cyclical pattern. Since 1979, San Francisco Bay herring biomass estimates have peaked three times (Figure 3.10).

Figure 3.10. San Francisco & Tomales Bay spawning stock biomass estimates based on CDFG spawn escapement surveys. (not conducted in 1978 & 1985 in Tomales Bay).



Biomass estimates for Tomales Bay have varied greatly. The 1992-93 season saw the Tomales Bay herring biomass estimate rebound to a figure that approached the average spawning biomass for the last 23 years. In the following season the biomass dropped but rebounded in the

1994-95 season to the second highest biomass estimate for the preceding eight years. In the 1995-96 season the spawning biomass of 2,085 tons fell again below the 23-year average but was still just 10% lower than the 10-year average of 2,313 tons. Biomass estimates have continued to decline in the 1996-97 and 1997-98 seasons with estimates of 1,469 tons and 586 tons, respectively. Heavy rainfall most likely inhibited spawning in both seasons in addition to the compounding El Niño effects in 1997-98 on herring abundance, nutrition, and gonadal development, further depressing the spawning biomass estimate in Tomales Bay. Although no clear trend is evident with spawning biomass since the reopening of the Tomales Bay herring fishery in the 1992-93 season, there have been two El Niños and recently two extremely wet years in a row as the biomass has declined. Commercial catch rates have not been excessive since the fishery reopened and while the fishery was likely negatively impacted by the extended drought in the late 1980's, the latest shift in weather patterns to extremely wet winters is also quite likely to have negatively impacted spawning biomass estimates for the Tomales Bay herring population.. No other stock abundance assessment data are available for Tomales Bay.

3.2.2.1.2 Hydroacoustic Surveys

Hydroacoustic surveys determine the size and density of fish schools using sound transmission. Hydroacoustic surveys of Pacific herring spawning stocks have been conducted by the Department almost exclusively in San Francisco Bay. Initial development of procedures began in the early 1980's. The first estimate of spawning stock biomass was made during the 1982-83 spawning season (Reilly and Moore 1983). Methods used to collect and analyze hydroacoustic data have changed considerably through time.

Early and present-day work is conducted with a scientific-grade echosounder (Raytheon model DE-719B) using the visual integration method. Echosounder plots of school density and area are obtained from diagonal transects across the school. Densities are determined for each transect based on comparisons to standards (visual integration). Standards were developed by chartering a purse seine vessel to capture and determine the actual weight of herring after obtaining an echosounder trace. The purse seine was assumed to capture a representative sample of herring at the density recorded by the echosounder. Initial translations of echosounder traces into biomass relied on mapping areas with equal density. The latest method averages densities along a track and applies that average to the area represented by the diagonal track.

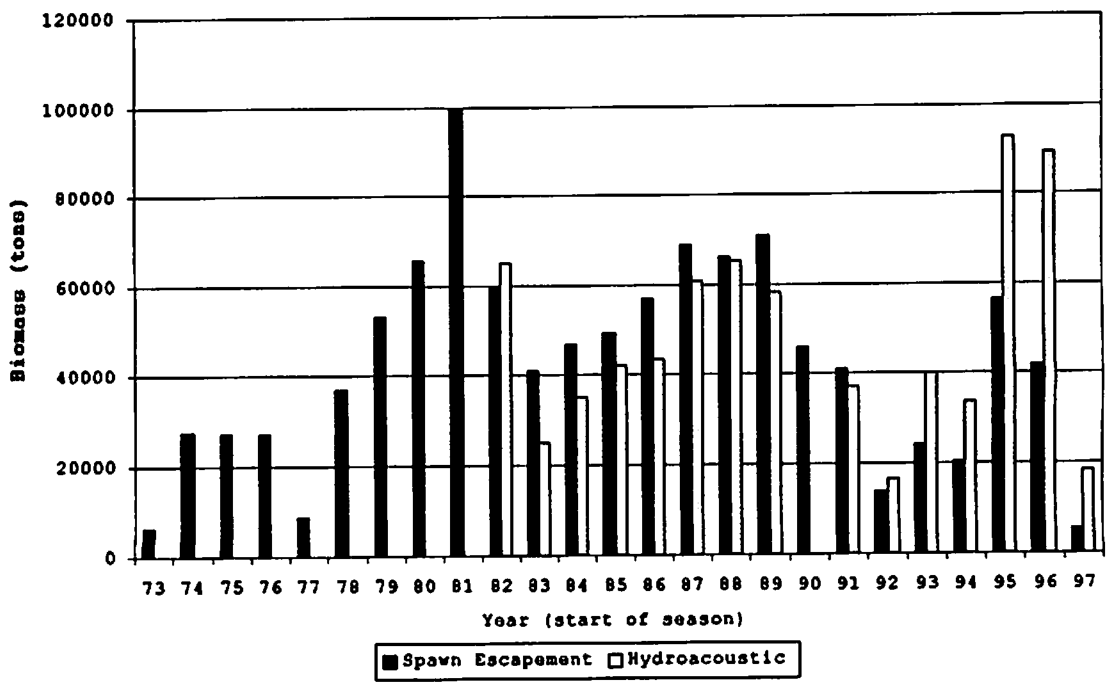
An echo integration method was initiated in the 1986-87 spawning season to estimate spawning biomass of some schools and was utilized through the 1989-90 season. Basic data collection methods remained unchanged, other than using a refined echosounder (Biosonics model 105) and a transducer with a narrower beam width. Data analysis was initiated by processing tapes of stored data through an echo integrator. The integrator provided herring densities by depth strata. These were subsequently converted to biomass through multiplication by representative surface areas. Reduced staffing and technical difficulties with this equipment resulted in the discontinuation of the echo integration method.

The largest estimate obtained from either of the hydroacoustic methods was used when school biomass estimates were cumulated for a peak seasonal spawning biomass estimate. Biomass estimates of the spawning stock in San Francisco Bay from hydroacoustic surveys have generally followed a pattern similar to that shown by spawn escapement surveys (Figure 3.11).

3.2.2.1.3. Spawn Survey Biomass Surveys Combined Hydroacoustic and

Prior to the 1989-90 season, the hydroacoustic survey method was considered

Figure 3.11. San Francisco spawning stock biomass estimates based on spawn escapement & hydroacoustic surveys.
(1994 Partial Hydroacoustic estimate due to mechanical difficulties).



experimental and still under evaluation, and thus was not used for quota establishment. Beginning with the 1989-90 season, the San Francisco Bay herring population estimates from spawning ground and hydroacoustic surveys have been merged to generate a single "best" annual biomass estimate to use as a basis for calculation of herring catch quotas. Results from the two techniques are treated independently during the season, but following the season, results are reviewed on a school-by-school basis to obtain the most accurate biomass estimate of each spawning school.

Each survey method has its strengths and weaknesses, thus a merged biomass procedure attempts to minimize survey deficiencies. If both survey methods yield acceptable results for a given spawning event, then the biomass estimates are averaged. If the project staff encounters problems with one method (e.g. foul weather, equipment failure, or inability to gather adequate samples), then results from the other method are employed.

3.2.2.1.4 Age Composition Analysis

Information on historic stock sizes can be obtained from an analysis of the age of the fish taken in the commercial fishery (cohort analysis)(Pope 1972). Data for the analysis come from landing records which provide seasonal landings by gear type. Dockside sampling by the Department provides data on the size and age structure of the catch by gear type.

In a cohort analysis, the earlier estimates in a time series are more accurate reflections of stock abundance than are more recent estimates (Pope 1972). One great advantage of this type of analysis is that it can be used to verify other indices (fishery-independent stock abundance estimates).

A cohort analysis was completed by the Department for the San Francisco Bay stock, using the catch information described above from the roe fishery covering the period from the 1973-74 to the 1989-90 spawning seasons. Estimates from cohort analysis and spawn escapement surveys were compared using only the abundance of herring older than 2 years. The proportion of two-year-old herring in the population that join the spawning stock is large but variable. By eliminating all fish younger than three years from the comparison, the differences in the portion of two-year-olds represented by the two biomass estimates is controlled. Without correction, cohort analysis estimates all two-year-old herring and spawn escapement estimates an unknown proportion of that age group.

With few exceptions, the annual estimates from the two methods are very similar (Figure 3.12). Both suggest an increase in spawning biomass through the period analyzed (1973-74 to 1989-90). In two instances the estimate from cohort analysis was notably different. In the first

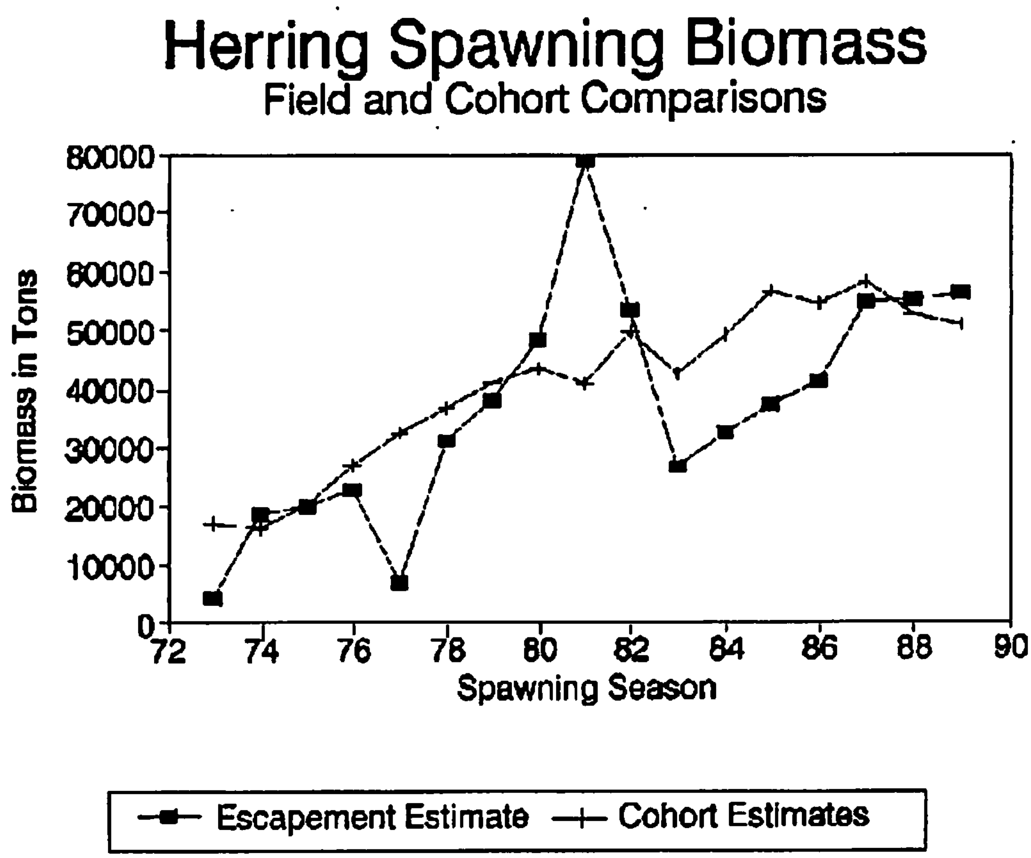


Figure 3.12 San Francisco Bay spawning stock biomass estimates (for 3-yr-old and older) based on spawn escapement survey and cohort analysis.

instance (1977-78), a change in Department personnel may have lead to an underestimate based on spawn escapement surveys. In the second, unaccounted for changes in natural mortality rates associated with the 1982-84 El Niño event may have lead to underestimates of biomass based on cohort analysis just prior to the event (1981-82) and slight overestimates immediately following the event.

3.2.2.1.5 Forecasting

Spawning biomass estimates are used as a basis for setting fishery quotas. Current management strategy is to base the quota on biomass estimates from the preceding season. This practice generally works well. However, significant fluctuations in biomass attributable to differences in recruitment have resulted in quotas being set too high and too low. The possibility of forecasting recruitment levels is being evaluated. An index of recruitment to the fishery has been developed based on the abundance of young-of-the-year herring in midwater trawl samples. If validated, the index could improve the method for setting quotas based on anticipated recruitment levels. The index accurately predicted poor recruitment of the 1990 year-class (Oda and Wendell 1990).

3.2.2.2 Status of Stocks

The status of Pacific herring stocks in California are evaluated by assessing abundance and age composition trends. Both types of information provide insight into a stock's resiliency to fishing mortality. Age composition information allows an assessment of survival at successive ages and provides a measure of the effects of fishing effort. This information is available to evaluate the status of San Francisco Bay and Tomales Bay stocks, which support the two largest roe fisheries, and partially available or completely absent for Humboldt Bay and Crescent City stocks.

3.2.2.2.1 San Francisco Bay Spawning Stock

San Francisco Bay supports the largest spawning stock of Pacific herring in California. All sources of information on stock abundance (spawn escapement, hydroacoustic surveys, and cohort analysis) show a fluctuating pattern of abundance over time (Figures 3.11 and 3.12). Several successive years of stronger than average year-classes from 1984 through 1988 allowed the spawning stock to build during those years (Table 3.2). This period was followed by two years of poor recruitment from the extremely weak 1989 and 1990 year-classes, resulting in a decline in spawning biomass which began with the 1990-91 season. A third consecutive year of poor recruitment from the 1991 year-class (as two-year-olds) resulted in the lowest spawning

Table 3.2. Estimated numbers of 2-, 3-, and 4-year-old Pacific Herring (X1000) by year-class in the San Francisco Bay spawning population. Numbers based on biomass estimates from: 1) spawn escapement surveys for 1981 to 1987 year-classes; 2) a combination of spawn escapement surveys for 1988 to 1994 year-classes

Year Class	Age 2	Age 3	Age 4
1982	332,669	190,988	126,535
1983	185,742	160,613	134,528
1984	162,422	194,365	136,604
1985	168,962	292,508	139,248
1986	233,193	222,058	136,248
1987	146,525	237,377	[1]
1988	294,631	[1]	208,265
1989	[1]	126,616	79,045
1990	14,073	50,398	162,584
1991	48,925	136,333	94,833
1992	19,428	236,783	282,069
1993	39,363	359,357	183,370
1994	483,164	359,459	59,650[2]
1995	290,497	115,241[2]	
1996	24,178[2]		

[1] not available - incomplete 1990-91 field season.
[2] estimates are preliminary and subject to revision.

biomass estimate recorded during the 1992-93 season.

In San Francisco Bay, the appearance of two-year-olds usually provides a reasonable indication of year-class strength, although full recruitment to the spawning population does not occur until age three. The poor showing of the 1991 year class at age two was followed by an improved appearance at age three, and accounted for most of the increase in biomass for the 1993-94 season. Biomass remained essentially the same during 1994-95, with good numbers of two, three, and four-year-old herring. The very strong 1994 year class, in combination with the 1993 and 1992 year classes, accounted for the leap in spawning biomass to 99,000 tons during the 1995-96 season. These year classes in addition to a strong 1995 year class sustained spawning biomass at 89,570 tons during 1996-97.

Severe El Niño conditions during 1997-98 heavily impacted spawning biomass for San Francisco Bay. The 1997-98 spawning biomass estimate for San Francisco Bay was 20,000 tons, only 20% of the previous season's estimate of 89,570 tons. Given the very large spawning biomass estimates for 1996-97 (89,570 tons) and 1995-96 (99,000 tons), and the strength of the 1995, 1994, 1993, and 1992 year-classes, many fewer fish than expected returned to spawn during 1997-98. Whether El Niño conditions caused increased mortality for herring or simply prevented herring from reaching reproductive condition remains to be seen. Many of the fish that returned to spawn during the 1997-98 season were under-weight with under-developed gonads. Schools took an unusually long time to ripen and spawn.

3.2.2.2.2 Tomales Bay Spawning Stock

The information base available to evaluate the status of the Tomales Bay spawning stock is not as complete as that available for San Francisco Bay. Spawn escapement surveys indicate a high degree of variability in spawning biomass through time. The estimates of stock biomass for the 1988-89 season through the 1991-92 season are among the lowest since surveys began in 1973 (Spratt and Moore 1992). However, a trend of increasing biomass did continue from the 1989-90 spawning season estimate of 345 tons to the 1992-93 spawning season estimate of 4,079 tons, indicating the stock was in recovery. While the anticipated post El Niño decline did occur in the 1993-94 season, during the 1994-95 season the spawning biomass estimate rebounded to 3,979 tons, the second highest since the 1986-87 season. The 1995-96 biomass estimate of 2,085 tons fell again below the 23-year average but was still just 10% lower than the 10-year average of 2,313 tons. However, the 1996-97 biomass estimate of 1,469 tons is the lowest biomass estimate since the fishery reopened in the 1992-93 season. Heavy rains reduced bay salinities and most likely inhibited spawning and may have kept some herring from entering the bay since schools were small and commercial catches were light. It may be necessary to wait several more seasons to ascertain what the post-recovery average biomass will be.

The dominant age groups commonly caught in commercial gill nets and variable mesh research nets are 4- through 6-year-old herring. Fish caught with the variable mesh research gill net are more representative of the population structure and samples taken with these nets in recent years showed all age groups present in proportions suggesting good recruitment. The mean length of commercial gillnet-caught herring from small catches given to Department biologists by fishermen (there was never enough herring caught to make a landing) increased this season and was slightly larger than the 5-yr. average. The relatively strong 1992 year class of 6-yr-olds dominated the commercial catch samples and was responsible for the slight increase in mean length. Due to the poor condition of the herring this season, only the larger 5-year and older herring were caught in commercial gillnets. Tomales Bay research gill net catch was too small to be of value in the 1997-98 season.

Age composition of the commercial gill net catch does not show large changes in catch-at-age through time (Table 3.3)(Spratt and Moore 1992). However, the commercial gill net gear is selective for older ages and does not provide any indication of the abundance of younger ages in the stock. Although data do exist to indicate that San Francisco Bay and Tomales Bay stocks are indeed separate (Moser and Hsieh 1992), wandering from the San Francisco stock (migration into Tomales Bay) could be maintaining the apparent stability in age structure of the catch. However, without signs of significant change in age structure, and in light of significant differences in some consecutive biomass estimates that are not attributable to recruitment, migration of fish from Tomales Bay seems to be the most likely cause of the current low biomass level (Spratt 1990). The current status of the Tomales Bay stock is considered to be fair; however, no clear trend is evident with recent spawning biomass estimates.

3.2.2.2.3 Other California Spawning Stocks

Very little information is available to evaluate the status of other spawning stocks in California. Spawn escapement surveys conducted during the 1974-75 and 1975-76 seasons in Humboldt Bay established the basis for the 60 ton Humboldt Bay quota (Rabin and Barnhart 1986). Spawn escapement surveys conducted in the 1990-91 season estimated a Humboldt Bay herring biomass of 400 tons, confirming the current quota is in the proper range (Spratt 1991). The Crescent City area also supports a small-scale fishery; however, beyond the aforementioned surveys, the status of the Crescent City stock and stocks not supporting fisheries is unknown.

Season	Age (Percent by Number) 3	4	5	6	7	8	9	Mean Length	Size Range
77-78[1/]	-	1	11	41	29	17	1	217	194-248
78-79			no samples						
79-80	-	14	41	27	4	14	1	214	196-236
80-81	3	10	30	33	15	7	2	208	172-234
81-82	2	8	21	28	25	13	3	211	176-236
82-83	-	4	24	34	24	11	3	208	184-236
83-84	-	13	36	35	11	2	3	199	174-242
84-85	7	13	27	33	15	4	1	202	164-232
85-86	14	25	27	18	10	5	1	198	166-226
86-87	4	20	38	27	6	3	2	197	174-236
87-88	<1	11	31	34	18	4	<2	201	170-234
88-89	4	22	33	28	9	3	1	197	170-236
89-90	2	9	18	37	26	8	-	204	172-222
90-91	4	21	32	26	12	4	1	197	174-232
91-92	10	26	37	21	6	-	-	194	168-214
92-93[2/]	1	15	47	30	7	-	-	196	166-226
93-94[2/]	<1	14	40	36	8	2	-	197	170-234
94-95[2/]	6	18	32	19	21	4	-	196	164-230
95-96[2/]	4	50	34	8	2	2	-	189	164-223
96-97[2/3/]									
97-98[2/]	-	-	18	68	14	-	-	196	194-212

Table 3.3. Age Composition of the Tomales Bay/Bodega Bay Gill Net Catch.

[1/] Tomales Bay has been a gill net only fishery since 1977.
[2/] Outer Bodega Bay closed to herring fishing.
[3/] No data currently available for this season.

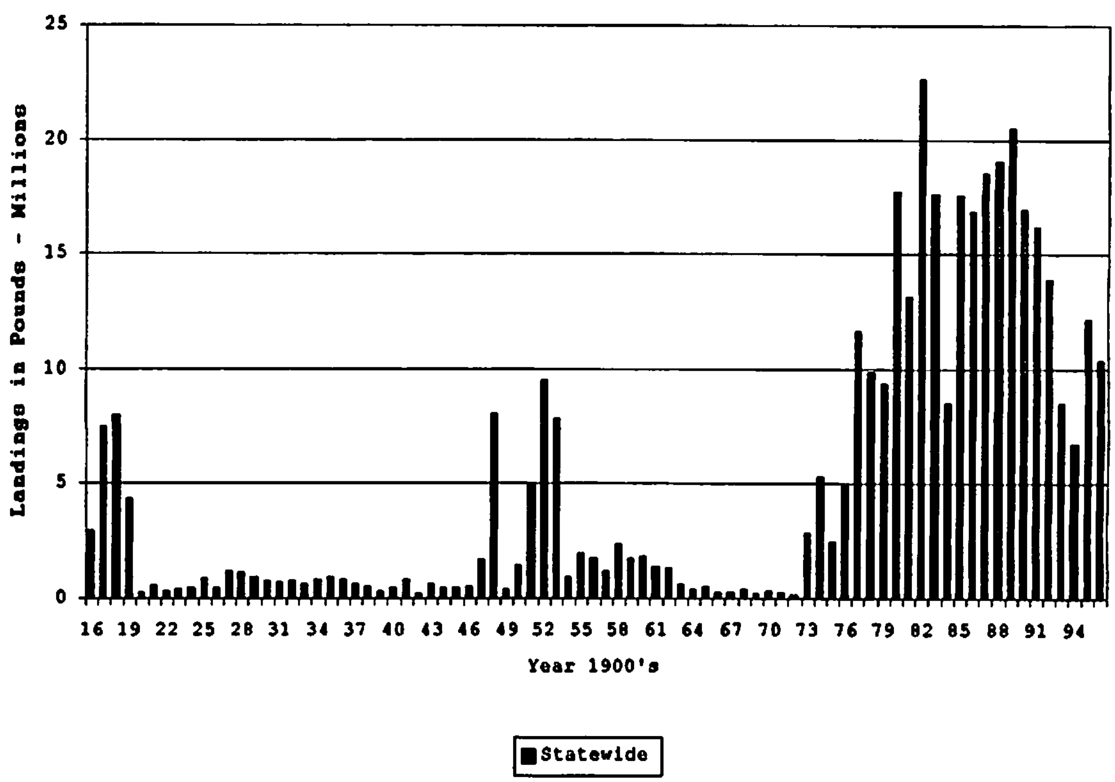
3.2.3 Human Use

Herring have been used by humans for a very long time. The Atlantic herring fishery is probably the oldest continuous fishery in the world (Obrebski and Hedgpeth 1984). The dominant product from herring fishing has varied considerably. Sac-roe, or mature egg skeins, which is used as a food product, is currently the dominant product on the west coast of the United States and Canada (Trumble and Humphreys 1985). Other uses of herring have included human food, bait for a variety of fisheries, animal food, and herring eggs-on-kelp. Herring eggs-on-kelp is a product of growing importance (Moore and Reilly 1989, Oda 1989). The dominant product from the Pacific herring fishery in California also has changed considerably through time.

3.2.3.1 Early Perspective

Pacific herring were commercially harvested in California before the turn of the century (Scofield 1918). There was a well established gill net fishery in San Francisco Bay in 1875. Continuous statistics on the State's fish landings have been kept since 1916 (Scofield 1952, Oliphant et al. 1990)(Figure 3.13).

Figure 3.13. Annual landings of Pacific herring in California.



Prior to 1916, most of the herring landed were consumed fresh but some were salted or smoked. As ocean sport fishing increased, more herring were used for bait. Landings for these uses have continued at low levels to the present day. Superimposed over this low level of use have been four peak periods when landings increased significantly.

During the four years 1916-1919 large quantities of herring were used for canning and for reduction into oil and meal. Most of these landings came from the Tomales Bay and San Francisco Bay areas. In the peak year 1918, the catch was about 8 million pounds. The California State Reduction Act of 1919 prohibited the reduction of whole fish of any species except by special permit. Permits were not issued to reduce herring, effectively ending the first period of peak landings.

During the 26-year period from 1920 through 1946, there was little or no canning of herring; but, moderate quantities continued to be sold for fresh consumption, for salting and smoking, and for bait. The second peak in landings began in 1947 in an effort to replace the sardine as a canned product. However, the product met with poor acceptance and landings declined by 1949 (Miller and Schmidtke 1956). The third peak followed shortly and lasted three years (1951-53). Some canning for human consumption continued and an unsuccessful effort was made to develop a pet food market for canned herring. Landings, primarily in the Monterey area, have continued at low levels to present; however, the herring are now used for bait and zoo animal food. The most recent peak in herring landings began in the early 1970's.

3.2.3.2 Recent Perspective

The most recent surge in landings started in 1973 when Japan began importing herring roe (egg skeins) from California. The herring egg skein is brined and sold as "Kazunoko", a delicacy in Japan (Spratt 1981). Annual landings increased rapidly, have exceeded 22 million pounds in recent years, and have averaged almost 15 million pounds since 1976 (Figure 3.13). The herring roe fishery starts in late fall and overlaps two calendar years. This results in two totals forherring landings, the annual herring landings and seasonal landings used for regulatory purposes (quota system).

Herring attain their highest economic value, based on roe content, just prior to spawning. This limits the roe fishery to the months of peak spawning activity (December through March). Spawning areas for herring in California occur in intertidal and shallow subtidal areas of protected bays and estuaries (Spratt 1981)(Figure 3.4). Only San Francisco Bay has a population large enough to support a major fishery. Small fisheries exist in the Tomales Bay area, Humboldt Bay and Crescent City Harbor.

Fishing technique has evolved somewhat in the herring roe fishery since its inception. Two gear types (gill nets and purse seines) have been primarily used in the herring roe fishery. Gill nets are single panels of net that are set (anchored) and left to capture herring by entanglement. Weights (along the bottom line) and floats (along the top line) hold the panel of webbing in a vertical position, to form a curtain-like wall of mesh. Purse seines are single panels of net that are rapidly laid out from a vessel and positioned to encircle herring. A small powered skiff aids in the encirclement process. Once encircled the bottom-weighted line is pursed to create a bag [Sec 4.2.6.1]. The bag volume is reduced by hauling the net onboard to concentrate the herring to the point where they can be tested for roe quality, and if acceptable, removed with a large scoop net or submersible pump. Fish of unacceptable quality are released. Beginning with the 1998-99 fishing season, gill nets will be the only gear used in the herring sac-roe fishery, following a regulation change which converts purse seine permits to gill net permits.

A small fishery also exists in San Francisco Bay that harvests Pacific herring eggs-on-kelp or "Kazunoko Kombu", for export markets (Moore and Reilly 1989, Oda 1989). Herring eggs-on-kelp, like herring roe, is a delicacy in Japan and is considerably higher in economic value. During the early phase in its development, the fishery harvested eggs spawned on naturally occurring algae in the bay (Spratt 1981). In 1985, giant kelp from the Channel Islands was used by suspending it from rafts anchored in likely spawning areas. This open pound eggs-on-kelp (ROK) fishing method is now exclusively used. Slightly over 106.8 tons of ROK from open pounds were landed during the 1995-96 season. This was equivalent to removing the spawning potential of 477 tons of herring for the season.

A herring dead bait and animal food fishery also contributes to current landings. This fishery occurs during the summer months with catches from Monterey Bay. Younger herring (1- and 2-yr-olds) are desired for bait and older herring are used for animal food. Peak landings of approximately 270 tons occurred in 1982.

3.2.4 Resource Management

The policy guiding the management of Pacific herring fisheries in California and the objectives of management are stated in the Fish and Game Code of California (Section 1700, Appendix 1). Briefly, the policy is to encourage the conservation, maintenance, and utilization of aquatic resources for the benefit of all the citizens of the State. The objectives of management under this policy include:

a. Maintaining sufficient populations to insure their continued existence.

b. Recognizing the importance of aesthetic, educational, scientific, and non-extractive recreational uses of the resource.

c. Maintaining sufficient resources to support a reasonable and satisfying sport use.

d. Promoting the growth of local commercial fisheries and use of unused resources when consistent with aesthetic, educational, scientific, and recreational uses.

e. Managing on the basis of adequate scientific information promptly promulgated for public scrutiny.

Management authority for regulating the herring roe fishery was initially in the control of the California State Legislature. During the first fishing season (1972-73), emergency legislative action (Fish and Game Code of California) established catch quotas for Tomales Bay and San Francisco Bay. The Legislature also established a herring fishery permit system.

The Legislature subsequently set catch quotas for the next season (1973-74), and included a catch quota for Humboldt Bay. Management authority for the Tomales and San Francisco Bay fisheries was then delegated to the Fish and Game Commission, including the authority to limit the number of herring permits. The Legislature also required the Commission to periodically review their regulations and policies.

The Commission has held the management authority for all herring fisheries in the State since 1976. A system has evolved to meet the legislative mandate to periodically review regulations and policies. The review occurs annually and is initiated when the Department presents its management recommendations based on stock assessments to the Director's Herring Advisory Committee. The Department's recommendations are modified, as necessary, based on the committee's comments and are presented at a public hearing. The recommendations are again modified, as necessary, and presented to the Fish and Game Commission. The recommendations and comments from the Department, other agencies, and the public are typically presented to the Commission at two meetings each year (June and August). The Commission subsequently adopts new regulations for the next fishing season (California Code of Regulations, Title 14. Natural Resources).

The Commission has available to it a variety of explicit regulations that can be introduced to achieve objectives identified in Section 1700, Fish and Game Code (Appendix 1). Several concepts new to commercial fisheries management in California have been introduced by either the Legislature or Commission to regulate the herring roe fishery, including: limited entry, 2) permits issued by lottery, 3) catch allocation by gear, and 4) individual vessel quotas. In general, the regulations either control the amount of fishing, control the composition of the catch, or control the allocation of the catch.

One of the most direct methods of controlling the amount of fishing is setting limits on total catch through a quota system. Many strategies have been developed by fishery scientists to set catch quotas. An objective of State policy is to regulate the catch from a commercial fishery at a level that is within the limits of maximum sustainable yield (MSY) to insure the continued existence of a harvested population. MSY is an estimate of the largest catch that can be taken continuously from a stock. The estimate is based on average characteristics of the stock computed over many years and on well established fishing practices. However, herring are known to undergo large fluctuations in stock size due largely to variations in annual recruitment. Average MSY harvest values can be excessive when recruitment has been poor and stocks are low. As a result, use of MSY is not the most appropriate strategy in formulating annual catch quotas in herring fisheries and is not used in California (Murphy 1977, Appendix 3).

A mathematical model (HMODEL) developed by the Pacific Fishery Management Council (PFMC) has been used to examine the long-term consequences of different harvest strategies for

Pacific herring (Pacific Herring Fishery Management Plan - Draft, Appendix 3). The model, using selected biological characteristics of a stock, allowed comparisons of biomass, harvest levels, and stock stability over a long period for a series of harvest strategies.

Several results emerged from the PFMC analysis that are germane to the selection of an alternative harvest strategy for Pacific herring in California. Two strategies were identified by the PFMC that maintained a long-term production even with strong fluctuations in stock size. One of these strategies is currently used by all Pacific coast states with herring fisheries, including California. The chosen strategy, discussed below, allows harvesting at a constant percentage of the estimated stock biomass. This strategy avoids excessive harvest rates that could occur under a constant tonnage (quota) approach and is more responsive to current stock and environmental conditions.

A range of constant harvest percentages were tested using HMODEL. At a harvest level of 20 percent and assuming a natural mortality of M = 0.4, the stock and harvest fluctuated, but did not decline during a 100-year simulation. At 40 percent, a long-term decrease occurred; but, the decline did not occur for over 25 years, indicating that heavy fishing pressure may be maintained if recruitment levels were high. The strategy of harvesting at a maximum of 20 percent of biomass was selected by the Department for use in California based on the above considerations.

In addition to setting quotas based on biomass estimates, a variety of other regulations have been promulgated by the Commission as a result of their periodic review of existing regulations or as a result of additional guidance from the Legislature. Many of the changes have addressed socioeconomic issues. The proposed project (regulation of the commercial herring fisheries in California) has evolved, in large part, as a consequence of prior Commission action.

The exact text of the most recent pertinent sections of the Fish and Game Code and Title 14 are provided in Appendix 1. A brief review of key management actions by geographical area follows.

3.2.4.1 Monterey Bay Area

Commercial herring fishing is restricted in open ocean areas to an area north of Yankee Point in Monterey county. Within this area fishing is further restricted to exclude those areas used for herring roe fishing (specific bays and estuaries). The total amount of fishing effort is not controlled other than stipulating that herring taken in open ocean waters may not be used for herring roe purposes. A season is set (April 1 to November 30) that excludes the typical spawning period.

3.2.4.2 San Francisco Bay Area

Commercial herring fishing is restricted in San Francisco Bay to portions of San Pablo, Central, and South Bays (Fish and Game Districts 11, 12, and 13)(Figure 3.14). Within this broad area, fishing is further restricted in area through specific closures to selected fishing gears. The total amount of fishing effort in the San Francisco Bay herring fisheries has been controlled in two primary ways. Permits have limited the number of participants in the fishery and quotas have limited the catch. The number of permits and the quotas in San Francisco Bay both increased rapidly during the early phase of the herring roe fishery (Figure 3.15 and 3.16).

The first significant increase in herring roe permits occurred during the 1976-77 season when a lottery for permits was discontinued and permits were issued to all qualified applicants. The majority of new permits issued at this and subsequent seasons went to gill net fishermen. The qualification criteria were tightened the next season by introducing a point system and fewer permits were issued.

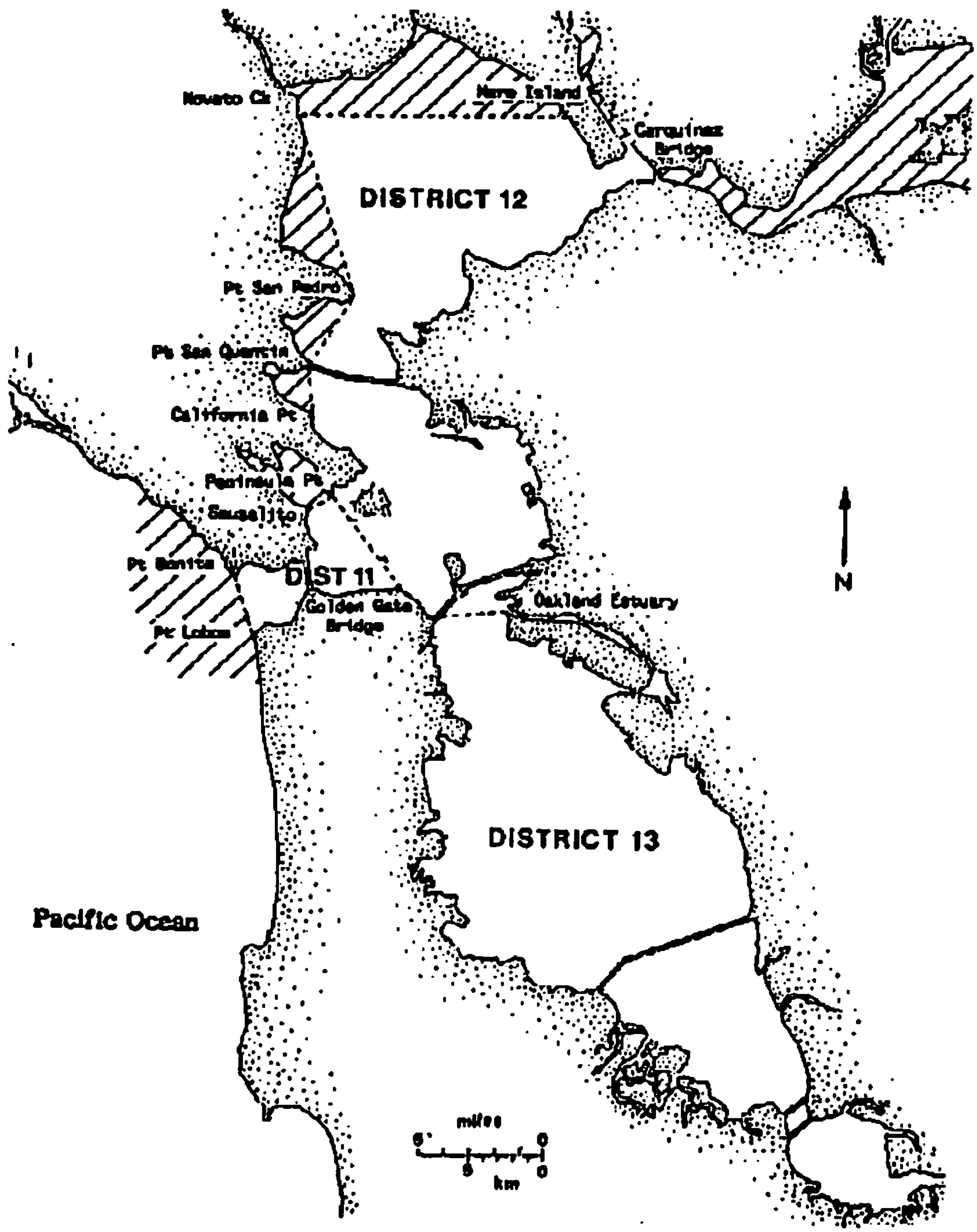
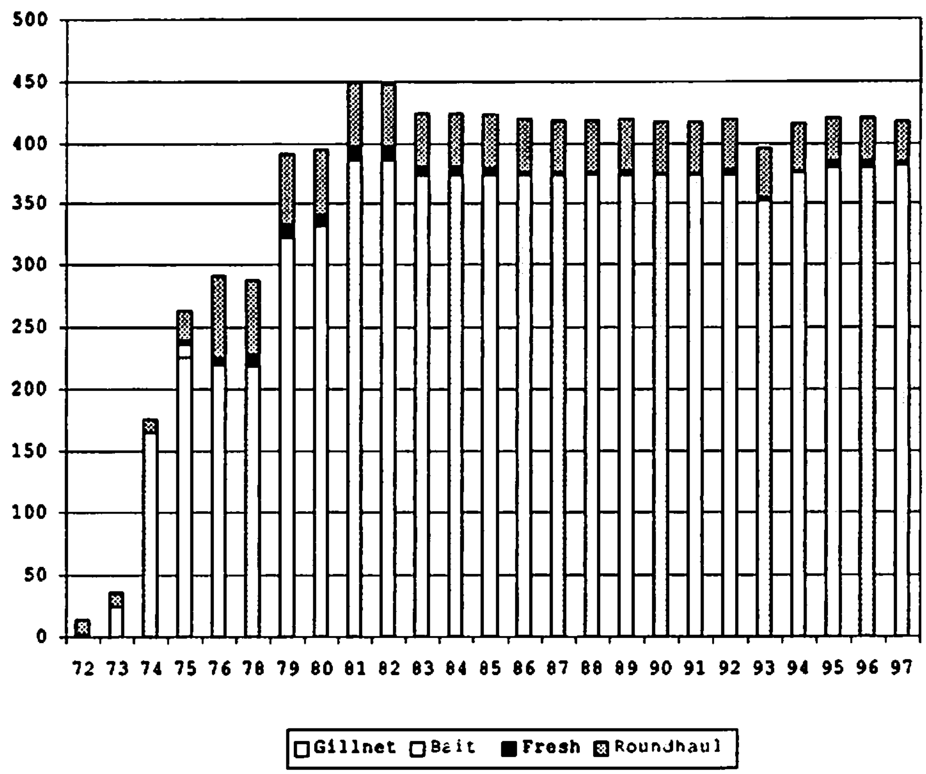


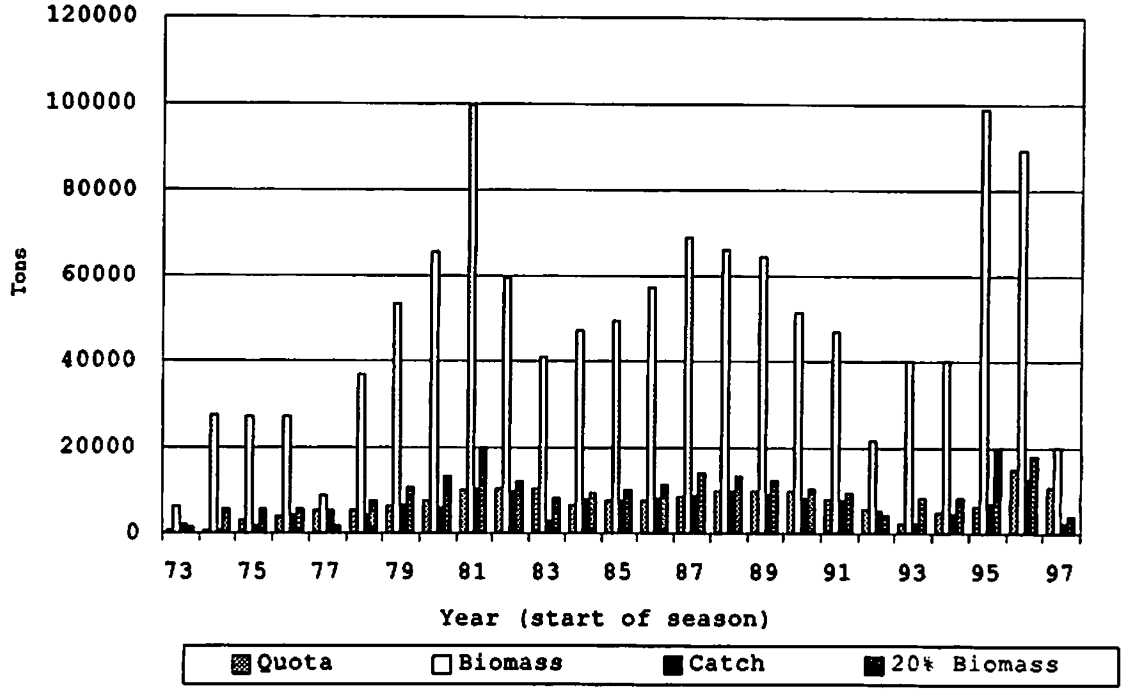
Figure 3.14. Commercial fishing districts open to herring roe fisheries within San Francisco Bay

Figure 3.15. Number of permits by gear type issued to fish in San Francisco Bay herring roe fishery.



The next significant increase in the number of permits occurred during the 1980-81 season. Other than a few transfers from the Tomales Bay fishery during the next two seasons (1981-82 and 1982-83), an increase in the XH gill net platoon in 1982-83, and five new permits issued in the 1986-87 season, no additional permits have been issued in the San Francisco Bay herring roe fishery. The maximum number of permits active in any season was 430 (1982-83). Regulations have also evolved to establish qualification criteria for permits and to monitor the business aspects of procuring, selling and transferring permits.

Figure 3.16. Relationship between targeted catch (20% or less of spawning biomass) and actual catch - San Francisco Bay herring roe fishery.



Ten permittees are allowed to transfer into an eggs-on-kelp fishery. The quotas from their respective gear types and platoons were converted to an eggs-on-kelp quota.

Catch quotas are a primary tool for limiting total catch. They are based on Department recommendations and set by the Commission. Quota recommendations are based on no more than 20 percent of the previous season's spawning biomass, which is the closest possible estimate. A procedure has not been developed to provide a "real-time" (immediate) estimate of spawning biomass to set quotas in season [Sec 4.2.6.1]. Previous season spawning biomass may not accurately reflect stock size for the coming season. When biomass declines, a quota based on prior-season spawning biomass may be too high. The Commission can make in-season adjustments to quotas on an emergency basis, if necessary. Gear restrictions and quota allocations have been enacted to reduce congestion on the San Francisco Bay fishing grounds and to control the rate of catch. Limiting the amount of gear helps achieve timely quota closures by improving the accuracy of landing projections. Congestion is also alleviated by dividing the permittees into platoons (Odd, Even, and DH) and assigning separate fishing periods and quotas.

A variety of other management actions have been taken designed primarily to address social and economic issues. For example, closures, either in time or area, have been enacted to reduce gear conflicts, to minimize conflict with recreational uses of the Bay, and to address military concerns [Sec 4.2.7]. Closures have also been enacted to control noise pollution, to protect sensitive habitat, and to help insure safety [Sec 4.2.7].

3.2.4.3 Tomales Bay

Commercial herring fishing within the Tomales Bay has been limited in geographic extent to a small portion of Commercial Fishing District 10 (Figure 3.17).

Comparable actions to those used in the San Francisco Bay fishery have been taken to control the total amount of fishing in Tomales Bay (Tomales Bay discussion includes Bodega Bay). The number of permits issued increased rapidly as the fishery developed, peaking at 70 gill net permits in the 1980-81 season (Figure 3.18). Gill net permits accounted for most of the in-crease and have been the only permitted gear in this fishery since the 1980-81 season. The total declined to 40 permits during a two year period (1981-82 and 1982-83) when transfers were

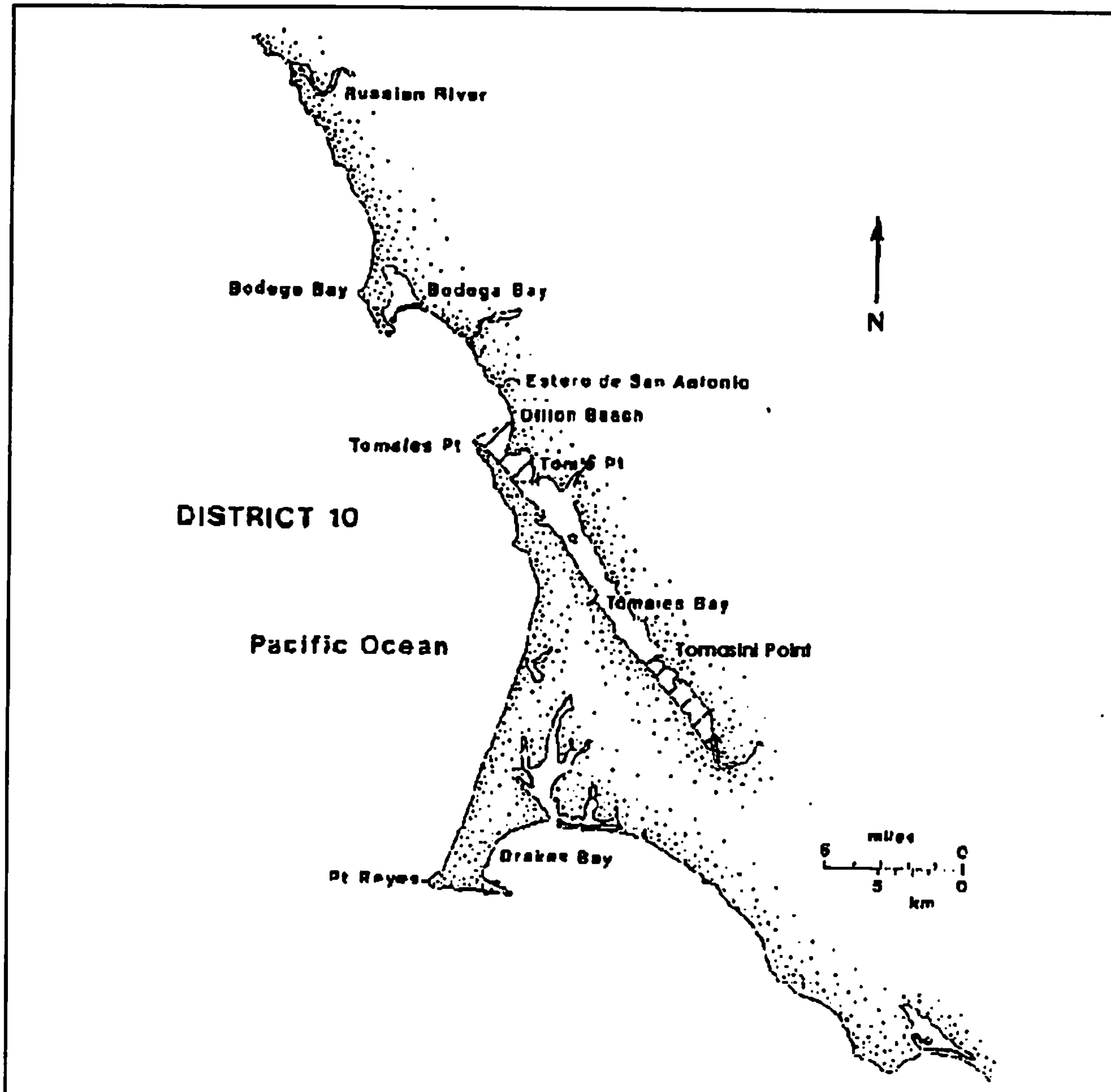
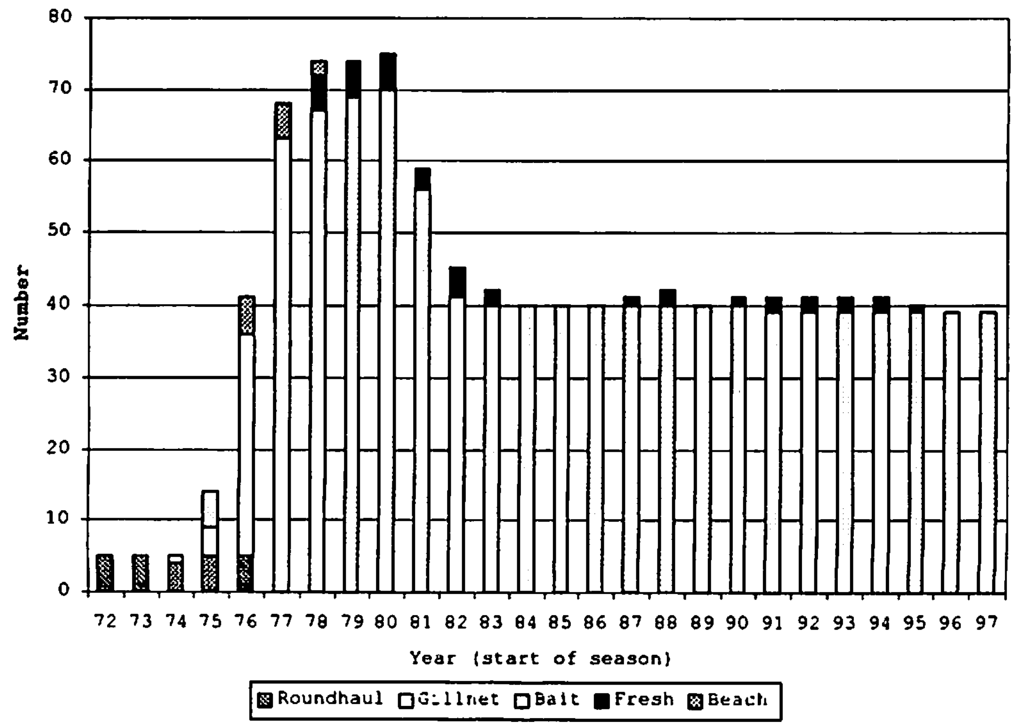


Figure 3.17. Hash marks designate areas closed to commercial fishing in Tomales Bay.

allowed into the San Francisco Bay fishery. No eggs-on-kelp fishery exists in these bays.

The same general management strategy used elsewhere in California has been applied to setting quotas in Tomales Bay. Quotas were typically set closer to the allowable maximum (20 percent) (Figure 3.19). Quotas have fluctuated with biomass; the maximum quota allowed to

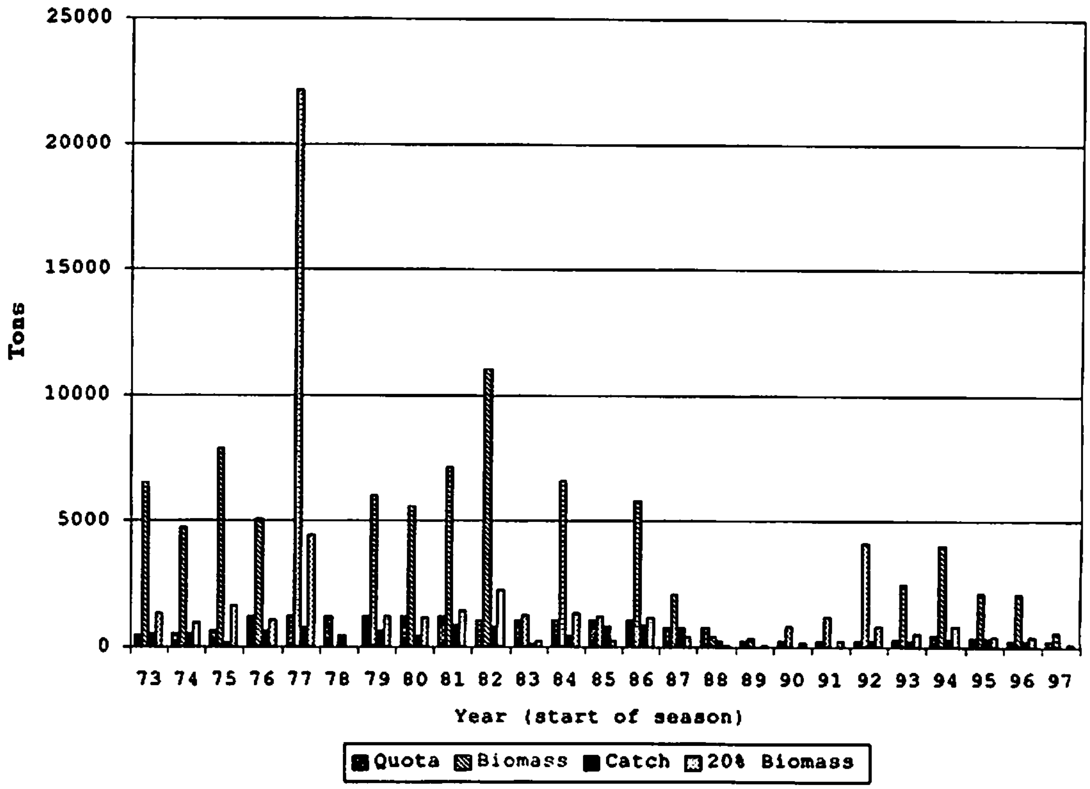
Figure 3.18. Number of permits by gear type issued to fish in Tomales Bay and Bodega Bay herring roe fishery.



date was 1210 tons. This is approximately 12 percent of the maximum allowed in the San Francisco Bay fishery.

Congestion and allocation issues have not been as prevalent in the Tomales Bay fishery. The use of round haul gear (purse seines and lampara nets) was precluded early in the fishery due largely to public sentiment. Platoons were initially created to reduce congestion when Tomales Bay and Bodega Bay permittees were grouped together; however, the platoon system is not currently in use. Weekend closures minimize conflict with recreational uses of the Bay.

Figure 3.19. Relationship between targeted catch (20% or less of spawning biomass) and actual catch - Tomales Bay.



3.2.4.4 Humboldt Bay and Crescent City Areas

Commercial herring roe fishing is restricted to Fishing Districts 8 and 9 in Humboldt Bay and a small portion of District 6 in the Crescent City Area. Open-ocean fishing for herring (bait and animal food) is permitted offshore of both areas. However, the only commercial herring fishing in either area targets on herring roe. Permits and quotas are used to control the amount of fishing for herring roe as part of a statewide policy. A maximum of four permits have been issued for Humboldt Bay and three for the Crescent City Area. The number of permits has not changed since the 1977-78 season. Quotas for Humboldt Bay were adjusted from 20 ton to 50 tons during the 1976-77 spawning season as a result of biomass estimates obtained during the 1974-75 and 1975-76 spawning seasons (Rabin and Barnhart 1986) [Sec 4.2.6.1]. The quota was increased to 60 tons during the 1982-83 season. The catch has exceeded the quota on three occasions in both the Humboldt Bay fishery and the Crescent City Area fishery. Gill nets are used exclusively to take herring for roe in both areas. Weekend closures are not in effect in either area.

3.3 Specific Biological and Environmental Descriptions

3.3.1 Monterey Bay Area

3.3.1.1 Physical Environment

Although commercial herring fishing is permitted in ocean waters from Yankee Point (Monterey County) north to Oregon, the only existing ocean fishery is located within Monterey Bay (Figure 3.20). The description of the open ocean portion of the project area is restricted to the pelagic habitats occupied by herring. The pelagic habitat is a three-dimensional area composed of seawater which is influenced by ever-changing features such as sea-surface temperature, currents, and eddies, and provides a dynamic physical environment. Only the surface layer (surface to 150 meters) receives sufficient light to support plant growth. Plant populations (phytoplankton) in the surface layer provide food (primary production) to support organisms in the surface layer as well as in the deeper pelagic and bottom areas. Herring tend to occupy the neritic (overlying the continental shelf) portion of the pelagic zone.

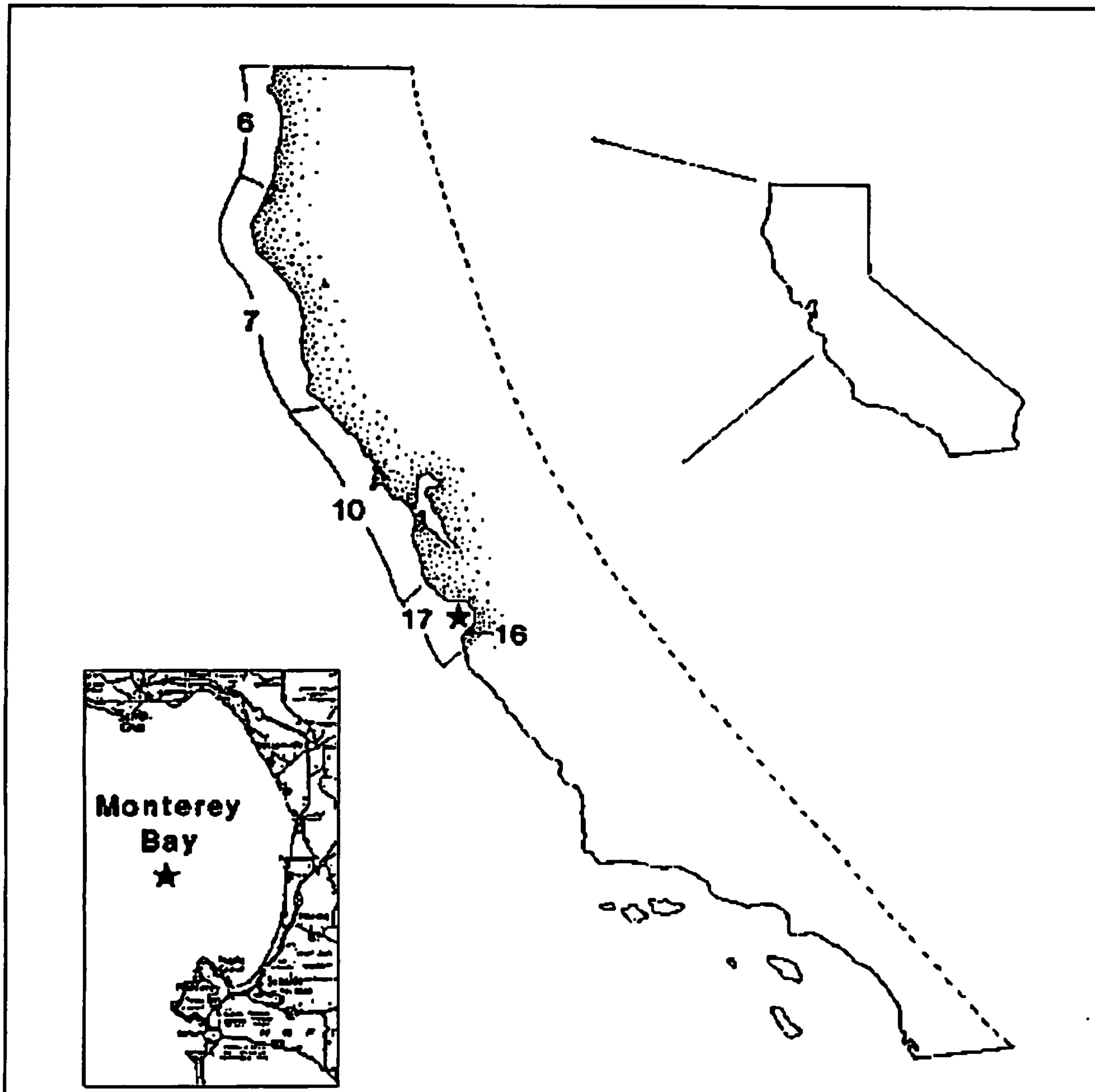


Figure 3.20. Areas (districts) open to commercial herring fishing in ocean waters.

Currents form one of the primary physical features of the ocean portion of the project area. The major alongshore currents off northern and central California coast are an offshore, southward flowing current (California Current) and a nearshore, northward flowing current

(California Countercurrent).

The California Current system is a part of the huge clockwise circulation of the North Pacific Ocean. Near the coast of North America this flow divides into two branches. One moves south, becoming the California Current which eventually turns west merging with the Equatorial current. Superimposed upon the general southward flowing California Current are narrow, meandering bands of high velocity flow. The edges of the currents mix to create a series of eddies and swirls with occasional jets and filaments of water flowing offshore. The jet and eddy system can change substantially over short time scales (Mooers and Robinson 1984) and can have significant effects on water properties.

The nearshore northward-flowing California Countercurrent only reaches the surface when it is at its strongest in the fall and winter. At this point, it is generally called the Davidson Current (Hickey 1979). Northward flowing currents are warmer and typically poorer in nutrients.

During the summer, persistent northwesterly winds along the California coast blow the surface water southward and westward, covering the countercurrent. The surface water is replaced by cold nutrient-rich upwelled water. Upwelling is particularly strong along the coast in the vicinity of capes and submarine canyons. The commercial herring open-ocean fishery coincides with upwelling conditions and is generally restricted to the southern half of Monterey Bay, south of the large submarine canyon located in the middle of Monterey Bay.

Three distinct seasonal phases are present in the physical conditions of Monterey Bay waters, paralleling the phases observed on a larger scale. These are the upwelling period of summer, a calm warm "oceanic" period in fall, and the Davidson Current period in winter. In January and February, surface water temperature is relatively warm (13°C) with low salinity

(33.2°/oo). As upwelling begins in spring, deep water rises, and the surface water cools and becomes more saline. Warming occurs in the fall, and the surface salinity decreases in winter (McLain and Thomas 1983).

Northwesterly air flows are the dominant pattern during the spring, summer, and autumn seasons. Wind speeds associated with the northwesterly-type flow pattern range from 2 to 7 mi/hr during the morning and evening hours and from 8 to 16 mi/hr during the afternoon. A variety of flow patterns exist associated with the movement of winter storms through the area.

3.3.1.2 Biological Resources

The biological component of the pelagic habitat in the Monterey Bay area is composed of organisms from northern subarctic areas mixed with organisms from southern transition areas. Phytoplankton populations are dominated by diatoms with other less conspicuous seasonal components. There is also some seasonality and patchiness in zooplankton abundance, dominated by the presence of crustaceans (copepods and euphausiids) and arrow worms (chaetognaths).

The primary consumers within the pelagic community are schooling fishes. Northern anchovy, Pacific and jack mackerel, Pacific sardine, and Pacific herring are the most abundant species in this group. The market squid, an invertebrate, occupies the same general niche and is also an important food source for higher trophic level feeders.

Fluctuations in the strength of the California counter-current have had notable effects on the distribution and abundance of various marine organisms. Of particular interest is the impact of major El Niño warming events. Phytoplankton and zooplankton characteristic of low latitudes become more prominent in the warm years (Garrison 1979). However, both plankton communities are typically depressed during warming events leading to changes throughout the food web. These fluctuations can have significant influences on the abundance and distribution of species that occupy higher trophic levels.

A number of marine birds may feed on herring in ocean waters; included are the shearwaters, cormorants, common murre, auklets, puffins, marbled murrelet, and brown pelican. The availability of herring as prey for many bird species is dependent on herring vertical migrations, bringing herring into shallow surface waters where they are accessible as prey.

A number of marine mammals are known to prey on pelagic schooling fish in the open ocean. Among the marine mammals that may feed on herring in the Monterey area are the California sea lion, the northern elephant seal, Steller sea lion, and the northern fur seal. All of the smaller cetaceans are likely to be herring predators. Among the larger cetaceans, Minke whales, humpback whales, and fin whales are known to be fish eaters. The remaining large whales may consume herring incidentally. This group includes the California gray whale in some areas. However, the California gray whale does not typically eat during its migrations through California waters.

Threatened or endangered species found within this region include the brown pelican (*Pelecanus occidentalis californicus)*, southern sea otter (*Enhydra lutris nereis*), marbled murrelet (*Brachyramphus marmoratus*), and the Steller sea lion (*Eumetopias jubatus*). The brown pelican is state and federally listed as endangered; the sea otter is federally listed as threatened; the marbled murrelet is state listed as endangered and federally listed as threatened; and the Steller sea lion is federally listed as threatened.

The brown pelican is found in the area during seasonal migrations. Brown pelicans tend to follow their primary prey, the anchovy. Anchovy abundance increases in the Monterey Bay area during the fall, and decreases in late winter when fish move offshore and to the southeast to spawn. Sea otters are year-round residents of the Bay, occupying near-shore kelp beds and feeding on a variety of shellfish. The marbled murrelet, another coastal resident species, nests inland and feeds on inshore marine fishes including Pacific sandlance, anchovy, and Pacific herring (Burkett 1995). The Steller sea lion occurs occasionally in transit through Monterey Bay. This species breeds to the north of Monterey Bay at Año Nuevo and is a likely consumer of herring in addition to other fish species.

3.3.1.3 Socioeconomic Environment

Regional Economy:

The area used to characterize the regional economy is Monterey County. The 1990 population estimate for the county is 360,200 (California Statistical Abstracts 1990). Over 35 percent of the population lives in the immediate vicinity of the Monterey peninsula.

The county is a leading producer of vegetable crops (ranked first in the State) with over 65 percent of land dedicated to farms. Between 1988 and 1991, unemployment levels ranged from 8.1% to 10.9% (Employment Development Department 1992).

Commercial Fisheries:

A number of commercial fisheries operate in or near the Monterey Bay area. Included among these are several that occur in the same area where herring are taken and that use the same vessels (squid, mackerel, anchovy, and sardine fisheries). Commercial salmon trolling also occurs in the same general area on a seasonal basis. Of significant economic value to the fishing industry in the area is the bottom trawl fishery operating offshore of typical herring habitat. This fishery targets on Dover sole, thornyheads, rockfishes, lingcod, and other groundfish.

Commercial fishery support facilities are located in the Monterey harbor, in Moss Landing, and in Santa Cruz harbor. Most of the activity mentioned within this section operates from the Monterey harbor.

Commercial Shipping:

Very little commercial shipping occurs in the immediate vicinity of Monterey. Tankers do use moorings outside of Moss Landing to offload fuel for use in power generation at the Moss Landing Pacific Gas and Electric Company facility.

Recreation:

Recreational uses of the nearshore waters in the Monterey Bay area include fishing for salmon, halibut, rockfishes, and lingcod. The nearshore waters along the peninsula are also heavily utilized by the sport diving community, kayakers, motor boaters, and sailing enthusiasts.

3.3.2 San Francisco Bay Area

3.3.2.1 Physical Environment

San Francisco Bay is a natural estuary which is separated from the Pacific Ocean by an approximately one mile wide natural opening called the Golden Gate. San Francisco Bay is situated on the central California coast about 400 miles (640 km) north of Los Angeles. The Bay is characterized by broad shallows carved by narrow channels whose depths are maintained by swiftly moving currents. The average depth of the Bay is 20 feet (6 m) with a maximum depth of 360 feet (110 m) in the Golden Gate area.

There are at least four distinct reaches (areas) within San Francisco Bay: 1) Suisun Bay, 2) San Pablo Bay, 3) Central Bay, and 4) South Bay. Commercial herring fishing is presently permitted within portions of all reaches except Suisun Bay (Figure 3.21). The primary fresh water inflow into San Francisco Bay is into Suisun and San Pablo Bays from the Sacramento and San Joaquin Rivers. The Sacramento and San Joaquin drainage basin encompasses approximately 40 percent of the State of California. It is estimated that ten million cubic yards of sediment move into San Francisco Bay annually from these sources and other natural runoff (Krone 1966).

Tidal velocities within the Bay determine the distribution of particles from this sediment load. The coarser sediments may be found near the estuary mouth (Golden Gate), with fine-grained muds being deposited on the flat, shallow bottom areas in most of the Bay. Channel beds dominated by large-grained particles, especially coarse sands. The particles are constantly being resuspended, transported, and redeposited by water movement. Water movement is dominated by a two-layered circulation pattern that results from opposition of freshwater outflows and tidal inundations of seawater. Higher outflows result in more rapid net circulation and more intensive mixing of water masses. Wind stress-caused turbulence also mixes the fresh and seawater layers.

Tidal amplitude is another major driving force in estuarine circulation. During strong spring tides, total water exchange with the Pacific Ocean may be as much as 24 percent of the total volume of the Bay in a single tidal cycle (Herrgesell et al. 1983).

The principal factors that influence air quality in the area are mixing height and wind speeds. The mixing height is the height of the top of the air layer in which relatively vigorous vertical mixing occurs. Mixing height is usually lower in the morning than in the afternoon. In the San Francisco Bay area, morning mixing heights range from 1300 to 2300 ft and afternoon mixing heights range from 2100 to 3500 ft (Holzworth 1972).

Northwesterly air flows are the dominant pattern during the spring, summer, and autumn

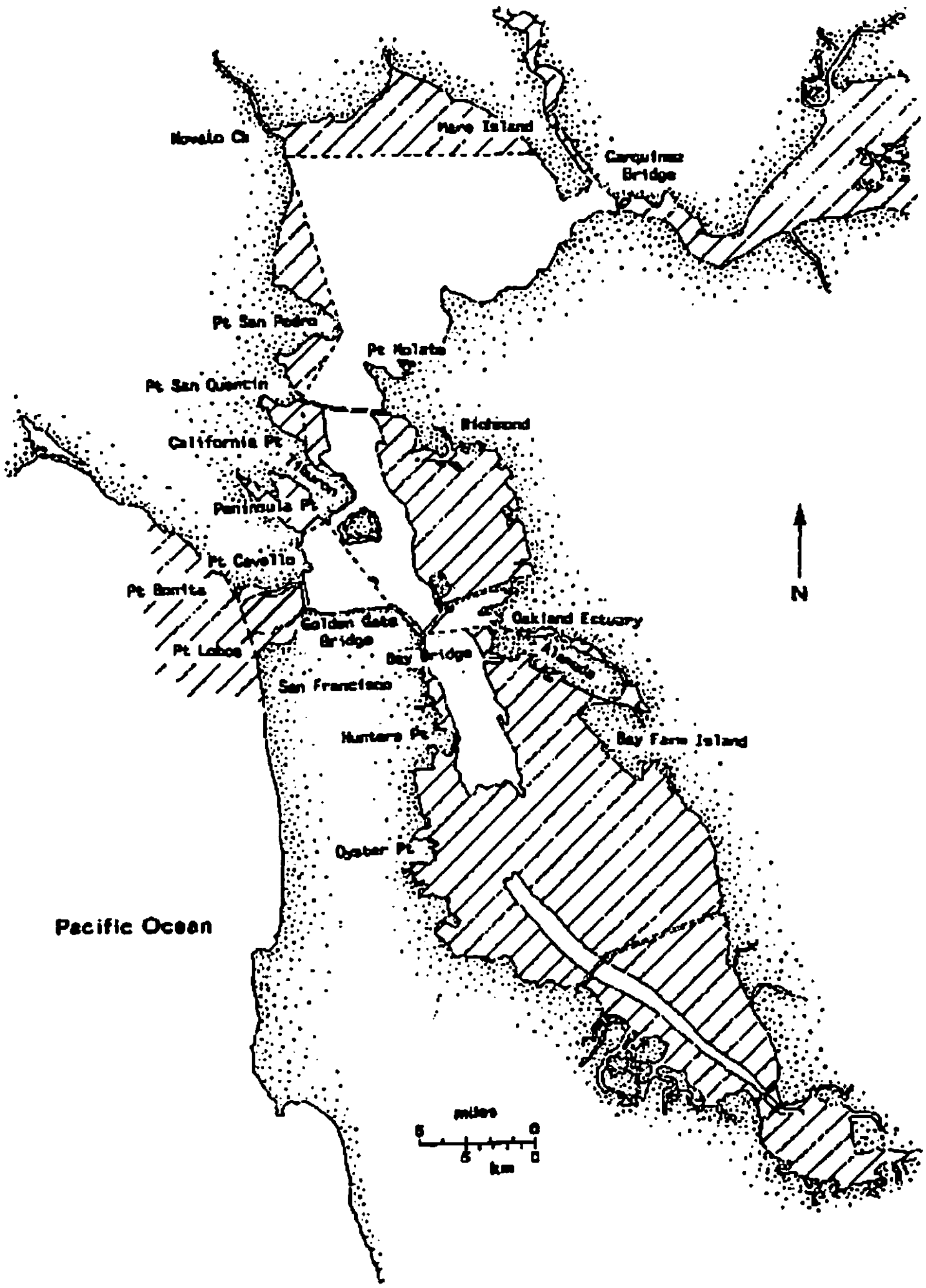


Figure 3.21. Areas within San Francisco Bay estuary used by commercial herring fisheries. Areas marked by diagonals conditionally closed to roundhaul.

seasons. Wind speeds associated with the northwesterly type flow pattern range from 2 to 7 mi/hr during the morning and evening hours and from 8 to 16 mi/hr during the afternoon. A variety of flow patterns exist associated with the movement of winter storms through the area.

Because the prevailing winds blow off the Pacific Ocean, the air quality in San Francisco is among the least degraded of all the developed portions of the Bay Area. The primary air quality problems are levels of carbon monoxide (CO) and total suspended solids (TSP). The primary source of CO is motor vehicles. The primary sources of TSP's are demolition, construction activities, and motor vehicle travel over paved roads. Motor vehicles also contribute significantly to ozone production through the emissions of hydrocarbons and nitrogen oxide.

The latest emission inventory (1996) for the San Francisco Bay area was extracted from the Bay Area Air Quality Management District (Toch Manget, pers. comm.)

3.3.2.2 Biological Resources

The Bay supports a diverse assemblage of organisms. Each reach of the Bay is a distinct habitat area characterized by different salinity regimes and by different biota. The estuarine species are most concentrated in the northern bays and the marine species are more abundant in the South and Central Bay.

Generally, turbid bay water reduces the area suitable for attached and rooted plant growth to very shallow waters and marsh areas. These plant forms are important at particular locations, but phytoplankton are more important to the total Bay productivity. Diatoms, a type of phytoplankton, represent a substantial portion of the total plant production in the Bay. Phytoplankton production is concentrated in the large shallow areas where light readily penetrates. Peak abundance of phytoplankton typically occurs during the spring and abundance is greatest in the Central Bay area.

The bottom community in Suisun and San Pablo Bay is dominated by the Asian clam, an introduced species that has reached densities >10,000 m^2 in some areas (Hymanson 1991). Since late 1986, both the number of species and the number of individuals of species other than the Asian clam have declined. The percentage contribution of the Asian clam to total abundance in this portion of San Francisco Bay has reached 95 percent. Concurrently, the abundance of the common estuarine copepod (zooplankton) in the upper estuary has declined >90 percent (Kimmerer et al. unpub. manus.) and the summer phytoplankton bloom in the upper estuary has disappeared since 1987 (Alpine and Cloern 1992). These are dramatic changes in the bays ecosystem and are attributed to grazing by the Asian clam. The Asian clam is also well established south of the Dumbarton Bridge and is spreading southerly and westerly in the south bay (L. Schemel USGS, Menlo Park pers. commun.). The Asian clam may represent a major link in the benthic-pelagic coupling of the San Francisco Bay estuary.

Dominant mobile invertebrates (animals without backbones) in the San Pablo Bay area include the bay shrimp and the Dungeness crab. Bay shrimp spawning occurs in more saline areas of the Bay but juveniles migrate to shallower, lower salinity regions after larval settling. The Dungeness crab is present in the Bay only as last-stage larvae and juveniles. The larvae move into the Bay during April and May. Young-of-the-year spend about one year growing in the Bay before returning to the ocean.

The bottom community in the Central and South Bay areas is more diverse. The Japanese cockle, the bent-nosed clam, and the Atlantic soft-shell clam are dominant clams in these areas. The bay shrimp is joined by a related species in the more marine environment typical of Central and South Bay. The Dungeness crab is also found in both reaches of the bay.

A variety of vertebrate (animals with backbones) consumers are supported by the estuary. Some estuarine fish are resident species, completing their entire life cycle within the estuary. The most common estuarine fish include the plainfin midshipman, topsmelt, jacksmelt, bay pipefish, shiner surfperch, yellowfin goby, prickly sculpin, and Pacific staghorn sculpin. Marine species tend to use the Bay seasonally as a spawning ground or nursery area. Coastal species that commonly occur in the Bay include several species of sharks and rays, smelts, surfperch, rockfish, gobies, sculpin, white croaker, starry flounder, California halibut, and English sole, as well as the northern anchovy and Pacific herring.

The estuary also serves as an acclimation zone, facilitating the physiological changes necessary for anadromous fish to make the transition between salt water and fresh water. Anadromous fish may pass through the estuary only during spawning and out migrations (salmon and steelhead) or reside in the estuary for longer periods (sturgeon, American shad, longfin smelt, three-spined stickleback, and striped bass).

A large variety of water-associated birds use the San Francisco Bay estuary. They include waterfowl, shorebirds, gulls and terns, seabirds, raptors, wading birds, and song birds. The heaviest use of the Bay by shorebirds and waterfowl comes during the spring and fall migrations; however, many also remain during the winter. Gulls are most numerous during the winter months, while terns are more commonly seen in summer months. Ducks, grebes and other water-associated birds are primarily winter visitors to the Bay. Other groups may be found year-round.

The San Francisco Bay estuary has a significant role in supporting ducks and shorebirds during their winter residency. Approximately 23 percent of the diving ducks in the Pacific

Flyway (migration pathway) winter in San Francisco Bay. They arrive in the Bay area about mid-October and may remain in the area for 6 to 8 months each year, feeding primarily on small clams and snails. The most numerous diving ducks are canvasback, scaup, scoter, and ruddy ducks.

Sea lions and harbor seals are commonly found in many areas of the Bay. Harbor seals are resident in the Bay year-round, while sea lion abundance is greatest in winter during the non-breeding season. This provides the opportunity to feed on schools of herring that peak in abundance in the Bay during the same time frame.

Several endangered animal species are known to dwell or have potential to dwell in the vicinity of the project area. California least terns, *Sterna antillarum browni* nest in the Alameda area and forage in nearby waters. The California least tern is listed as endangered by both State and Federal agencies. The least tern is a fish-eating bird, capturing small fish in its bill by diving into the water from low flight. The majority of its diet consists of four types of fish: the northern anchovy, silversides, surfperch, and to a lesser extent, the Pacific herring (Bailey 1985). It appears that tern foraging distribution and intensity may be linked to the availability and distribution of forage fish. The breeding and nesting season in the San Francisco area occurs between May and September. This colony is the largest north of San Luis Obispo with the number of nests ranging from 40 to almost 75.

The California brown pelican (*Pelecanus occidentalis californicus*) is also listed as endangered by both State and Federal government agencies. It uses open water areas of the Central and South Bay for feeding, and rocks, jetties, and piers for roosting. This use is concentrated in the summer months after breeding in southern California, but also occurs during winter months when Pacific herring are spawning in the Bay. Open-ocean food habit studies have shown that anchovy comprise a large part of the California brown pelican's diet; however, Pacific saury and rockfish have also been observed. Pacific herring in bay waters can be found near the surface, particularly during spawning, and should be considered as likely prey.

The Sacramento river winter-run king salmon have recently been designated as a threatened species by the Federal government (PFMC 1990). Winter-run king salmon enter the estuary in October enroute to spawn in the Sacramento River. Offspring of winter-run king salmon move rapidly downstream in the fall. Downstream migrants feed primarily on insects and marine crustaceans; however, small fish are also a component in their diet.

3.3.2.3 Socioeconomic Environment

Regional Economy:

Geographically, the Bay Area extends south to San Mateo and Santa Clara counties, north to Marin and Sonoma counties, and east through Napa and Solano counties. The central region, which is the location of the fisheries regulated by the proposed project, includes San Francisco, Marin, and San Mateo counties to the west and Alameda County to the east.

The nine-county Bay Area represents one standard consolidated statistical area and is the fifth largest metropolitan area in the country. As of 1995, the Bay Area had a total population of 6,394,300 (ABAG 1997).

The diverse employment profile in the Bay Area is the reason for the growth and resistance to recessionary trends. San Francisco is the central hub of the Bay Area. It contains the headquarters for the Bay Area government, financial, and planning sectors. The majority of jobs in San Francisco , approximately 33.1 percent (Employment Development Department 1989), are in the service industry. The newest and fastest growing sector of the Bay Area economy is the high-technology industry. Also known as the Silicon Valley, Santa Clara County is home to several hundred high-technology firms.

The employment diversity within the Bay Area has resulted in unemployment rates below state and national average. In 1990, the unemployment rate for the nine Bay Area counties was 5.2 percent while the statewide rate was 6.6 percent and the national rate was 6.3 percent (Association of Bay Area Governments, 1990). All of the counties in the Bay Area reported unemployment rates below six percent in 1990, with most of the unemployment rates below five percent (Employment Development Department 1992).

Commercial Fisheries:

Currently, the major commercial fishery within San Francisco Bay waters is for Pacific herring. A California halibut hook-and-line fishery occurs in the Bay during the spring and summer months. Bay shrimp and anchovy support bait fisheries in the Bay. During the 1993-94 season, 13 bay shrimp permittees were active (i.e. landed bay shrimp). One commercial concern fishes for anchovy within San Francisco Bay. The remaining commercial activities are on a very small scale and are entirely hook-and-line activities.

The San Francisco Bay area is one of the State's largest landing ports for marine resources. Approximately ten fish businesses buy herring within San Francisco Bay each season. Last season nine of these were located along the San Francisco waterfront, and one was located in Sausalito.

Commercial Shipping:

San Francisco Bay is an important area for the commercial shipping industry. The ports along the Bay serve as primary import-export centers. The Bay serves 25 military installations, 11 of which use the Bay for transport. The Bay is also used by commuting and sightseeing ferries, and recreational, maintenance, and service vessels such as tugboats.

Commercial use of the Bay represents 98 percent of all Bay traffic and 88 percent of this traffic remains in the Bay. The commercial traffic consists of tugboats with tow, tugboats without tow, and ferries. The remaining 12 percent of the commercial traffic enters and leaves the Bay through the Golden Gate. In 1987, there were 83,073 recorded vessel movements in San Francisco Bay (U.S. Navy 1988).

Recreation:

White and green sturgeon, striped bass, chinook salmon, American shad, California halibut, starry flounder, jacksmelt, white croaker, brown rockfish, sevengill shark, leopard shark, brown smoothhound shark, bat rays, staghorn sculpin, herring, and various surfperch support recreational fisheries in the San Francisco Bay estuary.

South, Central, and San Pablo Bays are used for recreational boating. A large portion of that use is for sailing and tends to occur during the weekend.

3.3.3 Tomales Bay Area

3.3.3.1 Physical Environment

Tomales Bay (Figure 3.17) is located approximately 40 miles north of San Francisco. The Bay occupies the northern end of the San Andreas Rift between the Point Reyes Peninsula and the rest of the coast. The San Andreas fault separates the Tomales Bay region into two distinctive geologic areas. The west side of the Bay is bordered by steep slopes of granitic rock on Point Reyes. The east side is comprised of a mixture of rock types consisting mainly of sandstones, with minor amounts of other material (shale, undifferentiated basaltic rock, conglomerate).

The Bay encompasses an area of 11 square miles, is 13 miles long and slightly over 1 mile wide at its widest.

The tides in Tomales Bay are semi-diurnal. Two unequal low tides and two unequal high tides occur in each 25-hour period. Because of the long, narrow shape of the Bay, tidal incursion has a time lag of about one hour from the entrance to the back bay. Maximum tidal range during spring tides can be over 8 ft. As a result, the tidal flux of sea water into the Bay is about 50 percent of the Bay's total volume. Even though the Bay does not completely flush with each tidal cycle, it is a well-mixed water body dominated by tidal flow.

The flushing action in the Bay has been affected by the damming of inflowing streams. Without large inflows the Bay acts as an effective nutrient trap, with increased algal blooms and eutrophication. Drainage into Tomales Bay is primarily from two sources: the largest is from the Lagunitas Creek system, followed by the Walker Creek drainage system. Both of these streams supply most of the continental sediment that enters the Bay. Tidal flats are extensive in Tomales Bay. Most of the sandflats occur near the mouth of the bay. Sand is initially supplied to the bay entrance by southerly longshore currents in Bodega Bay. The most extensive mudflats are located in the upper bay. Rocky shoreline, found primarily on the western side of the Bay, is not extensive

.3.3.3.2 Biological Resources

The habitats found in Tomales Bay support a diverse fauna. In many regards, the plants, fish, birds, and marine mammals found in Tomales Bay are comparable to those found in San Francisco Bay. Eel grass beds are more extensive, as are clam beds (gaper clam, Washington clam, and geoduck) found in soft bottom areas dominated by silty-sands.

Threatened and endangered species found in the waters of Tomales Bay are the California brown pelican and the marbled murrelet. Brown pelicans utilize Tomales Bay for feeding and roosting as described for San Francisco Bay [Sec. 3.3.2.2]. The marbled murrelet is a coastal resident species which feeds on inshore fishes including Pacific herring, anchovies, and sandlance (Burkett 1995). The Steller sea lion may occasionally visit Tomales Bay; although it typically utilizes outer coast areas, hauling out on rugged offshore rocks.

3.3.3.3 Socioeconomic Environment

Regional Economy:

Tomales Bay is located in Marin County. Statistical summaries for the county are used to characterize the regional economy. The county's population in 1990 was 237,000. Only a small portion of that population (26 percent) lived in the unincorporated areas of Marin County including the towns of Tomales and Bodega Bay (Sonoma County). Over 50 percent of the land in the county is devoted to farms, with an emphasis in livestock production. The unemployment rate was the second lowest for any county in California in 1987 (3.2 percent) and the per capita income was the highest in the State.

Commercial Fisheries:

Commercial fisheries operating within Tomales Bay include a minor surfperch fishery occurring primarily during spring, a year-round small bait fishery for mud and ghost shrimp, a small late spring through summer troll fishery for California halibut, and oyster and clam mariculture which occurs throughout most of the Bay.

Commercial Shipping:

No large commercial shipping occurs in the immediate vicinity of the Tomales Bay and

Bodega Bay area. The area cannot handle deep-draft shipping and offshore mooring is not present.

Recreation:

Sport fisheries exist for bay clams (primarily gaper and Washington clams) in both Tomales Bay and Bodega Bay. Use of Tomales Bay can be extensive during the lowest tides of the year. Nearshore coastal sport fisheries exist for salmon, California halibut, Dungeness crab, rock crab, abalone, and rockfish. Salmon are caught by trolling. Rockfish and halibut are also taken using hook-and-line gear. Dungeness and rock crab are taken using small traps. Much of the nearshore sport fishing effort occurs within the Bodega Bay area.

3.3.4 Humboldt Bay Area

3.3.4.1 Physical Environment

Humboldt Bay is located approximately 200 miles north of San Francisco. The herring roe fishery is restricted to Humboldt Bay waters (Figure 3.22). Excluding its tributary sloughs the bay is about 25 square miles in size, with freshwater inflows from a 288 square mile drainage basin. The main tributary streams are: Jacoby Creek, Freshwater Creek, Elk River, and Salmon Creek. The bay is 14 miles long and 4.5 miles wide at its widest point.

Humboldt Bay is essentially a lagoon created by the presence of a long baymouth bar sand spit. During extreme high tides and high seas, the surf often passes over the low dunes directly into the Bay. The Bay consists of two wide, shallow northern and southern arms connected by a relatively narrow channel, that connects the Bay to the ocean. Both Bay segments are extremely shallow with large mud flats exposed at low tide. Tidal channels average 25 feet in depth near the Bay mouth and decrease in depth in the Bay's upper reaches.

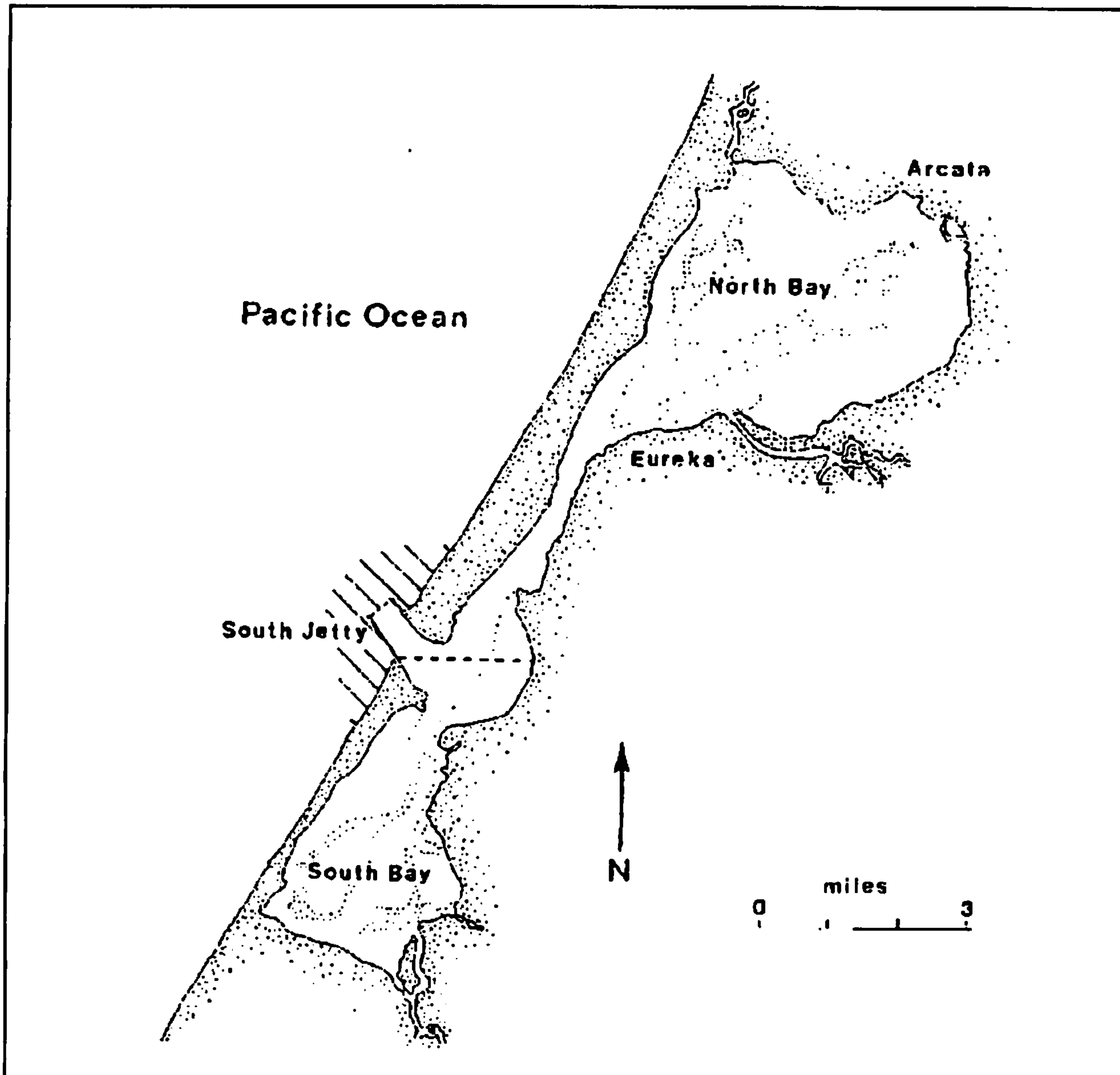


Figure 3.22. Area open to commercial herring fishing in Humboldt Bay waters.

Water currents determine the pattern of the tidal channels and the character of bottom sediments. Higher velocity water prohibits the settling out and accumulation of mud within the channels. Sand is coarse near the inlet and along the main channel and becomes finer and is mixed with some silt and clay farther into the Bay. Low intertidal flats are composed mostly of silt with some sand and clay, while high flats are primarily clay with some silt. Generally, the pattern of sediment distribution is one of decreasing particle size with increasing elevation and distance from the bay mouth.

3.3.4.2 Biological Resources

Both phytoplankton (microscopic freely floating plants) and eel grass (rooted plants) are important in Humboldt Bay's primary production. Eel grass beds are located on the broad low mudflats in both Bay segments. These mudflats also support a rich shallow infauna (invertebrates within six inches of the surface). The species and numbers present depends to a large extent on the sediment composition and location. The Bay is also an important nursery area for Dungeness crab and English sole.

The higher forms (fish, birds, mammals) utilizing the Bay are, to a large extent, similar to those described for San Francisco and Tomales Bays [Sec. 3.3.2 and 3.3.3]. Anadromous fish use of the Bay is limited because the inflow streams are small and limited. Migratory and resident waterfowl, shorebird and wading bird use of the Bay is significant due to the presence of large mudflats and abundant eel grass beds.

Threatened and endangered species that use Humboldt Bay include the brown pelican, and marbled murrelet. Their use of the Bay and its resources is similar to that described for Monterey Bay [Sec. 3.3.1.2] and Tomales Bay [Sec. 3.3.3.2]. The Steller sea lion is probably an infrequent visitor to Humboldt Bay due to its tendency to utilize the open coast rather than bays and estuaries.

3.3.4.3 Socioeconomic Environment

Regional Economy:

Statistical summaries from Humboldt County are used to characterize the regional economy. The population base in the county is small compared to more southerly counties with herring roe fisheries. The 1990 county population estimate was 120,300. Roughly 33 percent of the population live in Eureka and Arcata; both cities are located along the edge of Humboldt Bay. Approximately 27 percent of the county area was devoted to farming in 1987. Timber harvest and wood products provide the leading source of income in the county. Humboldt County was the leader in timber harvest during 1987. Unemployment during the same period was moderate compared to counties statewide (7.5 percent).

Commercial Fisheries:

The herring roe fishery and oyster culture are the only significant commercial fishing activities to occur within Humboldt Bay. Oyster culture uses the north bay almost exclusively yielding the bulk of the State's oyster production. Offshore commercial activities include a large trawl fishery targeting on Dover sole, a variety of other flatfish, widow rockfish, thornyheads, and sablefish. The area supports a large salmon troll fishery, a shrimp trawl fishery targeting on Pacific ocean shrimp, and a Dungeness crab trap fishery.

Commercial fishing is considered to be a major industry in the area, along with agriculture, tourism, and wood products. The commercial fish landings in Humboldt Bay were greater than those of any other California port north of Los Angeles in 1989. Harbor and service facilities that support the local commercial fishing fleet are found at Fields Landing, King Salmon, and the Eureka waterfront. Several processing plants are located on the Bay.

Commercial Shipping:

The commercial shipping industry exists primarily to meet the demand for transportation of saw logs, lumber, and paperpulp. Docking facilities for ocean-going cargo vessels are located on the Samoa Spit, Fields Landing and the south Eureka waterfront.

Recreation:

A wide variety of water based recreational activities exist in Humboldt Bay. These activities include waterfowl hunting (a large percentage of the total State black brant kill occurs in Humboldt Bay), angler sport fishing (primarily shore fishing), and clamming. Other uses include nature study, wildlife observation, and photography.

3.3.5 Crescent City Area

3.3.5.1 Physical Environment

The Crescent City area is approximately 15 miles south of the Oregon - California border. Approximately 11 miles of coastal waters south of Point Saint George and Crescent City harbor are open to commercial herring roe fishing (Figure 3.23). Beaches in the area are of limited distribution along the otherwise rocky coast. This section of open pelagic habitat has the same general characteristics described for the open ocean fishery [Sec 3.3.1.1].

3.3.5.2 Biological Resources

Biological resources in the area have also been characterized in the section describing the open ocean fishery [Sec 3.3.1.2]. The Dungeness crab and Pacific Ocean shrimp populations are bottom or near bottom dwellers in the northern portions of ocean waters open to herring roe fishing that were not mentioned in the section focusing on Monterey Bay.

Threatened or endangered species that use Crescent City area waters include the brown pelican, marbled murrelet, and Steller sea lion. Their use of this area is similar to that described for Monterey Bay [Sec. 3.3.1.2.].

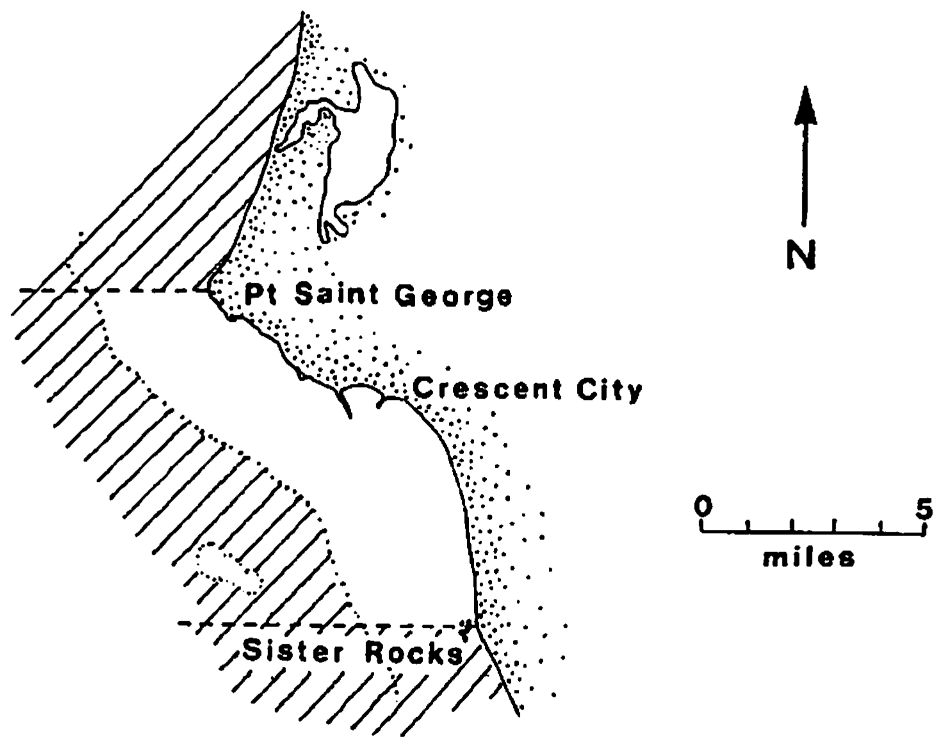


Figure 3.23. Areas open to commercial herring roe fishing in the Cresent City area.

3.3.5.3 Socioeconomic Environment

Regional Economy:

Statistical summaries from Del Norte County are used to characterize the regional economy. The population base in the county is the smallest for all counties supporting commercial herring fisheries. The 1990 county population estimate was 22,250. Almost 20 percent of the population lived in the Crescent City area. Only 2 percent of the county land was devoted to farming in 1987. Timber harvest levels were the fourth largest in the State. Unemployment, at 11.8 percent was the second highest in the State.

Commercial Fisheries:

The offshore fishery for Pacific Ocean shrimp and Dungeness crab are larger in the Crescent City area than they are in regions to the south. Large landings of Pacific whiting are also a feature of commercial fisheries activity that set the Crescent City area apart. Trawl landings of Dover sole, thornyhead, sablefish, and widow rockfish are made in the Crescent City area. Salmon trolling for both king and silver salmon also constitutes a significant part of the commercial catch in the area.

Commercial Shipping:

No large commercial shipping occurs in the immediate vicinity of the Crescent City area. The area cannot handle deep-draft shipping, and offshore mooring is not present.

Recreation:

Water orientated recreational activities in the area used by commercial herring roe fishery are similar to those described for nearshore recreational activities in the Humboldt Bay area. Nearshore recreational activities are directed primarily toward fishing. Species of interest include salmon, Pacific halibut, redtail surfperch, rockfish, lingcod, albacore, and Dungeness crab.

Chapter 4. ENVIRONMENTAL IMPACT ANALYSIS

This section discusses the impacts or effects of the proposed project on the existing environment described in Chapter 3. The proposed project and most alternatives will permit a continuation of the regulated commercial harvest of Pacific herring in California. Existing regulations permit the commercial harvest of herring in five geographical areas: San Francisco Bay, Tomales Bay, Humboldt Bay, the Crescent City area, and the open ocean (Monterey Bay). A preliminary assessment was performed of the environmental sensitivity in each area to existing commercial harvest levels to provide focus for the impact analysis (Table 4.1).

4.1 Preliminary Assessment

Thirteen general environmental categories were selected for consideration in the preliminary assessment (Table 4.1). Three categories (land use, archaeology, and growth inducement) were considered to have no environmental sensitivity to commercial herring fishery activity in any geographical area. The basis for this assessment and the elimination from further consideration is provided below.

Land Use:

Dockside berthing and product processing facilities are the principal land-based facilities supporting commercial herring fishery operations. The facilities that handle Pacific herring also handle a wide variety of other commercial fishing products. The dynamic nature of commercial fishing activities has lead to considerable flexibility in the ability of the land-based support facilities to switch among a variety of vessels and products. These facilities are adequate to handle the quantity of herring likely to be available from existing or foreseeable stock levels. The proposed project and alternatives should not lead to a change in land use or a change in existing land use that supports a broad spectrum of commercial fishing operations.

Growth Inducement:

Approval of the proposed project or alternatives will not induce growth in the fishing industry. The herring roe and herring eggs-on-kelp (ROK) fisheries in the State are limited entry fisheries. The California Fish and Game Commission established a ceiling on the number of permits to be allowed in the herring roe fisheries in the 1980-81 season. No increase in the number of herring roe permits has occurred since 1986 [Sec 3.2.4.2], when the last five were issued, precluding any further roe fishery growth. The number of permits available in the ROK fishery has increased; but, not the total number of permittees in both fisheries. Available ROK permits are issued only to herring roe permittees in lieu of fishing for herring roe. The open-ocean herring fishery is the only herring fishery with no limit on the availability of permits. Although no quota exists, market conditions have historically limited this fishery. In 1989, less than one percent (0.13%) of the statewide herring landings were made by this fishery. The proposed project or alternatives are not expected to result in noticeable growth in the project areas.

Archaeology:

Commercial herring fishing operations are, by their nature, water based activities. Submerged historic archaeological sites exist in the San Francisco Bay and Tomales Bay areas where commercial herring activities occur (MMS 1990). However, the soft-bottom sediments in those areas supporting herring roe fisheries and the relatively light weight of most commercial gear (anchors) preclude extensive damage to existing submerged historic or prehistoric remains (Alex Watt, MMS archaeologist, pers comm).

Table 4.1. Preliminary Assessment of Environmental Sensitivity to Commercial Herring Fisheries in Selected Areas.

Category	Area* 1	2	3	4	5
Land Use					
Traffic Circulation	□				
Water Quality	⬓	⬓	□	□	□
Air Quality	⬓	□	□	□	□
Housing	□				
Public Utilities	⬓	□			
Geological	□	□			
Biological	■	■	■	■	⬓
Archaeological					
Scenic	□	□			
Recreation	■	⬓			
Noise	⬓	□			
Growth Inducement					

*Note: Area 1 = San Francisco Bay
Area 2 = Tomales-Bodega Bay
Area 3 = Humboldt Bay
Area 4 = Crescent City Area
Area 5 = Open Ocean (Monterey Bay)

□ = low sensitivity

⬓ = medium sensitivity

■ = high sensitivity

The environmental sensitivity of the remaining categories varies with the intensity of the fishing operation and geographical location. Impact analysis and discussion is provided below for each category with potential sensitivity.

4.2 Impact Analysis

4.2.1 Traffic Circulation

Potential impacts to water-based and shore-based traffic circulation were considered to be most likely in a highly urbanized environment like San Francisco Bay, that supports the largest herring fishery in the State.

The maximum number of vessels fishing for herring within the Bay at any one time during the 1997-98 season was 125 (98 gill net, 18 round haul, and 9 ROK). Much of this fishing vessel traffic is concentrated at the location of a spawning run. The placement of fishing gear, including mobile eggs-on-kelp rafts, also presents potential impacts to water-based traffic circulation. Areas being intensively fished essentially eliminate access to other vessel traffic; however, those areas are typically close to shore and impede most vessel traffic for a short time.

Regulations exist to limit impediments to vessel traffic circulation by prohibiting fishing in selected areas (e.g. marina entrances, selected channel areas, military areas) and on weekends. Regulations also require the permittee and permit vessel to be within one nautical mile of set fishing gear in San Francisco Bay. The regulations to tend gear and limit gill net permittees to one net (shackle), and Department and Coast Guard patrol vessel enforcement effort have reduced potential traffic circulation problems.

The San Francisco Bay port authority also facilitates traffic circulation by monitoring vessel movements. With the authority to require the removal of set fishing gear when necessary, impediments to large vessel movement are also limited.

An unknown and variable number of vehicles provide support for the commercial herring fishing operations in San Francisco Bay. Each vessel is likely to have at least one vehicle available to run errands. The vehicles associated with these vessels are spread throughout the Bay Area, typically in areas that provide docking or marina facilities. They add incrementally to the volume of traffic within the Bay Area.

The proportion of these vehicles in use at any point in time will be highly variable. During active fishing operations, almost all use of vehicles by boat crew will cease. Gill net and ROK vessels may operate during the entire 24-hour day when spawning is occurring. Parking in the immediate vicinity of marinas and commercial docks providing support for the herring fishery is also likely to be impacted.

Traffic circulation including parking would potentially be impacted to varying degrees for the entire fishing season lasting 109 days (including non-fishing days).

Mitigation: Traffic circulation impacts are expected to be localized, short-term, and less than significant. Mitigation for impacts to traffic circulation is provided by regulations which: 1) prohibit fishing in selected high-traffic areas and on weekends, 2) require the permittee and permit vessel to be within one nautical mile of set fishing gear, 3) limit the amount of gill net gear to one net (shackle) per permittee, and 4) require eggs-on-kelp lines be suspended under suitable permanent structures so as not to hinder navigation, and eggs-on-kelp rafts or lines must be tied to a permanent structure (e.g. pier, dock) when placed in Belvedere Cove or Richardson Bay.

4.2.2 Water Quality

The potential for adverse impacts to water quality was considered to exist to some degree in all geographical areas supporting commercial herring fishing.

The principal potential adverse impacts to water quality are associated with the discharge of a slurry used to pump herring from the hold of the vessel to the dock, and the suspension of sediments from the bottom due to fishing activity. Saltwater is added to the herring in the hold of the boat to create a slurry just prior to off-loading. Decanted slurry would contain organic wastes including fish scales, eggs, and milt. The water quality variables potentially affected by the pumping operation are turbidity, dissolved oxygen levels, temperature, and nutrient concentration. Site-specific data on water quality characteristics at the herring pumping stations in the San Francisco Bay area are not available. Off-loading herring frequently occurs during ebb and flood tides when water movement limits fishing opportunities. With rapid water movement, changes in water quality characteristics would tend to be localized and of short duration.

Concentrations of suspended solids in the water column are likely to increase temporarily due to propeller wash in shallow water or contact of fishing gear with the bottom. The increases in turbidity would tend to be of short duration. However, the fine-grained sediment fractions (clay and silt) have a high affinity for several contaminants, such as trace metals and organics. This sediment fraction tends to remain in the water column longer than sand because of a lower settling velocity.

No significant long-term impacts are expected as a result of fishing-induced turbidity. However, some short-term impacts could occur. Bioassays using Bay sediments in suspension resulted in mortalities for some representative aquatic organisms (mysid shrimp) at all concentrations of particulates (U.S. Navy 1990). Sediment on spawning substrate may also inhibit spawning by herring (Stacy and Hourston 1982) and affect embryo survival (Lough et al. 1985).

Concern exists over the presence of radiation and other contaminants in the sediments at the Treasure Island Naval Station Hunters Point Annex (Barbara Smith, Regional Water Quality Control Board, pers. comm., Jeff Lewis, Department of the Navy, pers. comm.). Herring utilize pier pilings, sea walls, and rocky shoreline at Hunters Point for spawning. It is not known what effect, if any, contaminated sediments have on embryo and larval survival. Illegal fishing activity in the Hunters Point area would disturb sediments and possibly create an increased yet short-term exposure hazard to humans as well as the biota (Agency for Toxic Substances and Disease Registry, 1994). However, a restricted zone prohibits vessels from entering the area off of Hunters Point.

In the eggs-on-kelp fishery, kelp with no eggs or unacceptably few eggs attached, or unmarketable kelp stipes are returned to the water so that the eggs will have a greater probability of survival. The remaining decomposing kelp may have adverse but short-term effects on water quality.

Mitigation: Because the effects of increased turbidity, light attenuation and reduction in dissolved oxygen would be temporary and localized, and because a restricted area at Hunters Point prohibits any vessel traffic, no mitigation measures are proposed for impacts on water quality.

4.2.3 Air Quality

All areas supporting commercial herring operations were considered to have some level of sensitivity to impacts to air quality. However, the highly urbanized San Francisco Bay area was deemed to have the greatest sensitivity and provided the focus for the impact assessment.

Air quality is affected by emissions generated from the operation of gas and diesel engines in commercial fishing vessels, from the operation of gas and diesel engines in support vehicles, and from the operation of gas powered pumps used in off-loading operations.

Pollutant emission rates were estimated using the following assumptions regarding fishing activities and equipment.

vessels:	172 maximum using gill nets or harvesting eggs on kelp on any given day during peak fishing periods
	24 maximum assessing fish distribution or fishing during off-peak fishing periods
fuel usage:	11,008 gal/day during peak fishing periods (172 vessels x 8 gal/hr x 8 hr/day)
	1,536 gal/day during off-peak fishing periods (same fuel and activity rates)
emission factors:	adequately represented by off-highway mobile source information for vessels with inboard engines in coastal environments (source EPA, AP42, 1985)

Pollutant emission factors used in the calculations were based on use of diesel fuel and are as follows:

Carbon Monoxide (CO)	=110 lb/1000 gal fuel
Hydrocarbons (HC)	= 50 lb/1000 gal fuel
Nitrogen Oxides (No_x)	=270 lb/1000 gal fuel
Sulfur Oxides (So_x)	=27 lb/1000 gal fuel

The pollutant emissions released when vessels are underway are influenced by a variety of factors including power source, engine size, fuel used, operating speed, and load. The emission factors and assumptions used can only provide a rough approximation of daily emission rates. The estimated maximum daily emission rates for commercial fishing vessel operation during a season are at or well below one percent of San Francisco County daily emission rates, except for nitrogen oxide and sulfur oxide levels during peak fishing periods (3.46%, 1.49% respectively) (Table 4.2) (Bay Area Air Quality Management District 1993). An increase in pollutant emissions of one percent or less would have no significant short-term effect on the air quality in the Bay Area.

The number of support vehicles operating during the fishing season is unknown; however, to assess impacts from vehicle emissions, it is assumed that one support vehicle exists for each fishing vessel.

vehicles:	172 light duty trucks (sec 4.2.1)
usage:	local (20 mi/day)
emission factors:	adequately represented by emission rates generated at 75° F while traveling at 19.6 mph with 50% cold and 50% stabilized starts (source EPA, AP42, 1985)

Pollutant emission factors used in the calculations were as follows:

Carbon Monoxide (CO)	= 45.62 g/mi
Hydrocarbons (HC)	= 4.77 g/mi
Nitrogen Oxides (NO_x)	= 3.94 g/mi
Particulates	= 0.16 g/mi

The pollutant emissions released by support vehicles are well below one percent of the San Francisco County daily emission rates (Table 4.3). An increase in pollutant emissions of less than one tenth of one percent would have no significant short-term effect on the air quality in the Bay Area.

No long-term adverse impacts on Bay Area air quality are anticipated since no increased vessel activity is expected as a result of adopting the proposed regulations or alternatives.

Mitigation: Because no short-term or long-term adverse impacts on air quality are expected as a result of commercial herring fishing activity in San Francisco Bay, no air quality mitigation is proposed

Table 4.2. Daily Emission Rates From Commercial Herring Fishing Vessels(Tons/Day) in Comparison With San Francisco County Emission Rates (1990)

Pollutant	S.F. Rate	Fishing Rate	% of S.F. Rate	Searching Rate	% of S.F. Rate
Carbon Monoxide	235.0	0.065	.26	0.084	.04
Sulfur Dioxide	59.0	0.275	.47	0.038	.06
Nitrogen Oxides	43.0	1.490	3.46	0.027	.48
Sulfur Oxides	10.0	0.149	1.49	0.021	.21

Table 4.3. Daily Emission Rates From Commercial Herring Fishing Support Vehicles (Tons/Day) in Comparison With San Francisco County Emission Rates

Pollutant	Vehicle Emission Rate	S.F. Rate	% of S.F. Rate
Carbon Monoxide	.1730	235.0	.074
Hydrocarbons	.0181	59.0	.031
Nitrogen Oxides	.0149	43.0	.035
Particulates	.0006	39.0	.002

4.2.4 Housing and Utilities

The San Francisco Bay area supports the only fishery that is conducted by a large proportion of individuals from outside normal commute distances. Most permittees in other fisheries live in the immediate geographical area and the potential for impacts to housing and utilities is considered to be inconsequential.

Permittees, crew members, and fish buyers from outside the San Francisco Bay Area have to use temporary housing during the fishing season in San Francisco Bay. Eighty-two percent (342) of the 1990-91 season permittees fishing gill nets or round haul nets provided addresses outside of Bay area counties (assumed commute distance). Each gill net permittee has two or three crew members. Dividing the gill net permittees into platoons with different fishing seasons reduces the housing need. The largest number likely to need housing during the 1990-91 season, assuming 82% of the maximum crew need housing, is 650 individuals. However, the proportion of crew members from the local area is unknown and could be higher than assumed. In addition, many permittees and crew members live aboard their vessels during the herring season. No significant ecological effects or impacts are expected as a result of the increased need for housing or utilities.

Mitigation: No mitigation is proposed for impacts to housing and utilities because they are expected to be localized, short-term, and less than significant.

4.2.5 Geological

Potential geological impacts from commercial herring fishing activities are most likely in those geographical areas that support the largest fisheries. Analysis focused on potential geological impacts in San Francisco Bay.

Potential adverse impacts include scouring of soft-bottom sediments by propeller wash in shallow water areas and disruption of sediments while setting and pulling fishing gear (nets or anchors dragging along the bottom). However, the fine-grained muds found in most fishing areas within the Bay are constantly being resuspended, transported and redeposited by water movement. The dynamic nature of fine-grained sediment deposition suggests that no significant short-term or long-term impacts to the geology of the Bay bottom are likely.

Concentrations of suspended solids in the water column are likely to increase temporarily due to propeller wash in shallow water or contact of fishing gear with the bottom. The increases in turbidity would tend to be of short duration. However, the fine-grained sediment fractions (clay and silt) have a high affinity for several contaminants, such as trace metals and organics. This sediment fraction tends to remain in the water column longer than sand because of a lower settling velocity.

No significant long-term impacts are expected as a result of fishing induced turbidity. However, some short-term impacts could occur. Bioassays using bay sediments in suspension resulted in mortalities for some representative aquatic organisms (mysid shrimp) at all concentrations of particulates (U.S. Navy 1990). Sediment on spawning substrate may also inhibit spawning by herring (Stacy and Hourston 1982) and affect embryo survival (Lough et al. 1985).

Mitigation: No mitigation is proposed for geological impacts. The impacts on marine organisms suggested by the suspended phase particulates tests are short-term.

4.2.6 Biological

Potential environmental impacts to biological resources exist in all geographical areas that support commercial herring fisheries. This is because Pacific herring populations can fluctuate widely and play an important role in many marine food webs. The potential impacts may be divided into two categories: (1) direct harvest impacts and (2) trophic level (food web) impacts. Both short-term and long-term potential adverse impacts exist within each broad category.

4.2.6.1 Direct Harvest Impacts

Potential short-term direct harvest impacts include: effects on individual herring, effects on associated species incidentally taken, and effects on benthic organisms. Individual herring suffer death by suffocation during commercial harvest activities. Whether or not inflicting this pain for commercial profit, is ethically acceptable, is a topic of public debate not easily resolved. It is certainly not acceptable to some groups in our society (People for the Ethical Treatment of Animals (PETA) Factsheet). However, the fact that pain is experienced or individual herring die in the course of commercial fishing operations has no significant environmental impacts beyond the loss of individuals from a population.

A number of associated species are accidentally taken during commercial herring fishing operations. Species observed in gill nets include: jacksmelt, sardine, perch, soupfin shark, American shad, white croaker, and unidentified crab. However, the potential exists for any fish and for many invertebrates in the area to be taken. The species most likely to be taken are relatively small in size and more vulnerable to the mesh size used in herring gill nets.

No data exist on the relative rates of incidental take of other fish species in commercial gill nets set to catch herring. However, research gill nets with panels having mesh sizes that overlap the commercially legal mesh size have been used extensively by CDFG in San Francisco Bay. Although not identical to commercial gill nets, they were set to catch herring and provide some indication of the relative rate of the incidental take of other fish species (Table 4.4). Also, the nets were set throughout the herring season and were fished both during the day and night. Although the influence of overlapping mesh sizes cannot be factored out, less than one-half of one percent of the total catch of herring were incidentally caught species. The species taken in addition to herring included: brown smoothhound, spiny dogfish, English sole, Pacific sanddab, staghorn sculpin, smelt, shiner perch, and jack mackerel. No significant short-term or long-term ecological effects are expected as a result of this rate of take.

Table 4.4. Rate of Take (Proportion of Total Take) of Incidentally Caught Fish in Research Gill Nets Set to Catch Herring.

Season	Hours Fished	Herring Caught	Incidental Catch	Incidental Rate
1982-83	154.0	4393	7	.0016
1983-84	78.6	1636	8	.0049
1988-89	18.3	440	1	.0023

Gill nets are lost in the course of herring fishing activities. Not all are recovered (ghost nets) and those nets, to varying degrees, continue to capture fish and invertebrates. Currents, tides, and bottom debris in San Francisco Bay can tangle (ball up) lost nets. This is particularly true when floats and anchors are removed and only net mesh attached to the lead or float line remains. No data are available to determine the number of nets lost, the proportion of net that continues to fish, nor the quantity of organisms entrapped in the lost nets. However, some measure of the number of nets recovered is available. During the 1989-90 season, the crew of the CDFG Patrol Vessel Chinook recovered or arranged for recovery of 22 ghost nets. Patrol activity included echosounder surveys in heavily fished areas immediately after fishing effort ceased. Five of the recovered nets had marketable quantities (over one thousand pounds) of fresh herring; four were balled up with some herring; two had sturgeon entangled that were released alive. The remaining nets did not have large quantities of any fish species. The number of lost or ghost nets recovered each season is declining, only three such nets were found following herring fishing activity in the 1991-92 season. Moreover, the amount of gill net gear was reduced by 50 percent beginning with the 1993-94 season, when regulations were enacted limiting each permittee to one net (shackle). The potential impacts to aquatic resources from "ghost" net fishing can be inferred from these data. No significant long-term adverse impacts to aquatic resources are expected.

Field observations by Department staff have confirmed the absence of incidentally-taken species by the eggs-on-kelp fishery. The open pound method used by this fishery consists of suspending giant kelp, *Macrocystis* sp. from an unenclosed floating raft or line in a likely spawning area, with the expectation that free-swimming herring will spawn on the kelp fronds. Thus, unlike an encircling or entangling net, this form of egg harvest is not likely to incidentally take fish or other marine organisms.

Mitigation: The potential adverse impact on incidentally- taken species has been mitigated by a regulation prohibiting possession of sturgeon, halibut, salmon, and striped bass on any vessel involved in herring fishing. Because lost nets can continue to fish for extended periods of time, short-term impacts could be alleviated by continuing or intensifying patrol activity directed toward location and removal of lost nets. Mitigation for unrecovered gill nets in San Francisco Bay is provided by the restriction to one shackle of gill net, and the requirement that the net be tended.

Anchors and nets both have the potential for disturbing the bottom and impacting bottom-dwelling (benthic) animal species as well as subtidal vegetation. However, the soft-bottom benthic communities where herring roe and eggs-on-kelp fisheries occur are dynamic, having to adapt to wide salinity fluctuations and varying sediment stability (Herrgesell et al. 1983). The potential for individual organisms or vegetation to be lost is recognized; however, no data exist to quantify that loss. Localized areas, where net fishing is intense, would suffer the greatest short-term adverse effects. Additionally, herring egg deposits on substrates in shallow, soft-bottom areas could be affected by siltation from fishing-vessel propeller wash. However, the fine grained muds found in most fishing areas within the Bay are constantly being re-suspended, transported and redeposited by water movement. No significant long-term ecological effects are expected as a result of gear disturbance.

Mitigation: The short-term impacts of anchors and nets on benthic communities could be mitigated, if necessary, by use of drift gill nets; however, the use of drift gill nets has not proven effective in San Francisco Bay. Drift gill nets have been historically employed in the Humboldt Bay fishery. The potential impacts of eggs-on-kelp fishery anchors and vessels on shallow, soft-bottom communities and associated herring egg deposits is mitigated by the requirement that eggs-on-kelp rafts or lines be secured to permanent structures in Belvedere Cove and Richardson Bay.

Potential long-term direct harvest impacts are primarily stock related. The following discussion suggests that adverse impacts to herring stocks could exist as a result of commercial herring fishing activity. Herring stocks are noted for their instability under fishing pressure, frequently leading to stock collapse (Appendix 3). The potential for a stock to collapse in California is greatest in those stocks where stock evaluation is minimal. Evaluation of the status of stocks in California relies on a variety of independent stock assessment techniques such as spawn escapement surveys, hydroacoustic survey, and cohort analysis [Sec 3.2.2]. However, those techniques have been applied primarily to the largest stocks (San Francisco Bay and, to a lesser extent, to Tomales Bay and Humboldt Bay) [Sec 3.2.2]. Although Humboldt Bay and Crescent City spawning areas and the Monterey Bay open-ocean area continue to support small fisheries, ongoing evaluations of stock status and corresponding management adjustments to fishing pressure are not made.

The potential also exists for a stock to collapse in the intensively managed fisheries. The likelihood of this occurring is greatly reduced by the use of a conservative management strategy and a variety of independent stock assessment techniques. As discussed in Section 3.2.2 and Section 3.2.4, management objectives have been conservatively set by the Department based on an evaluation of results of mathematically modeling a variety of harvest strategies. The strategy selected sets a constant proportion harvest quota (<20 %) based on the prior season's spawning biomass. Only during the 1977-78, 1983-84 and 1992-93 seasons have quotas allowed a higher than desired catch in San Francisco Bay using this strategy (Figure 3.16). During the 1973-74, 1977-78 and 1992-93 seasons, management objectives were not met for the San Francisco Bay stock when catches exceeded 20% of spawning biomass. Catches in the San Francisco Bay herring roe fishery averaged slightly over 15% of spawning biomass for all other seasons combined. Catches in Tomales Bay have averaged 12.6% of spawning biomass over 19 seasons. Tomales Bay catches have exceeded the 20% recommended harvest rate during the 1987-88, 1988-89 and 1995-96 seasons.

Even with no commercial harvest, herring stocks can decline or fluctuate due to environmental influences [Sec 3.2.1]. Therefore, with a fishery, management must be prudently responsive in adjusting fishing pressure. The Commission has demonstrated its ability to respond to stock status concerns by reducing the San Francisco Bay harvest rate following the 1983-84 El Niño, and in 1992-93, 1993-94, and 1994-95 due to biomass declines, and by setting provisional quotas for the Tomales Bay fishery.

The degree to which California's herring spawning stocks mingle in the open ocean is unknown, and is a point of management concern, particularly for the Tomales Bay and San Francisco Bay areas. However, Moser and Hsieh (1992) suggest that Tomales Bay and San Francisco Bay herring are separate stocks that do not mingle in the open ocean. Differences in age-specific size between Tomales Bay and San Francisco Bay spawning populations also suggest seperate stocks [3.2.1.7]. However, if they originate from the same stock, San Francisco Bay biomass could remain high in the short-term through immigration from Tomales Bay despite actual declining population size. Data from Tomales Bay stocks do suggest that erratic biomass levels are attributable to emigration (leaving).

In addition to known fishing mortality through the harvest of herring, additional fish are lost as a result of fishing practices. The potential exists for adverse environmental impacts as a result of this unaccounted for fishing mortality. Unaccounted for harvest includes: fish dropping from gill nets, fish caught by lost gill nets, and illegal take beyond established quota levels. No direct data are available to quantify the additional amount of fishing mortality from these sources individually or collectively in California fisheries. However, "drop-out" from herring gill nets was considered to be an insignificant cause of mortality in British Columbia fisheries (Hay et al. 1982).

From a population dynamics perspective, all sources of mortality associated with fishing beyond those fish landed can be combined with natural mortality. Whether the fish are lost and unaccounted for as a result of fishing practices or lost through natural causes (such as predation), they are not available as part of the next season's spawning biomass, and quotas are adjusted accordingly. If the level of unaccounted for fishing mortality does not increase natural mortality beyond the assumed level of M=0.4 [Sec 3.2.4], no significant long-term adverse environmental impacts to the stock are expected. However, if unaccounted for fishing losses are chronic and severe, and increase natural mortality above the assumed level of M=0.4, the possibility of a gradual population decline exists. Biomass data [Sec 3.2.2] for the San Francisco Bay stock shows marked fluctuations, which have been linked to environmental conditions rather than unaccounted for fishing mortality. However, even if the unaccounted for losses are sporadic, they can have potential environmental impacts at the trophic level (discussed below).

Mitigation: Mitigation of the potential long-term impacts on the herring resource from stock collapse is provided by the implementation of current assessment techniques and management strategies. Annual stock assessments should herald any decline before the potential for a significant impact can be realized. These annual assessments are made for the Tomales Bay and San Francisco Bay stocks; the smaller Humboldt Bay and Crescent City stocks are not assessed annually. If stock collapse occurs, regardless of causal factors, fishery closures will be implemented to provide further protection.

Mitigation is also provided by limiting harvest quotas to no more than 20% of the previous season's spawning biomass estimate.

Mitigation of unaccounted for fishing losses is provided by an intensive enforcement effort as part of herring management. Establishing the closure of deep water areas in south San Francisco bay to gill net fishing serves to mitigate the impacts of unaccounted for losses. Mitigation is also provided by the counting of all trim, except stipes, towards eggs-on-kelp harvest quotas, and the conditional allowance for eggs-on-kelp harvest on weekends.

4.2.6.2 Trophic Level Impacts

Herring occupy an intermediate position in a number of marine food webs [Sec 3.2.1.8 - 3.2.1.10], transferring energy from primary producers (phytoplankton) to predators at higher feeding strata (fish, birds, marine mammals). The harvest of herring from the marine system has the potential to impact a wide variety of species connected through these food web relationships. Impacts include: a reduced availability of spawned eggs for consumption by invertebrates, fishes, and birds, and a reduction in adult herring for consumption by fishes, birds, and marine mammals. However, the extent of these impacts is difficult to assess because the complex and dynamic nature of marine food webs makes it particularly difficult to determine the extent that predator populations rely upon herring in their diet. For example, spawned herring eggs are available for relatively short periods during the winter months and restricted to a relatively few estuarine environments; thus, the degree of impact varies with geography and season.

A number of other factors influence the relative importance of herring as prey. The relative abundance of predators, their proximity to prey, predator food preferences, and competitive interactions between predator as well as prey species are examples. At higher trophic levels, spatial and temporal scales increase, with top predators feeding upon a wide choice of food species over longer periods of time and larger geographical areas. The complexity of the marine food web provides for some stability in the system.

Predator food habit studies provide insight into the relative use of herring, food preferences, and prey availability. Predator population status assessments can further highlight areas of potential concern, particularly if herring have been identified as important prey and food availability has been identified as a factor limiting population growth. This type of information is needed to determine the potential impacts of commercial harvest of herring on predator populations.

Marine mammals: The possible effects of commercial fisheries on marine mammal populations have given rise to much discussion. A major international workshop that examined this question was unable to find a case in which a fish-eating marine mammal population had been adversely affected by a fishery (Beverton 1985). California stocks of Elephant seal, California sea lion, and harbor seal populations have all increased in recent years (Boveng 1988a and 1988b). However, the Steller sea lion population is decreasing and prey availability may be a factor limiting population growth.

Individual marine mammals may be affected to the extent that reduced local availability of herring could affect search effort, prey selection, or capture effectiveness. The occurrence of herring in the diet of some marine mammal species along the California coast suggests limited short-term impacts to individuals. Herring have been identified as prey for elephant seals in California (9^{th} ranked prey in relative importance) (Morejohn et al. 1978), for harbor seals (6^{th} rank)(Suryan and Raum-Suryan 1990), and for harbor porpoise (6^{th} rank)(Dorfman 1990). Both harbor seals and California sea lions have also been observed feeding on herring in gill nets and round haul nets in San Francisco Bay (Miller et al. 1983). Herring have not been identified as prey for the northern fur seal, California sea lion, Steller sea lion, Pacific striped dolphin, Dall's porpoise, Pacific common dolphin, Risso's dolphin, and dwarf sperm whale sampled in California (Jones 1981, Antonelis et al. 1984, Morejohn et al. 1978). However, several of these species are recognized herring predators in more northern latitudes (Alaskan fur seal, Steller sea lion, Dall's porpoise). The relative consumption of herring also appears to increase with latitude for some marine mammals in California (Harvey 1987).

Mitigation Mitigation in recognition of the importance of herring as a forage item is provided by setting conservative exploitation rates [Sec. 3.2.4]. Further mitigation, if necessary, can be achieved by selection of Alternative 1. No additional mitigation is proposed for impacts to marine mammal populations because they are expected to be localized, short-term and less than significant.

Birds: Many marine birds feed upon spawned herring eggs, and juvenile and adult herring within shallow embayments during the spawning season, and upon adult herring in nearshore waters during the remaining seasons [Sec 3.2.1.8.1]. The potential short-term and long-term impacts of commercial harvest of herring to bird populations can be determined by assessing the status of bird populations and the importance of herring to those populations.

A classic example linking declines of seabird predators to oceanic conditions and the collapse of a fish stock is the Peruvian anchoveta fishery. Heavy fishing pressure over several years, in combination with El Nino conditions, lead to the demise of the fishery in 1972. Three seabird species (a cormorant, a gannet, and a pelican) which fed almost exclusively on anchoveta, declined dramatically beginning in the mid-1960s and have not yet recovered (Glantz and Thompson 1981). Variation in the abundance of fish prey species, including herring, is an important factor influencing breeding season and success, breeding places, and movements of seabirds in northern or boreal latitudes (Ashmole 1971, Furness and Ainley 1984, Pearson 1968, Perrins, Lebreton, and Hirons 1991).

In California, the availability of important food fish such as anchovy and shortbelly rockfish can be an important factor affecting the status of seabird populations (Ainley and Hunt 1991). Competition appears to exist among seabirds, marine mammals, and fisheries for use of fish resources (Furness and Ainley 1984, Ainley et al. 1994). Although seabirds may target certain prey species for specific energetic requirements, in general they are opportunistic feeders. They are able to switch to alternative prey species as they become available, often on a seasonal basis (Ainley and Boekelheide 1990).

Herring have been reported as prey during the non-breeding season for diving birds such as Common Murre, Rhinoceros Auklet, and Pelagic and Brandt's Cormorants in central California waters (Morejohn et al. 1978, Ainley et al. 1994). Herring have also been identified as an important winter and spring prey species for the Common Murre along the Marin county coastline (D. Ainley, PRBO, pers comm). Ainley et al. (1994) reported declines in Brandt's and Pelagic Cormorants and Common Murre, and increases in Rhinoceros Auklet in central and northern California waters. They attributed the cormorant and murre declines to reduced food resources during the non-breeding season. They hypothesized that the probable causes for the reduction in food resources were commercial fishing for herring and market squid, warmer oceanic conditions, and increased marine mammal populations.

Commercial herring fishing reduces the size of the spawning population by 10 to 15% each year. Assuming a sex ratio of 50% males:females, approximately 5.0 to 7.5% of females in the spawning population do not contribute to spawn depositions upon which various marine birds feed. The effect of that removal on bird predators is not known but is likely to be less than significant. Direct feeding by birds on herring roe has only been reported in the ornithological literature as a limited, or incidental, late-winter activity (Grass 1973, Norton et al. 1990).

A removal of 10 to 15% of spawning biomass by commercial fishing may increase search effort, limit capture success, or cause a switch in prey by marine bird predators.

Mitigation Mitigation in recognition of the importance of herring as a forage item for birds is provided by setting conservative exploitation rates [Sec. 3.2.4]. Further mitigation, if necessary, can be achieved by selection of Alternative 1. No additional mitigation is proposed for impacts to bird populations because they are expected to be localized, short-term and less than significant.

Fish: The potential effects of commercial herring fisheries on predator fish growth and survival has been a long-standing question. A large number of potential fish predators have been identified [Sec 3.2.1.8.1]; however, only limited information is available to assess the potential fisheries-related impacts on these predator populations. Of 14 fish species' food habits assessed in the Monterey Bay area, four used herring as prey (Morejohn et al. 1978). Those potential predators with herring remains in their stomach included: king salmon, silver salmon, Pacific hake, and blue shark. The importance of herring (rank), based on frequency of occurrence and volume were 9th, 6th, 5th, and 16th, respectively. Those potential predators without herring remains in their stomach included: sablefish, halibut, petrale sole, lingcod, curlfin turbot, sanddab, chilipepper, white croaker, and midshipman. Herring ranked 4th in importance for king salmon in the vicinity of San Francisco Bay (Merkel 1957). Herring eggs have been identified as seasonally important to adult white sturgeon in portions of San Francisco Bay, comprising as much as 20 percent of their diet in early winter and 80 percent in late winter (McKechnie and Fenner 1971).

The white sturgeon and the Sacramento River winter-run king salmon populations in the San Francisco Bay area have declined in recent years. The sturgeon population decline appears to be associated with declines in fresh-water outflows in the Bay-Delta area (Kohlhorst et al. 1991). The winter-run king salmon population is listed as endangered under state regulation and threatened under federal regulation. The decline of this run is attributed to altered water temperatures, inadequate instream flows, poor upstream and downstream passage and reduced spawning area and parent escapement (PMFC 1990). Neither population is considered to be food limited.

Several studies have foccussed on assessing herring-salmon interactions. A British Columbia study provided a range of values (% by weight) for herring in identifiable stomach contents of king and silver salmon (33-46% and 13-34%, respectively) (Pritchard and Tester 1944). The authors noted that species composition and dominance varied greatly between monthly periods and between sampling areas. However, they could not assess the effect of herring supply on salmon. A Canadian study addressing the same general question could find no relationship between the abundance of each species of salmon and the abundance of herring during a ten-year study period (Healey 1976). Herring are a major diet item of resident king salmon near Puget Sound, Washington, comprising 61% of prey biomass. Herring were most important during winter and spring (Fresh 1983). Fresh (1983) suggests that herring are not a required food item since salmon are opportunistic feeders; but, herring do contribute to a food rich environment that is attractive to salmon. Herring have been identified as important food items in a number of other king salmon food habit studies based on fish collected in waters north of California (Heg and Van Hyning 1951, Silliman 1941, Chapman 1936).

Merkel (1957) and Morejohn et al. (1978) provide the only accounts found of king salmon food habits in California waters. Pacific herring comprised approximately 13%, by volume (4th rank), of the food of king salmon in the vicinity of San Francisco. However, both studies noted marked seasonal changes in the composition of prey found in stomachs, with herring being most prevalent during the winter and spring. Merkel (1957) also noted that king salmon taken within San Francisco Bay had essentially ceased feeding.

Reduction in availability of herring through commercial fishing is not expected to have any long-term impacts on predator fish populations. Most predators are opportunistic in their feeding habits. However, short-term impacts to individual fish could be experienced. Available information is insufficient to determine the extent of any short-term impacts to individual fish associated with the removal of herring for commercial purposes. Since king salmon use herring in nearshore staging areas and essentially stop feeding once they are in the bay, the effect of fisheries-related removals is minimized. However, the annual removal of roughly 15 percent of spawning biomass by commercial fishing may lead to increases in search effort, to reduced capture success, to changes in movement patterns, or cause a switch in prey for those fish predators that rely most heavily on herring as a prey. These potential short-term impacts to individual fish are expected to be less than significant at population levels.

Mitigation Mitigation in recognition of the importance of herring as a forage item is provided by setting conservative exploitation rates of no more than 20% of spawning biomass. Further mitigation, if necessary, can be achieved by selection of Alternative 1. No additional mitigation is proposed for impacts to fish populations because they are expected to be localized, short-term and less than significant.

4.2.7 Scenic, Recreation, and Noise

There are a number of factors associated with commercial herring fishing that could create scenic, recreation, and noise impacts affecting the area's ambiance, background noise level, and individual point of view. Certainly, the impact that commercial herring fishing might have on ambiance would differ between a highly urbanized environment like San Francisco Bay and that of a more rural environment like Humboldt Bay. Noise levels associated with commercial herring fishing will also vary with fishing intensity, gear type used, distance, and background noise level. For example, the eggs-on-kelp fishery produces very little noise compared to other gear types used. There may be some low level noise associated with placing rafts and lines but once they are in place the noise level drops significantly. The scenic quality of herring fisheries will be viewed as aesthetically pleasing by some and not by others. That individual point of view can also vary with circumstance.

Various combinations of these factors have led to complaints during past herring roe fishing seasons in San Francisco Bay. Most of the complaints were related to noise from late night or early morning fishing activity.

The concentrated activity associated with the commercial herring roe fishery in San Francisco Bay could preclude the use of an area by recreational user groups for short periods of time.

Short-term disturbances from the commercial herring roe fishery are expected. However, no significant long-term impacts to scenic quality, noise level, or recreational uses are expected.

Mitigation: The adverse impacts to scenic quality, noise level, and other water uses are expected to be localized, short-term, and less than significant. Short-term impacts have been mitigated by regulation prohibiting fishing within 300 ft of selected piers, recreation areas, and buoyed channel entrances within San Francisco Bay. Impacts to recreational water use is also mitigated by regulation prohibiting commercial herring fishing from noon Friday through sunset Sunday. Herring fishing is also prohibited within Belvedere Cove and unloading of herring is prohibited at night (10 p.m. to 6 a.m.) in response to complaints about fishing related noise at night.

Chapter 5. CUMULATIVE EFFECTS

The current status of herring stocks in California was discussed in Chapter 3. A variety of factors have the capacity to influence future Pacific herring population status in California in addition to the proposed project or alternatives. The factors with the greatest potential include continued commercial harvest of herring, unusual biological events, competitive interactions with other pelagic fish, unusual weather events, habitat loss, and water quality. Several of these factors have been discussed [Sec 3.2], but will be reviewed briefly.

5.1 Continued Commercial Harvest of Herring

Although the proposed project only provides for the regulated commercial harvest of Pacific herring during the 1998-99 season, the long-term impacts from continued harvest should be considered [Sec 4.2.1.6]. A computer model was used to test the long-term impacts of various harvest strategies [Sec 3.2.4]. The harvest strategy selected for use in California was considered to be conservative and did not lead to herring population declines during a 100-year simulation.

The policies guiding the management of the state's herring resource, annual herring stock assessments, and the regulations designed to achieve the management objectives, are reviewed annually to insure the continued viability of a herring resource [Sec 3.2.4]. Changes are made to the regulatory framework as necessary based on this review and their utility assessed in subsequent reviews. The process, then, is dynamic and should reduce the likelihood of long-term deleterious impacts associated with the ongoing commercial harvest of Pacific herring to less-than-significant levels. Any long-term deleterious impacts would become apparent over a protracted period, not in the course of a single season.

5.2 Unusual Biological Events

The level of natural mortality assumed in the PFMC model [Appendix 3] (M = 0.4) to assess various harvest strategies may not be high enough to account for several potential changes in marine community structure. If the actual natural mortality rate is appreciably higher than assumed, the model will not accurately predict the impact of the selected harvest strategy. Additionally, the model assumes constant recruitment, and does not account for successive years of poor recruitment. If the factors influencing recruitment cause several contiguous years of poor recruitment, the model will not accurately predict the impact of the selected harvest strategy.

As with most marine fishes, no direct measure of the actual rate of natural mortality for herring is available. Any trend in predation could influence those rates without being recognized in the short-term. For example, a trend of increased predation would result in an increase in the rate of natural mortality, thus influencing the predictive capability of the PFMC model. Marine mammals are completely protected and a number of marine mammal populations are growing. A study of harbor seal food habits in the Monterey Bay area documented an increase in predation on herring associated with increases in harbor seal population size and shifts in foraging areas (Suryan and Raum-Suryan 1990). The potential exists, then, for an increase in the rate of predation by marine mammals and an increase in natural mortality for herring. This would require lower fishing harvest levels than currently used.

Several foreseeable changes in the marine community of which herring are a part could increase the possibility of poor recruitment during contiguous years. One such change with the potential for negatively impacting herring recruitment is the invasion and population explosion of the Asian clam in San Francisco Bay (Carlton et al. 1990, Nichols et al. 1990). This clam has demonstrated a remarkable capacity to reduce the standing crop of phytoplankton and zoo-plankton within the Bay. One of the critical stages in herring life history [Sec 3.2.1.4] is the age at first feeding. Success at this stage can lead to good year class recruitment. If the availability of herring prey (phytoplankton and microzooplankton) is chronically reduced, natural mortality of prerecruit ages could become chronically higher than previously experienced. As noted, the PFMC model used to predict appropriate harvest levels does not account for poor recruitment.

5.3 Competitive Interactions with Other Pelagic Fish

Herring are one of many small pelagic schooling fish to occupy the nearshore waters off the California coast. Interspecific links (e.g. competition at the larval, juvenile or adult stage), differential effects of fishing, or changes in the environment may preferentially favor one over the other of these species, leading to large shifts in their relative abundance. The large changes in the relative abundance of the anchovy and sardine in California, based on a study of fish scales in sediments collected in anaerobic basins, is an example of this type of shift (Soutar and Isaacs 1974).

5.4 Oceanographic Events

The occurrence of oceanographic conditions such as the El Niño phenomenon (warming of the ocean due to unusual changes in current systems) has had significant influences on the relative abundance of small pelagic schooling fishes. The present El Niño is one of the strongest on record, and heavily impacted herring stocks. The San Francisco Bay spawning population declined 78%. Many of the fish that did return to spawn showed signs of poor condition, such as low body weight and abnormal egg skeins. Given the large spawning biomass estimated for San Francisco Bay for the 1996-97 and 1995-96 seasons, and the strength of the 1995, 1994, 1993 and 1992 year-classes, many fewer herring than expected returned to spawn in San Francisco Bay for the 1997-98 season. Whether poor ocean conditions caused by El Niño increased natural mortality or prevented herring from reaching reproductive condition remains to be seen.

The last acute El Niño to severely affect California herring occurred in 1983. During this El Niño, the San Francisco Bay herring spawning biomass declined 60 percent, and growth rates and condition factors of herring were also poor (Spratt 1987). Less acute but longer-lasting warm water conditions occurred during 1986-87 and the early 1990's. Nutrient-depleted warm water masses and reduced prey availability that are associated with El Niños are expected to be detrimental to California's herring stocks. El Niños have had significant influences (including contributing to stock collapse) on other pelagic schooling species in other areas (Lasker 1985, Glantz and Thompson 1981).

In addition to warmer water and associated low productivity, El Niño events are often characterized by increased rainfall, resulting in lower salinities in bays and estuaries. While increased freshwater is thought to act as a trigger for spawning, too much freshwater can decrease embryo survival (Cherr and Pillai 1994).

5.5 Habitat Loss

The loss or degradation of spawning habitat can have an impact on the spawning success of herring. Loss of habitat has affected the status of other fish populations such as the endangered

Sacramento river winter-run king salmon (PFMC 1990).

Herring use both hard substrate and vegetation as a spawning substrate [Sec 3.2.1.3]. Pier pilings are a frequently-used substrate in San Francisco Bay. However, it is likely that pilings treated with anti-fouling agents (e.g. creosote) are toxic to herring embryos and represent a source of mortality. The 1996 Cape Mohican Oil Spill along the San Francisco waterfront deposited oil on pier pilings within a six foot tidal amplitude zone prior to the 1996-97 spawning season. Potential exists for this oil to also cause mortality of herring embryos spawned on pier pilings.

No significant changes are expected in the quantity of man-made hard substrate (e.g. pier pilings) in the foreseeable future. The San Francisco Bay Conservation and Development Commission (BCDC) regulates development within the first 100 feet inland from the Bay, as well as all filling and dredging. During the 19-year period ending in 1988 there was only a net increase in Bay surface area of 760 acres (BCDC 1988). However, the abundance and distribution of vegetation suitable for spawning has changed and could change to greater extents in the foreseeable future.

Eelgrass is an important and often critical component of the nearshore ecosystem. Eelgrass is commonly found in relatively calm estuarine environments and is vulnerable to coastal urbanization that heavily targets these same environments. Efforts to mitigate the effects of development have generally been inadequate. Light, temperature, salinity, tidal range, and water motion influence growth and productivity of eelgrass. However, light most often appears to be the controlling factor. Processes that increase the overall turbidity of the estuarine environment could have marked effects on eelgrass density and distribution (Zimmerman et al. 1991). Long-term reduction in the availability of suitable spawning substrate such as eelgrass would increase the vulnerability of herring to perturbations.

The red algae, *Gracilaria* spp., was abundant and commonly used by herring in San Francisco Bay as a spawning substrate during the 1970s and early 1980s (Spratt 1981). Richardson Bay, with its dense *Gracilaria* beds, was the primary subtidal spawning area in the Bay during this time. With the decline in *Gracilaria* densities (0.48 kg/m^2 to 0.04 kg/m^2) in 1982, Richardson Bay was relegated to a minor spawning area (Spratt 1983). Storm action during the 1982-83 El Niño is thought to have removed much of the *Gracilaria* sp. from the area. The trend of herring spawning in areas of San Francisco Bay other than Richardson Bay continued through the 1992-93 season. *Gracilaria* sp. densities increased to a mean of 0.39 kg/m^2 for the 1993-94 season. In addition, eelgrass has expanded in abundance in Richardson Bay in recent years. Perhaps as a consequence, spawning activity has increased in Richardson Bay in recent seasons.

Since the 1995-96 season, *Gracilaria* sp. has been difficult to find in Richardson Bay, while eelgrass distribution has increased slightly. The reason for the disappearance of *Gracilaria* sp. in this area is not known. Despite the loss of subtidal vegetation, Pacific herring have continued to spawn in Richardson Bay, often on pilings and boat bottoms in marinas as well as on eelgrass.

5.6 Water Quality

San Francisco Bay, like other urbanized estuaries, faces continuing water quality problems. Contributing to the problem are the multiplicity of pollution sources, limited water exchange capabilities, and reduced volume of fresh water inflow. The quantity of hazardous wastes generated in the Bay region is expected to increase (BCDC 1988). These pollutants, acting singly or in combination, could influence the viability of herring using the Bay. For example, a large spill of elemental phosphorus caused high mortality in a Canadian herring population (Jangaard 1972).

Although overall chemical and physical conditions such as turbidity, nutrients, coliform organisms and chemical oxygen demand in the Bay have been improved, pollutants still exist in the water column, sediments, and tissue in concentrations which are cause for concern (SWRCB 1989). Pollutants of particular concern because of the aquatic toxicity to biota include heavy metals (cadmium, chromium, copper, mercury, selenium, silver, tributyltin), hydrocarbons, and agricultural chemicals (chlorinated hydrocarbons and organo-phosphates). These substances are not readily transported from the system nor are they readily broken down since the physical, chemical, and biological processes affecting them are slow.

Dredging is an ongoing loading source that can make formerly isolated contaminants available, and several of these pollutants are known to bioaccumulate (SWRCB 1989). Dredging and disposal of dredge spoils within the Bay contribute to elevated levels of turbidity as well.

Particular concern exists over the presence of radiation and other contaminants in the sediments at the Treasure Island Naval Station Hunters Point Annex (Barbara Smith, Regional Water Quality Control Board, pers. comm., Jeff Lewis, Department of the Navy, pers. comm.). Herring utilize pier pilings, sea walls, and rocky shoreline at Hunters Point for spawning. It is not known what effect, if any, contaminated sediments have on egg and larval survival. A restricted zone prohibits vessel traffic in the vicinity of Hunters Point. Illegal fishing activity in the Hunters Point area would disturb sediments and possibly create an increased yet short-term exposure hazard to humans as well as the biota (Agency for Toxic Substances and Disease Registry, 1994).

Although the direct and indirect effects of these pollutants on various life stages of herring are largely unknown, their toxic effect on marine organisms has been well documented (SWRCB 1989). The likelihood of increased loading of many pollutants could have impacts on the herring resource in San Francisco Bay.

Increased fresh water inflow occurs periodically during increased rainfall years, often associated with El Niño conditions. During the 1996-97 season, a series of warm, tropical storms dramatically decreased salinities in San Francisco and Tomales Bays. Spawning was delayed by as much as three weeks during January, and the survival of embryos was probably affected.

Reduced fresh water inflows, either from drought or diversion, have had significant impacts on estuarian benthic community structure (Carlton et al. 1990, Herrgesell 1983). The Department's Bay/Delta Project has gathered data that suggests an association between young-of-the-year herring abundance and high Delta outflows (Kathy Hieb, Bay/Delta Project, pers. comm.). Although spawning, fertilization, hatching and larval development occur under a wide range of reduced salinities, studies have established optimal salinities for herring spawning and young-of-the-year survival. For example, for British Columbia herring stocks, Alderdice and Hourston (1985) reported optimal salinities for spawning (27-28.7ppt) and hatching (17.0 ppt); Alderdice and Velsen (1971) reported optimal salinity of 16.4 ppt for larval development. For San Francisco Bay herring, Griffin et al. (1998) reported optimal salinity for fertilization at 12-24 ppt, and optimal salinity for development through hatching at 8-24 ppt. Fertilization was inhibited at high (28 ppt, 32 ppt) and low (4 ppt, 8 ppt) salinities (Griffin et al. 1998).

Several studies have shown that higher salinities are tolerable for herring reproduction if temperatures are low. Therefore, it is possible that the combination of increased salinities in the Bay (due to reduced Delta outflows during the recent seven-year drought) with a prolonged warm water period contributed to the decline of San Francisco Bay's herring population in the early 1990's. Reduced fresh water inflows have also been identified as a potential factor affecting the use of Tomales Bay as a herring spawning area (Spratt 1990).

Fresh water inflow into San Francisco Bay has been influenced by water development activities. Inflows have been reduced by construction of upstream reservoirs, increased consumptive uses in the basin, and exports. Existing developments have reduced inflow levels for most months during all water-year types. However, the proportional reductions are more severe during dry and critical years than in wet or normal years.

The combined influence of drought and water diversion on salinity profiles within San Francisco Bay will result in salt water intrusion further into the estuary. However, assessing the impact of these changes on herring use of the Bay is difficult and conjectural.

If San Francisco Bay remains an acceptable spawning area for herring, drought and diversion-related changes in the salinity profile in various reaches of the Bay could result in more spawning area in San Pablo Bay. Herring have used the highly marine reaches of the Bay as spawning areas. Decreasing fresh water inflow could change San Pablo Bay to a more marine-influenced reach. The point of concern is whether decreased salinities are necessary in the selection and timing of use of any or all of an estuary as a spawning area. Decreased fresh water inflows could simply cause a shift in spawning areas.

Mitigation: Several potential cumulative impacts have been identified that could result in unusual stress being placed on the commercially harvested herring resources. In the foreseeable future these impacts are less than significant. Regardless of the level of impact from cumulative effects, mitigation will be provided through changes in the level of commercial harvest of herring or in selection of a no fishery alternative. These changes will occur through the annual review process and subsequent adjustments to commercial herring regulations.

Chapter 6. ANALYSIS OF ALTERNATIVES

The Department recommends that the Commission adopt regulations that will provide for and control the commercial harvest of Pacific herring. An array of regulations (Section 163 and 164, Title 14, CCR presented in Appendix 1) has evolved to provide for the efficient harvest and orderly conduct of herring fisheries [Sec 3.2.4]. The proposed project reflects both Department and public recommendations for continuation, amendment, or change to existing regulations to meet the State's policy for managing the herring resource. However, three regulatory alternatives are also provided for consideration.

The three commercial harvest alternatives were selected for consideration by the Commission based on public comment received during the normal review process, or in response to the Notice of Preparation (NOP). These alternatives were selected to provide the Commission with a range of commercial harvest alternatives. All commercial harvest alternatives contain common elements with only selected elements of the management framework considered as alternatives. A "no project" (no commercial harvest of herring) alternative is also provided.

The potential environmental impacts associated with each alternative will be assessed below. The project alternatives section of Chapter 2 provides a brief overview of the unique regulation characteristics associated with each alternative and a description of the problem or condition that the regulation change is intended to address.

6.1 Alternative 1 (no project)

The "no project" alternative would eliminate commercial harvest from the Pacific herring resource management framework. Selection of this alternative would be expected to: 1) reduce total mortality and allow herring stocks to increase to carrying capacity; 2) reduce the health of stocks through density dependent intraspecific interactions; 3) increase interspecific competition and reduce standing crops of closely related species; 4) increase the availability of herring to predators by reducing search effort and increasing capture success; 5) eliminate the ethical concern of those opposed to the commercial harvest of herring; 6) eliminate the scientific information on herring derived from sampling the commercial harvest; 7) eliminate revenues to local and regional economies and State and Federal agencies derived from the commercial harvest of herring.

Localized, short-term, and less than significant impacts to traffic circulation, water quality, air quality, housing, utilities, scenic quality, recreational opportunities, and noise levels would be eliminated.

The potential biological impacts associated with a "no project" alternative include an increased rate of natural mortality. The sources of natural mortality and mortality rates typically vary with the age of fish within a population (Sec 3.2.1.8]. This is particularly true when all life stages are considered (egg, larvae, juvenile, and adult).

Natural mortality of eggs may increase with population size, if population size influences egg deposition density and assuming limits exist on suitable spawning habitat. The number of egg layers affects hatching success [Sec 3.2.1.3]. The optimal number of layers varies with depth, but, hatching success tends to decrease when egg deposition exceeds medium densities.

Natural mortality may or may not increase due to increased predation by various marine fish, bird, and mammal species that consume herring, as predation would likely increase in proportion to herring population levels.

Increases in the standing crop of herring could have negative impacts on those species that compete with herring [Sec 3.2.1.10]. Competitors include other pelagic schooling fish with overlapping spatial distribution, juvenile and subadult coho salmon in shallow sublittoral habitat, and a variety of zooplankton. Other than competition with pelagic schooling species, most of the competition will likely have only localized effects. Competition among pelagic schooling fish can contribute to large shifts in relative abundance [Sec 5.3]. However, the mechanisms involved in these competitive interactions are not well understood, thus limiting any predictive capability in this assessment.

Although not an environmental impact, the no project alternative has potential negative socio-economic impacts. For example, approximately 470 permittees and at least that many crew members derive income, in some cases a significant proportion of their annual income, from the herring fishery. That income would have to be obtained from other endeavors should the herring fisheries be precluded by selection of this alternative. A rough estimate of the gross income to the fishermen (ex-vessel income) provided by the San Francisco Bay herring roe fishery during the 1992-93 season was four million dollars generated over a relatively short fishing season (3 months) with a relatively low cost structure.

No study of herring roe fishery economics has been done. However, several generalizations can be made to place the economic impacts of a "no project" alternative into perspective. Value to the local economy would be roughly twice the amount paid to the fisherman (Ed Ueber, NMFS, pers. comm). Value to the national economy would be greater because fishery products in general have a large positive contribution to our balance of trade. Herring roe products are almost entirely exported. As a result, almost the entire value benefits the balance of trade.

6.2 Alternative 2 (existing regulations)

In most regards, the environmental impacts of all the alternatives that provide for the commercial harvest of herring will be similar to those of the proposed project. Impact assessments of the alternatives will focus on those elements that differ from the proposed project.

In alternative 2, the only amendments proposed are those that adjust seasons to the current calendar and quotas by current biomass estimates. The impact assessment for the proposed project applies to these changes [Sec 4.2].

However, adopting regulations as they exist does not address problems or conditions addressed by the changes and amendments in the proposed project. Some of the changes and amendments in the proposed project address harvest rates, notification and/or administrative issues, efficiency issues, eggs on kelp fishery issues, or are simply clarification changes and are without apparent environmental implications.

Those changes or amendments that do have environmental implications include the quota alternatives for San Francisco Bay and Tomales Bay. The environmental implications of quota changes are almost entirely biological in nature.

6.3 Alternative 3 (individual vessel quota)

This alternative modifies alternative 2 by establishing individual boat quotas for the herring roe gill net fishery in San Francisco Bay. The individual boat quotas would be established in a manner comparable to that used to establish individual boat quotas for the round haul fishery. Although largely an economic issue, providing for individual boat quotas in the herring roe gill net fishery does have some subtle environmental implications.

Localized, short-term, and less than significant impacts of this alternative to traffic circulation, water quality, air quality, housing, utilities, scenic quality, recreational opportunities, and noise levels are expected to be comparable to the proposed project. However, fishing effort could extend further into the season since the economic incentive would direct effort toward higher quality rather than quantity. In this regard, without individual boat quotas, overall quotas have typically been met long before season closure. Having the latitude to strive for higher quality could add incrementally to most impacts. Daily pollution emissions, for example, may occur on a greater number of days than has occurred in the past if more effort was spent in search of fish with high roe content.

No data are available to quantitatively assess the potential impacts of individual boat quotas from a biological perspective. Individual boat quotas for the herring roe gill net fishery in San Francisco Bay (this alternative) could have potential negative biological impacts. These impacts would result from having the time and incentive to sort and discard males and immature females to maximize landings value. Landings with higher roe content bring higher prices. There would also be greater incentive to discard entire gill net catches of lower quality (low roe content) and also increase the opportunity to make unreported landings. As a result, true fishing mortality would be underestimated by actual landings. The potential impacts of this type of practice have been discussed [Sec 4.2.6].

With no individual boat quotas, the biological impacts will result from the tendency to land as much fish as quickly as possible. More nets than are legally provided for could be set and more nets lost. Potential impacts from "ghost" nets are more likely under this scenario [Sec 4.2.6]. There is also an incentive to fish gill nets with smaller mesh than provided for legally. This puts greater pressure on age classes that have had fewer opportunities to reproduce. Long-term stability could be affected if that pressure results in establishing a narrow age structure in the population.

Chapter 7. CONSULTATION

An integral part of all the Department's marine resource management programs includes consulting with other agencies and qualified professionals in pertinent fields. To this end, Department staff involved in herring resource management are continually in contact with other agencies, professional biologists and researchers involved in herring management. Concurrent with maintaining close informal contact (telephone and meetings in the field) with these professionals, Department personnel also maintain formal contact by attending professional workshops, conferences and seminars.

Consultations also occur during the annual review of regulations guiding the commercial harvest of herring. The process is initiated when the Department presents their management recommendations to a Herring Advisory Committee established by the Director. The Committee is comprised of representatives from each of the three gill net platoons in the San Francisco Bay fishery, two representatives from the round haul fleet, one representative from the Tomales-Bodega Bay area, one from the Eureka-Crescent City area, and two representatives from fish processors. They meet annually, in March, to review the status of the fishery and provide recommendations, as necessary, for regulatory change.

The Department's recommendations are modified, as necessary, based on the Committee's comments and presented at several public hearings. The recommendations are again modified, as necessary, based on information and comments received during the public hearings and are then presented to the Fish and Game Commission.

Prior to preparation of the draft environmental document, the Department initiated a broader consultation by distributing a notice of preparation (NOP) that announced the intent to prepare the document. The NOP requested submittal of views on the scope and content of the environmental information to be contained therein. The notice was distributed to members of the public and interested organizations that had expressed prior interest in herring management. The NOP was also provided to the State Clearinghouse for distribution to appropriate responsible and trustee agencies.

Issues raised in response to the NOP and during the scoping session can be divided into the following four general categories:

1. Potential negative impacts on marine food webs that include herring eggs, juveniles, or adults.

    - role of herring as forage for other fish, sea birds, and marine mammals, particularly salmon, striped bass, common murre, sea lion, and humpback whale

    - effect of harvest on plankton resources

2. Potential negative impacts on resources in the vicinity where herring are being harvested.

    - effect of harvest on stock, particularly the potential for stock collapse, changes in average `size of fish, and validity of management practices

    - effect of incidental take, particularly on striped bass, and sturgeon

    - intentional take of sea lions

    - effects of lost gear

    - precision of spawning population estimates

    - effect on recruitment

    - effect of oil or chemical spills

3. Potential negative impacts on habitat associated with the harvest of herring.

    - effect of harvest on selection of spawning sites

4. Potential negative impacts on human uses of area in the vicinity where herring are being harvested.

    - effect on salmon, halibut, striped bass, rockfish and other sport and commercial fisheries

Every effort has been made to consider relevant issues brought forth in response to the NOP in the draft environmental document, including development of alternatives to the proposed project.

Chapter 8. Responses to Comments Regarding the Proposed Project

Pursuant to Sections 2180.5(d)(2)(vi) and 2180.5(d)(3)(ii) of the Public Resources Code, a copy of the Draft Environmental Document was placed on file and made available for public review for a 45 day period. Notice was also given at the time of filing that any person interested could submit statements in writing relevant to the environmental document until 5:00 p.m. on August 7, 1998, at the Fish and Game Commission office in Sacramento. Written and oral comments relative to the draft environmental document were also solicited by the Commission at its August 7, 1998 meeting in Point Reyes Station.

8.1 Summary of Comments Received

No oral or written comments regarding the Draft Environmental Document were received by the Department during the public review period.

8.2 Department Response to Comments

Not applicable.

8.3 Copy of Letters Received

None received.

LITERATURE CITED

ABAG. 1997. Projections 1998. Association of Bay Area Governments, San Francisco, CA.

Agency for Toxic Substances and Disease Registry. 1994. Treasure Island Naval Station Hunters Point Annex San Francisco, San Francisco County, California. U.S. Dept. Health & Human Services. CERCLIS No. CA1170090087.

Ainley, D.G. 1980. Birds as marine organisms. CalCOFI Rpt. 21:48-53.

Ainley, D.G. and R.J. Bockelheide. 1990. Seabirds of the Farallon: Ecology, Dynamics, and Structure of an Upwelling Community. Stanford Univ. Press, Palo Alto.

Ainley, D.G. and G.L. Hunt. 1991. Status and Conservation of Seabirds in California. 103-114. In: J.P. Croxall (ed) Seabird Status and Conservation: A Supplement. Int. Coun. of Bird Pres. Tech Pub. No. 11.

Ainley, D.G., W.J. Sydman, S. A. Hatch, and U. W. Wilson. 1994. Seabird population trends along the west coast of North America: Causes and the extent of regional concordance. Studies in Avian Biology. 15:119-133.

Aioi, K., H. Mukai, I. Koike, M. Ohtsu, and A Hattori. 1981.Growth and organic production of eelgrass (*Zostera marina* L.) in temperate waters of the Pacific coast of Japan. II. Growth analysis in winter. Aquat. Bot. 10:175-182.

Alderdice, D.F. and A.S. Hourston. 1985. Factors influencing development and survival of Pacific herring (*Clupea harengus pallasi*) eggs and larvae to beginning of exogenous feeding. Can. J. Fish. Aquat. Sci. 42 (Suppl 1):56-68.

Alderdice, D.F. and F.P.J. Velsen. 1971. Some effects of salinity and temperature on early development of Pacific herring (*Clupea pallasi*). J. Fish. Res. Bd. Can.28:1545-1562.

Alpine, A.E. and J. E. Cloern. 1992. Trophic interactions and direct physical effects control phytoplankton biomass and production in an estuary. Limnol. and Oceanogr. 37(5):946-955.

Aneer, G. 1987. High natural mortality of Baltic herring (*Clupea harengus*) eggs caused by algal exudates. Mar. Biol. 94(2):163-170.

Antonelis, G.A.,Jr., C.H. Fiscus, and R.L. DeLong. 1984. Spring and summer prey of California sea lions, *Zalophus californianus*, at San Miguel Island, California, 1978-79. Fish. Bull., 82:67-76.

Anthony, V.C. 1971. The density dependence of growth of the Atlantic herring in Maine. Rapp.

P.V. Reun. Cons. Int. Explor. Mar 160:196-205.

Anthony, V.C. and M.J. Fogarty. 1985. Environmental effects on recruitment, growth and vulnerability of Atlantic herring (*Clupea harengus harengus*) in the Gulf of Maine region. Can.J. Fish. Aquat. Sci. 42 (Suppl 1):158-173.

Arai, M.N. and D.E. Hay. 1982. Predation by medusae on Pacific herring (*Clupea harengus pallasi*) larvae. Can. J. Fish. Aquat. Sci 39:1537-1540.

Ashmole, N.P. 1971. Seabird Ecology and the Marine Environment.224-286. In: D.S. Farner and J.R. King (eds) Avian Biology. Academic Press, New York.

Bailey, S. 1985. California least tern foraging and other off-colony activities around Alameda Naval Air Station during 1985, Final Report. Calif. Acad. Sci., San Francisco, CA.

Barnhart, R.A. 1988. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) - Pacific herring. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.79). U.S. Army Corps of Engineers, TR EL-82-4. 14 pp.

Barton, L.H. 1978. Finfish resource surveys in Norton Sound and Kotzebue Sound. OCSEAP, Final Report (March 1976-September 1978), ADF&G, Comm. Fish. Div., Anchorage, September.

Barton, L.H. and V.G. Wespestad. 1980. Distribution, biology, and stock assessment of Western Alaska's herring stocks. In Melteff and Wespestad, 1980. Proceed. of the Alaska Herring Symposium. Alaska Sea Grant Rep 80-4:27-53.

Bay Conservation and Development Commission. 1988. Annual Report. San Francisco, CA.

Bayer, R.D. 1980. Birds feeding on herring eggs at the Yaquina Estuary, Oregon. Condor 82:193-198.

Beverton, R.J.H. 1985. Analysis of marine mammal fisheries interaction. In: Beddington, J., Beverton, R.J.H. and Lavigne, D.M. (eds.), Marine Mammals and Fisheries, pp. 3-33, George Allen and Unwin, London.

Blaxter, J.H.S. 1985. The herring: a successful species? Can. J. Fish. Aquat. Sci. 42 (Suppl. 1):21-30.

Blaxter, J.H.S. and F.G.T. Holliday. 1963. The behavior and physiology of herring and other clupeoids. Adv. Mar. Biol. 1:261-393.

Blaxter, J.H.S. and J.R. Hunter. 1982. The biology of the clupeoid fishes. Adv. Mar. Biol. 20:3-223.

Blaxter, J.H.S. and B.B. Parrish. 1965. The importance of light in shoaling, avoidance of nets and vertical migration by herring. J. Cons. 30(1):40-57.

Boehlert, G.W. and M.M. Yoklavich. 1984. Carbon assimilation asa function of ingestion rate in larval Pacific herring, *Clupea harengus pallasi* Valenciennes. J. Exp. Mar. Bio.Ecol. 79:251-262.

Boveng, P. 1988a. Status of Pacific harbor seal population on the U.S. west coast. NOAA-NMFS, S.W. Fisheries Center, Admin. Rpt. LJ-88-06.

Boveng, P. 1988b. Status of California sea lion population on the U.S. west coast. NOAA-NMFS, S.W. Fisheries Center, Admin. Rpt. LJ-88-07.

Brawm, V.M. 1960. Survival of herring (*Clupea harengus* L.) in waters of low salinity. J. Fish. Res. Bd. Can. 17:725-726.

Breder, C.M. 1976. Fish schools as operational structures. Fish. Bull. U.S. 74:471-502.

Burkett, E.E. 1995. Marbled murrelet food habits and prey ecology. In: Ecology and conservation of the Marbled murrelet. John, R.C., G.L. Hunt, Jr., M.G. Raphael, J.F. Piatt, Tech. Eds.; Gen. Tech. Rep. PSW-GTR-152. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 420 p.

California Department of Fish and Game. 1992. Revised Draft Environmental Document: Migratory Game Bird Hunting (water fowl, coots, moorhens, and common snipe). State of California, The Resources Agency, Department of Fish andGame.

Carlson, R.H. 1980. Seasonal distribution and environment of Pacific herring near Auke bay, Lynn Canal, Southeastern Alaska. Trans. Amer. Fish. Soc. 109:71-78.

Carlton, J.T., J.K. Thompson, L.E. Schemel, and F.H. Nichols. 1990. Remarkable invasion of San Francisco Bay (California USA) by the Asian clam *Potamocorbula amurensis*.I. Introduction and dispersal. Mar. Ecol. Prog. Ser. 66:81-94.

Chapman, W. 1936. The pilchard fishery of the state of Washington in 1936 with notes on the food of the silver and chinook salmon off the Washington coast. Wash. Dept. Fish.,Biol. Rept. no. 36C, 30p.

Chapman, W.M., M. Katz, and D.W. Erickson. 1941. The races of herring in the state of Washington. Wash. Dept. of Fisheries. Biol. Rpt. No. 38A. 36 pp.

Chilton, D.E. and R.J. Beamish. 1982. Age Determination Methods for fishes studied by the Groundfish Program at the Pacific Biological Station. Can. Spec. Publ. Fish. Aquat. Sci. 60:102p.

Chilton, D.E. and M. Stocker. 1987. A Comparison of Otolith and Scale Methods for Aging Pacific Herring. N. Am. J. Fish. Mgt. 7:202-206.

Cloern, J.E., A.E. Alpine, B.E. Cole, R.L. Wong, J.F. Arthur, and M.D. Ball. 1983. River discharge controls phytoplankton dynamics in the northern San Francisco Bay estuary. Estuarine, Coastal and Shelf Science 16:415-429.

Corten, A. 1985. The recruitment failure of herring in the central and northern North Sea in the years 1974-78 and the mid-1970's hydrographic anomaly. Intern. Counc. Explor. Sea.Gen: 12 Mini Symposium.

Cushing, D.H. 1975. "Marine Ecology and Fisheries". Cambridge University Press.

Daan, N., A.D. Rijnsdorp, and G.R. VanOverbeeke. 1985. Predation by north sea herring, *Clupea harengus*, on eggs of plaice, *Pleuronectes platessa*, and cod, *Gadus morhua*. Trans. Amer. Fish. Soc. 114(4):499-506.

Day, D.E. 1987. Changes in the natural mortality rate of the S.E. Strait of Georgia sac roe herring spawning stock, 1976-1985. Wash. Dept. of Fisheries Tech. Rep. 98:1-34.

Dorfman, E.J. 1990. Distribution, behavior, and food habits of harbor porpoise (*Phocoena phocoena*) in Monterey Bay. MS Thesis, Moss Landing Marine Laboratories, San Jose State Univ.

Doubleday, W.G. 1985. Managing herring fisheries under uncertainty. Can. J. Fish. Aquat. Sci. 42 (Suppl. 1):245-257.

Eldridge, M.B. and W.M. Kaill. 1973. San Francisco Bay area's herring resource- a colorful past and a controversial future. Mar. Fish. Rev. 35(11):25-31.

Emmett, R.L., D.R. Miller, and T.H. Blahm. 1986. Food of juvenile chinook, *Oncorhynchus tshawytscha*, and coho, *O. kisutch*, salmon off the northern Oregon and southern Washington coasts, May-September 1980. Calif. Fish Game 72(1):38-46.

Employment Development Department. 1995. Labor Market Information Division.

Environmental Impact Statement. 1978. Environmental Impact Statement/Fishery Management Plan for the Atlantic Herring Fishery of the Northwest Atlantic. New England Fishery Management Council.

Eschmeyer, W.N., E.S. Herald, and H. Hamman. 1983. A field guide to Pacific coast fishes of North America from the Gulf of Alaska to Baja California. Houghton Mifflin, Boston. 336 pp.

Fossum, P. 1986. The duration of the first two yolk sac stages in herring (*Clupea harengus* L.) larvae. Fisker direkoratets Skrifter 18(2):77-82.

Fresh, K.L. 1983. Some aspects of the trophic ecology of Pacific herring in Puget Sound. In: Buchan, Kurt (ed.) Proceedings of the fourth Pacific coast herring workshop. Oct 7-8, 1981. Can. Man. Rep. Fish. Aquat. Sci. No. 1700:113-114.

Fresh, K.L., R.D. Cardwell, and R.R. Koons. 1981. Food habits of Pacific salmon, baitfish, and their potential competitorsand predators in the marine waters of Washington, August 1978 to September 1979. Wash. Dept. of Fish., Prog. Rept. No. 145. 58 p.

Furness, R.W. and D.G. Ainley. 1984. Threats to Seabird presented by Commercial Fisheries. 701-708. In: J.P. Croxall, P.G. Evans, and R.W. Schreiber (eds). Status and Conservation of the World's Seabirds. Paston Press, Norwich, England.

Galkina, L.A. 1971. Survival of spawn of Pacific herring (*Clupea harengus pallasi* Val.) related to the abundance of the spawning stock. Rapp. P.V. Reun. Cons. Int. Explor. Mer 160:30-33.

Garrison, D.L. 1979. Monterey Bay phytoplankton I. Seasonal cycles of phytoplankton assemblages. J. Plankton Res. 1(3):241-265.

Gibson, R.N. and I.A. Ezzi. 1985. Effect of particle concentration on filter- and particulate-feeding in the herring *Clupea harengus*. Mar. Biol. 88:109-116.

Glantz, M.H. and J.D. Thompson, eds. 1981. Resource management and environmental uncertainty. Lessons from coastal upwelling fisheries. John Wiley & Sons, Inc., 491 pp.

Gonyea, G. and B. Trumble. 1983. Growth and mortality rates for Puget Sound herring. In: Buchanan, Kurt (ed.) Proceedings of the fourth Pacific coast herring workshop Oct. 7-8, 1981. Can. Man. Rep. Fish. Aquat. Sci. No 1700:133-139.

Graham, J.J. and D.W. Townsend. 1985. Mortality, growth, and transport of larval Atlantic herring, *Clupea harengus*, in Maine coastal waters. Trans. Amer. Fish. Soc. 114(4):490-498.

Grant, W.S. 1986. Biochemical genetic divergence between Atlantic, *Clupea harengus*, and Pacific, *C. pallasi*, herring.Copeia 3:714-719

Grass, A. 1973. Mew Gulls and Black Turnstones feeding on herring eggs. Murrelet 54(3):38-39.

Griffin, F.J., M.C. Pillai, C.A. Vines, J. Kaaria, T. Hibbard-Robbins, R. Yanagimachi, G.N. Cherr. 1998. Effects of Salinity on Sperm Motility, Fertilization, and Development in the Pacific

Herring, *Clupea pallasi*. Biol. Bull. 194: 25-35.

Gulland, J.A. 1988. Fish Population Dynamics. Wiley, New York.422 pp.

Haegele, C.W., R.D. Humphreys, and A.S. Hourston. 1981. Distribution of eggs by depth and vegetation type in Pacific herring (*Clupea harengus pallasi*) spawnings in southern British Columbia. Can. J. Fish. Aquat. Sci., Vol 38(4):381-386.

Haegele, C.W. and J.F. Schweigert. 1985. Distribution and characteristics of herring spawning grounds and discription of spawning behavior. Can. J. Fish. Aquat. Sci. 42 (Suppl.1):39-55.

Haist, V. and M. Stocker. 1985. Growth and maturation of Pacific herring (*Clupea harengus pallasi*) in the Strait of Georgia. Can. J. Fish. Aquat. Sci. 42 (Suppl. 1):138-146.

Harden Jones, F.R. 1968. "Fish Migration". Arnold, London.

Hardwick, J.E. 1973. Biomass estimates of spawning herring, Clupea harengus pallasi, herring eggs, and associated vegetation in Tomales Bay. Calif. Fish Game 59(1):36-61.

Harrison, P.G. 1982. Spatial and temporal patterns in abundance of two intertidal seagrasses, *Zostera americana* den Hartog and *Zostera marina* L. Aquat. Bot. 12(4):305-320.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Can. Bull. 180, Ottawa. 740 pp.

Harvey, J.T. 1987. Population dynamics, annual food consumption, movements, and dive behaviors of harbor seals, *Phoca vitulina richardsi*, in Oregon. PhD Thesis, Oregon State University.

Hay, D.E. 1983. Role of larval survival in determination of year-class strength in Pacific herring. In: Buchanan, Kurt (ed). Proceeding of the fourth Pacific coast herring workshop, Oct 7-8, 1981. Can. Man. Rep. of Fish. Aquat. Sci. No. 1700 p116.

Hay, D.E. 1985. Reproductive biology of Pacific herring (*Clupea harengus pallasi*). Can. J. Fish. Aquat. Sci. 42 (Suppl. 1):111-126.

Hay, D.E. 1986. Effects of delayed spawning on viability of eggs and larvae of Pacific herring. Trans. Amer. Fish. Soc. 115(1):155-161.

Hay, D.E., Cooke, K.D. and Gissing, C.V. 1982. Gillnet dropout in the roe herring gillnet fishery in British Columbia. Can. Ind. Rep. Fish. Aquat. Sci., No. 131, 21 pp.

Hay, D.E. and D.C. Miller. 1982. A quantitative assessment of herring spawn lost by storm action in French Creek, 1980. Can. MS Rep. Fish. Aquat. Sci. 1636:1-9.

Healey, M.C. 1976. Herring in the diets of Pacific salmon in Georgia Strait. Fish. Res. Bd. Can. MS Rept. No. 1382. 38 p.

Heg, R. and J. Van Hyning. 1954. Food of the chinook and silver salmon taken off the Oregon coast. Oregeon Fish. Comm. Res. Briefs, vol. 3, no. 2, p. 32-40.

Henderson, P.A. 1987. The vertical and transverse distribution of larval herring in the River Blackwater estuary, Essex. J. Fish Biology 31(1):281-290.

Henri, M., J.J. Dodson, and H. Powles. 1985. Spatial configuration of young herring (*Clupea harengus harengus*) larvae in the St. Lawrence estuary: importance of biological and physical factors. Can. J. Fish. Aquat. Sci. 42 (Suppl 1):91-104.

Herrgesell, P.L., R.G. Schaffter, and C.J. Larsen. 1983. Effects of freshwater outflow on San Francisco Bay biological resources. Interagency Ecol. Study Prog. for the Sacramento-San Joaquin Estuary. Tech. Rpt. No. 7:1-86.

Hickey, B.M. 1979. The California Current System-hypothesis and fact. Prog. Oceanog., 8:191-279.

Holzworth, G.C. 1972. Mixing heights, wind speeds, and potential for urban air pollution throughout the contiguous United States. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Hourston, A.S. 1980. The biological aspects of management of Canada's west coast herring resource. In: Melteff and Wespestad (ed.) Proceedings of the Alaska herring symposium, Feb. 1980. Alaska Sea Grant Rep. 80-4:69-90.

____________. 1982. Homing by Canada's west coast herring to management units and divisions as indicated by tag recoveries. Can. J. Fish. Aquat. Sci. 39:1414-1422.

Hourston, A.S., H. Rosenthal, and S. Kerr. 1981. Capacity of juvenile Pacific herring (*Clupea harengus pallasi*) to feed on larvae of their own species. In: Canadian technical report of fisheries and aquatic sciences No. 1044. 9 pp.

Hymanson, Z. P. 1991. Results of a spatially intensive survey for (*Potamocorbula amurensis*) in the upper San Francisco Bay estuary. Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary. Tech. Rpt. 30, 21pp.

Iles, T.D. 1967. Growth studies of north sea herring, I. The second year's growth (I-group) of East Anglican herring, 1939-63. J. Cons. Reun. Int. Explor Mer 31(1):56-76.

Jangaard, P.M. 1972. Effects of elemental phosphorus on marine life. Fish. Res. Bd. Can. circ., 2.

Jones, B.C. 1972. Effect of intertidal exposure on survival and embryonic development of Pacific herring spawn. J. Fish. Res. Bd. Can. 29:1119-1124.

Jones, R.E. 1981. Food habits of smaller marine mammals from northern California. Proc. Calif. Acad. Sci. 42(16):409-433.

Jones, R. and W. Hall. 1974. Some observations on the population dynamics of the larval stage in the common gadoids. In: The Early Life History of the Fish (J.H.S.Blaxter ed.), pp. 87-102, Springer-Verlag, Berlin.

Kemp, W.M., R.R. Twilley, J.C. Stevenson, W.R. Boynton, and J.C. Means. 1983. The decline of submerged vascular plants in upper Chesapeake Bay: summary of results concerning possible causes. Mar. Tech. Sci. J. 17(2):78-89.

Kimmerer, W. J., E. Gartside, and J. J. Orsi. 1994. Predation of an introduced clam as the probable cause of substantial declines in copepods of San Francisco Bay. Mar. Ecol. Prog. Ser. 113:81-93.

Kiorboe, T. and P. Munk. 1986. Feeding and growth of larval herring, *Clupea harengus*, in relation to density of copepod nauplii. Environ. Biol. of Fishes 17(2):133-140.

Kiorboe, T., P. Munk, and J.G. Stottrup. 1985. First feeding by larval herring *Clupea harengus* L. Dana 5:95-107.

Kohlhorst, D.W., L. Botsford, J. Brennan, G.M. Cailliet. 1991. Aspects of the structure and dynamics of an exploited Central California population of white sturgeon (*Acipenser transmontanus*). In: *Acipenser*: Actes du premier colloque national sur l'esturgeon, Bordeaux, 3-6 Octobre, 1989 (P. Williot, ed.) CEMAGREF publ. p. 277-293.

Krone, R.B. 1966. Predicted suspended sediment inflows to the San Francisco Bay system. Report to Central Pacific RiverBasins Comprehensive Water Pollution Control Proj., Federal Water Pollution Control Proj., Federal Water Pollution Control Admin. (South-west Region). 33 p.

Lambert, T.C. 1987. Duration and intensity of spawning in herring, *Clupea harengus*, as related to the age structure of the mature population. Mar. Ecol. 39(3):209-220.

Lasker, R. 1975. Field criteria for survival of anchovy larvae: the relation between inshore chlorophyll maximum layers and successful first feeding. U.S. Natl. Mar. Fish. Serv. Fish.Bull. 73:453-462.

Lasker, R. 1978. The relation between oceanographic conditions and larval anchovy food in the California current: identification of factors contributing to recruitmentfailure. Rapp. P.V. Reun. Cons. Int. Explor. Mer 178:375-388.

Lasker, R. 1985. What limits clupeoid production? Can. J. Fish. Aquat. Sci. 42 (Suppl 1):31-38.

Lasker, R. and A. MacCall. 1983. New ideas on the fluctuation of the clupeoid stocks off California. In: Proceedings of the Joint Oceanographic Assembly 1982, General Symposia, Dalhousie Univ., Halifax, Nova Scotia, Canada. pp110-120.

Levings, C.D. 1983. Some observations of juvenile herring at the Fraser River estuary, B.C. In: Buchanan, Kurt (ed.) Proceedings of the fourth Pacific coast herring workshop, Oct. 7-8, 1981. Can. Man. Rep. Fish. Aquat. Sci. No. 1700:91-103.

Lo, N.C. 1985. Egg production of the central stock of northern anchovy, *Engraulis mordax*, 1951-82. Fish. Bull. 83(2):137-150.

Lough, R.G., G.R. Bolz, M. Pennington, and M.D. Grosslein. 1985. Larval abundance and mortality of Atlantic herring (*Clupea harengus* L.) spawned in the Georges Bank and Nantucket Shoals areas, 1971-78 Seasons, in relation to spawning stock size. J. Northw. Atl. Fish. Sci., Vol. 6:21-35.

MacCall, A.D. 1980. The consequences of cannibalism in the stock-recruitment relationship of planktivorous pelagic fishes such as *Engraulis*, p. 201-220. In: G. Sharp (ed.) Workshop on the effects of environmental variation on the survival of larval pelagic fishes. UNESCO. Intergovernmental Oceanographic Commission. Workshop Report 28.

McGurk, M.D. 1984. Effects of delayed feeding and temperature on the age of irreversible starvation and on the rates of growth and mortality of Pacific herring larvae. Mar. Biol.84(1):13-26.

McGurk, M.D. 1987. The Spatial patchiness of Pacific herring larvae. Environ. Biol. of Fishes 20(2):81-90.

McKechnie, R.J. and R.B. Fenner. 1971. Food habits of whitesturgeon, *Acipenser transmontanus*, in San Pablo and Suisun Bays, California. Calif. Fish Game 57(3):209-212.

McLain, D.R. and D.H. Thomas. 1983. Year-to-year fluctuations of the California countercurrent and effects on marine organisms. CalCOFI Rep. Vol. XXIV:165-181.

Marliave, J.B. 1980. Survival through metamorphosis of Pacific herring prevented from schooling. Trans. Amer. Fish. Soc. 109:327-328.

Merkel, T.J. 1957. Food habits of the king salmon, *Oncorhynchus tshawytscha* (Walbaum), in the vicinity of San Francisco, California. Calif. Fish Game 43(4):249-270.

Miller, D.J. and J. Schmidtke. 1956. Report on the distribution and abundance of Pacific herring (*Clupea pallasi*) along the coast of central and southern California. Calif. Fish Game

42:163-187.

Miller, D.J., M. Herder, and J. Scholl. 1983. California marine mammal fishery interaction study, 1979-81. NMFS SWFC Admin. Rpt. LJ-83-13C.

Minerals Management Service. 1990. California, Oregon, and Washingtion archaeological resource study. OCS Study MMS 90-0087. Vol I: Management Summary 50pp.

Moller, H. 1984. Reduction of a larval herring population by jellyfish predator. Science 224 (4649):621-622.

Mooers, C.N.K. and A.R. Robinson. 1984. Turbulent jets and eddies in the California current and inferred cross-shore transport. Science 223:51-53.

Moore, T.O, and P.N. Reilly. 1989. Pacific herring, *Clupea harengus pallasi*, experimental roe-on-kelp open pound fishery studies in San Francisco Bay, December 1987 to February 1988. CDFG Mar. Res. Div., Admin. Rpt. 89-3:1-27.

Morejohn, G.V., J.T. Harvey, and L.T. Krasnow. 1978. The importance of *Loligo opalescens* in the food web of marine vertebrates in Monterey Bay, California. In: Biological, oceanographic, and acoustic aspects of the market squid, *Loligo opalescens*, Berry. C.W. Recksiek and H.W. Frey, eds. CDFG Fish Bull. 169:1-185.

Moser, M. 1983. Parasites as biological tags for herring. In: Buchanan, Kurt (ed) Proceed of the fourth Pacific Coast herring workshop. Oct 7-8, 1981. Can. Man. Rep. Fish. Aquat. Sci. No 1700 pp 125-127.

Murphy, G.I. 1977. Clupeoids. In "Fish Population Dynamics" (J.A. Gulland, ed.), pp 283-308. John Wiley, London.

Nelson, W.R., M.C. Ingham, and W.E. Schaaf. 1977. Larval transport and year-class strength of Atlantic menhaden, *Brevoortia tyrannus*, U.S. Natl. Mar. Serv. Fish. Bull. 75:23-41.

Nichols, F.H. and J.K. Thompson. 1985. Persistence of an introduced mudflat community in south San Francisco Bay, California. Mar. Ecol. Prog. Ser. 24:83-97.

Nichols, F.H., J.K. Thompson, L.E. Schemel. 1990. Remarkable invasion of San Francisco Bay (California, USA) by the Asian clam *Potamocorbula amurensis*. II. Displacement of a former community. Mar. Ecol. Prog. Ser. 66:95-101.

Nielsen, L.A. and D.L. Johnson, eds. 1983. *Fisheries Techniques*. Bethesda, MD.: American Fisheries Society. 496pp.

Norton, D.W., S.E. Senner, R.E. Gill, P.D. Martin, J.M. Wright, and A.K. Fukuyama. 1990.

American Birds 44(3):367-371.

Obreski, S. and J.W. Hedgpeth. 1984. California herring: the biology and management of central California herring stocks. Report to the Ocean Reasearch Institute, San Francisco.

Oda, K.T. 1994. Pacific herring, *Clupea pallasi*, studies in San Francisco Bay, April 1990 to March 1992. CDFG Mar. Res.Div., Admin. Rpt. 94(2):38 p.

Oda, K.T. 1989. The Pacific herring, *Clupea harengus pallasi*, open pound roe-on-kelp experimental fishery in San Francisco Bay, 1988 to 1989. CDFG Mar. Res. Div., Admin Rpt. 89(7):1-18.

Oda, K.T. and F. Wendell. 1990. Pacific herring, *Clupea harengus pallasi*, studies in San Francisco and Tomales Bays, April 1989 to March 1990. CDFG Mar. Res. Div., Admin. Rpt. 90(14):1-55.

Oliphant, M.S., P.A. Gregory, B.J. Ingle, and R. Madrid. 1990. California marine fish landings for 1977-1986. Calif. Dept. Fish Game, Fish Bull., 173:1-52

Outram, D.N. 1958. The magnitude of herring spawn losses due to bird predation on the west coast of Vancouver Island. Fish. Res. Bd. Can. Pac. Prog. Rep. 111:9-13.

Outram, D.N. and R.D. Humphreys. 1974. The Pacific herring in British Columbia waters. Fish. Mar. Serv., Pac. Biol. Stn. Circ., 100:1-26.

Pacific Fishery Management Council. 1990. Review of 1989 Ocean Salmon Fisheries. Portland, Or.

Parrish, R.H., C.S. Nelson, and A. Bakun. 1981. Transport mechanisms and reproductive success of fish in the California Current. Biol. Oceanogr. 1:175-203.

Pearson, T.H. 1968. The feeding biology of seabird species breeding on the Farne Islands, Northumberland. J. Anim. Ecol. 37, 521-552.

Perrins, C.M., J.D. Lebreton, and G.J.M. Hirons. 1991. Bird Population Studies: Relevance to Conservation and Management. Oxford Univ. Press, Oxford.

Phillips, R.E., D.I. Gutoff, J.E. Hansen, and J.E. Hardwick. 1986. Distribution of major marine macrophyte season estimates of *Gracilaria* standing crop, and spawning activities of the Pacific herring, *Clupea harengus pallasii*, in Elkhorn Slough, California; 1979-1982. Calif. Fish Game72(4):232-243.

Picquelle, S.J. and R.P. Hewitt. 1983. The northern anchovy spawning biomass for the 1982-83 California fishing season. Calif. Coop. Oceanic Fish. Invest. Rep. 24:16-28.

Pope, J.G. 1972. An investigation of the accuracy of virtual population analysis using cohort analysis. Int. Comm. Northwest Atl. Fish., Res. Bull. 9:65-74.

Pritchard, A.L. and A.L. Tester. 1944. Food of spring and coho salmon in British Columbia. Fish. Res. Bd. Can. Bull. 65:1-23.

Prokhorov, V.G. 1968. Winter period of life of herring in the Bering Sea. Proceedings of the Pacific Scientific Research Institute of Fisheries and Oceanography 64:329-338. In Russian. Transl. 1970, Fish. Res. Board Can., Transl. Ser. 1433).

Purcell, J.E., T.D. Siferd, and J.B. Marliave. 1987. Vulnerability of larval herring (*Clupea harengus pallasi*) to capture by the jellyfish *Aequorea victoria*. Mar. Biol.94(2):157-162.

Purcell, J.E. and J.J. Grover. 1990. Predation and food limitation as causes of mortality in larval herring at a spawning ground in British Columbia. Mar. Ecol. Prog. Ser. 59:55-61.

Rabin, D.J. and R.A. Barnhart. 1977. Fecundity of Pacific herring, *Clupea harengus pallasi*, in Humboldt Bay. Calif. Fish Game 63(3):193-196.

Rabin, D.J. and R.A. Barnhart. 1986. Population characteristics of Pacific herring, *Clupea harengus pallasi*, in Humboldt Bay, California. Calif. Fish Game 72(1):4-16.

Reilly, P.N. and T.O. Moore. 1983. Pacific herring, *Clupea harengus pallasi*, studies in San Francisco Bay, Monterey Bay, and the Gulf of the Farallones, July 1982 to March 1983. CDFG Mar. Res. Div., Admin. Rpt. 83-5:1-49.

Reilly, P.N. and T.O. Moore. 1984. Pacific herring, *Clupea harengus pallasi*, studies in San Francisco Bay, Monterey Bay, and the Gulf of the Farallones, May 1983 to March 1984. CDFG Mar. Res. Div., Admin. Rpt. 84-3:1-67.

Reilly, P.N. and T.O. Moore. 1986. Pacific herring, *Clupea harengus pallasi*, studies in San Francisco Bay, central and northern California, and Washington, March 1985 to May 1986.CDFG Mar. Res. Div., Admin. Rpt. 86-6:1-88.

Reilly, P.N. and T.O. Moore. 1987. Pacific herring, *Clupea harengus pallasi*, studies in San Francisco Bay, April 1986 to March 1987. CDFG Mar. Res. Div., Admin. Rpt. 87-15:1-73.

Reilly, P.N. 1988. Growth of young-of-the-year and juvenile Pacific herring from San Francisco Bay, California. Calif. Fish Game 74(1):38-48.

Reilly, P.N., K. Oda, and F. Wendell. 1989. Pacific herring, *Clupea harengus pallasi*, studies in San Francisco and Tomales Bays, April 1988 to March 1989. CDFG Mar. Res. Div., Admin.Rpt. 89-4:1-62.

Rexstad, E.A., and E.K. Pikitch. 1986. Stomach contents and food consumption estimates of Pacific hake, *Merluccius productus*. Fish. Bull. U. S. 84:947-956.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Bd. Can. Bull. 191:1-382.

Robins, C.R., R.M. Bailey, C.E. Bond, J.R. Brooker, E.A. Lachner, R.N. Lea, and W.B. Scott. 1991. Common and Scientific Names of Fishes from the United States and Canada. 5th edition. American Fisheries Society, Spec. Pub. 20. 183 pp.

Rosenthal, R.J., V. Moran-O'Connell, and M.C. Murphy. 1988. Feeding ecology of ten species of rockfish (Scorpaenidae) from the Gulf of Alaska. Calif. Fish Game 74(1):16-37.

Rounsefell, G.A. 1930. Contribution to the biology of the Pacific herring *Clupea pallasii*, and the condition of the fishery in Alaska. Bull. U.S. Bur. Fish. 45, 263-91.

Schweigert, J.F. and M. Stocker. 1988. Escapement model for estimating Pacific herring stock size from spawn survey data and its management implications. North Amer. Jour. Fish. Management 8(1):63-74.

Scofield, N.B. 1918. The herring and the development of the herring industry in California. Calif. Fish Game, 4(2):65-70.

Scofield, W.L. 1952. The Tomales Bay herring fishery. Calif. Fish Game 38(4):499-504.

Silliman, R.P. 1941. Fluctuations in the diet of the chinook and silver salmons (*Oncorhynchus tschawytscha* and *O. kisutch*) off Washington, as related to the troll catch of salmon. Copeia 2:80-87.

Sissenwine, M.P., E.B. Cohen, and M.D. Grosslein. 1984. Structure of the Georges Bank ecosystem. Rapp. P.V. Reun. Cons. Int. Explor. Mer 183:243-254.

Soutar, A. and J.D. Isaacs. 1974. Abundance of pelagic fish during the 19th and 20th centuries as recorded in anaerobic sediments of the Californias. U.S. Natl. Mar. Fish. Serv. Bull. 72:257-273.

Spratt, J.D. 1981. Status of the Pacirfic Herring, *Clupea harengus pallasii*, Resource in California 1972 to 1980. Calif. Dept. Fish and Game Fish Bull. 171:1-107.

Spratt, J.D. 1983. Biomass estimates of Pacific herring, *Clupea harengus pallasi*, in California from the 1982-83 spawning-ground surveys. CDFG Mar. Res. Div., Admin. Rpt. 83(3):1-23.

Spratt, J.D. 1987. Variation in the growth rate of Pacific herring from San Francisco Bay, California. Calif. Fish and Game 73(3):132-138.

Spratt, J.D. 1990. Biological Characteristics of the Gill Net Catch from the 1989-90 Pacific Herring, *Clupea pallasi*, RoeFishery in California. CDFG Mar. Res. Admin. Rpt. 90-12:1-16.

Spratt, J.D. 1991. Biomass estimates of Pacific herring (*Clupea pallasi*) in California from the 1990-91 spawning-ground surveys. Calif. Fish and Game, Mar. Res. Admin. Rept. 91(4):1-41.

Spratt, J.D. and T.O. Moore. 1992. Biological Characteristics of the gillnet catch from the 1991-92 Pacific herring, *Clupea pallasi*, roe fishery in California. CA Dept. Fish & Game Mar. Res. Admin. Rpt. 92(4):22pp.

Stacy, N.E. and A.S. Hourston. 1982. Spawning and feeding behavior of captive Pacific herring, *Clupea harengus pallasi*. Can. J. Fish. Aquat. Sci. 39(3):489-498.

State Water Resources Control Board. 1989. Pollutant Policy Document, San Francisco Bay/ Sacramento-San Joaquin Delta Estuary.

Stevenson, J.C. 1962. Distribution and survival of herring larvae (*Clupea pallasi* Valenciennes) in British Columbia waters. J. Fish. Res. Board. Can. 19:735-789.

Stocker, M., V. Haist, and D. Fournier. 1985. Environmental variation and recruitment of Pacific herring (*Clupea harengus pallasi)* in the Strait of Georgia. Can. J. Fish. Aquat. Sci . 42 (Suppl. 1):174-180.

Suryan, R.M. and K.L. Raum-Suryan. 1990. Analysis of scat to determine prey consumption of harbor seals (*Phoca vitulina richardsi*) inhabiting Elkhorn Slough, Moss Landing, California: a comparison of studies conducted in 1975-1977 and September-October 1990. Unpublished MS, Moss Landing Marine Laboratory, CA.

Tanasichuk, R.W. amd D.M. Ware. 1987. Influence of interannual variation on fecundity and egg size in Pacific herring(*Clupea harengus pallasi*). Can. J. Fish. Aquat. Sci. 44(8):1485-1495.

Taylor, F.H.C. 1964. Life history and present status of British Columbia herring stocks. Bull. Fish. Res. Bd. Can. 143:1-81.

_____________. 1971. Variation in hatching success in Pacific herring (*Clupea pallassii*) eggs with water depth, temperature, salinity, and egg mass thickness. Rapp. P.V.Reun. Cons. Int. Explor. Mer 160:34-41.

Trumble, R.J. and R.D. Humphreys. 1985. Management of Pacificherring (*Clupea harengus* *pallasi*) in the eastern Pacific ocean. Can. J. Fish. Aquat. Sci. 42 (Suppl. 1):230-244.

U.S. EPA. 1985. Compilation of air pollutant emission factors, Vol. II Mobile Sources. AP-42. Ann Arbor, MI.

U.S. EPA. 1989. Alameda, Contra Costa, Napa, San Francisco, SanMateo, Solano and Sonoma Counties emissions inventories. U.S. Environmental Protection Agency Region IX, National Emission Data System, San Francisco CA.

U.S. Navy. 1988. Environmental assessment. Breakwater gap modifications: Naval Air Station Alameda, California. U.S. Navy, Western Division, Naval Facilities Engineering Command,San Bruno, CA.

U.S. Navy. 1990. Final Environmental Impact Statement for proposed new dredging. U.S. Navy Military Construction Project: P-202 Naval Air Station Alameda, San Francisco CA.

Wales, W. 1984. Photic behavior and vertical migration in herring larvae. Mar. Behav. and Phys. 11(2):1-139.

Walters, C., M. Stocker, A.V. Tyler, and S.J. Westrheim. 1986. Interactions between Pacific cod (*Gadus macrocephalus*) and herring (*Clupea harengus pallasi*) in the Hecate Strait, British Columbia. Inter. North Pacific Fish. Comm. Bull. 47:87-100.

Ware, D.M. and G.A. McFarlane. 1986. Relative impact of Pacifichake, sablefish and Pacific cod on west coast of Vancouver Island herring stocks. Internat. North Pacific Fisheries Comm. Bull. 47:67-78.

Ware, D.M. and R. Tanasichuk. 1988. Herring distribution and recruitment. In: La Perouse Project: Third Annual Progress Report, 1987. Dept. Fisheries and Oceans, Nanaimo, B.C. 34-35.

Ware, D.M. and R. Tanasichuk. 1989. Biological basis of maturation and spawning waves in Pacific herring (*Clupea harengus pallasi*). Can. J. Fish. Aquat. Sci. 46:1776-1784.

White, A.W. 1980. Reoccurrence of kills of Atlantic herring (*Clupea harengus harengus*) caused by dinoglagellate toxins transferred through herbivorous zooplankton. Can. J. Fish.Aquat. Sci. 37:2262-2265.

Zimmerman, R.C., J.R. Reguzzoni, S. Wyllie-Echeverria, M. Josselyn, and R.S. Alberte. 1991. Assessment of environmental suitability for growth of *Zostera marina* L. (eelgrass) inSan Francisco Bay. Aquat. Bot. 39:353-366.

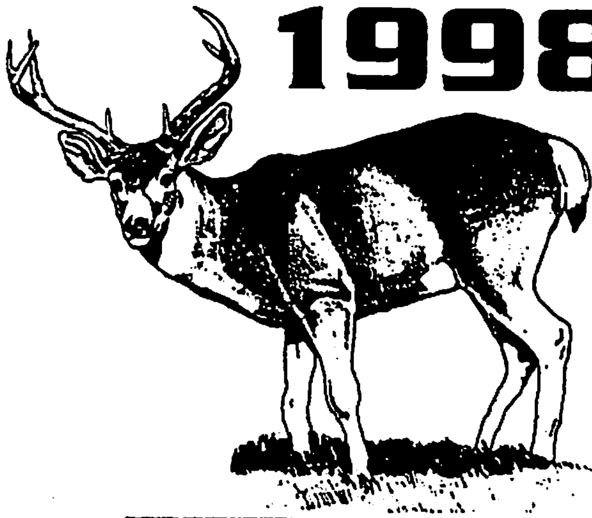
NOTE: These documents are generally available in university libraries. Documents prepared by governmental agencies can be obtained through those agencies.

LIST OF APPENDICES

APPENDIX 1

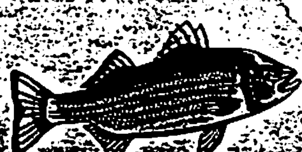
Fish and Game Code and Title 14, California Code of Regulation Sections Referenced in Environmental Document Regarding Commercial Harvest of Pacific Herring

FISH & GAME CODE 1998



UNABRIDGED CALIFORNIA EDITION

RESOURCES AGENCY
CALIFORNIA
DEPARTMENT
FISH & GAME



QWIK-CODE

LawTech Publishing Co., Ltd.

A-2.1

the people of the State of California, and any actions relating to the same violation may be joined or consolidated.

(e) In any civil action brought pursuant to this chapter in which a temporary restraining order, preliminary injunction, or permanent injunction is sought, it is not necessary to allege or prove at any stage of the proceeding any of the following:

(1) That irreparable damage will occur if the temporary restraining order, preliminary injunction, or permanent injunction is not issued.

(2) The remedy at law is inadequate. The court shall issue a temporary restraining order, preliminary injunction, or permanent injunction in a civil action brought pursuant to this chapter without the allegations and without the proof specified in this paragraph or paragraph (1).

(f) All civil penalties collected pursuant to this section shall not be considered fines or forfeitures as defined in Section 13003 and shall be apportioned in the following manner:

(1) Fifty percent shall be distributed to the county treasurer of the county in which the action is prosecuted. Amounts paid to the county treasurer shall be deposited in the county fish and wildlife propagation fund established pursuant to Section 13100.

(2) Fifty percent shall be distributed to the department for deposit in the Fish and Game Preservation Fund. These funds may be expended to cover the costs of any legal actions or for any other law enforcement purpose consistent with Section 9 of Article XVI of the California Constitution.

(Added by Statutes 1991 Chap. 844)

A-2.2

1603.3. Department to Provide Cover Letter to All Applicants; Contents

The department shall provide all applicants for an agreement pursuant to Section 1601 or 1603 with a cover letter which sets forth all of the following information:

(a) The time period for review of the application.

(b) An explanation of the applicant's right to object to conditions proposed by the department.

(c) The time period within which objections may be made in writing by the applicant to the department.

(d) The time period within which the department is required to respond to the applicant's objections, and that the response must be in writing.

(e) An explanation of the right of the applicant to appeal the department's imposition of conditions for the agreement, including the right to arbitration.

(f) The procedures for arbitration and the timelines set forth in statute for using the arbitration procedure, including, but not limited to, information about the payment requirements for the arbitrator's fees.

(g) The current fee schedule for obtaining the agreement, including, but not limited to, an explanation of how the fees are calculated.

1603.5. Napa River Watershed Project Agreements [Added Stats 1996]

The department may enter into an agreement with any person, state or local governmental agency, or any public utility, for projects in the Napa River watershed in accordance with a watershed management plan developed by the Napa Resource Conservation District. Notice to, and agreement with, the department is not required for a project subsequent to the initial agreement pursuant to this subdivision, unless the work as described in the agreement is substantially changed, or conditions affecting fish and wildlife resources substantially change, and those resources are adversely affected by the activity conducted under the agreement.

(Added Statutes 1996 Chap. 166)

1604. Arbitration - Petition For Judiciary Review

Any party affected by a decision made by an arbitration panel pursuant to Section 1601 or 1603 may petition a court of competent jurisdiction for confirmation, correction, or vacation of the decision in accordance with the provisions of Chapter 4 (commencing with Section 1285) of Title 9 of Part 3 of the Code of Civil Procedure.

1605. Modifications or Conditions - Include In Bid Notice

Any governmental agency, state or local, or public utility which intends to specify any location of possible construction material such as borrow pits or gravel beds, for the use in any construction project undertaken on its behalf which would be subject to this chapter, shall include in any notice inviting bids, any modifications or conditions established pursuant to Section 1601 of this code.

1606. Timber Harvesting Plans - Contents

Persons submitting timber harvesting plans under provisions of Section 4581 of the Public Resources Code may consider that notification to the department as required in Section 1603 has been given, provided, however, the following information is provided in the contents of such plan:

(a) The volume, type, and equipment to be used in removing or displacing any one or combination of soil, sand, gravel or boulders.

(b) The volume of water, intended use, and equipment to be used in any water diversion or impoundment, if applicable.

(c) The equipment to be used in road or bridge construction.

(d) The type and density of vegetation to be affected and an estimate of the area involved.

(e) A diagram or sketch of the location of the operation which clearly indicates the stream or other water and access from a named public road. Locked gates shall be indicated. The compass direction must be shown.

(f) A description of the period of time in which operations will be carried out.

1607. Fees; Establishment of Schedule, Amounts

(a) The director may establish a schedule of fees to be charged to any entity or person subject to this chapter. The fees charged shall be established in an amount necessary to pay the total costs incurred by the department in preparing and submitting proposals and conducting investigations pursuant to this chapter and administering and enforcing this chapter. Fees received pursuant to this section shall be deposited in the Fish and Game Preservation Fund as a reimbursement.

(b) Pursuant to subdivision (a), the department shall establish the fees in an amount not less than fifty dollars ($50) or more than two thousand four hundred dollars ($2,400), as adjusted pursuant to Section 713.

(Amended by Statutes 1990 Chap. 1706)

CHAPTER 7. CONSERVATION OF AQUATIC RESOURCES

1700. Policy - To Encourage Conservation, Etc. of Living Resources

It is hereby declared to be the policy of the state to encourage the conservation, maintenance, and utilization of the living resources of the ocean and other waters under the jurisdiction and influence of the state for the benefit of all the citizens of the state and to promote the development of local fisheries and distant-water fisheries based in California in harmony with international law respecting fishing and the conservation of the living resources of the oceans and other waters under the jurisdiction and influence of the state. This policy shall include all of the following objectives:

(a) The maintenance of sufficient populations of all species of aquatic organisms to insure their continued existence.

(b) The recognition of the importance of the aesthetic, educational, scientific, and nonextractive recreational uses of the living resources of the California Current.

(c) The maintenance of a sufficient resource to support a reasonable sport use, where a species is the object of sport fishing, taking into consideration the necessity of regulating individual sport fishery bag limits to the quantity that is sufficient to provide a satisfying sport.

(d) The growth of local commercial fisheries, consistent with aesthetic, educational, scientific, and recreational uses of such living resources, the utilization of unused resources, taking into consideration the necessity of regulating the catch within the limits of maximum sustainable yields, and the development of distant-water and overseas fishery enterprises.

(e) The management, on a basis of adequate scientific information promptly promulgated for public scrutiny, of the fisheries under the state's jurisdiction, and the participation in the management of other fisheries in which California fishermen are engaged, with the objective of maximizing the sustained harvest.

(f) The development of commercial aquaculture.

1701. Marine Fishery Resources - Research and Management Studies; Reports To Legislature

(a) The Legislature declares that California's marine sport and commercial fisheries, and the resources upon which they depend, are important to the people of the state and should be managed in accordance with the policies of Section 1700.

(b) The department shall conduct research and management studies of marine fishery resources.

(c) Consistent with the policies established in Section 1700, the department shall closely monitor changes in the status of any marine fishery resource.

(d) When the department determines, based on the best available scientific information, that a marine fishery resource cannot be maintained at levels necessary to meet the policies and objectives established in Section 1700, the department shall report that determination to the Legislature.

(e) Determinations made by the department pursuant to subdivision (d) shall be based on, but not limited to, an analysis of catch and effort data, the age and size composition of the catch, information about the relative contribution of individual year classes to the fishery, and estimates of maximum sustainable yield when that information is available or when other fishery dependent or fishery independent information, which can describe changes in the fishery resource, is available.

(f) Any report to the Legislature pursuant to subdivision (d) shall include, but not be limited to, recommendations on measures necessary to rehabilitate the resource to levels necessary to meet the policies and objectives established in Section 1700.

(g) The Legislature finds and declares that recent efforts to protect anadromous fish have altered their availability to ocean recreational and commercial fisheries. This alteration has increased the need to assess and prioritize existing research and management activities involving state-managed ocean fisheries. Therefore, the department shall assess all of the current recreational fisheries management and research programs for ocean finfish fisheries north of Point Arguello and California halibut fisheries south of Point Arguello and, on or before January 1, 1998, report to the Legislature its recommendations for prioritizing and undertaking marine fisheries management programs and preparing and implementing marine fisheries management plans. The assessment and report shall address the important state-managed nearshore marine fisheries resources, including, but not limited to, California halibut and rockfish, and shall include an estimate of the resources required by the department to prepare management plans for those fisheries. Any management plan prepared pursuant to this section shall, to the extent possible, identify the amount of funding necessary to implement the management plan.

Added by Statutes 1986 Chap. 586)

A-2.3

CHAPTER 7.2. TRUST MANAGEMENT

1725. Title of Act

This act shall be known as the Trout and Steelhead Conservation and Management Planning Act of 1979.

1726. Findings and Declarations

The Legislature hereby finds and declares that it is the policy of the state to:

(a) Establish and maintain wild trout stocks in suitable waters of the state which are readily accessible to the general public as well as in such waters in remote areas.

(b) Establish angling regulations designed to maintain the wild trout fishery in such waters by natural reproduction.

1726.4. Determining Angling Regulations

It is the intent of the Legislature that the department, in administering its existing wild trout program, shall conduct a biological and physical inventory of all California trout streams and lakes to determine the most suitable angling regulations for each stream or lake. A determination shall be made for each stream or lake regarding whether it should be managed as a wild trout fishery, or whether its management should involve the planting of trout. In making such inventory, priority shall be given to those streams and lakes where public use is heaviest, which have the highest biological potential for producing sizeable wild trout, which are inhabited by rare species, or where the quality of the fishery is threatened or endangered. Biological and physical inventories prepared for each stream, stream system, or lake shall include an assessment of the resource status, threats to the continued well-being of the fishery resource, the potential for fishery resource development, and recommendations, including necessary changes in the allowed take of trout, for the development of each stream or lake to its full capacity as a fishery.

This section does not furnish any public entity or private party with any new or additional authority to affect the management of, or access to, any private land without the written consent of the owner. Privately owned lakes and ponds not open to the use of the general public shall be subject to the provisions of this section only with the written consent of the owner. This chapter shall not be construed as authorizing or requiring special treatment of adjacent land areas or requiring land use restrictions. It is the intent of the Legislature that this chapter shall not diminish the existing authority of the department, nor shall it interfere with the department's existing fisheries management planning process.

1726.5. Funding of Wild Trout Program

The Legislature further finds and declares that activities and programs mandated by this chapter are a continuation and perpetuation of the department's existing wild trout program and other programs, and as such they shall be funded from existing budgetary resources.

1727. Wild Trout Program - Maintain; Develop Catch and Release Program

In order to provide for a diversity of available angling experiences throughout the state, it is the intent of the Legislature that the commission maintain the existing wild trout program, and as part of such program develop catch and release fisheries in the more than 20,000 miles of trout streams and approximately 5,000 lakes containing trout in California. As part of this program, beginning in 1980:

(a) The department shall establish an ongoing program to determine the viability of various forms of catch and release regulations for trout streams and lakes. A zero-limit catch and release fishery means that all trout must be released by the angler. A one-trout-limit catch and release fishery means that only one trout may be kept by the angler, and a two-trout-limit catch and release fishery means that only two trout may be kept by the angler. In conjunction

8077. Public Hearing and Finding Required

No permit shall be issued except after a public hearing and a finding by the commission that the granting thereof would promote the economic utilization of the fish resources of the State in the public interest. In making such finding the commission shall take into consideration the interest of the people of the State in the utilization and conservation of the fish supply and all economic and other factors relating thereto, including the efficient and economical operation of reduction plants.

8078. Hearing and Notice

A hearing pursuant to this article shall be held within 30 days after application for a permit, upon such notice as the commission shall prescribe. The commission may extend such a hearing from time to time for a total period of not more than 30 days.

8079. Limitations on Permits

The commission shall, whenever necessary to prevent over-expansion, to insure the efficient and economical operation of reduction plants, or to otherwise carry out the provisions of this article, limit the total number of permits which are granted.

8079.1. License for Disposal of Dead or Dying Fish

Notwithstanding any other provision of this code or regulation enacted pursuant thereto, the Director of the Department of Fish and Game, or a representative appointed by him, may, without notice or a hearing, grant a license to fish reduction plants to dispose of dead or dying fish. The license may be immediately issued by the director or his representative whenever such person determines, in his discretion, that an emergency situation exists. The estimated tonnage to be reduced shall be specified as a limit in the license.

8080. Court Powers not Restricted by this Article

Nothing in this article restricts the power of any court in any proceeding relating to any matter arising out of the provisions of this article.

Article 9. Limited Entry Fisheries

8100. Limited Entry Fishery

"Limited entry fishery" means a fishery in which the number of persons who may participate or the number of vessels that may be used in taking a specified species of fish is limited by statute.

(Amended Statutes 1996 Chap. 870)

8101. Eligibility to Participate

(a) Any licensed commercial fisherman shall be eligible for inclusion during the initial year of a limited entry fishery which is established by statute that becomes operative after January 1, 1982, regardless of the prescribed conditions for entry into the fishery, if the fisherman presents to the department satisfactory evidence that he or she has been licensed as a California commercial fisherman for at least 20 years and has participated in the fishery affected for at least one of those 20 years.

(b) Fishermen who have established eligibility to participate in a limited entry fishery under this section are subject to conditions of continuing eligibility established by statute or regulation if those fishermen desire to maintain their eligibility.

8102. Issuance of Permit to Partner

(a) The Legislature finds and declares that, in some limited entry fisheries, two or more partners may be operating with one of the partners holding the permit to participate in the fishery. The Legislature further finds and declares that undocumented, de facto, family partnerships are a longstanding custom in these fisheries. The Legislature further finds and declares that great hardship results when the permittee partner is no longer able to continue working and leaves the other partner without a permit to continue participating in the fishery.

A-2.4

(b) In any limited entry fishery in which permits are allocated to participants in the fishery, and where the death, incapacity, or retirement of a permittee from that fishery would deprive a working partner of the permittee of the ability to continue to derive a livelihood from that fishery, a permit shall be issued, upon application, to one remaining partner.

(c) A working partner for the purposes of this section shall be a spouse, child (including an adopted child), or sibling of the permittee, whose investment or equity need not be proven by documentation, or a person who can prove an investment or equity in the vessel or gear used in the fishery, and who would otherwise have been eligible for a permit and did not obtain one because he or she was working with or was a partner with the permittee.

(d) The working partner shall also provide substantial evidence of an actual physical working participation aboard the vessel supported by the submission of documents filed with the Franchise Tax Board and supported by trip settlement sheets or similar documents that demonstrate earnings from that participation. "Trip settlement sheet" means a document prepared after a vessel has completed a fishing trip which displays the costs incurred, revenues received, and profits paid out. Investment or equity alone does not establish that the person is a working partner.

(e) Those existing working partners other than the family relationships specified in subdivision (c) may, not later than February 1, 1984, declare and prove the working partnership in a manner satisfactory to the department and request that the department state the fact of the working partnership upon the permit. Thereafter, a nonfamily working partnership shall be declared, proved, and noted upon any limited entry permit at the first issuance of the permit.

(f) This article does not apply to permits to take herring for roe in California.

(Amended by Statutes 1988 Chap. 1505)

8103. Accidental Death - Transfer of Limited Entry Permit

(a) The Legislature finds and declares as follows:

(1) The accidental death of a limited entry permittee results in great hardships on the permittee's family.

(2) Under the law as it existed immediately prior to January 1, 1987, if a member of the permittee's family has not been actively working in the fishery, the limited entry permit could not be transferred to a member of the family, an action which deprives the family of the opportunity to continue to derive a livelihood from the fishery and which imposes greater hardships.

(3) When there is an accidental death of a limited entry permittee, a transition period is necessary to allow a family member to join the fishery and to become acclimated, knowledgeable, and experienced in the fishery.

(b) Notwithstanding Section 8102, the department shall transfer a permit for a limited entry fishery, upon application, to a parent, spouse, child, or sibling of a permittee whose death was the result of an accident which occurred after January 1, 1986.

(c) Application for the transfer of a permit pursuant to subdivision (b) shall be made on or before January 1, 1987, or not more than one year after the death of the permittee, whichever is later.

(d) The director may authorize another person, when requested by the new permittee, to serve in the place of the new permittee and to engage in fishing activities under the authority of the limited entry permit for not more than two years from the date of the permit transfer.

(e) "Accidental death" means death resulting directly and solely from any of the following:

(1) An accidental injury visible on the surface of the body or disclosed by an autopsy, sustained solely by external, violent, and accidental means.

(2) A disease or infection resulting directly from an accidental injury and beginning within 30 days after the date of the injury.

(3) An accidental drowning.
(Amended by Statutes 1988 Chap. 120)

8104. Death of a Limited Entry Permittee - Disposition of Permit

Upon the death of a limited entry permittee, the permit shall vest in the permittee's estate or in the surviving community estate and may be transferred by the executor, administrator, personal representative, or surviving spouse to a qualified pointholder pursuant to Section 8552.2 or to a partner qualified pursuant to Section 8552.6. This transfer shall be initiated by notice to the department, in writing, sent by certified mail, within one year of the date of death. If no transfer is initiated within one year of the date of death, the permit shall revert to the department for disposition pursuant to Section 8552.4 and shall be thereafter treated as a herring permit that has not been renewed. The department may, upon written application, grant an extension of time up to one additional year for the transfer to be initiated.
(Added by Statutes 1989 Chap. 207)

Article 10. Far Offshore Fishing

8110. Legislative Findings and Declarations

(a) The Legislature finds and declares that dramatic changes have very recently taken place in the methods and geographic areas of effort by California-based commercial fishermen.

(b) The Legislature further finds and declares that because the conditions which now exist could not be seen at the time of their inception, some existing regulations are now unreasonably restrictive. In some cases, existing statutes and regulations prohibit California fishermen from participating in or landing in California the primary product, or the incidental product, of their effort in the newly developed far offshore fisheries. This situation is detrimental to the interests of the fishermen, the fish processors, and the consumers of California.

A-2.5

8111. Far Offshore Fishery

"Far offshore fishery" means a fishery that lies outside the United States 200-mile exclusive economic zone, as defined by paragraph (6) of Section 1802 of Title 16 of the United States Code.
(Amended by Statutes 1995 Chap. 619)

8112. Fish Taken in Offshore Fishery May be Landed in State

Notwithstanding any other section of this code, fish taken in a far offshore fishery, which may be lawfully imported, may be landed in this state by persons operating a commercial fishing vessel registered pursuant to Article 4 (commencing with Section 7880) who took the fish in the far offshore fishery.
(Amended by Statutes 1995 Chap. 619)

8113. Declaration Filing to Fish in Far Offshore Fishery

(a) Prior to departure from any port in the United States for the purpose of taking fish in the far offshore fishery, the operator of any vessel landing fish in California that will be taken in the far offshore fishery shall file a declaration with the department on forms prescribed by the department.

(b) The declaration shall be valid when signed by the vessel operator and completed with information prescribed by the department.

(c) Upon completion of the trip and within 12 hours of arrival at a port in this state, the operator of the vessel shall complete and submit the return portion of the declaration to the department.
(Repealed and Added by Statutes 1995 Chap. 619)

8114. Fishing in Fishery Economic Zone - Unlawful

It is unlawful for the operator of any vessel operating under authority of this article to fish in, or land fish from, any waters within the United States 200-mile exclusive economic zone during any trip for which the operator filed a declaration with the department to fish in the far offshore fishery.
(Amended by Statutes 1995 Chap. 619)

Article 11. High Seas Interception of Salmon
(Added by Statutes 1990 Chap. 745)

8120. Environmental Purpose; High Seas Interception; Humanitarian Purpose; Process; Written Instrument

The definitions in this section govern the construction of this article:

(a) "Environmental purpose" means the intent to prevent or minimize adverse ecological effects to water quality.

(b) "High seas interception" means the unauthorized taking of salmon for commercial purposes outside the United States 200-mile fishery conservation zone. "Unauthorized" means contrary to a statute or regulation of the United States or this state or to a treaty or international fishery agreement, or in violation of a foreign law.

(c) "Humanitarian purpose" means the intent to provide medical services for a sick or injured person, or to prevent the loss of human life.

(d) "Process" means affecting the condition or location of salmon, including preparation, packaging, storage, refrigeration, or transportation.

(e) "Written instrument" means hand written or printed matter, including vessels' logs and papers, bills of lading and sale, documents relating to processing, shipping, and customs, and information stamped on or affixed to cans, crates, containers, freight, or other means of storage or packaging.
(Added by Statutes 1990 Chap. 745)

8121. Unlawful Acts

It is unlawful for any person to do any of the following:

(a) To buy, sell, trade, process, or possess salmon, or attempt to buy, sell, trade, process, or possess salmon, with the knowledge that the salmon has been, or will be, obtained by high seas interception.

(b) To knowingly provide financing, premises, equipment, supplies, services, power, or fuel used to buy, sell, trade, process, or possess salmon that has been, or will be, obtained by high seas interception.

(c) Act as a broker or middleman, or otherwise act on behalf of another person, to arrange for or negotiate, or attempt to arrange for or negotiate, the purchase, sale, trade, processing, or possession of salmon, with the knowledge that the salmon has been, or will be, obtained by high seas interception.
(Added by Statutes 1990 Chap. 745)

8122. False Written Information Relating to Salmon

It is unlawful for any person to create, circulate, or possess any written instrument related to salmon with the knowledge that the written instrument conveys misleading or untrue information about the ownership, possession, processing, origin, destination, route of shipping, type, or condition of salmon, or the time, place, and manner of the taking of the salmon.
(Added by Statutes 1990 Chap. 745)

8123. Interaction with Salmon Fishing Vessel; Prohibited Acts

(a) If any person knows that a vessel contains salmon obtained by high seas interception or that the owner or operator of the vessel intends to engage in the high seas interception of salmon, it is unlawful for that person to do any of the following:

8386. Barracuda and Yellowtail - How to Measure

Barracuda and yellowtail shall be measured from the tip of the lower jaw to the end of the longer lobe of the tail.

(Amended by Statutes 1992 Chap. 1370)

8387. Yellowtail; Size and Seasons

It is unlawful from May 1st to August 31st, inclusive, for any one person to have in his or her possession on any boat, barge, or other vessel, more than 500 pounds of yellowtail. From May 1st to August 31st, inclusive, not more than 2,500 pounds of yellowtail may be possessed on any boat, barge, or other vessel at any one time.

This section does not apply to yellowtail taken in waters lying south of the international boundary line between the United States and Mexico extended westerly into the Pacific Ocean.

(Amended by Statutes 1992 Chap. 1370)

8388. Angel Shark ; Size; Taking Requirements

(a) No female angel shark measuring less than 42 inches in total length or 15 ¼ inches in alternate length and no male angel shark measuring less than 40 inches in total length or 14 ½ inches in alternate length may be possessed, sold, or purchased, except that 10 percent of the angel sharks in any load may measure not more than ½ inch less than the minimum sizes specified herein.

(b) Angel shark total length shall be measured from the anterior end of the head to the tip of the tail while the fish is lying in a position of natural repose. When measuring total length or alternate length, the tip of the tail may be laid flat against the surface of the measuring device. Angel shark alternate length shall be measured from the point where the leading edge of the first dorsal fin meets the back to the tip of the tail. Angel sharks may be constrained from lateral movement during measurement by restraining devices approved by the department.

(c) Angel sharks taken in gill or trammel nets shall be landed (brought ashore) with at least one intact pelvic fin and the tail fin attached.

(d) Angel sharks taken in gill or trammel nets shall not be transferred to or from another vessel, except that angel sharks may be transferred to or from vessels with a department observer on board. An observer shall observe and make a written record of that transfer.

(Amended by Statutes 1991 Chap. 873)

8388.5. Leopard Sharks; Taking Requirements

(a) A person shall not take, possess, sell, or purchase for commercial purposes any leopard shark less than 36 inches in total length.

(b) Notwithstanding subdivision (a), leopard sharks less than 36 inches in total length possessed by a person for aquarium display on or before January 1, 1994, may be retained by that person if a letter declaring that the shark was legally obtained prior to January 1; 1994, is provided to the Sacramento office of the department on or before January 1, 1995.

(Added by Statutes 1993 Chap. 1100)

8389. Herring Eggs; Taking Restrictions

(a) Herring eggs may only be taken for commercial purposes under a revocable, nontransferable permit subject to such regulations as the commission shall prescribe. In addition to the license fees provided for in this code, every person taking herring eggs under this section shall pay a royalty, as the commission may prescribe, of not less than fifty dollars ($50) per ton of herring eggs taken.

(b) Whenever necessary to prevent overutilization, to ensure efficient and economic operation of the fishery, or to otherwise carry out this article, the commission may limit the number of permits which are issued and the amount of herring eggs taken under those permits.

A-2.6

(c) In limiting the number of permits, the commission shall take into consideration any restriction of the fishing area and the safety of others who, for purposes other than fishing, use the waters from which herring eggs are taken.

(d) Every person operating under a permit issued pursuant to this section is excepted from the provisions of Chapter 6 (commencing with Section 6650) of Part 1 of Division 6 for aquatic plants taken incidental to the harvest of herring eggs.

(Amended by Statutes 1988 Chap. 1009)

8391. Halibut; Taking

California halibut (Paralichthys californicus) may be taken at any time.

8392. Halibut; Size Requirements

(a) No California halibut may be taken, possessed, or sold that measures less than 22 inches in total length, unless it weighs four pounds or more in the round, three and one-half pounds or more dressed with the head on, or three pounds or more dressed with the head off. Total length means the shortest distance between the tip of the jaw or snout, whichever extends farthest while the mouth is closed, and the tip of the longest lobe of the tail, measured while the halibut is lying flat in natural repose, without resort to any force other than the swinging or fanning of the tail.

(b) Not more than four California halibut of less than 22 inches in total length or less than the minimum weights specified in subdivision (a) may be possessed aboard a vessel for noncommercial use at any time, if taken incidentally with a gill net, trammel net, or trawl net while commercial fishing.

(Amended by Statutes 1995 Chap. 619)

8393. Marlin; Buy, Sell, Possess; Exceptions

(a) Except where subdivision (b) has been complied with, marlin meat, whether fresh, smoked, canned, or preserved by any means, shall not be bought or sold, or possessed or transported for the purpose of sale.

(b) Notwithstanding the provisions of subdivision (a) of this section, black marlin (Makaira Indica) may be imported into this state for the purpose of processing (manufacturing) a product commonly known as fish cakes for human consumption. All such black marlin (Makaira Indica) imported into this state must be in an identifiable condition and accompanied by a bill of lading, showing the name of the consignor, the consignee, and the weight or number of fish shipped. A copy of the bill of lading must be delivered to the nearest office of the Department of Fish and Game either prior to or no later than two days after receipt of the fish. No such marlin (Makaira Indica) imported into California may leave the premises of the original consignee unless written permission is received from the Department of Fish and Game, or unless processed into the form of the product commonly known as fish cakes.

8394. Swordfish; Taking Requirements

Swordfish shall not be taken, possessed aboard a boat, or landed by a person for commercial purposes except under a valid swordfish permit. At least one person aboard the boat shall have a swordfish permit issued to that person that has not been revoked or suspended, subject to regulations adopted by the commission.

(Amended Statutes 1996 Chap. 870)

Article 12. Crayfish

8490. Lake Tahoe Crayfish; Sell or Purchase Unlawful

No crayfish taken from Lake Tahoe or the Lake Tahoe Basin may be sold or purchased.

8491. Taking Subject to Regulations of Commission

The taking of crayfish shall be subject to such regulations as the commission may prescribe.

8492. Overfishing in Sacramento-San Joaquin Delta - Prevention

The department shall take the steps it determines are necessary to prevent overfishing of crayfish in the Sacramento-San Joaquin Delta. Those steps may include, but are not limited to, submitting to the Legislature proposed legislation to place limitations on the commercial crayfishing in that area.

(Added by Statutes 1990 Chap. 528)

Article 13. Halibut Trawl Grounds

8495. Designated Area

The following area is designated as the California halibut trawl grounds:

The ocean waters lying between one and three nautical miles from the mainland shore lying south and east of a line running due west (270° true) from Point Arguello and north and west of a line running due south (180° true) from Point Mugu.

(Amended by Statutes 1992 Chap. 1370)

8496. Trawl Nets; Season, Taking Requirements

A-2.7

Within the California halibut trawl grounds the following requirements shall apply to the use of trawl nets:

(a) Open season shall be June 16 through March 14.

(b) California halibut shall only be taken pursuant to Section 8392.

(c) Not more than 500 pounds of fish other than California halibut may be possessed, except that any amount of sharks, skates, sea cucumbers, or rays may be taken or possessed.

(d) It is unlawful to operate a trawl net in a way that damages or destroys other types of fishing gear which is buoyed or otherwise visibly marked.

(e) Sections 8833 and 8836 do not apply to trawl nets when used or possessed on California halibut trawl grounds.

(Amended by Statutes 1988 Chap. 353)

8497. Closure of Grounds

If the director determines that the California halibut resource, or existing fishing operations, within the designated California halibut trawl grounds are in danger of irreparable injury, he or she may order the closure of the area, or portions thereof, to trawl net fishing or further restrict the nets that may be used in the area, or portions thereof. Any such closure or restriction order shall be adopted by emergency regulation in accordance with Chapter 3.5 (commencing with Section 11340) of Part 1 of Division 3 of Title 2 of the Government Code.

The department shall bring to the attention of the Legislature within 30 calendar days after commencement of the next succeeding regular session of the Legislature any regulation adopted pursuant to this section.

Article 14. Tidal Invertebrates

8500. Commercial Taking Restrictions

Except as otherwise expressly permitted in this chapter, no mollusks, crustaceans, or other invertebrates may be taken, possessed aboard a boat, or landed for commercial purposes by any person in any tide pool or tidal area, including tide flats or other areas between the high tidemark and 1,000 feet beyond the low tidemark, unless a valid tidal invertebrate permit has

been issued to that person that has not been suspended or revoked. The taking, possessing, or landing of mollusks, crustaceans, or other invertebrates pursuant to this section shall be subject to regulations adopted by the commission.

(Amended Statutes 1996 Chap. 870)

Article 15. Herring

8550. Permit Required to Take

Herring may be taken for commercial purposes only under a permit, subject to regulations adopted by the commission The commission may, whenever necessary to prevent overutilization, to ensure efficient and economic operation of the fishery, or to otherwise carry out this article, limit the total number of permits that are issued and the amount of herring that may be taken under the permits.

The commission, in limiting the total number of permits, shall take into consideration any restriction of the fishing area and the safety of others who, for purposes other than fishing, use the waters from which herring are taken.

(Amended Statutes 1996 Chap. 870)

8550.5. Net Permits for Commercial Fishermen

(a) A herring net permit granting the privilege to take herring with nets for commercial purposes shall be issued to licensed commercial fishermen, subject to regulations adopted under Section 8550, as follows:

(1) To any resident of this state to use gill nets, upon payment of a fee of two hundred sixty-five dollars ($265).

(2) To any nonresident to use gill nets, upon payment of a fee of one thousand dollars ($1,000).

(3) To any resident of this state to use round haul nets, upon the payment of a fee of four hundred dollars ($400).

(4) To any nonresident to use round haul nets, upon the payment of a fee of six hundred sixty dollars ($660).

(b) The commission shall not require a permit for a person to be a crewmember on a vessel taking herring pursuant to this article.

(Amended by Statutes 1992 Chap. 701)

8552. Herring Roe; Taking Restrictions

(a) It is unlawful to take herring for roe on a vessel unless the operator holds a herring permit issued by the department pursuant to commission regulations. The permit may be transferred pursuant to Sections 8552.2 and 8552.6.

(b) No person may be issued more than one herring permit, and the department shall not issue a herring permit to more than one person except as provided in Section 8552.6.

(c) Herring permits shall only be issued to and shall be held only by a natural person.

(d) Herring permits shall not be used as any form of security for any purpose, including, but not limited to, financial or performance obligations.

(e) The permittee shall be on board the vessel at all times during herring fishing operations, subject only to exceptions provided for in this code and regulations adopted under this code.

(Amended by Statutes 1988 Chap. 1505)

8552.2. Transfer of Permit

Notwithstanding Section 1052, a herring permit may be transferred from a herring permitholder to a non-permitholder having a minimum of 20 or more herring fishery points, as follows: The permitholder shall mail, by certified or registered mail, to the department and every individual listed on the department's list of maximum 20 or more point herring fishery participants, his or her notice of intention to transfer his or her herring permit, which notice shall specify the gear type to be used under the herring permit; the name, address, and telephone number of the transferor and proposed transferee; and the amount of consideration, if any, sought by the transferor. Sixty days after mailing the notice, the transferor may transfer the permit to any person having 20 or more experience points without the necessity for giving further notice if the transfer occurs within six months of the date the original notice was given. Transfers after that six-month period shall require another 60-day notice of intention to be given. No person may hold more than one herring permit. A true copy of the notice of intention to transfer a permit shall be filed with the department by the transferor under penalty of perjury and shall be available for public review.

(Amended by Statutes 1989 Chap. 207)

8552.4. Revoked Permit Drawing

Herring permits that are revoked or not renewed may be offered by the department for a drawing to persons having 20 or more experience points in the fishery on the first Friday of August of each year.

(Amended by Statutes 1989 Chap. 207)

8552.5. Revocation of Permit; Grounds

The commission shall revoke any herring permit if the holder of the herring permit was convicted of failing to report herring landings or underreported herring landings or failed to correctly file with the department the offer or the acceptance for a permit transferred pursuant to Section 8552.2.

(Added by Statutes 1988 Chap. 1505)

8552.6. Partnership Permit Requirements

A-2.8

(a) Notwithstanding Section 8552, a herring permit may be issued to two individuals if the individuals are married to each other and file with the department a certified copy of their certificate of marriage and a declaration under penalty of perjury, or a court order, stating that the permit is community property or if (1) both are engaged in the herring roe fishery either by fishing aboard the vessel or by personally participating in the management, administration, and operation of the partnership's herring fishing business and (2) there is a partnership constituting equal, 50 percent, ownership in a herring fishery operation, including a vessel or equipment, and that partnership is demonstrated by any two of the following:

(A) A copy of a federal partnership tax return.

(B) A written partnership agreement.

(C) Joint ownership of a fishing vessel used in the herring fishery as demonstrated on federal vessel license documents.

(b) For purposes of this section, a herring permit does not constitute a herring fishing operation. A herring permit may be transferred to one of the partners to be held thereafter in that partner's name only if that partner has not less than 10 points computed pursuant to paragraph 2 or subdivision (a) of Section 8552.8 and there has been a death or retirement of the other partner, a dissolution of partnership, or the partnership is dissolved by a dissolution of marriage or decree of legal separation. A transfer under this section shall be authorized only if proof that the partnership has existed for three or more consecutive years is furnished to the department or a certified copy of a certificate of marriage is on file with the department and the permit is community property as provided in subdivision (a). The transferor of a permit shall not by reason of the transfer become ineligible to participate further in the herring fishery or to purchase another permit.

(Amended by Statutes 1989 Chap. 207)

8552.7. Transferred Permit; Reissuance and Fee

The department shall reissue a herring permit which has been transferred pursuant to Section 8552.2 or 8552.6 upon payment of a transfer fee by the transferee of the permit. Before April 1, 1997, the transfer fee is two thousand five hundred dollars ($2,500), and, on and after April 1, 1997, the transfer fee is five thousand dollars ($5,000). The fees shall be deposited in

the Fish and Game Preservation Fund and shall be expended for research and management activities to maintain and enhance herring resources pursuant to subdivision (a) of Section 8052.

(Amended by Statutes 1994 Chap. 360)

8552.8. Experience Points - Herring Roe Fishery

(a) For purposes of this article, the experience points for a person engaged in the herring roe fishery shall be based on the number of years holding a commercial fishing license and the number of years having served as a crewmember in the herring roe fishery, and determined by the sum of both of the following:

(1) One point for each year in the previous 12 years (prior to the current license year) that the person has held a commercial fishing license issued pursuant to Section 7852, not to exceed a maximum of 10 points.

(2) Five points for one year of service as a paid crewmember in the herring roe fishery, as determined pursuant to Section 8559, using the type of year that is authorized under the herring permit to be obtained, three points for a second year of service as a paid crewmember, and two points for a third year as a paid crewmember, beginning with the 1978-79 herring fishing season, not to exceed a maximum of 10 points.

(b) The department shall maintain a list of all individuals possessing the maximum of 20 experience points and of all those persons holding two points or more, grouped in a list by number of points. The list shall be maintained annually and shall be available from the department to all pointholders and to all herring permittees. All pointholders are responsible to provide the department with their current address and to verify points credited to them by the department.

(c) A herring permittee may use the department's list and rely upon that list in making offers for transfer of his or her permit until the date of the annual distribution of the new list. On and after the date of the annual revision of the list, the permittee shall use the new list.

(d) The point provisions in this section are for purposes of sale of a permit or transfer to a partner of a coowned permit.

(Amended by Statutes 1989 Chap. 207)

8552.9. Transfer of Tomales Bay Permit

(a) Notwithstanding Section 8552.7, herring permits issued for use in Tomales Bay may be transferred to another person for continued use in Tomales Bay upon payment of a transfer fee of one thousand dollars ($1,000) to be paid by the transferee.

(b) This section shall remain in effect only until April 1, 1997, and as of that date is repealed unless a later enacted statute which is enacted before April 1, 1997, deletes or extends that date.

(Amended by Statutes 1994 Chap. 360)

8553. Regulations by Commission to Enforce Article

The commission may make and enforce such regulations as may be necessary or convenient for carrying out any power, authority, or jurisdiction conferred under this article.

8554. Temporary Substitution of Permittee; Adoption of Regulations

The commission, in adopting regulations for the commercial herring fishery, shall provide for the temporary substitution of a permittee to take herring, if the permittee is ill or injured, by a crewmember aboard the vessel operated by the permittee. The commission may require that proof of the illness or injury be substantiated to the satisfaction of the department.

(Added by Statutes 1986 Chap. 725)

8555. Periodic Meetings with Commercial Industry Representatives

The director shall periodically meet and confer with representatives of the commercial herring roe fishery to review regulations and policies of the commission and the department

concerning that fishery and to receive recommendations on the regulation and management of that fishery. In particular, those representatives and their legal counsel may recommend to the department, for recommendation to the commission for adoption by the commission as regulations, requirements for the payment of civil damages that may be imposed in lieu of revoking or suspending a permit issued pursuant to this article or for violations of regulations adopted by the commission pertaining to the herring roe fishery.
(Added by Statutes 1986 Chap. 725)

8556. Gill Nets and Mesh Size; Commission Shall Determine

Notwithstanding any other provision of law, the commission shall determine, by regulation, if drift or set gill nets may be used to take herring for commercial purposes. The commission may also determine, by regulation, the size of the meshes of the material used to make such gill nets.

8557. Round Haul Nets in Districts 12 and 13; Commission Shall Determine

Notwithstanding any other provision of law, the commission shall determine if round haul nets may be used to take herring in Districts 12 and 13 and the conditions under which those nets may be used.
(Amended by Statutes 1987 Chap. 269)

8558. Herring Research and Management Account; Expenditure of Funds; Accountability of Funds

A-29

(a) There is established a herring research and management account within the Fish and Game Preservation Fund. The funds in the account shall be expended for the purpose of supporting, in consultation with the herring industry pursuant to Section 8555, department evaluations of, and research on, herring populations in San Francisco Bay and those evaluations and research that may be required for Tomales Bay, Humboldt Bay, and Crescent City and assisting in enforcement of herring regulations. The evaluations and research shall be for the purpose of (1) determining the annual herring spawning biomass, (2) determining the condition of the herring resource, which may include its habitat, and (3) assisting the commission and the department in the adoption of regulations to ensure a sustainable herring roe fishery. An amount, not to exceed 15 percent of the total funds in the account, may be used for educational purposes regarding herring, herring habitat, and the herring roe fishery.

(b) The funds in the account shall consist of the funds deposited pursuant to Sections 8558.1, 8558.2, and 8558.3, and the funds derived from herring landing taxes allocated pursuant to subdivision (a) of Section 8052.

(c) The department shall maintain internal accountability necessary to ensure that all restrictions on the expenditure of the funds in the account are met.
(Added Statutes 1996 Chap. 584)

8558.1. Take Herring Commercially - Stamp Required; Fee; Use of Revenues

(a) No person shall purchase or renew any permit to take herring for commercial purposes in San Francisco Bay without first obtaining from the department an annual herring stamp. The fee for the stamp shall be one hundred dollars ($100). The revenue from the fee for the herring stamps shall be deposited into the herring research and management account established pursuant to Section 8558.

(b) This section shall become operative on April 1, 1997.
(Added Statutes 1996 Chap. 584)

8558.2. Difference Between Fees for Nonresidents and Residents - Deposit in Herring Research Account

The amount of the difference between fees for nonresidents and resident fees, collected pursuant to Section 8550.5, shall be deposited into the herring research and management account established pursuant to Section 8558, and all fees for San Francisco Bay herring permit

transfers, collected pursuant to Section 8552.7, shall also be deposited into the herring research and management account.
(Added Statutes 1996 Chap. 584)

8558.3. Royalties from Roe-on-kelp Fisher - Deposit in Herring Research Account

One-half of all royalties collected by the department from the roe-on-kelp fishery collected pursuant to paragraph (2) of subdivision (f) of Section 164 of Title 14 of the California Code of Regulations shall be deposited into the herring research and management account established pursuant to Section 8558.
(Added Statutes 1996 Chap. 584)

8559. Vessel Operation Permit Applicant - Provide Proof of Pay as Crewmember

The commission, in determining experience requirements for new entrants into the herring fishery after January 1, 1987, shall require that any person seeking a permit to operate a vessel to take herring and claiming crew experience shall demonstrate, to the satisfaction of the department, proof of payment as a crewmember in the herring fishery based on tax records or copies of canceled checks offered and accepted as payment for service on a crew in the California herring roe fishery.
(Added by Statutes 1986 Chap. 725)

Article 16. Drift Gill Net Shark and Swordfish Fishery

8561. Permit Required to Take with Drift Gill Nets

(a) Notwithstanding Section 8394 shark and swordfish shall not be taken for commercial purposes with drift gill nets except under a valid drift gill net shark and swordfish permit issued to that person that has not been suspended or revoked and is issued to at least one person aboard the boat.

(b) A drift gill net shark and swordfish permit shall not be required for the taking of sharks with drift gill nets with a mesh size smaller than eight inches in stretched mesh and twine size no. 18 or the equivalent of this twine size or smaller.
(Amended Statutes 1996 Chap. 870)

8561.5. Transferring Permits; Requirements

(a) Notwithstanding Section 8102, a permit issued pursuant to Section 8561 may be transferred by the permittee only if one of the following conditions is met:

(1) The permittee has held the permit for three or more years.

(2) The permittee is permanently injured or suffers a serious illness that will result in a hardship, as determined in a written finding by the director, to the permittee or his or her family if the permit may not otherwise be transferred or upon dissolution of a marriage where the permit is held to be community property.

(3) The permittee has died and his or her surviving spouse, heirs, or estate seeks to transfer the permit within six months of the death of the permittee or, with the written approval of the director, within the length of time that it may reasonably take to effect the transfer.

(b) A permit may be transferred only to a person who holds a commercial fishing license issued pursuant to Section 7850 and a general gill net permit issued pursuant to Section 8681.

(c) The transfer of a permit shall only become effective upon notice from the department. An application for transfer shall be submitted to the department with such reasonable proof as the department may require to establish the qualification of the person the permit is to be transferred to, the payment to the department of a transfer fee of one thousand five hundred dollars ($1,500), and a written disclosure, filed under penalty of perjury, of the terms of the transfer.

(d) Any restrictions on participation that were required in a permit transferred pursuant to Section 8102 before January 1, 1990, are of no further force or effect.
(Amended by Statutes 1992 Chap. 701)

STATE OF CALIFORNIA
FISH AND GAME COMMISSION

CALIFORNIA CODE OF REGULATIONS
SEPTEMBER 1, 1997

TITLE 14. NATURAL RESOURCES

DIVISION 1. FISH AND GAME COMMISSION – DEPARTMENT OF FISH AND GAME

PETE WILSON, Governor

FISH AND GAME COMMISSION

DOUGLAS B. MCGEOGHEGAN
PRESIDENT
Maxwell

RICHARD T. THIERIOT
VICE PRESIDENT
San Francisco

FRANK D. BOREN
Inverness

MICHAEL CHRISMAN
Visalia

ROBERT R. TREANOR, Executive Director

A-2.10

hours of the transaction.

Imported sardines sold at retail must be delivered to the consumer in packages or containers showing the name of the dealer, the weight of the contents of each package or container, the country of origin, and a statement that the sardines were legally imported for sale as bait.

NOTE

Authority cited: Section 8150.5, Fish and Game Code.

HISTORY

1. New section filed 3-12-74; effective thirtieth day thereafter (Register 74, No. 11).

2. Amendment of NOTE filed 10-19-81; effective thirtieth day thereafter (Register 81, No. 43).

3. Page reprinted to correct paging error (Register 81, No. 47).

4. Editorial correction filed 12-29-82 (Register 83, No. 1).

158. Sardines.

(a) Pursuant to Section 190 of these regulations, a permittee taking sardines for bait under the provisions of Fish and Game Code Section 8152 shall complete and submit a record of daily fishing activity on a form [Live Bait Log, DFG 158 (10/89), see Appendix A] provided by the Department.

(b) The fee for a Sardine Permit issued pursuant to Section 8150.7 of the Fish and Game Code and for a Sardine Live-Bait Permit issued pursuant to Section 8152 of the Fish and Game Code shall be the same as the permit fee authorized by Section 699, Title 14, CCR.

NOTE

Authority cited: Sections 1050, 8026 and 8152, Fish and Game Code. Reference: Sections 1050, 8026, 8150.7 and 8152, Fish and Game Code.

HISTORY

1. New section filed 12-8-89; operative 1-1-90 (Register 89, No. 50).

2. New subsection (b) and subsection renumbering filed 5-11-92; operative 6-10-92 (Register 92, No. 1-8).

163. Harvest of Herring.

Herring may be taken for commercial purposes only in those areas and by those methods specified in subsections (f)(1) and (f)(2) of this section under a revocable permit issued to an individual on a specified fishing vessel by the department. Transfer of permits from one boat to another may be authorized by the department upon written request by the permittee, accompanied by a copy of the current commercial boat registration of the new vessel. The fee for any approved transfer or substitution of a permit pursuant to paragraph one shall be $50 after the issuance date of November 15. The $50 transfer fee must be received in the department's Menlo Park office no later than five working days after written approval of any boat transfer or permittee substitution. Any permittee denied a transfer pursuant to paragraph one of this section may request a hearing before the commission to show cause why his request should not be denied. Permittees shall have their permit in their possession and shall be aboard the vessel named on their permit at all times during herring fishing operations, except that the department may authorize a permittee to have a crewmember temporarily serve in his or her place aboard the vessel during a season. Requests for temporary permittee substitution must be submitted in writing by the permittee, accompanied by a copy of the temporary substitute's current California commercial fishing license. No permittee may simultaneously fish his or her own permit and a permit temporarily transferred to him or her. Two permits may be jointly fished on a single vessel upon written request by both permittees to the department.

(a) Qualifications of Permittee. To obtain a permit to take herring a person shall:

(1) Be a currently licensed California commercial fisherman and be the owner or operator of a current California registered commercial fishing vessel. When a permit is held in partnership (pursuant to the provisions of Section 8552.6 of the Fish and Game Code), both partners must be currently licensed California commercial fishermen, and at least one partner must be the operator of a current California registered commercial fishing vessel.

(2) Have been a permittee during the previous herring season and have validated said permit each year as specified in subsection (b)(4) of these *regulations*.

(3) Qualify for an odd- or even-numbered permit as specified in subsection (c)(1)(B).

(4) Qualify for a "DH" gill net permit as specified in subsection (c)(1)(C).

(5) Have submitted lists of crewmembers assisting in fishing operations as specified in subsections (e)(2) of these regulations, release of property forms and payment for all herring landed in excess of an established individual permit quota as specified in subsection (e)(5) of these regulations, and all fees from prior seasons.

(6) Any person denied a permit under these regulations may request a hearing before the commission to show cause why his permit should not be denied. Applicants disqualified under subsections (c)(1)(B) or (c)(1)(C) will be granted a hearing if the number of points claimed would have placed them in the point category from which new permits will be issued.

(b) Permit Applications. Each applicant for a herring permit shall:

(1) Completely fill out and submit the required department application form (available at department's Menlo Park or Eureka office). No person shall submit more than one application per season. Applications shall include the filing fee, as specified in section 8550.5 of the Fish and Game Code, and copies of the current California certificate of boat registration and commercial fishing license of the applicant.

(2) Permittees will be issued permits for the same area and gear type they held during the previous season except that in San Francisco Bay round haul permittees

may transfer gear type to gill net, to be designated as CH-(600-642)-SF permits. For every conversion of gear type to gill net by a round haul permittee, the amount of herring allocated to each round haul permittee, pursuant to subsection (g)(4)(A), will be transferred from the round haul quota to the gill net quota. For each round haul permit converted prior to October 6, 1995, fishing with gill net gear is authorized in two of the following fishing periods: odd-numbered permits, even-numbered permits, or December herring ("DH") permits. The permitholder of a converted round haul ("CH") permit will permanently designate the two fishing groups ("DH", odd-, or even-numbered permit). For every conversion of gear type to gill net by a round haul permittee after October 6, 1995 but before October 2, 1998, the department will assign the two fishing groups ("DH", odd-, or even-numbered permit). All remaining round haul permits as of October 3, 1998 will be converted to gill net permits and assigned to a single gill net group.

Upon transfer, the department will assign each converted "CH" permit to a single gill net group ("DH", odd numbered, or even-numbered permit) as designated by the permitholder. A round haul herring permit, held in partnership prior to November 3, 1994 and subsequently converted to a "CH" permit prior to October 2, 1998, is not subject to assignment to a single gill net group upon transfer to one of the partners.

(3) Submit the required application form for Humboldt, Tomales or San Francisco bays, or Crescent City in time for it to be received at the Department of Fish and Game office, 411 Burgess Drive, Menlo Park, California 94025, prior to 5:00 p.m. on the first Friday of October. Any application received or postmarked after the above deadline will not be eligible for consideration for the current California herring season.

(4) Validation of Applications. Permittees shall validate their permit each year. To validate a permit, a person shall:

(A) Have been actively engaged in California's herring fishery during the current herring season by landing herring; or

(B) If no landings are made, demonstrate an intent to fish during the next successive herring season by providing written notice submitted through certified mail to the Department of Fish and Game, 411 Burgess Drive, Menlo Park, California 94025, by March 31. Failure to land fish during two successive seasons may result in loss of eligibility to participate in the fishery.

Subsections (a)(2) and (b) do not apply to permits issued for taking herring in ocean waters or to fresh fish market permits.

(c) Permits.

(1) No new round haul permits shall be issued for San Francisco Bay. No new gill net permits shall be issued for the Tomales Bay permit area until the maximum number of permits is less than 35. No new odd- or even-numbered gill net permits shall be issued for San Francisco Bay until the maximum number of permits is less than 232. No new "DH" permits shall be issued until the maximum number of permits is less than 116. The permittee shall be responsible for all crew members acting under his or her direction or control to assure compliance with all Fish and Game regulations as provided in this section, or in the Fish and Game Code, relating to herring.

(A) The total number of gill net permits issued to individuals not qualifying under subsection (a)(2) shall be the difference in number of permittees meeting such qualifications and the total number of gill net permits authorized by the commission in subsection (c)(1).

(B) Individuals not qualifying under subsection (a)(2) will be eligible to apply for any available odd- or even-numbered gill net permits provided they are a currently licensed California commercial fisherman, and the operator of a current California registered commercial fishing vessel.

(C) Individuals not qualifying and receiving permits under subsections (a)(2) or (c)(1)(B) will be eligible to apply for any available "DH" gill net permits provided they are a currently licensed California commercial fisherman and the operator of a current California registered commercial fishing vessel.

(D) In the event that the number of eligible applicants qualifying under subsections (c)(1)(B) or (c)(1)(C) exceeds the available permits, a lottery shall be held. Preferential status in the lottery will be given under the following conditions:

1. One point (maximum of ten) for each year an applicant has held a valid California commercial fishing license in the previous twelve years (prior to the current license year). A point shall be granted only if the applicant's name appears on the department's master file of commercial licensees or if the applicant presents a valid commercial fishing license or verifiable receipt for the year claimed.

2. Five points for one year of service as a paid crewmember in the herring fishery, three points for a second year of service as a paid crewmember, and two points for a third year as a paid crewmember, beginning with the 1978-79 herring fishing season, not to exceed a maximum of 10 points.

3. Preference points awarded for participation in the herring fishery shall only be granted if the applicant's name has been filed with the department pursuant to subsection (e)(2) of these regulations, and is supported by documentation demonstrating proof of payment for service on a crew in the California herring roe fishery as specified in section 8559 of the Fish and Game Code.

4. Permits will be issued predicated on the total number of points accrued by an applicant, beginning with those applicants who accrue the maximum number of points and working in descending order from this maximum. A drawing will be held to allocate the remaining permits when the permits available are exceeded by the number of applicants in a particular point category.

(E) Preferential status points will not be given for participation on vessels with permits specified in subsections (c)(2) and (c)(3) of this section.

(2) Fresh Fish Market. Ten permits will be issued to take herring for the fresh fish market in San Francisco Bay and five in Tomales Bay. See subsection 699(b) of these regulations for the fee for this permit. However, no permittee may take or possess herring except in the amount specified on a current daily market order, not to exceed 500 pounds, from a licensed fish dealer. Fresh fish market permits will be issued beginning November 1 at 411 Burgess Drive, Menlo Park, California 94025. In the event there are more applicants than the specified number of available fresh fish permits, a lottery will be held to determine the permittees. Applicants may apply for only one bay. Fresh fish market permits shall be in force from November 2 through November 29 and April 1 through October 31.

(3) Ocean Waters. Permits to take herring in ocean waters will be issued by the department at its offices in Monterey, Menlo Park and Eureka. See subsection 699(b) of these regulations for the fee for this permit.

Herring taken under the authority of subsections (c)(2) and (c)(3) may not be sold for roe purposes.

(d) Vessel Identification. The master of any boat engaged in taking herring under these regulations shall at all times while operating such boat, identify it by displaying on an exposed part of the superstructure, amidship, on each side and on top of the house visible from the air, the herring permit number of that vessel in 14-inch high, 2-inch wide black Roman alphabet letters and Arabic numerals painted on a white background permanently fixed to each side of the vessel.

(e) Monitoring of Herring.

(1) Herring taken for roe purposes may only be delivered to a person licensed pursuant to subsection (j) of these regulations.

(2) Within four weeks of the date an individual quota is reached, or within four weeks of the end of the season, the permittee shall submit to the Department of Fish and Game, 411 Burgess Drive, Menlo Park, California 94025 a list of crewmembers assisting in fishing operations during the current herring season. The list shall include the full name and California commercial fishing license number of each crewmember. Gill net permittees shall notify the department's Menlo Park office within 24 hours if they terminate fishing operations for the season prior to the overall quota being taken. Round haul permittees shall notify the department's Menlo Park office within 24 hours if they terminate fishing operations for the season prior to their individual quota being taken.

(3) The department will estimate from the current trend of individual boat catches the time at which the herring season catch will reach any quota permitted under these regulations and will publicly announce that time on VHF/Channel 16. It shall be the responsibility of all permittees to monitor this radio channel at all times. Any announcement made by the department on VHF/Channel 16 shall constitute official notice. All fishing gear must be removed from the water by the announced time terminating fishing operations. The department may announce a temporary closure for the gill net fishery in order to get an accurate tally of landings and to allow all boats to unload. If the fishery is reopened, permittees may be limited to the possession and use of one shackle of net (65 fathoms). As an alternative, permittees may be placed on allotted tonnages to preclude exceeding a quota and, if necessary, additional time may be granted to reach the quotas.

(4) It is unlawful to transfer herring or herring nets from one permittee to another or from one boat to another, or from one gear type to another except that, nonmotorized lighters may be used, provided they do not carry aboard any gear capable of taking herring, including net reels, and that the catches of not more than one permittee are aboard the lighters at any time. Permit vessels shall not serve as lighters for other permit boats. In San Francisco Bay a permittee and his gear must stay together when delivering fish to market. Except as specified in subsection (e)(6) of these regulations, all fish taken by gill nets shall be retained and landed. Gill net permit vessels may not be used to assist in herring fishing operations during their off-week.

(5) All herring landed in excess of any established permit quota shall be forfeited to the department by the signing of an official release of property form. Such fish shall be sold or disposed of in a manner determined by the department. The proceeds from all such sales shall be paid into the Fish and Game Preservation Fund.

(6) Sturgeon, halibut, salmon, steelhead and striped bass may not be taken by or possessed on any vessel operating under the authority of these regulations. All round haul vessels shall have a rigid grate acceptable to the department covering the hold hatch at all times while loading fish in their hold. Such grate shall have rigid bars with a gap between bars of not more than 3 inches. All sturgeon, halibut, salmon, steelhead and striped bass shall be returned immediately to the water.

(7) During the period beginning at 5:00 p.m. on January 4 and ending at noon on February 13, no herring may be taken by round haul nets except designated test boats subject to the following provisions:

(A) Number of test boats and area of operation.

1. The total number of test boats shall be four (4) during any test boat fishing period (TBFP).

2. The test boats may operate in any area of San Francisco Bay in which round haul permittees may legally fish. Herring may not be unloaded between the hours of 10:00 p.m. and 6:00 a.m., or at any time on Saturdays and Sundays, unless the permittee has notified and received prior approval from the department to conduct such activities during those hours.

(B) Starting time of each TBFP.

1. After each spawning episode, the department shall announce the date, day and time at which the next

TBFP shall start.

2. This information shall be broadcast by the department, or its designee, on VHF Channel 16 every hour on the hour for a minimum of four (4) hours prior to that time.

3. Only designated test boats are allowed to fish during TBFP. If none of the designated test boats choose to fish, the department may designate one or more alternate test boats.

4. The department shall determine, based on the presence or absence of spawning activities, if the opening of each week's fishing period, shall be a TBFP or open fishing period. The department or its designee shall announce its determination on VHF Channel 16 every hour on the hour beginning a minimum of four (4) hours prior to the opening of each week's fishing period.

5. A test boat may retain on board the catch from only one (1) set during a TBFP until such time as the department or its designee has announced the opening of the fishery to all round haul permittees.

(C) End of TBFP and opening of fishing. Fishing shall be open to all round haul permittees when all of the following conditions are met:

1. At least two (2) test boats have each taken and retained a load of herring with a roe content of 9 percent or more;

2. each roe content of 9 percent or more has been verified by a herring buyer licensed pursuant to subsection (j) of these regulations, or such buyer's representative;

3. the buyer, or buyer's representative, has notified the department's designated representative that a test boat has retained a load of herring with a roe content of 9 percent or more, and has identified himself or herself to the department's designated representative by name of speaker, buying company, and test boat; and

4. the department or its designee has announced the opening of the fishery on VHF Channel 16.

(D) Possession of herring during open fishing period.

1. During any open fishing period, all fish taken or encircled by a round haul net shall be retained and landed, regardless of roe quality.

(E) End of open fishing period and start of TBFP.

1. During an open fishing period, the department shall continuously monitor landing receipts to determine the daily average roe content for all round haul permittees landing fish. If the daily average roe content is less than 9 percent, the department shall announce the end of the open fishing period and the start of a TBFP.

2. This information shall be broadcast by the department or its designee on VHF Channel 16 every half hour beginning a minimum of two (2) hours prior to the start of the TBFP.

(F) Selection of test boats and notification by the department.

1. The department shall determine, by random drawing, the order in which all permitted round haul vessels shall be designated as test boats or alternate test boats. Boats shall be designated in the order in which they are drawn.

2. The random drawing shall be conducted prior to the season and all round haul permittees shall be notified of the selection order at the time permits are mailed.

(f) Methods of Take.

(1) For purposes of this section regarding harvest of herring: San Francisco Bay is defined as the waters of Fish and Game districts 12 and 13 and that portion of district 11 lying south of a direct line extending westerly from Peninsula Point, the most southerly extremity of Belvedere Island, to the easternmost point of the Sausalito ferry dock; Tomales Bay is defined as the waters of district 10 lying south of a line drawn west, 252 degrees magnetic, from the western tip of Tom's Point to the opposite shore; ocean waters are limited to the waters of districts 6 (excluding the Crescent City area), 7, 10 (excluding Tomales Bay), 16 and 17 (except as specified in subsection (h)(6) of these regulations); Humboldt Bay is defined as the waters of districts 8 and 9; Crescent City area is defined as Crescent City Harbor and that area of the waters of district 6 less than 20 fathoms in depth between two nautical measure lines drawn due east and west true from Point Saint George (41 degrees, 39 minutes, 30 seconds) and Sister Rocks (41 degrees, 46 minutes, 59 seconds).

(2) The use of round haul nets to take herring for roe purposes is prohibited in districts 6, 8, 9, 10 (including Tomales Bay) and in district 11, in waters greater than 20 fathoms in depth, west of the Golden Gate Bridge. Round haul permittees may fish in district 13 in waters greater than 6 fathoms in depth and in that portion of district 12 west of a line extending between the westerly tip of Yerba Buena Island and the most westerly portion of Castro Rocks, and north of the Oakland Bay Bridge in waters greater than 6 fathoms in depth except that round haul permittees may fish in waters less than 6 fathoms in depth between Southampton Shoal Channel and the main shipping lanes. Round haul permittees may fish in all of district 12 and district 13 only after gill net quotas have been reached, or upon prior notification by the department in the event that gill net fishing is temporarily suspended. Round haul permittees shall not fish or possess more than a total of 240 fathoms of net. Set and drift nets may be used only to take herring pursuant to these regulations.

(A) No permittee shall possess or fish more than a total of 65 fathoms (1 shackle) of gill net in San Francisco and Tomales bays. Said gill nets shall not exceed 120 meshes in depth. In Humboldt Bay and Crescent City Harbor, no permittee shall possess or fish in combination more than 150 fathoms of gill net. Fresh fish permittees shall not possess or fish more than 65 fathoms (1 shackle).

Set gill nets shall be anchored by not less than 35 pounds of weight at each end, including chain; however, at least one-half of the weight must be anchor. Gill nets shall be tended at all times in San Francisco Bay. Tended means the registered gill net permittee shall be in the immediate proximity, not exceeding one nautical mile, of any gill net being fished.

(B) In Tomales Bay the length of the meshes of any gill net used or possessed in the roe fishery shall not be less than 2 1/8 inches or greater than 2 ½ inches. In Humboldt Bay and Crescent City Harbor the length of the meshes of any gill net used or possessed in the roe fishery shall not be less than 2 1/4 inches or greater than 2 ½ inches. In San Francisco Bay the length of the meshes of any gill net used or possessed in the roe fishery shall not be less than 2 1/8 or greater than 2 ½ inches, except that three permittees (designated by the department in writing) participating in department-sponsored research on mesh size may use gill nets provided by the department with mesh less than 2 1/8 inches. The meshes of any gill net used or possessed by fresh fish permittees shall not be greater than 2 inches.

Length of the mesh shall be the average length of any series of 10 consecutive meshes measured from the inside of the first knot and including the last knot when wet after use; the 10 meshes, when being measured, shall be an integral part of the net as hung and measured perpendicular to the selvages; measurements shall be made by means of a metal tape measure while 10 meshes are suspended vertically from a single peg or nail, under one-pound weight. In Humboldt Bay and Crescent City Harbor, the length of any series of 10 consecutive meshes as determined by the above specifications shall not be less than 22 ½ inches or greater than 25 inches. In Tomales and San Francisco bays, the length of any series of 10 consecutive meshes as determined by the above specifications shall not be less than 21 1/4 inches or greater than 25 inches. For the 1996-97 season only, in Tomales and San Francisco bays, a 3 percent tolerance will be allowed in the mesh measurement; thus, the length of any series of 10 consecutive meshes as determined by the above specifications shall not be less than 20 5/8 inches or greater than 25 3/4 inches.

(C) No net shall be set or operated to a point of land above lower low water or within 300 feet of the following piers and recreation areas: Berkeley Pier, Paradise Pier, San Francisco Municipal Pier between the foot of Hyde Street and Van Ness Avenue, Pier 7 (San Francisco), Candlestick Point State Recreation Area, the jetties in Horseshoe Bay, and the fishing pier at Fort Baker. No net shall be set or operated within 70 feet of the Mission Rock Pier. In the Crescent City area and Humboldt Bay gill nets may be set or operated within 300 feet of any pier.

(D) No nets shall be set or operated in Belvedere Cove north of a line drawn from the tip of Peninsula Point to the tip of Elephant Rock. Also, no gill nets shall be set or operated from November 30 through February 13 inside the perimeter of the area bounded as follows: beginning at the middle anchorage of the western section of the Oakland Bay Bridge (Tower C at 37 degrees, 47 minutes, 54 seconds N, 122 degrees, 22 minutes, 43 seconds W) and then in a direct line southeasterly to the Lash Terminal buoy #5 (G"5" buoy, flashing green at 37 degrees, 44 minutes, 24 seconds N, 122 degrees, 21 minutes, 36 seconds W), and then in a direct line southeasterly to the easternmost point at Hunter's Point (Point Avisadero at 37 degrees, 43 minutes, 44 seconds N, 122 degrees, 21 minutes, 26 seconds W) and then in a direct line northeasterly to the Anchorage #9 buoy "A" (Y"A" buoy, yellow in color, flashing yellow at 37 degrees, 44 minutes, 48 seconds N, 122 degrees, 19 minutes, 24 seconds W) and then in a direct line northwesterly to the Alameda N.A.S. entrance buoy #1 (G"1" buoy, green in color, flashing green at the entrance to Alameda Carrier Channel, 37 degrees, 46 minutes, 36 seconds N, 122 degrees, 20 minutes, 24 seconds W) and then in a direct line northwesterly to the Oakland Harbor Bar Channel buoy #1 (G"1" buoy, green in color, flashing green at 37 degrees, 48 minutes, 12 seconds N, 122 degrees, 21 minutes, 24 seconds W) and then in a direct line southwesterly to the point of beginning, Tower C of the Oakland Bay Bridge.

(E) No boats or nets shall be operated or set in violation of existing state regulations applying to the navigation or operation of fishing vessels in any area, including but not limited to San Francisco Bay, Tomales Bay, Humboldt Bay and Crescent City Harbor.

(F) Gill nets shall be marked at both ends with a buoy displaying above its waterline, in Roman alphabet letters and Arabic numerals at least 2 inches high, the official number of the vessel from which such net is being fished. Buoys shall be lighted at both ends using matching white or amber lights that may be seen for at least a distance of 100 yards and marked at both ends with matching flags (same color) acceptable to the department, on a staff at least 3 feet above the water, at each end bearing the herring permit number in contrasting 4-inch black letters.

(g) Quotas.

(1) Crescent City Area: The total take of herring in the Crescent City area for commercial purposes by use of gill net only shall not exceed 30 tons per season.

(2) Humboldt Bay: The total take of herring in Humboldt Bay for commercial purposes by use of gill net only shall not exceed 60 tons per season.

(3) Tomales Bay: The total take of herring for commercial purposes by use of gill net only shall be as follows:

(A) In Tomales Bay waters a fishing quota, not to exceed 220 tons, shall be permitted for the season. However, if spawning escapement, as determined by the department, reaches or exceeds 2,200 tons prior to February 15, the quota shall be increased as follows:

1. If spawning escapement is more than 2,200 tons, the total take of herring shall not exceed 320 tons for the season.

2. If spawning escapement is more than 3,200 tons, the total take of herring shall not exceed 420 tons for the season.

3. If spawning escapement is more than 4,200 tons, the total take of herring shall not exceed 520 tons for the season.

(B) The total take of herring for the fresh fish market shall not exceed 10 tons per season.

(4) San Francisco Bay: The total take of herring in San Francisco Bay for commercial purposes shall not exceed 10,748 tons for the season. Tonnage shall be allocated on the following basis:

(A) Round haul permittees: 2,975 tons. No round haul permittee shall take more than 85 tons of herring per season.

(B) Gill net permittees (including "CH" permittees): 7,753 tons; 2,684 tons of the gill net vessel quota shall be allocated to permittees described in subsection (h)(3)(A), and 2,745 tons to permittees described in subsection (h)(3)(B) and 2,324 tons to permittees described in subsection (h)(3)(C) of these regulations. No gill net permittee (designated by the department in writing) participating in research sponsored by the department shall take more than 20 tons of herring per season.

(C) The total take of herring for the fresh fish market shall not exceed 20 tons per season.

(5) Ocean Waters: Herring may not be taken for roe purposes.

(h) Season.

(1) Humboldt Bay: The season shall be from noon on January 2 until noon on March 10.

(2) Crescent City: The season shall be from noon on January 15 until noon on March 24.

(3) San Francisco Bay: The season shall be from 5:00 p.m. on November 30 until noon on December 19, and from 5:00 p.m. on January 4 until noon on March 13.

(A) In San Francisco Bay, gill net permittees with even permit numbers and "CH" permittees assigned to "even" fishing group shall be permitted to fish only on the following dates: January 4-9, January 18-23, February 1-6, February 15-20, March 1-6.

(B) In San Francisco Bay, gill net permittees with odd permit numbers and "CH" permittees assigned to "odd" fishing group shall be permitted to fish only on the following dates: January 5-10, January 19-24, February 2-7, February 16-21, March 2-7.

(C) In San Francisco Bay, gill net permittees with "DH" permit numbers and "CH" permittees assigned to "DH" fishing group shall be permitted to fish only on the following dates: November 30-December 5, December 7-12, December 14-19. In the event permittees described under subsections (h)(3)(A) and (h)(3)(B) both reach their quotas pursuant to subsection (g)(4)(B), "DH" permittees, on notification by the department, may resume fishing operations until such group has reached the successive established termination date or quota.

(D) In San Francisco Bay, round haul permittees shall be permitted to fish from 5:00 p.m. on January 4 until noon on March 13.

(E) No more than three gill net permittees (designated in writing by the department) participating in research sponsored by the department shall be permitted to fish, under the direction of the department, from 5:00 p.m. on November 30 until noon on December 19 and from 5:00 p.m. on January 4 until noon on March 13.

(4) In Tomales Bay, the season shall be from 5:00 p.m. on December 28 until noon on March 13.

(5) Herring fishing in Tomales Bay and San Francisco Bay is not permitted from noon Friday through 5:00 p.m. Sunday night.

(6) Ocean Waters: The season shall be from April 1 to October 31 for all authorized fishing gear except in districts 16 and 17 where the season shall be from April 1 to November 30.

(7) In the event permittees described under subsections (h)(3)(A) or (h)(3)(B) reach their quota pursuant to subsection (g)(4)(B), the alternate group of permittees on notification by the department may commence fishing operations until such group has reached the successive established termination date or quota.

(i) Any permit issued pursuant to this section may be cancelled or suspended at any time by the commission for cause after notice and opportunity to be heard, or without a hearing upon conviction of a violation of this section by a court of competent jurisdiction. A permittee whose permit has been suspended or revoked for conviction of a violation of this section may request a hearing before the commission to show cause why his herring fishing privileges should be restored. A person whose herring permit has been revoked by the commission may not participate in the fishery during the following season. If a herring permit that had a temporary substitute is suspended or revoked by the commission due to the actions of the temporary substitute, the person who acted as the temporary substitute may not participate in any herring fishery during the following season.

(j) Herring Buyer's Permit. A holder of a current primary fish receiver's license shall obtain a permit to buy herring for roe purposes for each fishing area specified in subsection (f)(1) of these regulations and approved by the department. After approval of an application and payment of the $750 filing fee (filing fees in Humboldt Bay and Crescent City area shall be waived), a revocable, nontransferable permit to buy herring for roe purposes may be issued subject to the following regulations:

(1) The permittee shall permanently mark all vehicles, containers or pallets with individualized serial numbers and predetermined tare weights.

The serial number and predetermined tare weight shall be permanently marked in letters, and numerals at least 3 inches high on each side of vehicle container or pallet.

(2) A landing receipt must be made out immediately upon completion of weighing of any single boat load (hereinafter "load") of herring of a permittee. No herring will be taken for testing purposes that have not been weighed and recorded.

(A) The landing receipt for each vessel must be completed and signed by both the herring permittee and a certified weighmaster or his deputy prior to commencing unloading operations of another vessel.

(B) The weighmaster or deputy filling out the landing receipt must include all information required by Fish and Game Code Section 8043 and shall sign the landing receipt with his complete signature.

(C) All landing receipts that have not been delivered to the department must be immediately available to the department at the weigh station.

(D) A reasonable amount of herring will be made available by the herring buyer to the department, at no cost, for management purposes.

(3) Prior to weighing herring, each permittee shall have each weighing device currently certified and sealed by the County Division of Weights and Measures.

(4) Weight tally sheets shall be used when any load of fish is divided and placed into more than one container prior to the completion of the landing receipt. Weight tally sheets shall include the time unloading operations begin.

(A) The tally sheets shall be composed of four columns:

1. The serial or I.D. number of all containers in which the load is initially placed and all subsequent containers, if any, in which the load is placed until, and including for, shipment from the buyer's premises.

2. The gross weight;

3. The tare weight of the bin or containers; and

4. The net weight of fish. Net weight will include the weight of the herring taken for testing purposes.

(B) The work or weight tally sheets shall be retained by the permittee for one year, and must be available at all times for inspection by the department.

(C) When requested by the department, the buyer shall submit to the department a California Highway Patrol weighing certificate for any truck load designated by the department. Such certificate shall be placed in the U.S. Postal system to the department's Menlo Park office within twenty-four (24) hours of the truck's departure from buyer's premises.

(5) In San Francisco Bay, herring may not be unloaded between the hours of 10 p.m. and 6 a.m., or at any time on Saturdays and Sundays, unless the permittee has notified and received prior approval from the department to conduct such activities during those hours.

(6) Every permittee shall comply with all applicable sections of the Fish and Game Code.

(7) The permittee is responsible to ensure that all provisions of the herring buyer's permit are complied with, even though the tasks may be delegated to others.

(8) The permit may be revoked upon violation of any provisions contained herein by the holder of the permit, his agents, servants, employees, or those acting under his direction of control and shall not be renewed for a period of one year from the date or revocation.

NOTE

Authority cited: Sections 1050, 5510, 8550 and 8553, Fish and Game Code. Reference: Sections 8043, 8550, 8553, 8554, 8556, 8557 and 8559, Fish and Game Code.

HISTORY

1. Amendment of subsections (a), (e)-(h) and (j) filed 9-15-88; operative 10-15-88 (Register 88, No. 39). For prior history, see Register 87, No. 47.

2. Amendment of subsection (h) filed 12-21-88 as an emergency; operative 12-21-88 (Register 89, No. 1). A Certificate of Compliance must be transmitted to OAL within 120 days or emergency language will be repealed on 4-20-89.

3. Amendment filed 11-27-89 as an emergency; operative 11-27-89 (Register 90, No. 2). A Certificate of Compliance must be transmitted to OAL within 120 days or emergency language will be repealed on 3-27-90.

4. Certificate of Compliance as to 11-27-89 order transmitted to OAL 3-26-90 and filed 4-24-90 (Register 90, No. 19).

5. Amendment of subsection (c) filed 4-18-91; operative 5-18-91 (Register 91, No. 21).

6. Amendment of subsections (a), (b), (c), (e), (f), (g), (h) and (j) filed 12-13-91; operative 12-13-91 pursuant to Government Code section 11346.2(d) (Register 92, No. 1-8).

7. Amendment of subsections (b), (c), (e), (f), (g), and (h) filed 11-10-92; operative 11-10-92.

8. Amendment of first paragraph and subsections (a), (b), (e), (f), (g) and (h) filed 10-28-93; operative 11-28-93.

9. Amendment of first paragraph and subsections (b), (c), (e), (f), (g) and (h) filed 11-3-94; operative 11-3-94.

10. Amendment filed 11-7-95; operative 11-7-95.

11. Amendment filed 11-12-96; operative 11-12-96.

12. Amendment filed 10-8-97; operative 10-8-97.

163.5. Penalties in Lieu of Suspension or Revocation-Herring Permittees.

(a) Pursuant to the provisions of Section 309 of the Fish and Game Code and sections 163 and 746 of these regulations, any permit issued pursuant to Section 8550 of the Fish and Game Code may be canceled or suspended at any time by the commission for cause, after notice and an opportunity to be heard, or without a hearing upon conviction of the permittee or his/her substitute (pursuant to Section 163, Title 14, CCR) of a violation of the commercial herring regulations by a court of competent jurisdiction. A permittee whose permit has been suspended or revoked for conviction of a violation of the commercial herring regulations may request a hearing before the commission to show cause why his or her herring fishing or buying privileges should be restored.

(b) Notwithstanding subsection (a), the Executive Director of the Commission shall enter into a stipulated compromise settlement agreement with the consent of the permittee for category I violations, and may enter into a compromise for category II violations with the consent of the permittee. The provisions of this section regarding compromise settlement agreements shall not apply if action is brought to recover civil damages under Section 2014 of the Fish and Game Code from the person subject to action under this section.

(c) Terms and Conditions of a stipulated compromise agreement may include, but are not limited to, the payment of monetary penalties, the reduction of a revocation to a suspension for a specified period of time, a period of probation not to exceed three years or any other terms and conditions, mutually agreed upon by the Executive Director acting for the Commission and the permittee, without further hearing or appeal.

(d) A compromise settlement agreement may be entered before, during or after the Commission hearing on the matter, but is valid only if executed and signed by the Executive Director and the permittee prior to the adoption of the decision by the Commission. Any monetary penalty included in a compromise settlement agreement shall be within the range of monetary penalties as prescribed in subsection (f) of these regulations and shall be due and payable within 30 days after the compromise is entered into. Any and all funds submitted as payment in whole or in part by a permittee of any monetary penalties stipulated in a compromise settlement agreement shall be nonrefundable.

(e) If the permittee fails to perform all of the terms and conditions of the compromise settlement agreement, such agreement is thereby declared void and the Commission, notwithstanding the compromise settlement agreement, may take any action authorized by section 163 of these regulations against the permittee.

(f) Procedures for determining monetary penalties:

(1) Monetary penalties (score range multiplied by the monetary range) for compromise settlement agreements shall be based on the following point system:

SCORE RANGE (Total Points)	MONETARY RANGE
1-10	$200 per point as provided in subsection (f)(2) below.
11+	$400 per point as provided in subsection (f)(2) below.

(2) The score range shall be based on a cumulative total of the points assigned in this subsection:

(A) POINTS ASSIGNED FOR CATEGORY I VIOLATIONS ARE AS FOLLOWS:

1. Failure to properly identify vessel (Sec. 163(d))	1 point
2. Improperly marked buoys or flags (Sec. 163(f)(2)(F))	1 point
3. Failure to validate permit (Sec. 163(b)(4))	1 point
4. Failure to submit application for renewal of permit prior to the established deadline (Sec. 163(b)(3))	1 point plus 1/4 point for each state working day, or portion thereof, the application is late, not to exceed the cost of a nonresident herring permit as specified in section 8550.5, Fish and Game Code
5. Failure of permittee to have herring permit, commercial fishing license, or boat registration aboard the permit vessel (Sec. 163, para. 1)	2 points
6. Setting or operating nets within 300 feet of specified piers and jetties, (Sec. 163(f)(2)(C), and (f)(2)(E))	3 points
7. Failure to "tend" nets (Sec. 163(f)(2)(A))	5 points
8. Failure of herring buyer to permanently mark all vehicles, containers or pallets (Sec. 163(j)(1))	5 points

(B) POINTS ASSIGNED FOR CATEGORY II VIOLATIONS ARE AS FOLLOWS:

1. Failure to have a rigid grate covering hold hatch while loading fish (Sec. 163(e)(6))	6 points
2. Unloading fish without recovering both nets and having them aboard vessel (Sec. 163(e)(4))	6 points

3. Fishing in a closed area (Sec. 163(f)(1) and 163(f)(2)(D))	12 points, plus all fish and nets on the vessel at the time of the violation shall be forfeited to the department and such fish and nets shall be sold or disposed of in a manner determined by the department with the proceeds from all such sales paid into the Fish and Game Preservation Fund
4. Failure to remove fishing gear from water by announced time terminating fishery operations (Sec. 163(e)(3))	6 points, plus ½ point for each hour, or portion thereof, after closing time
5. Possession or use of nets with undersized mesh (Sec. 163 (f)(2)(B))	12 points, plus all fish and nets on the vessel at the time of the violation shall be forfeited to the department and such fish and nets shall be sold or disposed of in a manner determined by the department with the proceeds from all such sales paid into the Fish and Game Preservation Fund
6. Failure to immediately return all halibut, sturgeon, salmon and striped bass to the water (Sec. 163 (e)(6))	10 points
7. Possession or use of extra nets or nets which exceed maximum length restrictions (Sec. (f)(2)(A))	12 points, plus ½ point for every 5 fathoms of net, or portion thereof, exceeding maximum, plus all fish and nets on the vessel at the time of the violation shall be forfeited to the department and such fish and nets shall be sold or disposed of in a manner determined by the department with the proceeds from all such sales paid into the Fish and Game Preservation Fund
8. Failure of permittee to be aboard the vessel during herring fishing operations (Sec. 163, para 1)	10 points
9. Failure to complete and maintain weight tally sheets (Sec. 163(j)(4))	10 points
10. Failure to immediately complete a Fish and Game receipt upon completion of weighing any load or lot of fish (Sec. 163(j)(2))	15 points

(C) For each prior conviction of the permittee within the past three years for violations of the laws or regulations pertaining to the commercial take of herring:

1. The following additional points shall be assessed:

a. For one prior conviction for a violation of the commercial herring fishing laws or regulations within the past three years, the monetary assessment shall be doubled if the total point score (points from prior violation added to points for current violation) is 10 or less, and tripled if such total point score is 11 points or more.

b. For two prior convictions for violations of the commercial herring fishing laws or regulations within the past three years, the monetary assessment shall be quadrupled if the total point score (points from prior convictions added to points for current violation) is 17 or less.

2. The permit shall be revoked, or suspended for a period of at least 1 year, if the total point score is 18 points or more.

(3) Conviction of multiple violations, committed at the same time, shall be treated as one conviction for the purposes of implementing the provisions of this section.

(4) All monetary penalties for compromise agreements assessed under this section shall be deposited by the Department to the Fish and Game Preservation Fund.

NOTE

Authority cited: Sections 8553 and 8555, Fish and Game Code. Reference: Sections 309, 8552, 8553 and 8555, Fish and Game Code.

HISTORY

1. New section filed 1-3-89; operative 2-2-89 (Register 89, No. 1). For history of former section, see Register 76, No. 35.

2. Amendment of subsections (a) and (f) filed 1-15-92; operative 2-14-92 (Register 92, No. 1-8).
3. Amendment filed 11-12-96; operative 11-12-96.

164. Harvesting of Herring Eggs.

(a) Herring eggs may be taken for commercial purposes only under a revocable, nontransferable permit issued by the department.

(b) Herring eggs may be harvested only from the waters of San Francisco Bay. The harvest season is December 1 to March 31.

(c) For purposes of this section, San Francisco Bay is defined as the waters of Fish and Game districts 12, 13 and that part of district 2 known as Richardson Bay.

(d) No more than 11 permits may be issued under the provisions of these regulations. No new permits shall be issued until the maximum number of permits is less than 10. The commission will review and determine annually whether further action, other than permit attrition, is deemed necessary to achieve a reduction to 10 permits.

(e) Permits. Permits shall be issued in two categories:

(1) Prior permittee. Permits shall be issued to all prior permittees. A prior permittee is defined as any applicant who held a herring eggs on kelp permit and actively fished during the immediately preceding herring eggs on kelp season.

(2) New permittee. A new permittee is defined as any applicant who held a herring permit issued pursuant to Section 163 of these regulations during the preceding herring season, but does not qualify as a prior permittee as defined above. The total number of permits available to new permittees shall be the difference between the 10 permit limit and the number of permits issued to individuals qualifying as prior permittees. In the event that the number of eligible applicants qualifying for new permits exceeds the number of available permits, a lottery shall be held.

(f) Permit conditions: Every person operating under a permit to harvest herring eggs shall:

(1) Forfeit his or her herring fishing privileges authorized pursuant to section 163 of these regulations during the same season.

(2) In addition to any license fees required by the Fish and Game Code, pay a royalty of $500 per ton of herring eggs on kelp taken. (The royalty fee shall include the landing tax imposed pursuant to article 7.5, (commencing with section 8040) chapter 1, part 3, division 6, of the Fish and Game Code.), and the royalty fee required for the harvesting of kelp pursuant to Section 165(c)(5), Title 14, CCR).

(g) Permit applications. Each applicant for a herring eggs on kelp permit shall:

(1) Completely fill out and submit the required department application form (FG 164(5/95) Application for Herring-eggs-on-kelp Permit which is incorporated by reference herein (available at the department's Menlo Park office). No person shall submit more than one application per season. Applications shall include a performance deposit as specified in subsection (h), and shall be delivered to the department's Menlo Park office at 411 Burgess Drive, Menlo Park, CA 94025, or postmarked no later than 5 p.m. on August 1 of each year.

(2) Applications postmarked or presented after August 1 and before September 1 will result in a monetary penalty of $200 plus $50 for each state working day, or portion thereof, that the application is late, for a period of 30 days. Applications postmarked or presented after August 31 will not be eligible for renewal.

(h) Each application shall include a performance deposit equal to 50% of the royalty price for the permit (i.e., allotment). The deposit shall be credited to the amount payable by the successful applicants and shall not be refundable. The performance deposit shall be returned to an applicant who does not qualify for a permit.

(i) Method of Take. Herring eggs may only be taken by harvesting giant kelp (Macrocystis sp.), with spawn (i.e., eggs) attached, which has been artificially suspended using the following two methods: rafts and/or lines, a technique commonly known as the "open pond" method. For the purpose of this Section, a raft is defined as a temporary, mobile structure with a metal, wood or plastic frame. The total surface area of each raft is not to exceed 2,500 square feet. Rafts used by a licensed herring eggs on kelp permittee, prior to the 1995-96 season, are exempt from these size specifications. Such rafts may not be modified to exceed 2,500 square feet total surface area. Any new raft built after the 1995-96 herring eggs on kelp season must meet the specified dimensions. A line is defined as a continuous piece of line of any length that is suspended under a suitable permanent structure (e.g., pier or dock). Kelp lines suspended from a permanent structure (e.g., pier or dock) shall not be placed as to hinder navigation. If kelp lines are suspended under a permanent structure (e.g., pier or dock), or if a raft is tied up to a permanent structure (e.g., pier, dock or rock wall, natural stationary shoreline structures), permittee shall obtain prior written approval from the appropriate owners or controlling agency (e.g., wharfinger, Coast Guard, Navy or private owner).

(1) Not more than two rafts and/or two lines may be used per permit. Each raft shall have a light at each corner that may be seen for at least a distance of 100 yards. Each raft shall be further identified with the herring eggs on kelp permit number in 14-inch high, 2-inch wide black Roman alphabet letters and Arabic numerals painted on a white background permanently affixed to the raft. Lines shall be marked at the beginning and the end with a light that may be seen for at least a distance of 100 yards. Each line shall be further identified with the herring eggs on kelp permit number in 14-inch high, 2-inch wide black Roman

alphabet letters and Arabic numerals painted on a white background, permanently affixed to the line.

(2) Not more than ten sets of test kelp may be used per permit. Test kelp is defined as one stipe with blades, attached to a length of line for the purpose of testing for spawning activity. A set is defined as one length of line with test kelp attached. Each set must be attached to a permanent structure (e.g., pier, dock) and marked with the herring eggs on kelp permit number, in Roman alphabet letters and Arabic numerals at least 3 inches high, at a point above the waterline. No herring eggs on kelp shall be retained from test kelp sets for testing purposes that have not been weighed and recorded, pursuant to subsections (j)(3), (j)(4) and (j)(5) of this Section.

(3) Rafts and/or lines may not be placed in any waters or areas otherwise closed or restricted to the use of herring gill nets operating pursuant to Section 163 of these regulations, except where written approval is granted by the owners or controlling agency (e.g., Navy, Coast Guard). Rafts and/or lines may be placed in Belvedere Cove or Richardson Bay, only if permittees tie their rafts and/or lines to a permanent structure (e.g., pier, dock or rock wall, natural stationary shoreline structures), and obtain prior written approval.

(4) The total amount of herring eggs on kelp that may be harvested by each permittee shall be based on the previous season's spawning population assessment of herring in San Francisco Bay, as determined by the department. This assessment is used to establish the overall herring fishing quotas pursuant to Section 163 of these regulations.

The total amount of herring eggs on kelp that may be harvested by an individual possessing a round haul permit issued pursuant to Section 163 of these regulations shall be 19 tons per season. The total amount of herring eggs on kelp that may be harvested by an individual possessing a gill net permit issued pursuant to Section 163 of these regulations shall be 4.4 tons per season. The total amount of herring eggs on kelp that may be harvested by an individual possessing a "CH" permit issued pursuant to Section 163 of these regulations shall be 19 tons per season.

(5) Each vessel operating under or assisting in fishing operations under a permit issued pursuant to these regulations, shall be currently registered pursuant to Fish and Game Code Section 7787 (vessel registration), and be further identified with the permittee's herring eggs on kelp permit number in 14-inch high, 2-inch wide black Roman alphabet letters and Arabic numerals painted on a white background permanently affixed to each side of the vessel. If a herring eggs on kelp vessel is also used as an assist vessel in another permittee's fishing operation, it must be identified with the number of the permit it is assisting.

(j) Harvesting, Landing and Processing Requirements. Every person who harvests, receives, processes or wholesales herring eggs shall comply with the following requirements.

(1) Obtain all appropriate commercial fish business licenses and permits required by Fish and Game Code sections 8030-8038.

(2) Permittee shall notify the department biologist at the Menlo Park office designated on the herring eggs on kelp permit a maximum of 4 hours prior to suspending kelp on a raft and/or lines and supply the following information:

(A) Where the kelp suspension will take place; and

(B) Where rafts and/or lines will be fished.

(3) Permittee shall notify the department biologist at the Menlo Park office designated on the herring eggs on kelp permit a minimum of 12 hours prior to harvesting herring eggs on kelp on a weekday and supply the following information:

(A) Description and point of departure of the vessel used;

(B) The exact location of each raft and/or line and estimated time of beginning of each operation; and

(C) If harvesting occurs, the point of landing and time of landing or off-loading of the herring eggs on kelp harvested.

(4) Herring eggs on kelp may be harvested any time on weekdays, but shall not be off-loaded between the hours of 10:00 p.m. and 6:00 a.m.

(5) Herring eggs on kelp may be harvested on Saturdays and Sundays at any time if the permittee reimburses the department for the cost of operations. The department shall submit a detailed invoice of its cost of operations within 30 days of providing the services. Permittee shall remit payment to the department within 30 days of the postmark date of the department's invoice. Permittee shall notify the department's Region 3 Dispatch Center at (707) 944-5512, during normal business hours (between 8:00 a.m. and 5:00 p.m., Monday through Friday) prior to harvesting herring eggs on kelp on Saturday or Sunday, and shall supply the following information:

(A) Description and point of departure of the vessel used.

(B) The exact location of each raft and estimated time of the beginning of the harvesting operation, the estimated time of off-loading of the harvested product, and the point of off-loading.

(C) A local telephone number of the permittee for the immediate confirmation or clarification of the information required in the subsection 164(j)(5).

(6) Permittee shall have a certified scale aboard the vessel at all times if any processing operations are conducted aboard that vessel. This scale shall be used to determine the total weight of herring eggs on kelp prior to processing. For the purposes of this section, all portions of the kelp blade, including all trimmed-off portions (trim), shall be considered part of the harvested product and included in the total weight of herring eggs on kelp. The stipe and pneumatocyst shall not be considered a part of the harvested product; therefore, the weight of the stipe and pneumatocyst shall not be

considered in determining the total weight of herring eggs on kelp.

(7) All bins or totes shall be permanently marked with individualized serial numbers, beginning with the prefix CA, and predetermined tare weights (including lids). The serial number and predetermined tare wight shall be permanently marked in letters and numerals at least 3 inches high on each side of the bin or tote.

(8) Prior to weighing herring eggs on kelp, each receiver of herring eggs on kelp shall have a scale currently certified and sealed by the County Division of Weights and Measures.

(9) Weight tally sheets and a landing receipt shall be immediately completed upon the landing and weighing of any single permittee's boat load of harvested herring eggs on kelp (hereinafter "load").

(A) The landing receipt for each herring eggs on kelp permittee shall be completed and signed by the permittee prior to commencing unloading operations of another permittee's load.

(B) The landing receipt for each load shall include all information required by Fish and Game Code Section 8043. Tally sheets shall indicate the serial number, the tare weight of the bin or tote, the net weight of the product (eggs on kelp), excluding the salt and brine and the gross weight of each bin or tote. Filled bins or totes shall be weighed when landed on-shore, or before they are moved from the premises if processing takes place on-shore. The weight tally sheet shall be retained by the permittee for one year and shall be available at all times for inspection by the department. All herring eggs on kelp landed in excess of any established permit quota shall be forfeited to the department by the signing of an official Release of Property form (Form MRR/WLP [revised 10/93], which is incorporated by reference herein). Such excess of herring eggs on kelp shall be sold or disposed of, and the proceeds from all such sales shall be paid into the Fish and Game Preservation Fund.

(10) There shall be no landing or off-loading of herring eggs on kelp from a permittee's vessel, from 10:00 p.m. Friday to 6:00 a.m. Monday, unless processing operations are conducted at a shore-based facility. If processing occurs on-shore, the permittee shall notify the department's designated contact 12 hours prior to the shipping or removal of the bins or totes from the premises.

(k) These regulations and all sections of the Fish and Game Code pertaining thereto shall be set forth in all permits. Permits shall be issued upon the conditions contained in the application and signed by the applicant that he has read, understands, and agrees to be bound by all terms of the permit.

(l) A permit may be suspended by the Department of Fish and Game for breach or violation of the terms of the permit by the permittee, or any other person(s) operating under the terms of the permit. Any such suspension may be appealed to the Fish and Game Commission pursuant to section 746 of these regulations.

(m) Authorized agents. Each herring eggs on kelp permittee may designate two authorized agents to operate under his or her permit. To designate an authorized agent, the permittee shall submit to the department's Menlo Park office a completed, signed Authorized Agent Form (MRD 164 (8/97)) which is incorporated by reference herein. A permittee may replace an authorized agent by submitting a new Authorized Agent Form to the department's Menlo Park office. A person designated on the Authorized Agent Form shall act as an authorized agent only after the form has been received by the department's Menlo Park office. An authorized agent:

(1) May serve in the place of the permittee for all fishery activities requiring the presence or action of the permittee, including the signing of landing receipts;

(2) Shall possess a current California commercial fishing license;

(3) Shall not be another herring eggs on kelp permittee unless the other permittee has stopped fishing his or her permit for the season;

(4) Who does not hold a herring eggs on kelp permit, may act as an authorized agent for more than one herring eggs on kelp permittee.

NOTE

Authority cited: Section 5510, 8389, 8553 and 8555, Fish and Game Code. Reference: Sections 8043, 8389 and 8550-8556, Fish and Game Code.

HISTORY

1. New section filed 10-8-69 as an emergency; designated effective 11-10-69 (Register 69, No. 41). For history of prior section, see Register 63, No. 1.
2. Certificate of Compliance—Section 11422.1, Government Code, filed 12-17-69 (Register 69, No. 51).
3. Amendment filed 6-30-78; effective thirtieth day thereafter (Register 78, No. 26).
4. Amendment of NOTE filed 10-19-81; effective thirtieth day thereafter (Register 81, No. 43).
5. Amendment filed 3-29-90; operative 3-29-90 (Register 90, No. 19).
6. Amendment of subsections (i) and (j) filed 10-23-91; operative 11-22-91 (Register 92, No. 1-8).
7. Amendment of subsections (f) and (i) filed 11-10-92; operative 11-10-92.
8. Amendment of subsections (i) and (j) filed 10-28-93; operative 11-28-93.
9. Amendment of subsections (i) and (j) filed 11-3-94; operative 11-3-94.
10. Amendment of subsection (i) and (j) filed 11-7-95; operative 11-7-95.
11. Amendment of subsection (j) filed 11-15-95; operative 11-15-95.
12. Amendment filed 11-12-96; operative 11-12-96.
13. Amendment filed 10-17-97; operative 10-17-97.

165. Harvesting of Kelp and Other Aquatic Plants.

(a) General License Provisions. Pursuant to the provisions of section 6651 of the Fish and Game Code, no kelp or other aquatic plants may be harvested for commercial purposes except under a revocable license issued by the department.

APPENDIX 2

Commercial Fishing District Boundaries

Thence southerly along the line common to R. 41 and 42 E., M. D. M., to the point of intersection with the line common to T. 20 and 21 S., M. D. B., being the SW. corner of Sec. 31, T. 20 S., R. 42 E., M. D. B. & M.;

Thence westerly one-half mile, more or less, along the line common to T. 20 and 21 S., M. D. B., to the point of intersection with the line common to R. 41 and 42 E., M. D. M., being the NW. corner of Sec. 6, T. 21 S., R. 42 E., M. D. B. & M.;

Thence southerly along the line common to R. 41 and 42 E., M. D. M., to the point of intersection with the boundary line between Inyo and San Bernardino Counties;

Thence easterly along said county boundary line to the point of intersection with the easterly boundary line of the State of California;

Thence northwesterly along said easterly boundary line of the State to the point of beginning.

10931. Take, Possess, Harm, Interfere, etc. with any Burro in Sanctuary

Except as otherwise provided in Chapter 5 (commencing with Section 4600) of Part 3, Division 4 of this code it is unlawful to take, possess, harm, molest, harass, or in any manner interfere with any burro which is in the burro sanctuary described in Section 10930 of this code. Any violation of these provisions is a misdemeanor.

The provisions of this section, other than those relating to the taking and possession of burros, do not apply to persons while lawfully on lands included within the sanctuary and engaged in the business of raising cattle.

10932. Catalina Marine Science Center Marine Life Refuge; Boundaries

The following constitutes a marine life refuge and shall be designated the Catalina Marine Science Center Marine Life Refuge:

All that area bounded on the south and southeast by the mean high tide line and by the present seaward boundary of the lease to tide and submerged lands now held by the University of Southern California from the State Lands Commission (No. 3692.1 Public Resources Code Series) and extending from a point on the mean high tide line at 33° 26' 39 North Latitude 118° 29' 19 West Longitude, thence to 33° 26' 50 North Latitude 118° 29' 08 West Longitude, thence to 33° 26' 57.5 North Latitude 118° 28' 33.5 West Longitude, thence to 33° 26' 55 North Latitude 118° 28' 32 West Longitude, and thence to a point on the mean high tide line at 33° 26' 53.5 North Latitude 118° 28' 35 West Longitude.

(Added by Statutes 1988 Chap. 682)

A-3.1

DIVISION 8. DISTRICTS

CHAPTER 1. BOUNDARIES

11000. Division of State Into Districts; References to Townships and Ranges

For the protection of fish and game, the State of California is divided into fish and game districts to be known and designated as provided in this division.

Unless otherwise provided, the townships and ranges specified in this division are referred to the Mount Diablo base and meridian.

11001. District 1; Boundaries

The following constitutes Fish and Game District 1:

Those portions of the following counties not included in other districts: Shasta, Tehama, Plumas, Butte, Sierra, Sutter, Yuba, Nevada, Placer, Sacramento, Madera, Tulare; those portions of San Joaquin County lying east and north of the east bank of the San Joaquin River and not included in District 3; those portions of Stanislaus and Merced Counties lying east of the west bank of the San Joaquin River; those portions of Fresno County lying east of the west bank of Fresno Slough, Fish Slough and Summit Lake; those portions of Kings County lying east of the main power line of the San Joaquin Light and Power Company, crossing the north line of Kings County in Section 4, T. 18 S., R. 19 E., southerly to its crossing of State Highway No. 41 between Secs. 21 and 22, T. 21 S., R. 19 E., and east of State Highway No. 41 southerly to its intersection with State Highway No. 33, and easterly of State Highway No. 33 from said intersection to the south line of said county in Section 36, T. 24 S., R. 18 E.; those portions of Kern County lying east of State Highway No. 33 between the northerly line of said county in Section one (1), T. 25 S., R. 18 E., M. D. B. & M., and the City of Taft and U. S. Highway No. 399 between the City of Taft and the City of Maricopa, and lying north of State Highway No. 166 from the City of Maricopa easterly to the intersection of said highway with U.S. Highway No. 99 in Section twelve (12), T. 11 N., R. 20 W., S. B. B. & M., and lying east of U.S. Highway No. 99 from the above-mentioned point of intersection to where the said U.S. highway crosses the northern boundary line of Los Angeles County, not included in other districts.

11002. District 1⅜; Boundaries

The following constitutes Fish and Game District 1⅜:

Those portions of the following counties not included in other districts: Alpine, El Dorado, Amador, Calaveras, Tuolumne and Mariposa.

Except as otherwise provided, all of the provisions of this code relating to District 1 shall apply to District 1⅜.

11003. District 1½; Boundaries

The following constitutes Fish and Game District 1½:

Those portions of the Counties of Del Norte, Siskiyou, Trinity, and Humboldt not included in other districts.

11004. District 1¾; Boundaries

The following constitutes Fish and Game District 1¾:

Those portions of the County of Modoc not included in other districts and that portion of the County of Siskiyou lying east of the Weed-Klamath Falls Highway between the north line of the County of Siskiyou and the Town of Weed and east of the Pacific Highway between the Town of Weed and the junction of Pacific Highway and the McCloud-Fall River Mills Highway and north and east of the McCloud-Fall River Mills Highway to the Siskiyou and Shasta county line and that part of Shasta County lying north and east of the McCloud-Fall River Mills Highway to its junction with the road to Lake Britton at Dickson Flat and east of that road through Burney Falls State Park to its junction with the Hat Creek-Lassen Highway at the Redding-Alturas Highway and east of the Hat Creek-Lassen Highway to Lassen Volcanic National Park and north and east to the north and east boundary of Lassen Volcanic National Park to its junction with the Lassen county line. That part of Lassen County north and east of the north and east boundary of the Lassen Volcanic National Park to its junction with the north line of District 25 and east of the east boundary of District 25 to its junction with the Lassen-Plumas county line approximately one mile southeast of Coyote Peak in Sec. 24, T. 28 N., R. 10 E. and north and west of the Plumas-Lassen county line between the boundary of District 25 and the Susanville-Taylorsville road.

11005. District 2; Boundaries

The following constitutes Fish and Game District 2:

Those portions of the following counties not included in other districts: Mendocino, Glenn, Colusa, Yolo, Solano, Napa, Sonoma, and Marin; that portion of San Francisco Bay lying westerly of a line drawn from California Point to San Quentin Point; that portion of San Francisco Bay lying westerly of a line drawn from San Quentin Point to San Pedro Point, in Marin County; that portion of San Pablo Bay lying westerly of a line drawn from San Pedro Point to the south side of the mouth of Novato Creek; and that portion of San Pablo Bay lying northerly of a line drawn due east from the south side of the mouth of Novato Creek to the westerly shore of Mare Island.

11006. District 2¼; Boundaries

The following constitutes Fish and Game District 2¼:

Lake County and the waters of Clear Lake.

Any reference in this code to Clear Lake refers to District 2¼.

Except as otherwise provided, all of the provisions of this code relating to District 2 apply to District 2¼.

11007. District 1½; Boundaries

The following constitutes Fish and Game District 1½:

Those portions of T. 24 N., R. 18 and 19 W.; 23 N., R. 17 and 18 W.; 22 N., R. 17 and 18 W.; 21 N., R. 17 W., west of the summit of the divide between the Pacific Ocean and the south fork of the Eel River.

All of T. 12, 13, 14, 15, 16, 17, 18 N., R. 16 W.; and T. 12, 13, 14, 15, 16, 17, 18, 19 and 20 N., R. 17 W., and T. 17 and 18 N., R. 18 W.

All being townships located in western Mendocino County.

11008. District 3; Boundaries

The following constitutes Fish and Game District 3:

Those portions of the following counties not included in other districts: San Francisco, Contra Costa, Alameda, San Mateo, Santa Cruz, Santa Clara, San Benito, Monterey, San Joaquin, Stanislaus, Merced, Fresno, and Kings.

A-3.2

11009. District 3½; Boundaries

The following constitutes Fish and Game District 3½:

Those portions of the following counties not included in other districts: San Luis Obispo, Santa Barbara, Ventura, and Kern.

Except as otherwise provided all of the provisions of this code applicable to District 3 apply to District 3½.

11010. District 4; Boundaries

The following constitutes Fish and Game District 4:

Those portions of the following counties not included in other districts: San Bernardino, Riverside, and Orange.

11011. District 4⅛; Boundaries

The following constitutes Fish and Game District 4⅛:

All of Los Angeles County not included within other districts.

Except as otherwise provided, all of the provisions of this code applicable to District 4 apply to District 4⅛

11012. District 4½; Boundaries

The following constitutes Fish and Game District 4½:

Those portions of the Counties of Mono and Inyo not included in other districts.

11013. District 4¾ ; Boundaries

The following constitutes Fish and Game District 4¾:

Those portions of the Counties of San Diego and Imperial not included in other districts.

11014. District 6; Boundaries

The following constitutes Fish and Game District 6:

The ocean waters and tidelands of the State to the high-water mark lying between the northern boundary of this State and a line extending due west from the west end of the north jetty at the entrance of Humboldt Bay, excluding all sloughs, streams, and lagoons.

11015. District 7; Boundaries

The following constitutes Fish and Game District 7:

The ocean waters and tidelands of the State to high-water mark between a line extending due west from the west end of the north jetty at the entrance of Humboldt Bay and the southern boundary of Mendocino County, excluding the ocean waters between the north and south jetties at the entrance of Humboldt Bay from the westerly end of each of said jetties in the Pacific Ocean to their respective aprons on the shores of Humboldt Bay, and also excluding all sloughs, streams, and lagoons.

11016. District 8; Boundaries

The following constitutes Fish and Game District 8:

The waters and tidelands to high-water mark of Humboldt Bay lying north of a straight line running east from the center of apron at the approach of the south jetty at the entrance of Humboldt Bay to the east shore line of the bay including the entrance of Humboldt Bay not included in District 7, and excluding all rivers, streams, and sloughs emptying into the bay.

11017. District 9; Boundaries

The following constitutes Fish and Game District 9:

The waters and tidelands to high-water mark of Humboldt Bay lying south of a straight line running east from the center of apron at the approach to the south jetty at the entrance of Humboldt Bay to the east shore line of the bay, excluding all rivers, streams, and sloughs emptying into the bay.

11018. District 10; Boundaries

The following constitutes Fish and Game District 10:

The ocean waters and the tidelands of the State to high-water mark lying between the southern boundary of Mendocino County and a line extending west from the Pigeon Point lighthouse in San Mateo County, including the waters of Tomales Bay to a line drawn from the mouth of the unnamed creek approximately 1500 feet north of Tomasini Point southwesterly 218° magnetic to the mouth of the unnamed creek at Shell Beach, and excluding Bodega Lagoon and all that portion of Bolinas Bay lying inside of Bolinas bar, that portion of San Francisco Bay lying east of a line drawn from Point Bonita to Point Lobos and all rivers, streams, and lagoons.

The amendment of this section by the Legislature at the 1963 Regular Session has no effect on the cultivation of oysters by persons licensed under Article 4 (commencing with Section 6480), Chapter 5, Part 1, Division 6.

11019. District 11; Boundaries

The following constitutes Fish and Game District 11:

The waters and tidelands of San Francisco Bay to high-water mark bounded as follows: Beginning at the extreme westerly point of Point Bonita; thence in a direct line to the extreme westerly point of Point Lobos; thence around the shore line of San Francisco Bay to the foot of Powell Street; thence in a direct line northwesterly to Peninsula Point, the most southerly extremity of Belvedere Island; thence in a direct line westerly to the shore end of the Northwestern Pacific Railroad Ferry slip at Sausalito; thence southerly and westerly around the shore of San Francisco Bay to the point of beginning.

11020. District 12; Boundaries

The following constitutes Fish and Game District 12:

The waters and tidelands of San Francisco Bay to high-water mark not included in Districts 11 and 13, the waters and tidelands to high-water mark of San Leandro Bay, Oakland Creek or estuary, San Antonio Creek in Alameda County, Racoon Straits, and San Pablo Bay, and the Carquinez Straits to the Carquinez Bridge, and all lands and waters included within the exterior boundaries of these districts and excluding all tributary sloughs, creeks, bays, rivers, and overflowed areas not specifically described herein.

11022. District 13; Boundaries

The following constitutes Fish and Game District 13:

The waters and tidelands to high-water mark of San Francisco Bay lying to the south of a line drawn between the Ferry Building at the foot of Market Street in San Francisco and the mouth of the Oakland Creek or estuary in Alameda County, excluding all streams, sloughs, and lagoons.

11024. District 16; Boundaries

The following constitutes Fish and Game District 16:

The waters and tidelands to high-water mark of that portion of Monterey Bay lying to the south of a line drawn 100° magnetic from the extreme northerly point of Point Pinos in a straight line easterly to the eastern shore of Monterey Bay.

(Amended by Statutes 1988 Chap. 1009)

11025. District 17; Boundaries

The following constitutes Fish and Game District 17:

The waters and tidelands to high-water mark of Monterey Bay and the Pacific Ocean, lying between a line extending west from Pigeon Point Lighthouse and a line extending west from Yankee Point, Carmel Highlands in Monterey County, excluding the areas included in District 16, and excluding all rivers, creeks, sloughs and lagoons emptying into the Pacific Ocean and Monterey Bay within the boundaries thus defined.

(Amended by Statutes 1988 Chap. 1009)

A-33

11026. District 18; Boundaries

The following constitutes Fish and Game District 18:

The ocean waters of the State and tidelands to high-water mark not included in other districts, lying between a line extending due west from Yankee Point, Carmel Highlands, in Monterey County, and a line extending from Point Rincon near or at the common boundaries between Santa Barbara and Ventura Counties westerly through Richardson Rock, and excluding all rivers, streams, sloughs, and lagoons.

11027. District 19; Boundaries

The following constitutes Fish and Game District 19:

The ocean waters of the State and tidelands to high-water mark, and islands off the coast and waters adjacent thereto, lying southerly of Fish and Game District 18, and northerly of a westerly extension of the boundary line between the Republic of Mexico and San Diego County, excepting Districts 19A, 19B, 20, 20A, and 21, and excluding all rivers, streams, sloughs, lagoons, and bays.

11028. District 19A; Boundaries

The following constitutes Fish and Game District 19A:

The ocean waters and tidelands to high-water mark lying between the southerly extremity of Malibu Point and the westerly extremity of Rocky Point (Palos Verdes Point), excluding all rivers, streams and lagoons.

11029. District 19B; Boundaries

The following constitutes Fish and Game District 19B:

The ocean waters and tidelands to high-water mark northerly of the following line:

Beginning at the west end of the San Pedro Breakwater, thence in an extended line following the axis of said San Pedro Breakwater, the middle breakwater and the Long Beach Breakwater to the east end of the latter, thence to the outer end of the west jetty of Anaheim Bay.

Except as otherwise provided, all of the provisions of this code applicable to Districts 4 and 4 1/8 apply to District 19B.

11030. District 20; Boundaries

The following constitutes Fish and Game District 20:

Santa Catalina Island and the portion of the state waters within three nautical miles of the island's coast line on the northerly, easterly, and southerly side of the island, lying between a line extending three nautical miles west magnetically from the extreme westerly end of Santa Catalina Island to a line extending three nautical miles southwest magnetically from the most southerly promontory of China Point.

11031. District 20A; Boundaries

The following constitutes Fish and Game District 20A:

The waters lying around Santa Catalina Island, within three nautical miles of the coast line of the island, which are not included in District 20.

11032. District 21; Boundaries

The following constitutes Fish and Game District 21:

The waters and tidelands to high-water mark of San Diego Bay lying inside of a straight line drawn from Point Loma to the offshore end of the San Diego breakwater.

11033. District 22; Boundaries

The following constitutes Fish and Game District 22:

All of Imperial County and those portions of Riverside and San Bernardino Counties lying south and east of the following line: Starting at the intersection of Highway 99 with the north boundary of Imperial County, thence north along that highway to the intersection with Highway 60 and 70; thence east along Highway 60 and 70 to its intersection with the Cottonwood Springs Road in Sec. 9, T. 6 S., R. 11 E.; thence north along that road and the Mecca Dale Road to Amboy; thence east along Highway 66 to the intersection with Highway 95; thence north along Highway 95 to the California-Nevada boundary.

11034. District 23; Boundaries

The following constitutes Fish and Game District 23:

The lands and waters lying within the drainage area of Rubicon and Little Rubicon Rivers above their confluence in Sec. 13, T. 13 N., R. 13 E.; all lands and waters lying within the drainage area of the South Fork of the American River and all its tributaries above Chili Bar Bridge on the Placerville-Georgetown Highway; all of the lands and waters lying within the drainage area of Webber Creek above the Mother Lode Highway between El Dorado and Placerville; the waters of Lake Tahoe and the Truckee River, and all streams flowing into that lake and river, and all lands and waters within the drainage basin of that lake and river lying within this State; the waters of Silver Lake, Twin Lakes, Twin Lake, Blue Lakes, Meadow Lake, Wood Lake, Winnemucca Lake and Scott's Lake, Burnside Lake, the Carson River, the West Fork of the Carson River, Willow Creek and Markleeville Creek and all tributaries of those streams and all streams flowing into those lakes and all lands and waters lying within the drainage basin of those lakes, rivers and streams within this State; all the waters of the Cosumnes River and its tributaries, and all lakes lying within the watershed of that river and tributaries above the bridge on the Mother Lode Highway between Plymouth and Nashville, all being within the Counties of Alpine, Amador, and El Dorado.

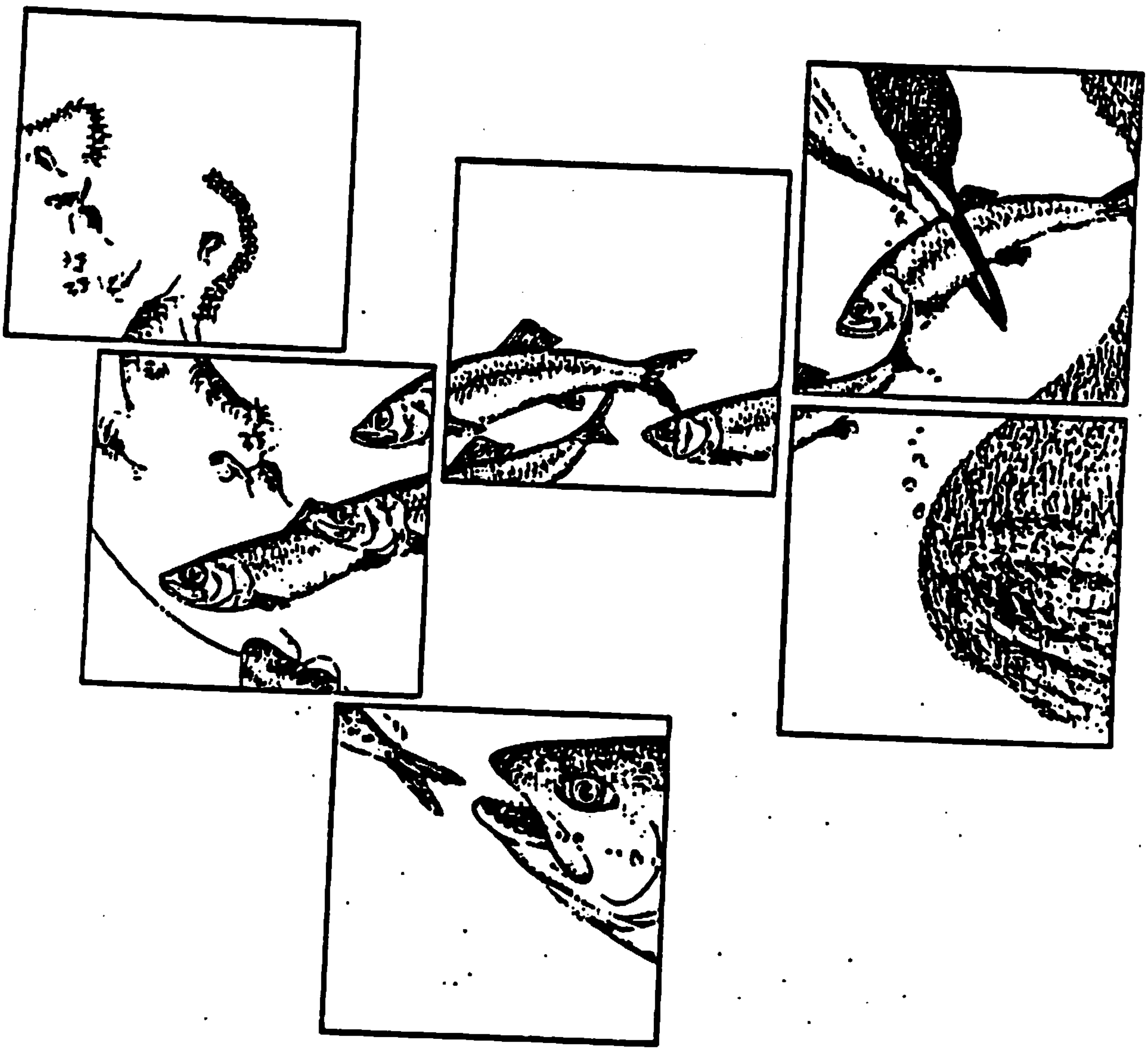
11035. District 25; Boundaries

The following constitutes Fish and Game District 25:

APPENDIX 3

Pacific Fishery Management Council's
Draft
Pacific Herring Fishery Management Plan

PACIFIC HERRING FISHERY MANAGEMENT PLAN



PACIFIC FISHERY MANAGEMENT COUNCIL 526 S.W. MILL ST. PORTLAND, OREGON 97201

SECOND DRAFT

PACIFIC HERRING PLAN

This document has been prepared for review by the Pacific Fishery Management Council on November 11-12, 1981 in Portland Oregon, and may be subject to substantial changes.

EXECUTIVE SUMMARY

INTRODUCTION

This fishery management plan (FMP) has been developed by the Pacific Fishery Management Council (PFMC) to manage the Pacific herring (*Clupea harengus pallasi*) resources in the Fishery Conservation Zone (FCZ) off the coasts of California, Oregon, and Washington. There are no domestic commercial herring fisheries in the FCZ, although an experimental offshore fishery occurred off the Washington coast in 1979 and 1980. Herring are presently harvested inshore under state management.

The PFMC determined that an FMP is necessary for the following reasons:

1. There is increasing industry interest in developing offshore herring fisheries for food and bait. The 1980 experimental fishery clearly demonstrated the potential for a fishery.

2. The authority of states to manage in the FCZ is uncertain.

3. Without an FMP, vessels can circumvent state management by landing in another jurisdiction.

4. Provisions for or control over joint venture or foreign fisheries is uncertain without an FMP.

5. Herring of US and Canadian origin intermingle in the FCZ

In March 1980, the Council adopted the primary management philosophy that social conflict and disruption of existing fisheries was to be avoided. Alternate philosophies included maximizing net economic return, and maximizing physical yield.

For the purpose of this plan, three distinct management units were established based on information concerning herring aggregations in coastal waters. The northern area includes transboundary mixed stocks of British Columbia and Washington origin found along the northern Washington coast. The central area includes the range of small stocks from southern Washington to northern California. The southern area encompasses the probable range of central California herring, primarily from San Francisco Bay. Available information strongly suggests that discrete populations of herring occur in the FCZ, but the data are not detailed enough to define these populations.

Description of the Fishery and Management

Herring along the Pacific coast are primarily caught commercially, although small quantities are taken by recreational fishermen. Many commercial uses have existed in the past, but herring for sac-roe is the major use now. The most significant fishery occurs in California, where landings have increased from approximately 1,300 mt in 1973 to 6,500 mt in 1980. Yearly landings in Washington have varied from about 1,500 - 4,000 mt, but have been approximately 2,000 tons from 1976 to 1980. Less than 100 mt are harvested in Oregon.

Herring fisheries for bait and other uses are more significant in Washington than in the other states. The Washington general purpose fishery, mainly for longline and pot bait, zoo food, or reduction to oil and meal, has harvested between 100 and 1,000 mt per year; 1980 landings were 869 mt. The Washington sport bait fishery targets on juvenile herring. Harvests have averaged about 500 mt for the past five years, and the 1980 catch was 765 mt.

An experimental herring fishery occurred off the Washington coast in 1979 and 1980. Negligible amounts of herring were taken in 1979, but landings increased to 182 mt in 1980. All herring in 1980 were taken off the northern Washington coast by a factory-trawler which froze the fish onboard. The fish entered the Japanese market for food, and the Alaskan market for king crab bait.

No directed fishing for herring by foreign nations has occurred in PFMC region, although incidental trawl catches have been reported.

Historic, world wide overexploitation of herring resources points to the need for prudent management measures. In many cases, incompatible multinational management objectives allowed fishing to exceed limits recommended by fishery scientists. Declines have also occurred when single nations allowed overfishing. A common component of overfishing this species includes harvesting juveniles as well as adults.

State management of inshore fisheries has focused on harvest quotas compatible with estimated biomass. In most cases quotas are set as a proportion of the biomass. In Washington, management of the roe fishery requires allocation under guidelines of U.S. vs Washington (the Boldt decision) which affirmed treaty Indian fishing rights.

Socio Economic Considerations

A variety of active and potential markets exist for Pacific coast herring, including food, bait, and roe. Diminished herring stocks have decreased consumption from approximately 500,000 mt to 250,000 mt in Europe, and from about 80,000 mt to 50,000-60,000 mt in Japan; this may create a large potential market for Pacific coast herring. The Pacific herring is on the lower end of sizes acceptable to the European market, but generally of a size acceptable in Japan. The domestic bait market absorbs approximately 5,000 mt of herring per year. Most is used in commercial pot and line fisheries, with less than 1,000 mt used in sport fisheries.

The Japanese market for roe dominates both value and volume for Pacific herring. As a luxury item with a limited market, severe price fluctuations for roe occur with changes in supply or demand. For roe fisheries in and adjacent to PFMC waters, Canada has the largest share. Capacity exists in the USSR, mainland China, and Korea to supply the entire roe demand, although only limited exports occur at this time. Potential exists for increased roe exports from the Bering Sea. The future of California, Oregon, and Washington roe fisheries is hard to predict, as they must compete with Alaska and Asia fisheries.

An offshore fishery would directly reduce the existing inshore fisheries. Egg skeins are too immature for use as roe, so offshore herring would be used as food or bait. Offshore catches in Oregon or California would reduce the allowable roe harvest. Off Washington, however, mixed stock herring are composed of approximately 20% Washington and 80% Canadian origin spawning stocks. A Washington offshore fishery would significantly increase overall landings in the state despite some reductions in the Washington roe fishery, but at the expense of the Canadian roe fishery.

Economic tradeoffs depend on relative price of roe and food or bait. At projected prices near $1,000 per ton for roe, $500-600 for food, and $200-300 for commercial bait, maintaining the roe fisheries will yield highest benefits for Oregon and California. The net value in Washington would increase with an offshore fishery, but would result in a larger decrease in value for Canada.

Within the Pacific region, most herring stocks are considered to be in good condition. California biomass estimates have increased each year partly because of increased survey effort; the stock is characterized as excellent. Oregon stocks, though generally small, are considered stable. The Strait of Georgia Washington herring stock has declined since the fishery began, from a combination of natural fluctuations and fishing. Continued decline could result in a closure. Most Canadian stocks are at or near historical levels, although Canadian scientists indicate that there is evidence of depletion in west coast Vancouver Island stocks.

Biological and Environmental Characteristics

Herring are a component of a diverse species complex inhabiting waters from California to Washington. In northern areas, demersal and semi-demersal species dominate; pelagic species here include herring, sandlance, smelt, northern anchovy, and salmon. Pelagic species including northern anchovy and jack mackerel tend to dominate in more southern waters. An ecosystem approach to interactions between these species, though desirable, is not currently feasible. It is well known, however, that in some regions herring are major prey for many predators. The major concern that offshore herring fishing would substantially decrease food available for salmon cannot be definitively answered. Salmon form only a small part of the biomass in the ecosystem and feed on a variety of food available; thus, it appears that a small offshore fishery for herring would have a minimal impact on salmon production.

Determination of Catch Levels

Various harvest strategies and inshore-offshore fishery effects were examined using a simulation model. Although the model cannot predict the course of events in any year, it does estimate long-term consequences of different management strategies. Two strategies examined, the harvest of all fish in excess of spawning requirement, and the harvest of a constant proportion of total biomass both give similar long term average catches. The former strategy was characterized by large fluctuations in catch, including many years with no catch. The latter strategy exhibited smaller fluctuations by spreading the harvest of strong year classes over several years. An offshore fishery would require some reduction in the inshore fisheries, or a reduction in spawning escapement, or a combination of the two.

Each state will set Acceptable Biological Catch (ABC) for fishable populations. If necessary, ABC's will be pooled for management areas. In the northern management area, an estimate of ABC for Canadian spawning stocks will be incorporated into the composite ABC. Optimum yield (OY) will not exceed ABC. If the Council sets an offshore OY, the states will set an inshore OY by subtracting offshore OY from ABC.

Total Allowable Level of Foreign Fishing (TALFF) for Pacific herring is set at zero. There is currently no harvestable surplus and there will be none in the foreseeable future.

Management Issues

Six major management issues must be considered in the formulation of a management plan.

1. Herring from many spawning areas, which probably include several independent stocks, intermingle in offshore waters. The most

complicating feature of mixed stock fishing is the need to protect depleted or weak stocks, which may preclude offshore fishing of other healthy stocks.

2. Herring as forage, especially for salmon, is often viewed as the "best use" of the species; alternatively, herring could be considered as only one of many potential diet items with little direct impact on other fishery resources.

3. Diverse biological, social, and political problems exist in the management areas, including transboundary mixed stocks (northern areas), small, discrete stocks (central area), unknown offshore distribution and migration (southern area).

4. An offshore fishery in the northern area will include a high proportion of herring which spawn in Canada. Such a fishery will increase the net value to U.S. fishermen at a larger expense to Canadian fishermen. Furthermore, international management would involve agreements between the U.S. and Canadian governments.

5. Herring harvests currently orient mainly to the unstable roe market. Diversification would likely require an offshore fishery. The present value of roe herring is significantly higher than the value of herring taken offshore.

6. Herring experience wide natural fluctuations in abundance; a management plan must be able to respond rapidly to low abundance/poor recruitment problems.

Management measures recommended in the Plan involve a proportional harvest concept, with a 20% harvest rate as the basic policy; this is the current management regime of the states for inside waters. Options for an offshore fishery include status quo (no offshore fishing) or a small quota which would be subtracted from the proportionally-derived inshore quota. Size of an offshore quota would vary by management area. Objectives of the plan favor existing fisheries, and little is known of the offshore phase of herring life history. An initial offshore fishery, if authorized, should be small, but of sufficient magnitude to be economically viable. A small, fixed quota meets these criteria. Options in the plan limit legal gear in offshore waters to trawls only, or to trawls and purse seines. Options are listed in Summary Table 1.

Summary Table 1. Proposed Management Options for Herring Fishing in the Pacific Regio Fishery Conservation Zone.

MANAGEMENT AREA[1/]

MANAGEMENT MEASURE	SOUTHERN (Central and Southern California)	CENTRAL (Northern California to Central Washington)	NORTHERN (Northern Washington
Quota			
Option	1) Status Quo (no fishery)	1) Status Quo (no fishery)	1) Status Quo no fishery)
	2) Fixed quota of between 1,000-4,000 mt	2) 100-500 mt quota for an experimental fishery No more than 50-250 mt can be harvested adjacent to any one state.	2) Small quota 1,000-4,000 mt
	3) Variable annual quota of between 1,000-4,000 mt.		3) Variable annual quota of betwee 1,000-4,000 mt.
			4) Large quota of 5000-20,000 mt
Season			
Option	1) Open all year	1) Open all year	1) Open all year
	2) Closed November 1 through March 30	2) Closed January 1 through April 30	2) Closed December through May 31
Fishing Gear			
Option	1) Pelagic trawls only	1) Pelagic trawls only	1) Pelagic trawls o
	2) Pelagic trawls and seine nets	2) Pelagic trawls and seine nets	2) Pelagic trawls a seine nets
Incidental Catch Allowances	Governed by other FMPs. For groundfish, propose 15 percent of the catch p trip of 3,000 lbs., whichever is greater. We propose no retention of salmon, crabs, shrimp or any other species of shellfish or finfish.		

1/ See Section 1.4 of the Pacific Herring Fishery Management Plan for a speci description of Management areas.

TABLE OF CONTENTS

1.0 INTRODUCTION

This fishery management plan (FMP) has been developed by the Pacific Fishery Management Council (PFMC) to manage the Pacific herring resources in the Fishery Conservation Zone (FCZ) off the coasts of California, Oregon, and Washington. Traditionally, there have been no domestic commercial fisheries for herring in the FCZ and, except for a small experimental fishery off the Washington coast, there are none at the present time. Herring stocks are harvested inshore after they have migrated from offshore feeding grounds in the FCZ. State agencies manage herring in State waters. This FMP discusses the harvest of herring in the FCZ by foreign nations, but such a fishery is currently prohibited by the Preliminary Management Plan for the Trawl Fisheries of Washington, Oregon, and California.

1.1 Justification for an FMP

Although there are currently no fisheries for herring in the FCZ, a FMP is necessary for the following reasons:

1. There is an increasing industry interest in development of an offshore herring fishery for food and bait. An experimental offshore herring fishery along the northern Washington coast in 1979 and 1980 clearly demonstrated the potential for such a fishery. A commercial offshore fishery would fall under Council jurisdiction.

2. The authority of states to manage resources and fisheries in the FCZ is uncertain. This applies to vessels which process at sea as well as those which deliver to shore-based processors. Also, fishing vessels transitting from Washington to Alaska can fish for herring in the Pacific Region FCZ and land in Alaska. Effective management of such a fishery is very difficult without a FMP.

3. There is a need for a comprehensive management plan for the entire Pacific Region. State management policies differ between California, Oregon, and Washington. A vessel fishing the FCZ coastal waters of one state can circumvent effective management by landing its catch in another jurisdiction.

4. Large quantities of herring reside in the FCZ for several months each year. These could be subject to foreign fisheries unless specifically prohibited by a FMP.

5. There can be no provision for or control over a joint venture operation in the FCZ without a FMP.

6. In some areas of the FCZ, stocks which spawn in U.S. and Canadian waters intermingle. Management of these transboundary stocks is an appropriate function of the Fishery Management Council process.

The PFMC thus concluded a FMP for Pacific herring is necessary and appropriate.

1.2 Objectives of the FMP

At its March 11-12, 1980, meeting in Renton, Washington, the Pacific Fishery Management Council selected a management approach from alternatives presented by the Herring Plan Development Team (refer to source document for entire list of alternatives). The Council directed the Team to prepare a draft Pacific Herring Management plan. The primary management philosophy adopted by the PFMC is to avoid social conflict and disruption of existing fisheries while achieving maximum benefit from the herring resource. Associated with this management approach are the following goals and operational objectives.

Goals

PRIORITY I

- Prevent significant reductions in the harvests of existing fisheries;

- Improve relevant noneconomic participation values, including recognition of Indian treaty rights;

- Provide adequate forage for salmon, marine mammals and other predator species;

- Improve the effectiveness and public acceptability of management, and reduce its cost;

- Provide for the optimal management of transboundary stocks.

PRIORITY II

- Increase the sum of net economic returns to all participants in the fishery (fishermen, processors, consumers, inshore and offshore);

- Encourage the use of herring for food;

- Increase the diversity of fishing opportunities available to U.S. fishermen.

Operational Objectives

- Support continuation of established fisheries;

- Insure a continuing supply of products currently being produced and marketed;

- Give priority to historical fishing rights and practices;

- Accommodate legally established Indian treaty fishery rights;

- Minimize incidental harvest of juvenile and adult salmon;

- Maintain adequate stocks of herring for forage for nonhuman resources.

1.3 Operational Definition of Terms

1) Determinants of catch levels.

   a. Maximum sustainable yield (MSY) is an average over a reasonable length of time of the largest catch which can be taken continuously from a stock. It should normally be presented with a range of

b. Acceptable biological catch (ABC) is a seasonally determined catch that may differ from MSY for biological reasons. It may be lower or higher than MSY in some years because of fluctuating recruitment. ABC may or may not be set at equilibrium yield (EY), which is the harvest that would maintain a stock at its current level, apart from the effects of environmental conditions. It may be set lower than MSY in order to rebuild depleted stocks.

c. Optimum yield (OY) may be obtained by a plus or minus deviation from ABC for purposes of promoting economic, social, or ecological objectives as established by law and public participation processes. Ecological objectives, where they primarily relate to biological purposes and factors, are included in the determination of ABC. Where objectives relate to resolving conflicts and accommodating competing uses and values, they are included as appropriate with economic and/or social objectives. OY may be set higher than ABC in order to produce higher yields from other more desirable species in a multispecies fishery. It might be set lower than ABC in order to provide larger-sized individuals or a higher average catch per unit of effort.

2) Determination of domestic annual fishing capacity and expected harvest.

a. Domestic annual fishing capacity (DAC) is the total potential physical capacity of the fleets, modified by logistic factors. The components of the concept are:

(1) An inventory of total potential physical capacity, defined in terms of appropriate vessel and gear characteristics (e.g., size, horsepower, hold capacity, gear design, etc.).

(2) Logistic factors determining total annual fishing capacity, (e.g., variations in vessel and gear performance, trip length between fishing locations and landing points, weather constraints, etc.).

b. Expected domestic annual fisheries harvest (DAH) is the domestic annual fishing capacity modified by other factors which will determine estimates of what the fleets will harvest (e.g., how fishermen will respond to price changes in the subject species and other species, etc.).

These concepts should be placed in a dynamic context of past trends and future projections. For example, physical fleet capacity should not simply be last season's inventory of vessels and hold measurements (although this is appropriate for present interim planning), but also next year's projected movement into and out of the fishery. Vessels under construction should be included and attrition should be estimated.

c. Domestic annual processing capacity (DAP) is the total potential physical capacity of the United States fish processing industry as established by the best available information. Factors used to establish domestic processing capacity include, but are not restricted to:

(1) Past performance by U.S. fish processors (i.e., actual quantities processed of the species covered by the FMP.).

(2) Geographic location of the processing facilities.

(3) The existence of contracts to purchase the species covered by the FMP from domestic fishermen.

(4) Physical and biological characteristics of the species covered by the plan (e.g., seasonal fluctuations, the migratory habits of the species, and the handling and storage characteristics of the species).

d. Joint venture processing capacity (JVP) is that amount of DAH which will not be utilized by domestic processors (JVP = DAH - DAP).

3) Total allowable level of foreign fishing (TALFF) is the foreign allowable catch which is determined by deducting expected domestic annual harvest from the optimum yield.

1.4 Description of the Management Unit

This plan applies to all marine waters north of the border between Mexico and California and south of the border between Canada and Washington (Figure 1:1). A precise delineation of the present boundaries is included as Appendix I. If boundaries are modified for any reason, this plan will apply to the boundaries acknowledged by the U.S. government.

The management region includes waters under both state and federal jurisdiction. Because herring occur in state and federal waters at different times of the year, the management regime for each must be considered jointly if they are to complement one another and be effective in achieving their objectives.

Though this FMP devotes much discussion to the management regimes and fisheries which occur in state waters, it promulgates regulations only for waters of the FCZ.

For purposes of this plan, the fisheries and the herring resources of the Washington-California region can be separated into three distinct management units. The separation is based on the best available information concerning location of herring aggregations in coastal waters. The first aggregation, composed of mixed stock herring which spawn in British Columbia and Puget Sound, Washington, can be found along the northern Washington coast and the west coast of Vancouver Island. The U.S. segment of this area is designated the Northern Management Area. The second aggregation, spawning stocks primarily from San Francisco Bay, move offshore of the central California coast, but their distribution offshore is not known. This region has been designated the Southern Management Area, with broad boundaries to encompass these fish. No large spawning stocks nor large offshore aggregations are known to exist from northern California to southern Washington, an area designated the Central Management Area. As a convenience, management unit boundaries were chosen to correspond with existing INPFC statistical areas. The areas are:

1. Southern Management Area - U.S./Mexico border to Cape Mendocino, California (40°30'N. latitude). Large stocks of herring from San Francisco and Tomales Bays are present in this area and are currently heavily exploited in inshore waters.

2. Central Management Area - Cape Mendocino, California to Cape Elizabeth, Washington (40°30'N. to 47°20'N. latitude). Small stocks are present in and adjacent to embayments along this coastal area. Fisheries are small in this area.

3. Northern Washington - Cape Elizabeth to U.S./Canada boundary (North of 47°20'N. latitude). Spawning stocks from British Columbia and Puget Sound form mixed stock aggregations in the U.S./Canada transboundary area but can be managed by the Council only in the U.S. portion. Stocks in U.S. and Canada are heavily exploited in inshore waters.

The herring resources and fisheries in these areas are described in Sections 3.0, 4.0 and 7.0.

2.0 DESCRIPTION OF THE FISHERY

2.1 Areas and Stocks

Pacific herring stocks extend from San Diego, California northward along the coasts of Oregon, Washington, British Columbia, and Alaska and across the Pacific rim to Asia. Vancouver Island, British Columbia, demarks the approximate southern limit of consistent high concentrations of herring in the eastern Pacific. While relatively large quantities of herring spawn along Vancouver Island and in the Canadian Strait of Georgia, lesser amounts are found in Washington State waters and in the San Francisco Bay area of California. Small quantities of spawning herring also occur within Puget Sound and in embayments along the ocean coast.

Analysis of meristic and morphometric characteristics for prespawning herring from Vancouver Island during the 1930's showed statistically significant differences between fish from various areas (Tester 1937). This analysis implied the presence of discrete populations. Subsequent tagging of Vancouver Island herring showed that straying occurred between major spawning areas but was generally limited to 20% or less (Harden Jones 1968).

More recent analyses showed that genetically discrete herring populations exist in the Pacific Ocean, at least for widely separated areas (Grant, in prep). Electrophoretic techniques identified gene frequencies for herring south of the Aleutian Islands (eastern North Pacific) as significantly different from herring north and west of the Aleutian Islands (Bering Sea and western North Pacific). Small scale differentiation occurred within the two major groupings, but was insufficient to identify components of mixed stocks.

The problem of stock identification has not been resolved, but each spawning area that supports a commercial fishery is managed as if it contained a genetically distinct stock.

In California, known spawning areas include San Diego Bay, San Luis River, Morro Bay, Elkhorn Slough, San Francisco Bay, Tomales Bay, Bodega Bay, Russian River, Noyo River, Shelter Cove, Humboldt Bay, and Crescent City Harbor.

During the summer months, herring are found in fishable concentrations in Monterey Bay. The origin of herring in Monterey Bay is unknown but is assumed to be a mixture of several spawning stocks, with Tomales Bay and San Francisco Bay the major contributors. Historically, herring spawning in Oregon has occurred entirely within coastal estuaries including Coos, Umpqua, Yaquina, Tillamook and Columbia.

Biological data collected from prespawning herring aggregations in Puget Sound, Washington suggest that genetic differences may exist (Trumble 1979). For example, statistically significant differences between the variables L and K of the von Bertalanffy growth equation were detected for three areas of Puget Sound. Herring from the three areas also demonstrated noticeably different patterns of annuli deposition on scales. Differences include consistent disparity in the reliability of scale interpretation for aging, as well as differences in growth patterns. Two of the three aggregations occur at similar times in southern Puget Sound, and the third is from northern Puget Sound and occurs several months later.

n summary, available evidence strongly suggests that discrete populations of acific herring occur in PFMC region waters. The data are not detailed enough o assign boundaries to spawning grounds which make up the individual opulations, to determine the total number of such populations, or to estimate he amount of straying which may occur.

.2 History of Exploitation

.2.1 Domestic Fishery

mmercial landings dominate herring catches in the PFMC region waters. mmercial uses include sac-roe, reduction to oil and meal, bait, animal food, d human consumption. Small quantities are caught by recreational fishermen r personal use as bait or food. Recreational fishermen in some areas rely a supply of herring for bait but depend on a commercial fishery to supply is bait. The states of California, Oregon, and Washington contain various mbinations of these fisheries, but their relative importance varies by ate.

2.2.1.1 Catch Trends

Annual landings have varied greatly over the years (Table 2-1). It should be recognized that the fluctuations in annual landings may well reflect market demand rather than availability of fish or stock size. The history of landings is characterized by cycles resulting from demands for herring for specific purposes.

The California herring fisheries since 1916 exhibit three major cycles (source document). Landings reached 3,600 mt in 1918 during a reduction fishery which extended from 1916 to 1919. Herring were harvested as a replacement for the declining sardine fishery from 1948 to 1953 with a peak of 4,307 mt in 1952. The current roe fishery began in 1973; landings totalled 6,447 mt in 1980, with 5,832 mt taken in San Francisco Bay.

Oregon's landings since 1928 have been principally for bait and do not show any definite trends. Annual catches were highly variable with peak landings approximately 45 mt per year.

Washington herring landings since 1935 show two main periods of catch. The first period, through 1956, was characterized by generally low landings ranging from approximately 50 mt to 500 mt. Catches were used primarily for halibut and crab bait through about 1950, with a shift toward bait for recreational use during the early 1950's. Landings jumped dramatically during the second period, regularly exceeding 2,000 mt when the general purpose fishery began in 1957. The general purpose fishery, originally for meal and oil, but more recently as bait for line and pot fisheries dominated the landings until about 1970. General purpose landings began declining after 1970, but this reduced production was compensated for by the sac-roe fishery which began in 1973.

Table 2-1. Commercial landings of Pacific herring by state,1/ 1960-1980 (metric tons).

	STATE		
Year	California	Oregon	Washington
1960	817	4	1,861
1961	636	8	1,634
1962	592	7	2,889
1963	286	7	3,167
1964	158	15	1,674
1965	234	23	3,790
1966	110	42	2,048
1967	123	38	2,924
1968	162	17	2,924
1969	77	35	3,764
1970	143	20	2,004
1971	109	12	1,718
1972	52	12	1,566
1973	1,276	19	3,130
1974	2,382	26	5,506
1975	1,099	32	5,961
1976	2,123	35	2,683
1977	4,401*	25	3,023
1978	5,239*	63	2,933
1979	4,236*	79	3,517
1980	6,447*	64	3,228*

* - Preliminary

1/ - Data from state agencies

Current herring fisheries are predominantly roe fisheries. In California, only Tomales Bay and San Francisco Bay support major fisheries. Humboldt Bay and Crescent City Harbor stocks are relatively minor and support very limited fisheries. Relatively small sport fisheries exist in San Francisco Bay and the Noyo River.

The roe fishery began in Tomales and San Francisco Bays in 1973. For the first three seasons, the fishery was controlled by the state legislature which set very conservative catch quotas. In 1976 the Fish and Game Commission assumed control of the fishery, and expansion of the fishery began. The 1980 catch quotas totalled 6,630 mt.

Oregon presently has two herring fisheries, one in Yaquina Bay for sac-roe and one in the Umpqua estuary for bait. The total landings in 1980 were 64 mt.

Three commercial fisheries for herring presently occur in Washington: sac-roe, general purpose, and bait used by recreational fishermen. The sac-roe fishery is restricted to April and May in the Strait of Georgia and adjacent waters. This fishery exploits the largest known herring population in Washington. Yearly landings have varied from 1,500 to 4,000 mt, and have been approximately 2,000 mt since 1976. The 1980 catch totaled 1,434 mt.

The general purpose fishery occurs in specified areas of northern Puget Sound. The fishery currently operates on a limited scale, harvesting between 100-1,000 mt per year. Landings for 1980 were 844 mt. The herring fishery for sport bait is directed toward juvenile fish, in contrast to adult fish as in the other herring fisheries. The bait fishery occurs throughout Puget Sound but most catches are taken from southern Puget Sound and northern Hood Canal-Admiralty Inlet. Landings for the past five years have averaged about 700 mt, although landings are slowly increasing; the 1980 catch was 768 mt.

An offshore experimental herring fishery harvested approximately 182 mt in the FCZ off Washington in 1980.

2.2.1.1.1 Offshore Experimental Herring Fisheries

During the summer and autumn of 1979 and 1980, the Washington Department of Fisheries authorized a limited, experimental offshore herring fishery in the FCZ off the northern Washington coast. Following a recommendation by PFMC in February 1979, the WDF and NMFS implemented a research program to obtain information on the offshore phase of the herring life cycle, and information about the herring resource and the effects of offshore fishing.

Only negligible landings occurred during the 1979 experimental offshore herring fishery. Landings increased substantially in 1980 with two vessels landing about 182 mt of herring in 70 tows. While the season was open from July through December, all fishing activity occurred after late September. Few herring of suitable size were available at seasons' end. (Trumble and Reid, 1981). Two boats fished in 1980; 70 directed tows were made, and about 182 mt of herring were landed. The season extended from July through December, but all activity occurred after late September. Landings occurred in mid-October and mid-December. By late December, few herring of suitable size were available.

All landings were taken off the northern coast of Washington, mainly along the J.S.-Canada fishing boundary, by one vessel which made two successful trips. 'irtually no herring were located off southern Washington during exploration 'y a second vessel.

erring retained in the fishery were generally of a size suitable for a human onsumption market. The Japanese market apparently will accept herring as mall as 17 cm (7 inches), but prefers fish greater than 20 cm (8 inches). owever, catches during the experiment had too many fish in the 17-20 cm size ange to be considered prime quality. Approximately two-thirds of the herring ntered the Japanese market for use as food for humans. The remainder of the atch, though of a suitable size for food, was transported directly to Alaska or use as king crab bait, because a marketing agreement could not be reached ith Japanese importers.

All herring landed during the experiment were frozen on board a factory-trawler. Immediate processing provided for high quality herring, but catch rates were limited by processing capacity. Periods of several days during which herring could not be found limited the success of the factory-trawling operation; non-productive time resulted in longer trips or less than capacity loads, and reduced profitability of the experiment. Since none of the vessels engaged in the experimental fishery brought in a load of herring for shore processing, the quality or volume tradeoffs are not known.

Yellowtail rockfish made up the bulk of the incidental catch, with dogfish next in abundance. Yellowtail incidence was very high on Trip 1 for nearly a week of fishing, but dropped off after specific efforts to avoid them. Small quantities of yellowtail were caught during Trip 2. Dogfish could not be avoided during the experiment. Salmon were the only prohibited species caught. Highest catch rates of salmon occurred when herring were absent or low in abundance. (Further details are presented in Trumble and Peterson, 1980 and Trumble and Reid, 1981)

2.2.1.2 Description of User Groups

Commercial fishermen currently operate within the states' three-mile territorial waters. Herring in California, Oregon, and Washington are fully utilized. The roe fisheries which dominate landings do not currently conflict with other herring fisheries.

Recent federal court rulings such as U.S. vs. Washington (the 1974 Boldt decision), established that certain Indian tribes have treaty rights to fish herring, salmon, and steelhead and that special regulations may be required to allow the tribal members to obtain their court-ordered allocations. Washington state law prohibiting allocation between user groups originally conflicted with the federal rulings, and severe conflicts occurred between Indian and non-Indian fishermen. A 1979 ruling by the U.S. Supreme Court upheld the basic Boldt decision, and the Washington State Supreme Court subsequently ruled allowing allocation. Treaty Indian herring fishing has been mainly for sac-roe. Only limited effort by treaty fishermen has been expended on the bait herring fishery or the winter general purpose fishery.

Recreational fishermen take some herring for bait and human consumption, mainly for pickling, but also for roe in California. The magnitude of the recreational fishery is not known but is considered minor in relationship with commercial fisheries. The main use of herring by recreational fishermen is as bait obtained from the commercial bait fishery.

A component of the recreational fishing community believes that commercial herring fishing has depleted local stocks, resulting in lost forage and reduced fishing success for salmon. A major conflict between commercial and recreational users could occur if a depletion of herring actually happened.

2.2.1.3 Description of Vessels and Gear

The California herring fishery was pursued with beach seines and gillnets in Tomales and San Francisco Bays until 1952. In 1952, lampara seines were introduced in Tomales Bay and were very effective in shallow water when the lead line rested on the bottom. Lampara boats are small, between 10 and 16 meters. The smaller lampara boats load their catches onto lighters with a holding capacity of 20-30 mt of fish. The larger lampara boats have a capacity up to 60 mt.

After 1953, the lampara boats fishing in Monterey Bay supplied a limited herring market for bait and animal food. In 1973, lamparas returned to Tomales and San Francisco Bays for the sac-roe fishery. Purse seines were introduced in 1974. Drift gillnets and beach seines were used continually through the years, but gillnets did not become a major gear type until the 1975-76 season.

The fishery was dominated by round haul boats (purse seine and lampara seine) until 1977 when set gillnets were legalized. In 1978, the round haul boats were prohibited from Tomales Bay.. Gillnets currently account for over one-half the annual harvest. In 1980, the limited entry program (discussed in section 3.1.1.2) allowed 348 vessels in the fishery, of which 294 were gillnetters.

In Oregon, purse seines and lampara nets are the primary harvest gear. During the 1980 roe season in Yaquina Bay, vessels up to 20 m fished, using both purse seines and lamparas up to 270 m long.

Bait fishing in the Umpqua estuary is done entirely with small skiffs and beach seines. The boats are about 5 m long and are used to set the net and for towing the live box of fish back to the dock. The seines are usually 120-200 m long by 3 or 4 m deep. The Yaquina Bay fishery uses larger vessels to 11 m in length which employ lamparas and purse seines ranging from 90 to 200 m long.

Until the advent of the sac-roe fishery, herring fishing in Washington normally consisted of purse seiners who fished in the general purpose fishery, and lampara seine and dip net fishermen who fished for sport bait. Herring gillnetting started with the sac-roe fishery.

Limited entry in Washington (Trumble, 1977), implemented early in the roe fishery, restricted gear to 34 purse seines (3 for bait only), six gillnet, 42 lampara, 46 dip net, 10 drag seine and one brush weir. Limited entry does not apply to Indians with treaty fishing rights. In the roe fishery all eligible non-treaty gilinet (6) and purse seine (31) fishermen participate. The exact number of treaty Indian fishermen is uncertain but there are approximately 15-18 Indian purse seiners and 250 gillneters. Gillnets are limited to 228 m in length, and purse seines to 520 m (non-treaty) and 570 m (treaty Indian).

An average of four to six purse seiners--only a few of those actually eligible--normally fish for general purpose use. In the 1980-81 season approximately 15 vessels participated. Potential participation is affected by salmon fishing in the fall, and a November-December departure to California for that state's roe fishery. Twenty to thirty active fishermen participate in the bait fishery. Lamparas are limited to 60 meters, dip nets to 3 m across, and drag seines to 110 m.

2.2.2 Foreign Fishery

Foreign fishing for groundfish off the coasts of Washington, Oregon, and California began about 1962 with the appearance of Japanese and Soviet exploratory vessels. Subsequently, Poland, East Germany, West Germany, Bulgaria and the Republic of Korea entered the fishery. Since implementation of the FCMA in 1977, only the U.S.S.R. and Poland have fished off Washington-California, and only for Pacific whiting and jack mackerel.

There has never been confirmed directed foreign fishing on Pacific herring in the Washington-California region. Poland reported herring catches of 58 mt in 1973 and 1,388 mt in 1975 while engaged in the Pacific whiting fishery. Since then, foreign herring catches have been very small and are such a minor component of the total catch that there is no requirement for reporting them. U.S. observers aboard Polish and Soviet vessels during 1977-79 reported only trace amounts (.25 kg per day) of herring in whiting catches.

There was some documented targeting in Canadian waters off Vancouver Island by two East German stern trawlers during December 1975-January 1976. Each vessel was taking about 40-50 mt per day in single tows of about 45 minutes duration. Most herring were frozen whole or filleted, but some were reduced to meal. The total catch was reported to be 1,130 mt. This fishery never fully developed because in subsequent discussions with East Germany, Canada and the U.S. discouraged further efforts in this direction. In addition, the U.S. closed the area (48°30'-47°30'N latitude) just south of the U.S.-Canada boundary to foreign trawling in 1975 to protect important Pacific ocean perch grounds. This closure effectively made large offshore concentrations of herring unavailable to a foreign fishery.

2.3 History of World Herring Fisheries

Herring have a very long history of exploitation by humans. Early relatively small fisheries for food have led to large-scale harvests for food and industrial uses within this century. Very often these fisheries intensified into actual overfishing, leading to stock failures. The major world herring fisheries will be summarized separately.

Japan

A Japanese herring fishery operated in the Hokkaido-Sakhalin area as early as 1870. Landings increased from 200,000 mt in the early 1870's to the 600,000 mt level ten years later. Fishing effort then increased greatly, and had doubled by 1908. Catches fluctuated greatly but remained in the 400,000 to 850,000 mt range until the early 1930's, when stocks began to collapse due to the very intensive fishing effort. Landings then declined rapidly and by 1938 were below 100,000 mt (Murphy, 1977).

Bering Sea

A domestic commercial herring fishery for food began in the late 1800's and continued until 1946; the peak harvest was 2,277 mt (Skrade, 1980). Foreign boats began fishing on wintering stocks in 1959. By the mid 1960's both Soviet and Japanese vessels were present (Skrade, 1980). Landings peaked in 1970 at 145,547 mt and subsequently declined. The reasons for the decline are unclear. At the present time no directed fishing for herring on the high seas is permitted although small incidental allowances are granted to the foreign trawl fishery.

A small sac-roe fishery began in Norton Sound and Bristol Bay during the 1960's. This fishery greatly expanded in 1977 and has continued since; 10,000 mt were landed in 1979.

A roe-on-kelp and bait fishery also operate in the Bering Sea. In 1979, these landed 188 mt and 817 mt, respectively.

Gulf of Alaska

A large reduction fishery operated in the Gulf of Alaska from the 1920's to the mid 1960's. Landings peaked in 1937 with 114,194 mt (Reid, 1971). Subsequently, market conditions forced closure of the fishery.

Current herring fisheries in the Gulf are for roe herring, food and bait, and roe-on-kelp. In 1979 these landed 8,619 mt, 3,316 mt, and 214 mt, respectively (Blankenbeckler, 1980).

British Columbia

The principal use of British Columbia herring from the early 1900's until the late 1920's was for export to the Oriental dry salted market. Catches increased to 85,000 mt in 1928 and then decreased as the market declined (Hourston, 1980).

The development of a reduction fishery led to increased landings from 1935 to the mid 1960's when as high as 250,000 mt were landed annually. By 1966, catches declined rapidly as the fishery collapsed under heavy exploitation. The reduction fishery was closed in 1968.

Very little fishing occurred during the next few years and stocks began to increase (Hourston, 1980). A roe fishery started in 1972; the catch peaked to the 80,000 mt level in 1976-1978 and then decreased to 10,000-30,000 mt in 1980 and 1981 under a revision of management policy.

Northwest Atlantic

Atlantic herring (Clupea harengus harengus) have been used by man along the Atlantic coast of Canada and the U.S. for centuries.

Total landings from this area remained fairly constant at 100,000 mt to 200,000 mt per year from 1920 to 1960. The development of new fisheries during the early 1960's led to greatly increased landings that peaked in 1968 when over 940,000 mt were taken. Catches then steadily declined to less than '46,000 mt in 1979 (Anthony and Waring, 1980).

everal distinct herring fisheries occur in the Northwest Atlantic. One is in he inshore waters along the Maine coast where juvenile fish are canned as ardines. Landings since 1950 have been as high as 90,557 mt, and have veraged 41,900 mt.

There is also a fishery in the Gulf of Maine for adult herring. Catches in this fishery escalated in 1968 when 31,900 mt were taken. Catches in recent years have ranged between 15,900 and 23,600 mt (Anthony and Waring, 1980).

The multinational Georges Bank fishery began in 1961 and developed rapidly; 373,600 mt were taken in 1968. Very heavy fishing occurred and was supported principally by several strong year classes. This fishery collapsed in 1977 due to overfishing. Landings dropped from 146,096 mt in 1975 to 2,157 mt in 1977 (Anthony and Waring, 1980).

A fishery for adult herring exists off Nova Scotia. Catches were generally high; between 1966 and 1977, landings stayed above 100,000 mt.

A major fishery occurs in the Gulf of St. Lawrence-Newfoundland area where ten separate stocks exist (Moore, 1980). A strong world market for herring led to an expansion of the fishery in the late 1960's. Landings remained above 100,000 mt from 1967 to 1973. Catch quotas kept landings since the mid 1970's at the 60,000 to 70,000 level.

Atlanto-Scandian Herring

The Atlanto-Scandian group of herring includes three stocks, the major one being the Norwegian spring spawning herring (Dragesund, 1980). This stock in the past supported multinational fisheries at several points along its migration route.

Total catch of Norwegian spring spawning herring fluctuated but stayed high from 1950 to 1967; over 1 million mt were landed annually eight times during this period (Murphy, 1977). These very intensive fisheries on both juveniles and adults finally led to the collapse of the stock. The largest annual catch (1,723,000 mt) occurred in 1966; by 1970 landings had dropped to 20,000 mt.

Beginning in 1972, the fisheries were regulated by international agreement; quotas were set to reduce landings. The critical period for the resource is probably past; a slight recovery has taken place since the late 1970's (Dragesund, 1980).

North Sea

The North Sea herring fishery has a long history of multinational exploitation (Schumacher, 1980). A fairly stable catch level around 600,000 mt occurred from the 1930's until 1963. However, this catch stability was maintained by increasingly efficient fishing methods and by increases in total effort; the catch per unit of effort (CPUE) decreased during this period (Murphy, 1977).

Landings continued to increase during the early 1960's in spite of sharply declining CPUE; the CPUE during 1966 and 1967 was only one-third of the 1956-1957 value (Murphy, 1977). Catches declined steadily from 1,425,000 mt in 1965 to 170,000 mt in 1976.

International agreements resulted in the establishment of closed seasons during 1971 to 1974 and of catch quotas starting in 1974 (Dornheim, 1978). During 1977 through 1979, a total ban on directed herring fishing was nstituted. As a result of these catch limits, the stock biomass has ncreased from a low of about 200,000 mt to 400,000 mt in 1980 (Schumacher, 980).

ummary

review of world herring fisheries illustrates that depletion due to fishing ffort has occurred several times. The situation may be as uncomplicated as ie nation simply depleting its resource through intensive fishing or as mplex as a multinational effort directed toward a single stock at several ints in its life history.

3.0 HISTORY OF MANAGEMENT

3.1 Domestic

3.1.1 Regulatory Measures Employed

3.1.1.1 Fishery Conservation Zone

Historically there have been no herring fisheries in the FCZ even though regulations have been minimal or nonexistant. California has traditionally required a special permit for experimental offshore fisheries, but neither California, Oregon nor Washington had regulations restricting herring fishing in the FCZ until 1978.

During the spring of 1978, following the decline of European herring stocks and exclusion of U.S. trawl fishermen from Canada, U.S. fishermen expressed considerable interest in beginning exploratory fishing for herring in the FCZ adjacent to Washington. In 1978, the Washington Department of Fisheries enacted a regulation which made it unlawful to fish for herring for commercial purposes in coastal waters adjacent to Washington state. This prohibition was designed to prevent harvest until the concept of an offshore fishery could be reviewed by the Pacific Fishery Management Council, which would be ultimately responsible should such a fishery be allowed. Acting on a request from the PFMC to allow an experimental offshore herring fishery, the Washington Department of Fisheries in 1979 modified the total ban by establishing provisions for a permit-only fishery. An experimental offshore herring fishery using midwater trawls and purse seines with a 1,350 mt quota took place in 1979 and 1980 (Trumble and Pedersen, 1980; Trumble and Reid, 1981).

3.1.1.2 State Waters

California

Prior to 1973, there were few regulations on herring fishing in California. The first three seasons of the roe fishery (1973-1975) were controlled by the state legislature. Regulations were extremely conservative. A lottery was also instituted which was the forerunner of the present California limited entry system. In 1976, the Fish and Game Commission assumed control of the fishery. The lottery was lifted in 1978, and everyone who applied was issued a permit. A total of 352 permits was issued in 1978. In 1980, guidelines for issuing 100 new gillnet permits were established effective for the 1981 season. No new roundhaul permits will be issued. Current management strategies call for a quota set at a maximum of 20% of the previous season's spawning biomass.

Oregon

For many years, the Oregon herring fishery operated in various estuaries with virtually no restrictions, taking fish with gillnets and beach seines. Gillnets were prohibited in all areas beginning in 1957. In 1975, interest was shown in developing a roe herring fishery. The Oregon Fish and Wildlife Commission effectively prevented roe fishing by closing the general commercial fishery from January 1 to April 30. The only fishery allowed during this period was for bait. This "bait only" regulation was designed to prevent a rapid expansion of the fishery during the spawning season until data on stock size could be obtained. Fishing for roe herring was authorized in Yaquina Bay in 1979 and 1980 with a 45.4 mt quota.

Washington

Prior to 1957, regulations in Washington were designed to limit the harvest of herring. In 1915 several herring spawning grounds were declared reserves and closed during the spawning season. In 1926, a "herring line" alternated the fishery each year to "inside" or "outside". In 1940, daily catch limits and in 1950 possession quotas were also used to protect reportedly depleted stocks. Gear limits were defined in 1926 for drag seine and dip bag net, in 1937 for locations of brush weirs, in 1940 for purse seines and gillnets, and in 1950 for lamparas.

The first major change in management philosophy occurred in 1957 when reduction to oil and meal was authorized with the newly established general purpose fishery. Seining was permitted over a wider area, and daily and possession limits were abolished. No further major regulatory changes occurred until 1973, the beginning of the sac-roe fishery. For the first two years of the sac-roe fishery, management was based on closed periods during the fishery to insure unmolested spawning. Since 1975, harvest has been limited by quotas set proportional to estimated abundance. The upper limit of harvest authorized is 20 percent of the total biomass if the biomass exceeds 8,163 mt (9,000 short tons). Treaty Indian participation under the Boldt decision guidelines required maintaining allocation schedules set by the court.

3.1.2 Effectiveness of Management Measures

Conservation regulations have met the objective of maintaining spawning stocks at a level high enough to prevent recruitment problems. Limited entry in California has effectively set a ceiling on the number of vessels fishing for herring. Washington's limited entry program is not entirely successful. The nontreaty fleet is considerably larger than needed for full harvest (Trumble, 1977). Limited entry does not apply to treaty Indians and numbers of treaty Indian herring fisherman have increased significantly.

3.2 Foreign

A program to manage a foreign herring fishery has never been implemented because neither the U.S. nor Canada has identified surplus stocks. While a rather large incidental catch was reported in 1975 by Poland, U.S. observers report very minor incidental catches in recent years. Herring are included within the "other fish" incidental catch limits set by the Preliminary Management Plan for the Trawl Fisheries of Washington, Oregon, and California, and herring catch records are not recorded separately.

4.0 HISTORY OF RESEARCH

Herring stocks have been investigated extensively in areas where they are commercially important (Cushing, 1975). Early research on Pacific herring occurred primarily in Southeastern Alaska and British Columbia (Reid, 1971; Taylor, 1964; Melteff and Wespestad, 1980). Much of the information on life history characteristics and population dynamics of Pacific herring originated from research in these areas.

4.1 United States Research in the Pacific Region

Research on herring stocks in the California-Washington area was sporadic and limited until about 1970 when research intensified. Investigations of herring from the early 1900's to 1970 usually coincided with developing fisheries.

4.1.1 California

Interest in Pacific herring as a commercial species in California has followed a unique cyclical pattern, characterized by short periods of intense fishing separated by long periods of little activity. This pattern has persisted at least since 1916, when the California Department of Fish and Game began tabulating annual landings.

It is not surprising that interest from the scientific community also follows a cyclical pattern characterized by periods of research associated with intense fishing. Pacific herring are currently in the midst of the third peak in interest both from the fishing industry and the scientific community. There have been many articles written since the early 1900's describing California's herring fisheries including the reduction fishery from 1916-1919 and the human consumption fishery in the early 1950's, but there has been very little research on herring in California.

Inconclusive racial studies were conducted in the 1920's. In 1955, investigations of spawning stocks were initiated in Tomales and San Francisco Bays (Miller and Schmidke, 1956).

Due to public concern, the California Department of Fish and Game initiated a study in 1970 in Tomales Bay to assess the size of the herring resource and to develop a management plan for the harvest of herring eggs on algae (Hardwick, 1973). Research has continued in Tomales and San Francisco Bays since 1973 to determine population size, age composition, growth rates, and other biological parameters which are utilized in management of the sac-roe fisheries (Spratt, in press).

4.1.2 Oregon

Oregon has a very short history of research on Pacific herring. Since 1976, age samples from the commercial and sport fisheries have been collected. Length, weight and sex data are also available from that time. In 1977, quantitative spawn surveys were begun that resulted in biomass estimates. A good knowledge of herring spawning areas exists. Twice, in 1973 and 1979, tagging experiments were conducted to determine whether herring from the Umpqua and Yaquina estuaries intermix; these experiments have not yielded conclusive data.

4.1.3 Washington

Although commercial herring fishing in Washington began in the late 1800's, little research was undertaken until the late 1930's. Early investigations included biological and racial studies and analyses of fishery statistics (Chapman et al., 1941). No further research was conducted until the mid-1950's when life history studies and spawning ground surveys were initiated to provide data for management of the Puget Sound herring fishery (Williams, 1959).

Recent herring research in Washington began in 1971 and continues today. A comprehensive research program includes hydroacoustic stock assessment surveys (Lemberg, 1978; Trumble, Thorne, and Lemberg, 1981), spawning ground surveys (Millikan and Penttila, 1972; Millikan et al., 1974; Trumble et al., 1977), and stock identification analysis (Trumble, 1979), and recruitment studies (Penttila and Stinson, in prep).

4.1.4 National Marine Fisheries Service

During August - October, 1979, the National Marine Fisheries Service, in cooperation with the Washington Department of Fisheries and Canada, conducted hydroacoustic surveys of the herring resource in the transboundary area off the northern Washington-southern Vancouver Island coast between 47°45'-40°20'N latitude. Objectives of this effort included obtaining estimates of distribution and abundance and collecting an array of basic biological data.

5.0 SOCIOECONOMIC CONSIDERATIONS

5.1 Introduction

The dominant economic characteristics of the Pacific Coast herring fishery are diversity and variability--diversity of participants and product forms, and variability from year to year in the volume and value of production.

The variety of herring fisheries that occur on the Pacific Coast from southern British Columbia to California is described in Table 5.1. The sac-roe fisheries are economically the most significant. In the sac-roe fishery, sexually mature herring are harvested during the short (2-4 week) winter spawning season. Either whole carcass or roe (about 10 percent of whole weight) are shipped to Japan. Roe is processed into kazunoko, a caviar-like specialty product which the Japanese consume primarily during their New Year holiday season. The carcasses are dried and smoked. The 1980 estimates of roe herring harvest (in metric tons round weight) are British Columbia 17,433, Washington 1,439, Oregon 45, California 6,439.

A number of other end products are produced from Pacific herring. These include bait for both sport and commercial fisheries, animal food, and very limited amounts for human consumption. There is also a very small harvest by recreational fishermen for sport bait and human consumption. By comparison with the roe fishery, the fisheries that supply these other uses are smaller but usually occur during longer periods of the year. Harvests in 1980 (in metric tons round weight) for all uses other than roe are southern British Columbia 7,875, Washington 1,816, California 36 and Oregon 34.

The harvest and processing of Pacific herring involves a substantial number of vessels, fishermen, processing plants and processing workers, as indicated in Table 5.1. For the most part, the herring fishery augments other fishing activities such as salmon fishing, rather than providing a primary source of income or employment. Fisheries that supply herring as sport bait, however, are composed of full time commercial fishermen who make this fishery their primary income.

Table 5.1 Characteristics of Pacific herring fisheries[1]

	Washington Sac Roe	Washington Sport Bait	Washington Winter General Purpose (Bait)	Southern British Columbia Sac Roe	Southern British Columbia Food and Bait	Oregon Sac Roe	Oregon Bait	California Sac Roe	California Bait
Legal Season	April-May	All year	Sept.-Feb.	Jan.-March	Nov.-Jan.	Jan.-March	Jan.-Dec.	Dec.-March	Apr.-Sept.
Number of purse seine Vessels (Total)	46	2	10-12	249	130	1	*	27	-
Treaty Indians	15	0	2	-	-	-	-	*	-
Number gill net vessels (Total)	206-256	0	0	1302	-	-	*	294	-
Treaty Indians	200-250	0	0	-	*	*	*	*	*
Number of other vessels	0	47-50	0	-	35	4	10	27	5
Treaty Indians	0	0	0	*	-	-	-	*	-
Investment in vessels and gear ($000)	15,184	3,235-4,030	750-1,500	72,609	40,255	*	400-420	14,000-21,800	625-1,000
Participating Fishermen (Total)	542	101-110	50-60	5,500	950	15	15	820-930	30-35
Treaty Indians	375	U	10	-	-	-	-	-	-
Landings (mt)	1,582	518	148	17,433	7,875	50	34	6,439	36
Treaty Indians (mt)	808	-	-	-	-	-	-	-	-
Ex-vessel price ($/mt)	772-882	441-1,323	221-331	*	1,732	1,323	*	1,000-3,000	110-441
Ex-vessel value of catch ($000)	*	*	*	*	*	67	*	9,940	46-71
Treaty Indians ($000)	*	-	-	-	-	-	-	-	-
Wholesale Price ($/ton)	1,323	1,654	551	*	*	1,600-1,700	3,308	*	*
Wholesale value of catch ($000)	*	*	*	60,089	4,461	85	-	-	-
Number of Processors	9	27	3	55	*	-	5	15	3
Investment in processing plant and Equipment ($000)	480-540	1,400	210-225	*	*	-	*	900	1,500
Number of processing workers	*	164-191	15-20	*	*	-	*	*	141-156
Processing worker wage ($/hr)	5.00	3.60-3.75	6.00-7.00	*	*	-	4.00-4.50	6.00-7.00	5.50
Federal and state revenue ($000)	*	*	*	*	*	*	*	129	*

1. 1980 data is used wherever available, otherwise 1978 or 1979 data is used.
2. * indicates data not yet obtained, - indicates zero entry.

The variability in volume, and particularly value, of Pacific herring harvest for roe described in Table 5.2 for Washington and California, reflects the underlying bioeconomic characteristics of the roe fishery which makes up the majority of total harvest.

The roe herring fishery serves essentially one market--the Japanese kazunoko market. By contrast, other fisheries, such as salmon and groundfish, serve a variety of consumers in different regions with several end products. Price instability is an inherent characteristic of such a single purpose product demand.

Any change in kazunoko demand will result in an approximately equal change in the total demand for roe herring. There will not usually be offsetting shifts in demand among users which result in a smaller net shift in demand at the ex-vessel level. If kazunoko demand drops by 10 percent at a given price level, then so will the demand for roe herring. Demand may be maintained by a compensating change in price.

It would, however, take rather dramatic price changes to affect the consumption of a luxury product like kazunoko. Hence, since there are no other uses for roe herring, it would take substantial price changes to keep roe herring demand equal to supplies during any period in which significant changes in demand and price occur, as in 1979 (See Section 5.2.1.2).

Roe herring supply is determined by the harvest quotas which state management authorities establish. For biological reasons discussed elsewhere, these quotas very substantially from year to year. When these quota changes are made prices must also adjust to clear the market--i.e. force demand into equality with legally mandated supply. For the above reasons, the price changes required to clear the market have been, and will continue to be, quite large.

Table [illegible] Volume and Value of Pacific Coast Roe Herring Production (1973-1980).

Year	Washington Catch (metric tons)	Washington Ex-vessel Value (current dollars)	Washington Price Per Ton (current dollars)	California Catch (metric tons)	California Ex-vessel Value (current dollars)	California Price Per Ton (current dollars)
1973	1,831	366,000	200	1,279	107,680	84
1974	3,976	1,200.000	302	2,386	556,758	233
1975	3,570	811,000	227	1,104	219,720	199
1976	1,980	729,000	318	2,186	482,783	221
1977	2,089	1,040,000	498	4,444	1,333,200	300
1978	1,934	2,032,000	1,051	5,215	3,650,500	700
1979	1,737	3,489,000	2,009	4,218	5,061,600	1,200
1980	1,435	1,110,000*	774*	6,440	9,016,000	1,400

* Preliminary

A-4.45

An offshore herring fishery would necessarily supply demands for products other than kazunoko, as the roe of offshore herring is not fully developed. Initial indications are that herring harvested offshore would be marketed in Europe or Japan as food herring, or on the Pacific Coast as bait for the crab and other commercial pot or line fisheries. Test fisheries were conducted in 1979 and 1980 by several groundfish trawlers under Washington Department of Fisheries regulations. To date, the results of these tests are inconclusive from the standpoint of commercial profitability.

The major economic questions which must be addressed in this plan can be seen by assuming that such an offshore fishery could profitably harvest any of several optimum yields that might be established for an offshore herring fishery in the FCZ. Any optimum yield greater than zero for the purpose of establishing a U.S. offshore food and bait fishery will involve reductions in harvest by the inshore (primarily herring roe) fisheries.

The management objectives which will govern the determination of the optimum yield for an offshore fishery include both efficiency and equity considerations. Efficiency, maximizing the net economic value of herring harvests, was established as a secondary management objective. Equity considerations that were identified among the primary management objectives include maintaining the economic positions of U.S. inshore fishermen and preserving or enhancing U.S.-Canadian fisheries relations. The latter can be viewed as a desire, other things equal, to also protect the economic interests of Canadian inshore fishermen. Hence, relevant social and economic data, as displayed in the remainder of this section, are those which can be used to relate management alternatives (offshore optimum yields) to achievement of those objectives.

5.2 Markets

5.2.1 Japan

5.2.1.1 The Japanese Food Herring Market

Japan annually consumes about 60,000 mt. of dried, salted, frozen, fresh, smoked, and pickled herring for an average total raw material utilization of approximately 77,000 mt per year.

The raw material has been supplied for the most part by domestic landings and imports of roe herring caracass, and frozen whole or dressed herring. However, with the advent of extended fishery conservation zones, Japan's catch of herring has been greatly reduced. Future Japanese domestic landings have been predicted to be about 14,000 mt, or approximately 18 percent of past supply levels.

In 1977, British Columbia exported 21,000 mt of frozen whole or dressed herring to Japan. Future exports of about 10,000 mt are expected.

The U.S. has produced an average of about 3,000 mt of roe herring carcass over the past seven years; most of this production is frozen in the round for export. With the California roe herring fishery increasing to about 7,000 mt in 1980, California, Oregon and Washington could supply approximately 9,000 mt of roe herring carcass. Alaska's roe herring fishery could supply up to 30,000 mt, based on 1980 quotas. However, biomass estimates and other biological information from the 1980 fishery indicate that Alaska herring stocks may be declining.

With domestic supplies at about 14,000 mt and imports from the U.S. and Canada in the 40-60,000 mt range, Japan could still be as much as 20,000 mt short of past levels of supply unless herring are available from other countries.

Freshness and size of the herring are critical market requirements. Product should be frozen within 24 hours of harvest. To be marketed in Japan, food herring must be at least 17 cm in length (tip of snout to base of tail). Herring 20 cm and larger carry premium prices.

5.2.1.2 The Japanese Market for Herring Roe

The world market for herring roe is restricted almost exclusively to Japan. Roe is made into kazunoko, a food traditionally served during the Japanese New Year (the first three days of January). Until 1980, Japanese consumers were willing to pay high prices for this delicacy. However, with retail prices rising 300 percent from 1977 to 1979, to about $60 per pound, consumers boycotted kazunoko in 1980. This left an estimated 60 percent of 1979/1980 inventory unsold and dropped the wholesale price from about $26 per pound to about $4.

Before the era of extended jurisdiction, Japan took most of its herring from the Okhotsk and Bering Seas. As Japan lost access to those waters, imports have played an increasingly important role. Herring roe imports have ranged between 7,000 and 12,000 mt from 1974 to 1978. The reader should note that this is the actual weight of roe and not of whole herring. The roe averages about 10 percent of the body weight.

On the western side of the Pacific, the USSR, Mainland China, and North and South Korea have exported herring roe or whole herring to Japan. The USSR has a very large herring resources. Although the Soviets have a very high domestic demand, they have the capacity to supply the entire Japanese demand if they so choose. North Korea has access to considerable stocks of herring and, because of the balance of trade problems between the two countries, exports to Japan are likely to increase. South Korea and Mainland China have limited domestic supplies at this time, but do have access to herring from other areas and can be expected to continue exporting around 1,500 mt of herring roe to Japan each year.

British Columbia has been the main supplier of herring roe to Japan, with a market percentage increasing from 31 percent in 1972 to 63 percent in 1979. With the large drop in British Columbia roe herring landings since 1978 (63,400 mt in 1978, 37,500 mt in 1979, and 16,000 mt in 1980), it appears that at least in the near term, supplies from Canada will be lower than normal. The projection for herring roe exports from British Columbia to Japan is around 2,700 mt weight of herring roe for the next several years, an equivalent of approximately 27,000 mt of round herring.

California, Oregon and Washington exported an average of 7,100 mt of whole herring to Japan in 1974-78, for an equivalent of about 710 mt of roe per year. These fisheries are at near full utilization and the quantities available for export are likely to remain stable in the near future.

The future of the California, Oregon, Washington, and British Columbia sac-roe fisheries is difficult to predict. With regard to quantities demanded, these fisheries must compete with Alaskan and Asian fisheries which have the capacity to supply all of the presently unstable Japanese roe market.

With regard to potential revenues, it would be unwise to predict the success or failure of the 1980/81 sac-roe season before the 1980/81 market in Japan gets underway. The 1979/80 market was a disaster for Japanese wholesalers and the repercussions were felt by all sac-roe fishermen in the form of greatly reduced ex-vessel prices. Prices offered by Japanese buyers are not likely to reach 1978/79 levels again but, assuming a return to a stable Japanese market at past levels of consumption, ex-vessel prices will probably stabilize at between $500 and $1,000/mt.

There is good potential for increasing roe exports from Alaska due to the large herring stocks in the eastern Bering Sea. In 1979, all of Alaska supplied 1,500 mt of herring roe--in 1980, the Bering Sea quota for roe herring was 30,000 mt, an equivalent of 3,000 mt of roe.

5.2.2 Europe (Food Herring)

In the period 1971-1977, Europe produced an annual average of 443,000 mt of frozen, dried, salted, smoked, canned, and pickled herring products, requiring approximately 570,000 mt of raw material per year.

The northeast Atlantic and North Sea supplied the market until the late 1960s when, after years of overfishing, the herring biomass was reduced to near extinction. The situation remained serious throughout the 1970s and there is currently a total ban on directed fishing on two of the most important European herring stocks.

Landings from the main herring fisheries in northern Europe have declined from over 2,000,000 mt in the late 1960s to around 450,000 mt in the late 1970s. In the past, over 50 percent of the landings went for reduction but, with the reduced supply, increasing percentages of the catch are being utilized for food products, even though much of the catch does not meet previous food quality standards.

The reduced supply has driven up retail prices with the result that consumption has markedly declined. Nevertheless, domestic supplies of around 250,000 mt of food quality herring are only about half of what the market demands, creating a favorable situation for exporting nations.

Canada's east coast fishermen have stepped into this vacuum and are supplying increasing amounts of herring in various product forms. Canada exported approximately 60,000 mt of herring products to Europe in both 1977 and 1978. The New England herring fishery has also supplied about 10,000 mt per year of frozen herring to West Germany.

With supplies of herring still less than demand at present prices, there appears to be good potential for a European market for offshore herring, provided it meets the market's quality requirements.

Size is very important and price varies accordingly. There is a small and very selective market for herring that run 7-11 per kg (20-23 cm; 8-9 inches). However, the price for fish of this size is about 10 percent less than for larger herring that run 5-7 per kg (over 23 cm). The size distribution of herring in the U.S. FCZ is 17-23 cm, with a few reaching 26 cm.

Fat content is important and should be between 10-14 percent. Freshness is also a factor and the fish should be frozen or processed within 48 hours from the time of harvest.

5.2.3 United States

The main U.S. herring markets are for bait for the pot and line fisheries for crab, halibut and black cod. Herring is also used as bait in the sport and commercial troll salmon fisheries. Approximately 5,000 mt per year are used for all bait purposes--mostly supplied from southeastern Alaska.

Bait herring for commercial purposes is sold at $200-300 (ex-vessel) per ton. Onshore processing is limited to freezing the whole herring in 20-40 lb. boxes. Freshness is the main quality requirement, although size is somewhat important. Crab fishermen prefer herring at least 5 inches long and longline fishermen prefer 8-inch herring. Bait herring utilized by sport fishermen averages $600-800 per ton. Onshore processing requires keeping live herring in holding pens, sorting individuals by size, and packaging in small quantities. Recreational fishermen usually prefer 6-inch (plug size) herring.

5.3 Social and Legal Considerations

5.3.1 Nature and Extent of Indian Treaty Fishing Rights

In February, 1974, U.S. District Court Judge George Boldt ruled that treaties signed in the 1850s gave certain Indian tribes of Washington State fishing rights to salmon and steelhead. In April 1975, Judge Boldt convened a hearing on herring, especially concerning sac-roe fishing, to establish authority and responsibility of the tribes and the Washington Department of Fisheries. Judge Boldt ruled that 11 tribes had established rights to fish herring; only four of these can fish in the present Washington sac-roe fishery.

Washington State limited entry legislation does not apply to Treaty fishermen. Treaty fisherman participation in the sac-roe fishery has increased substantially as the fishery prospered. Treaty fishermen currently participate in the other Washington herring fisheries only to a limited degree. There are currently no recognized treaty rights in the herring fisheries of Oregon or California.

5.3.2 Recreational Interests in the Fishery

California's recreational herring fishery occurs during the spawning season at San Francisco Bay and the Noyo River. Catches are not available but are considered to be minor. The fishery is controlled by a 50 pound daily limit.

Herring eggs on seaweed are also taken in San Francisco Bay by recreational fishermen. This fishery is controlled by a 25 pound (including plants) wet weight daily limit. Currently, in Washington and Oregon there is a very limited harvest of herring for recreational purposes. Sport fishermen take herring with "jigs" (multiple unbaited hooks) or dip nets. Some recreationally-caught herring are pickled or smoked for human consumption. Herring are also used as bait in other recreational fisheries. The daily limit of personal-use herring in Washington is 20 pounds per person and the Oregon limit is 25 pounds per person.

5.3.3. Community Dependence on Herring Fisheries

The herring roe fishery occurs during the winter and spring and employs many otherwise idle fishermen and processors. It is a welcome economic boost to communities involved, but herring production is small relative to total fisheries harvests, even at Bellingham, Washington and San Francisco, California where a substantial share of each states harvest is landed. Small communities within these larger areas may have a high seasonal dependence on herring. This is probably true for the Lummi Indian reservation near Bellingham, and for other areas such as Turlock, California. It is unlikely that an offshore fishery would comprise more than a small fraction of the economic base of communities in which the catch is landed, or where herring fishermen reside. Hence, there is little reason to consider secondary economic or social impacts of herring management alternatives on the non-fishing residents of these communities.

5.4 Interaction Between and Among User Groups

5.4.1 Inshore Roe Fishery

The assessment of effects of offshore herring fishing on inshore herring fisheries is based on the following estimates or assumptions, supported elsewhere in this plan:

1. In the case of a single stock offshore fishery, there will be a relationship between the level of offshore catch and the reouction in inshore biomass, determined by the natural mortality experienced by the stocks on their inward migration. Best estimates of natural mortality during this phase of the herring life cycle indicate that about 20 percent of the population available to the offshore fishery is lost to natural mortality before it is available to the inshore fishery.

2. The effects on inshore fisheries of a fishery in FCZ waters off northern Washington are complicated by the fact that an offshore fishery would harvest mixed stocks which spawn in Washington and British Columbia. This difficulty can be resolved by using the experience of the Atlantic herring fisheries that has shown that mixed stock fishing removes the fish in proportion to their stock abundance. However, as the individual stocks move to their inshore spawning grounds, they must separate from each other. If this separation begins in offshore waters, then an individual spawning stock could be harvested at a greater rate than if complete mixing occurred. For example, if herring from the west coast of Vancouver Island move north from the transboundary area in late fall or early winter, herring from Washington state would be mixed only with British Columbia spawners from the east side of Vancouver Island.

   If proportional harvesting occurs for Pacific herring in offshore waters, the effects on each inshore stock will be proportional to its share of total inshore biomass. Based on spawning stock estimates from southern British Columbia and Washington, it appears that of the herring that survive the inward migration, approximately 80 percent return to Canadian waters and 20 percent to U.S. waters.

3. Only about half of the Washington herring (or 10 percent of the total) return to areas where a sac-roe fishery is permitted. The other half return to spawning grounds in areas closed to sac-roe fisheries. Nearly all of the herring returning to Canada are susceptible to inshore fishing.

A reduced herring biomass available to inshore fisheries cannot necessarily be translated directly into lost revenues.

At one extreme, reduction in biomass by an offshore fishery would completely shut down the inshore fishery in order to maintain necessary spawning escapement. At the other extreme, only a proportion (20% in Washington, Oregon and California) of the inshore reduction would be lost to inshore harvest. In this latter case, however, the remainder of the inshore reduction would be lost to spawning escapement.

The Washington fisheries can be used as an example of the effects of offshore fishing on inshore stocks. The Washington sac-roe fisheries are managed on a percentage of biomass basis. Once a minimum adult herring biomass (9,000 short tons) has been shown to be present, 20% of that biomass is available for harvest. Below 9,000 tons no fishery is allowed. Table 5.3 shows the impact per 1,000 tons of catch in the U.S.-Canada transboundary area on inshore biomass. Two hundred tons are of U.S. origin, and 800 tons of Canadian origin. At 20% natural mortality following the offshore fishery, only 800 tons would naturally be lost to the inshore fishery (160 tons would be lost to the inshore stocks of Washington, and 640 tons to the inshore stocks of British Columbia). Only 50% (80 tons) of these Washington herring would have been available for roe harvest. At a 20% harvest rate of the remaining inshore biomass, 16 tons would be lost to harvest and 64 tons would be lost to spawning escapement. If management procedure requires that the 20% harvest rate applies to a stock throughout its range, then the inshore harvest will have to be reduced further to compensate for the additional fishing mortality offshore; in this case, the full reduction of inshore biomass will be lost to inshore harvest. As offshore harvest increases, the total inshore biomass decreases toward the 9,000 ton biomass limit for sac-roe fishing. This type of management approaches a situation of harvesting all herring above a

Table [illegible] Loss of inshore herring biomass resulting from offshore harvest in the U.S.-Canada transboundary area, per 1,000 tons of catch.

Category	United States Component (20%)	Canada Component (80%)	Total
Offshore catch	200 tons	800 tons	1,000 tons
Offshore mortality	(20%)	(20%)	
Loss to inshore biomass	160 tons	640 tons	800 tons
% available to roe fishery	(50%)	(100%)	
*Biomass available to roe (harvest 20% of available biomass)	80 tons	640 tons	720 tons
Roe harvest rate	(20%)	(all above threshhold)	
Roe harvest loss	16 tons	640 tons	656 tons
Spawn escapement loss, roe areas	64 tons	0	64 tons
*Biomass available to roe (maintain constant harvest rate)	80 tons		
Roe harvest loss	80 tons		
Spawn escapement loss, roe areas	0 tons		
Biomass unavailable to roe	80 tons	0	
Spawn escapement loss, non roe areas	80 tons	0	80 tons
Total inshore harvest loss (alternate 1)	16 tons	640 tons	656 tons
Total inshore harvest loss (alternate 2)	80 tons		
Total spawn escapement loss (alternate 1)	144 tons	0	144 tons
Total spawn escapement loss (alternate 2)	80 tons		
Total inshore loss	160 tons	640 tons	800 tons

* Alternate concepts

spawning escapement threshhold. The herring management strategy model (Section 7.0; Appendix II) shows that this generates an unstable harvest and biomass situation, with years of no harvest being probable.

The remaining 80 tons of Washington herring removed by the offshore fishery would most probably be lost to spawning escapement in areas of no roe fishery, rather than to reduced harvest.

As the fishery for sport bait targets on prereproductive herring which have not yet entered offshore waters, an offshore harvest would not directly affect the abundance of bait-sized herring. However, harvesting both juvenile and adult herring from the same stock can and has led to serious stock depletion (Melteff and Wespestad, 1980). The bait fishery would be reduced if additional mortality from an offshore harvest should seriously reduce recruitment. In the absence of a clear spawner-recruit relationship, it is not possible to determine the level of adult harvest which can safely be combined with juvenile harvest. Washington Department of Fisheries regulations minimize access to adult herring in areas where juveniles are the target of a commercial fishery.

The winter general purpose fishery harvests adult herring during a period of migration when their spawning ground destination is unknown. It is not clear if these fish are a portion of single stock, a total single stock, or a mixture of several stocks. The harvest is keyed to the general abundance, but without spawning escapement goals. Declines in the biomass would tend to lower harvest. However, fluctuations in availability of herring to the general purpose fishery may depend more on vagaries of stock composition or proportion of a stock involved than on the absolute magnitude of stock(s) abundance.

In British Columbia however, the entire biomass in excess of the desired (optimum) amount of spawners is available for harvest. Thus, a reduced biomass would either come entirely out of the fishermen's share, or would close the fishery if the biomass fell below the optimum spawning escapement level.

The assumptions above provide the basis for the following determination of the economic effects of establishing alternative optimum yields for an offshore herring fishery. A 1,000 mt offshore herring fishery would reduce the Canadian and Washington inshore roe fisheries harvest by 640 and 16 mt respectively. When offshore and inshore harvests are evaluated using the best estimates of roe and offshore ex-vessel values (Table 5.4), the effects on value of catch are as follows: the 1,000 mt of offshore catch adds $475,000 to the value of U.S. herring harvest; the reduction in inshore U.S. herring harvest is evaluated at $16,000, resulting in a net gain in the value of U.S.

herring harvest of $459,000. However, if reduced Canadian inshore harvest are also included, the loss in inshore harvest value is $656,000, resulting in a net loss of $181,000 in the overall value of herring harvests. For a 5,000 mt offshore harvest the gain in U.S. harvest value is $2,295,000 and the loss overall value is $905,000. For 10,000 mt offshore harvest the gain in U.S. harvest value is $4,590,000 and the loss in overall value is $1,810,000.

Obviously the exact nature of these trade offs will depend upon the biological and economic assumptions that underly the above calculations, particularly the prices used to evaluate inshore and offshore harvests.

However, the magnitudes of economic gains and losses are significant enough to support the conclusion that, for most reasonable assumptions, the shifting of herring from inshore to offshore harvest will increase the average value of U.S. herring harvest, but will decrease the average value of the combined U.S. and Canadian harvest.

The California herring roe fishery would also be heavily impacted by an offshore food fishery in waters adjacent to the state. Monterey Bay is the only area off California where commercial quantities of herring are known to occur during the oceanic phase of their life history. Assumming an offshore mixing of stocks, a food herring fishery in Monterey Bay would probably impact both Tomales and San Francisco Bay stocks proportionally. Since the San Francisco Bay stock is much larger than the Tomales Bay stock, the economic effect of the food fishery will be illustrated as if the entire catch were from the San Francisco Bay stock.

Table 5.4 Impact of an Offshore Herring Fishery Adjacent to Northern Washington on Ex-vessel Value of Harvest.

(thousands of dollars per year)

	Offshore Harvest (metric tons)		
	1,000	5,000	10,000
Increased offshore catch value[1]	475	2,375	4,750
Reduced inshore catch value[2]			
*Washington (20% of available biomass - alternate 1)	16	80	160
*Washington (maintain constant harvest rate - alternate 2)	80	400	800
Canada	640	3,200	6,400
Net impact on ex-vessel value of herring harvest			
Total (U.S. and Canadian) - alternate 1	-181	-905	-1,810
Total (U.S. and Canadian) - alternate 2	-245	-1,225	-2,450
U.S. only - alternate 1	+459	+2,295	+4,590
U.S. only - alternate 2	+395	+1,975	+3,950

1 Evaluated at $475/metric ton.
2 Evaluated at $1,000/metric ton.
* Alternative concepts

The roe herring quota in San Francisco Bay established at the end of the preceeding season. Part or all of this quota could be designated for an offshore food fishery. A quota of 10,000 tons is used for illustration.

The roe fishery is a terminal fishery, taking place on the spawning grounds when annual mortality has reduced the stock to its lowest level. The fall offshore food fishery takes place when approximately 80% of the annual natural mortality has been experienced by the stock. Thus the stock offshore is 20% larger than the same stock when it arrives at the spawning grounds. It follows that a 10,000 short ton inshore roe fishery quota would be equivalent to a (80% of) 12,500 ton quota if taken offshore. At one extreme, a 12,500 short ton catch offshore would remove 10,000 short tons from the stock by the time the stock reached the spawning grounds and would eliminate the roe herring fishery.

Using 1981 values of $1,000/short ton for roe herring and $475/short ton for food herring, any amount of offshore fishing for food herring would result in a net loss in total value of the overall fishery (Table 5.5).

A 5,000 to 12,500 short ton offshore food herring fishery would result in net losses between $1,625,000 and $4,063,000 in the ex-vessel value of the fishery. Economic losses of this magnitude are counter to the goals of this plan.

Average value over time is not, however, the only relevant object of economic choice. The inshore roe harvest will always be subject to a high degree of variability in ex-vessel prices. The reasons for this variability, as discussed above, are its dependence on a single specialized luxury market in Japan. By contrast, an offshore fishery of any size would most likely supply the more diverse food and bait herring markets in Europe, Japan, and the U.S.

During the development phase of such a fishery, there would certainly be a high degree of instability until harvest and processing techniques were developed and products gained acceptance. But once these obstacles are overcome, the fishery would have access to a far broader range of destination markets and end uses than will ever be accessible to a roe fishery. Hence, if it succeeds commercially, an offshore fishery should ultimately achieve more stable prices as well.

Table 5.5 Impact of Offshore Herring Harvest Adjacent to Central California on Ex-vessel Value of the San Francisco Bay Herring Fishery1/

	Offshore Harvest Options				
Offshore harvest2/	0	1,000	5,000	10,000	12,500
Offshore price ($/ton)	475	475	475	475	476
Ex-vessel value ($000)	0	475	2,375	4,750	5,937
Roe harvest3/	10,000	19,200	6,000	2,000	0
Roe price ($/ton)	1,000	1,000	1,000	1,000	1,000
Ex-vessel value ($000)	10,000	9,200	6,000	2,000	0
Total value ($000)	10,000	9,675	8,375	6,750	5,937
Net loss ($000)	--	325	1,625	3,250	4,063

1/ Assume entire offshore harvest is from San Francisco Bay stocks.

2/ California establishes quotas and keeps catch records in the English system.

3/ The 1981-82 roe fishery quota in San Francisco Bay is 10,000 short tons.

It is a well known business practice to prefer stability of costs and revenues and, in some cases, to even pay something in average returns for greater stability. Individuals who purchase insurance reflect this preference, as do investors who accept lower returns on more secure investments.

Such a preference for stability can be expressed quantitatively by using a lower interest rate to discount the more stable of two alternative benefit streams. In this case, the more stable benefit stream is the value of offshore herring harvests over time. Table 5.6 reports the annual and discounted present value of one ton of herring biomass, depending on whether it is harvested offshore or allowed to migrate inshore. In each case the undiscounted stream of revenue is assumed to continue in perpetuity.

The inshore harvest value is discounted at 10 percent in all cases, resulting in a present value of U.S. and Canadian harvest equal to $6,560 per mt of herring allowed to migrate inshore. However, if taken offshore, a range of lower discount rates is applied, from 10 percent to 6.5 percent. As Table 5.6 indicates, the breakeven point is 7 percent. That is, if the increased certainty associated with supplying a more diverse market is deemed to be worth a premium equivalent to a 3 percent return investment, then a U.S. offshore fishery will improve economic efficiency, as evaluated from a standpoint that recognizes both U.S. and Canadian interests. If a lower premium is attached to this gain in stability, then an offshore fishery will detract from economic efficiency.

5.4.2 Sport Bait Fishery

The Washington herring fishery for sport bait targets on prereproductive, juvenile herring. Although some harvest of adults occurs, management ractices severely limit the opportunity to catch adult herring in sport bait reas, because intensive harvests of juveniles and adults are incompatible. A everal thousand ton offshore herring fishery will remove considerably more dult herring than currently taken.

year class will virtually all pass through the sport bait fishery before eing vulnerable to an offshore fishery. An offshore fishery will not irectly remove herring from the age groups targeted on by the bait fishery.

Table 5.6 Impact of an Offshore Fishery on the Present Value of Herring Harvests

Ex-vessel value per ton		U.S. Only			U.S. and Canadian		
		If Taken Offshore	If Allowed To Migrate Inshore	Gain or Loss From Offshore Harvest	If Taken Offshore	If Allowed to Migrate Inshore	Gain or Loss From Offshore Harvest
Annual		475	16	459	475	656	(181)
Present value of perpetuity							
roe fishery discounted at	roe fishery discounted at						
.100	.100	4,750	160	4,590	4,750	6,560	(1,810)
.100	.095	5,000	160	4,840	5,000	6,560	(1,560)
.100	.090	5,278	160	5,118	5,278	6,560	(1,282)
.100	.085	5,588	160	5,428	5,588	6,560	(972)
.100	.080	5,938	160	5,778	5,938	6,560	(622)
.100	.075	6,333	160	6,173	6,333	6,560	(227)
.100	.070	6,786	160	6,626	6,786	6,560	226
.100	.065	7,308	160	7,148	7,308	6,560	748

A-4.62

However, the combined removals of adult herring will be a management concern should an offshore fishery be authorized, because increased harvest of adults would be counter to the management philosophy of the sport bait fishery.

5.4.3 User/Interest Group Perspectives on Management Goals

This section describes an empirical study conducted to elicit user/interest group perspectives on the following eight management goals considered by the Council in the development of the Pacific Herring Fishery Management Plan.

1. Increase the sum of net economic returns to all participants in the fishery (fishermen, processors, consumers; inshore and offshore).
2. Improve relevant noneconomic participation values, including the recognition of Indian treaty rights.
3. Increase the diversity of fishing opportunities available to U.S. fishermen.
4. Provide adequate forage for predator species.
5. Improve the effectiveness and public acceptability of management, and reduce its cost.
6. Prevent significant reductions in the harvests of existing fisheries.
7. Provide for the optimal management of transboundary stocks.
8. Encourage the use of herring for food.

e sample consisted of eight Pacific Council Advisory Panel (AP) members and ght additional subjects recommended by the AP. Roe fishermen were nsidered in one category despite the fact that they resided in different ates. Similarly, a charter vessel representative was considered together th recreational fishermen.

Two general perspectives emerge from an analysis of the results: a majority perspective and a minority perspective.

Majority Perspective

Twelve of the sixteen subjects agreed that prevention of significant reductions in the harvests of existing fisheries, and provision of adequate forage for predator species were the two most important considerations in the management of the offshore herring fishery. The lack of knowledge of the effects of an offshore fishery, economic self interest, and the reliance of salmon on herring for food were the main reasons given for the importance assigned to these two management goals.

There was also a general consensus among the majority group that the goal of improving of non-economic participation values, including the recognition of Indian treaty rights, was the least important goal. The low importance given to this goal was due to this goal's lack of regard for the importance of economic benefits. Most commercial fishermen are very sensitive to management decisions that might affect their income and are therefore opposed to management goals that downplay the importance of economics in fishery management. Other reasons given for assigning low priority to this goal revolved around individual opposition to Indian treaty rights, and from a lack of understanding of the meaning of the goal.

Increasing the diversity of fishing opportunities available to U.S. fishermen and encouraging the use of herring for food were also given low priority. There was skepticism concerning the viability of the offshore fishery as well as fear that offshore fishing would lead to depletion of herring resources.

Minority Perspective

Four of the sixteen subjects shared a minority perspective favoring offshore fishery development. Encouraging the use of herring for food and increasing the diversity of fishing opportunities available to U.S. fishermen were considered highest priority. Some of the reasons for the high priority given to these goals included the importance of utilizing the herring resource for human consumption, the perception that a food market exists for the offshore herring.

Like the majority group, the minority group gave lowest priority to improving noneconomic participation values, including the recognition of Indian treaty rights. They offered similar reasons for doing so.

The minority group reacted with skepticism to the two goals which received highest ratings with the majority group, prevention of significant reductions in the harvests of existing fisheries, and provision of adequate forage for predator species. The minority group was sensitive to the fact that offshore herring populations are possibly related to the inshore herring fisheries and offshore salmon fisheries. Until the relationships are established, they felt there should be no blanket condemnation of an offshore fishery. The general attitude was that if there are unutilized resources in the offshore waters, they should be made available to offshore fishermen.

6.0 BIOLOGICAL AND ENVIRONMENTAL CHARACTERISTICS

6.1 Life History Features

6.1.1 Distribution and Migration

The Pacific herring is found along the North American coast from Baja California to Cape Bathurst in the Beaufort Sea. The Asian distribution is from the Lena River in the Arctic Ocean to Korea (Hart, 1973).

Abundance south of British Columbia is irregular and commercial quantities occur only in limited areas. In the California-Washington region, large commercial quantities of herring are found in Tomales Bay and San Francisco Bay in central California (Spratt, in prep.) and in northern Washington (Trumble, 1980). Only small separated populations have been observed in the large area from north of Tomales Bay to northern Washington.

Pacific herring aggregate in ocean feeding grounds from late spring to early autumn. They then commence an inshore migration, spawn during the winter and spring, and subsequently move offshore to feed.

6.1.2 Spawning

Pacific herring generally deposit their adhesive eggs on marine vegetation in the intertidal and shallow subtidal zones in a range of about +2m to -7m in tidal elevation. The type of vegetation or substrate used depends mainly on the spawning locality. In sheltered bays and along sandy beaches the dominant substrate is eel grass, *Zostera marina* (Taylor, 1964), along rocky shores a variety of algae.

Herring eggs incubate on the vegetation for about two weeks. Hatching time is dependent upon temperature and other factors (Outram and Humphreys, 1974; Galkina, 1971). Initial spawn density varies from an egg or two per square inch of substrate surface to upwards of 2,000 eggs per square inch in layers six to eight eggs thick. Predation by birds, fishes and other animals, thermal stress, desiccation (for spawn exposed during low tides) and wave action all cause mortality during incubation (Outram, 1958; Taylor, 1971a; Jones, 1972; Dushkina, 1973). Mortality rates during the incubation period vary from year to year in an unpredictable manner depending on weather, spawn intensity and predator population levels. Thus, there is no clear-cut relationship between the numbers of eggs deposited and the eventual number of fish hatching and surviving to adulthood (Taylor, 1963).

6.1.3 Larval Development

At hatching, herring larvae average 8mm in length. Immediately after ıatching, the larvae have no swimming ability and are dispersed by tidal :urrents. About one week after hatching, the larvae, about 10mm in length, ıave absorbed their yolk sacs and have been feeding on tiny planktonic ›rganisms. About six weeks after hatching, they are approximately 20mm in ength and start developing swimming powers. At about 10-12 weeks in age, the arvae are about 30mm in length and undergo metamorphosis from the slender, early transparent larval form to the green/silver form recognizable as erring.

atural mortalities of herring during the larval stages, as with the ıcubation period, are generally very high due to predation, competition and arvation. Cushing and Harris (1973) suggest that year class strength is termined by density dependent factors during the larval drift period.

1.4 Juvenile Development

›n completion of metamorphosis, juvenile herring are free swimming and begin form shoreline oriented schools. The schools enlarge and move out of the 's as summer progresses (Taylor, 1964).

enile herring from many areas of British Columbia migrate to offshore ding areas during the late spring-early fall period in their first year of e. In central and southern Puget Sound, most juvenile herring overwinter migrate to offshore feeding grounds from March to July.

The distribution of juveniles in Oregon and California has not been extensively investigated but limited data suggest that their migrations follow the general pattern of the juveniles in northern areas.

Very little is known about the juvenile stage from the time they leave the inshore waters in their first summer until they are recruited to the adult population.

6.1.5 Offshore Life History

Little information is available regarding the distribution, abundance, behavior, and ecological relationships of herring once they arrive in offshore feeding areas. One of the more recent and productive studies was a cooperative trawl/hydroacoustic survey conducted by the NMFS, WDF, and Canada in the area off northern Washington - southern Vancouver Island during the late summer of 1979 (unpublished ms. Nelson & Munnalle). This study resulted in a total estimated biomass of 213,563 mt with 31,000 mt (14.6%) found on Cape Flattery Spit in U.S. waters and the remained on LaPerouse Bank (114,671 mt) and Swiftsure Bank (41,631 mt) in Canadian waters. Other Canadian studies have indicated a higher proportion of the biomass occurred in U.S. waters. No significant amount of herring were seen in other parts of the surveyed area. The ecological relationships of offshore herring are not understood, but herring, Pacific whiting, and dogfish sharks were the most abundant species taken in trawl hauls accounting for 94% of the weight of the total catch. Incidental catches of salmon occurred in 17 midwater trawl hauls aimed at herring concentrations. The highest incidence occurred on Swiftsure and La Perouse Banks in Canadian waters where 14 and 41 lbs. of salmon per metric ton (mt) of herring, respectively, were observed in catches. On Cape Flattery Spit in U.S. waters, the incidence was only 1.5 lbs. of salmon per mt of herring caught.

The biological data suggest that one-and two-year old herring do not associate with adults offshore. Two-year-olds were found in the same area as adults, but they seemed to maintain discrete schools. It appeared that new recruits begin joining adult schools at three yers of age, but even the three-year-olds may not be fully recruited until late in the year when the shoreward spawning migration occurs. Further study is needed to confirm this apparent behavior.

action all cause mortality during incubation (Outram, 1958; Taylor, 1971a; Jones, 1972; Dushkina, 1973). Mortality rates during the incubation period vary from year to year in an unpredictable manner depending on weather, spawn intensity and predator population levels. Thus, there is no clear-cut relationship between the numbers of eggs deposited and the eventual number of fish hatching and surviving to adulthood (Taylor, 1963).

5.1.3 Larval Development

\t hatching, herring larvae average 8mm in length. Immediately after ıatching, the larvae have no swimming ability and are dispersed by tidal :urrents. About one week after hatching, the larvae, about 10mm in length, ave absorbed their yolk sacs and have been feeding on tiny planktonic rganisms. About six weeks after hatching, they are approximately 20mm in ength and start developing swimming powers. At about 10-12 weeks in age, the arvae are about 30mm in length and undergo metamorphosis from the slender, early transparent larval form to the green/silver form recognizable as erring.

ıtural mortalities of herring during the larval stages, as with the ıcubation period, are generally very high due to predation, competition and :arvation. Cushing and Harris (1973) suggest that year class strength is :termined by density dependent factors during the larval drift period.

1.4 Juvenile Development

on completion of metamorphosis, juvenile herring are free swimming and begin form shoreline oriented schools. The schools enlarge and move out of the ys as summer progresses (Taylor, 1964).

/enile herring from many areas of British Columbia migrate to offshore ading areas during the late spring-early fall period in their first year of 'e. In central and southern Puget Sound, most juvenile herring overwinter i migrate to offshore feeding grounds from March to July.

The distribution of juveniles in Oregon and California has not been extensively investigated but limited data suggest that their migrations follow the general pattern of the juveniles in northern areas.

Very little is known about the juvenile stage from the time they leave the inshore waters in their first summer until they are recruited to the adult population.

6.1.5 Offshore Life History

Little information is available regarding the distribution, abundance, behavior, and ecological relationships of herring once they arrive in offshore feeding areas. One of the more recent and productive studies was a cooperative trawl/hydroacoustic survey conducted by the NMFS, WDF, and Canada in the area off northern Washington - southern Vancouver Island during the late summer of 1979 (unpublished ms. Nelson & Munnalle). This study resulted in a total estimated biomass of 213,563 mt with 31,000 mt (14.6%) found on Cape Flattery Spit in U.S. waters and the remained on LaPerouse Bank (114,671 mt) and Swiftsure Bank (41,631 mt) in Canadian waters. Other Canadian studies have indicated a higher proportion of the biomass occurred in U.S. waters. No significant amount of herring were seen in other parts of the surveyed area. The ecological relationships of offshore herring are not understood, but herring, Pacific whiting, and dogfish sharks were the most abundant species taken in trawl hauls accounting for 94% of the weight of the total catch. Incidental catches of salmon occurred in 17 midwater trawl hauls aimed at herring concentrations. The highest incidence occurred on Swiftsure and La Perouse Banks in Canadian waters where 14 and 41 lbs. of salmon per metric ton (mt) of herring, respectively, were observed in catches. On Cape Flattery Spit in U.S. waters, the incidence was only 1.5 lbs. of salmon per mt of herring caught.

The biological data suggest that one-and two-year old herring do not associate with adults offshore. Two-year-olds were found in the same area as adults, but they seemed to maintain discrete schools. It appeared that new recruits begin joining adult schools at three yers of age, but even the three-year-olds may not be fully recruited until late in the year when the shoreward spawning migration occurs. Further study is needed to confirm this apparent behavior.

6.1.6 Maturation and Fecundity

It appears that the onset of sexual maturity occurs earlier in the Pacific herring's southern range and progressively later proceeding northward. Stocks in California mature at 2 and 3 years of age (Spratt, in press) whereas herring in Washington and British Columbia mature between ages 3 and 4 (Trumble, 1980; Outram and Humphreys, 1974). Bering Sea herring spawn for the first time at ages 2-6 but the majority do not spawn until ages 3 to 5 (Barton, 1978).

Paulson and Smith (1977) reported an apparent decrease in fecundity at a specific length with increasing lattitude which is offset by a larger mean length at age for reproductively active females.

Average fecundity is about 20,000 eggs per female. Fecundity by age for selected populations is presented in Table 6.1. Eggs per female from most areas range from slightly under 10,000 for age 2 herring to over 40,000 for age 7 herring (Rabin and Barnhart, 1977; Katz, 1948; Nagasaki, 1958).

.1.7 Age and Growth

acific herring have been found to attain an age of 15 years (Barton, 1978) ut they generally occur in fisheries of the California-Washington region from ges 2-6 (Spratt, 1976; Day, 1980). Examples of age compositions of pulations from selected areas are presented in Figure 6.1. Conclusions awn from age composition data from any one year should be made with caution nce many variables (recruitment, fishing mortality, natural mortality, omalies in availability, fishing gear and methods, etc.) may cause gnificant year-to-year shifts in age composition within the overall age ructure of the population.

gure 6.2 shows a generalized growth curve for Pacific herring. At the end the first year of life, herring reach 9-10cm in length. By age 3-4 (first wning), their average length is about 16-18cm. Growth slows markedly after 4 in most stocks, the average length at age 8 being about 22cm.

Table 6.1. Fecundity versus age for Pacific Herring of various regions. Modified from Paulson and Smith, 1977.

	Humboldt Bay[a] California		Puget Sound[b] Washington		Southern[c] British Columbia		Northern[c] British Columbia		Prince William Sound Alaska	
Age	Fecundity	Sample Size	Fecundity	Sample Size	Fecundity	Sample Size	Fecundity	Sample Size	Fecundity	Sample Size
I			8,808	11	10,244	4				
II	12,874	11	15,815	17	14570	48	14,298	10	13,992	4
III	24,545	5	16,842	8	18,811	65	20,416	153	17,965	21
IV	28,637	5	26,414	2	22,404	29	24,695	45	22,528	26
V	36,286	3	38,376	1	25,695	7	31,098	19	23,391	98
VI	45,373	3	35,279	2	27,072	1	41,052	4	24,347	7
VII	42,101	3	39,914	1	26,287	1	34,639	1		
Mean Length of Spawning Females	181mm		169mm		195mm		197mm		212mm	

a/ Rabin and Barnhart (1977)
b/ Katz (1948)
c/ Nagasaki (1958)

A-4.72

Growth rates may consistantly vary between populations, even within small geographic areas. Von Bertalanffy growth parameters for several Pacific and Atlantic herring stocks are shown in Table 6.2.

6.1.8 Food and Feeding

Herring larvae start feeding on small planktonic organisms. During the postlarval stage, they consume a wide variety of organisms, among the most important are copepods, mollusc larvae and pelagic eggs. The predominant food of adult herring appear to be macrozooplankton, primarily copepods and euphausiids.

Herring search out and choose their prey rather than filtering the water indiscriminately. They are opportunistic feeders and will take what food becomes available. Larval herring, at the earliest stages, are size selective in seeking prey but become more opportunistic as their ability to capture a wide range of prey species increases. Their intensity of feeding varies with area and time of year. Mature herring feed most intensively in the spring after spawning and during the summer; they feed lightly in fall and winter.

5.1.9 Natural Mortality

Mortality is highly variable during embryonic development. Taylor (1964) found that egg mortality in British Columbia ranged from 55-99% and averaged 0-80%. Recent studies in British Columbia, however, have concluded that mortality during the eggs life averages less than 20 percent (Haegele, et al, 981). In the Strait of Georgia, Washington, egg mortality ranges from 90 to 9 percent (Palsson, pers. comm.). Major causes of mortality are wave action, xposure to air (desiccation and freezing) and bird predation.

Juvenile mortality is likely more similar to adult mortality in magnitude and egree of variation than to larval mortality. In years of high egg and larval urvival, juvenile mortality could be very high from intraspecific competition or food and from increased predation.

Table 6.2 Von Bertalanffy growth parameters for selected stocks of Pacific and Atlantic herring.

	L∞ (mm)	K	Reference
Pacific			
San Francisco Bay, CA	208	.59	Spratt, Pers. comm
Tomales Bay, CA	224	.47	Spratt, pers. comm
Case Inlet, WA	197	.59	Trumble, 1979
Carr Inlet, WA	230	.48	Trumble, 1979
Strait of Georgia, WA	263	.36	Trumble, 1979
Bristol Bay, AK	299	.18	Warner, 1976
Eastern Bering Sea, AK	314	.35	Bering/Chukchi Sea Herring Plan
Atlantic[1,2]			
Western Gulf of Maine	346	.40	
Georges Bank	333	.51	

1/ From "Environmental Impact Statement/Fishery Management Plan for the Atlantic Herring Fishery of the Northwest Atlantic". Prepared by the New England Fishery Management Council.

2/ 1968-1971 year classes.

Herring are preyed upon in their juvenile stages of their life cycle by invertebrates, and at other stages by fishes, birds, and mammals. Most herring predators have an opportunistic, nonselective diet and feed on the most conveniently available prey species of the proper size. The importance of herring as a food item in an area varies in different months and years (Macy et al., 1978).

Natural mortality rates of 0.20 to 0.85 were estimated for herring stocks in southeastern Alaska and British Columbia (Skud 1963; Tester, 1955). The rates in British Columbia were found to decrease from south to north and the rate for a given age in southeastern Alaska was lower than in British Columbia. The instantaneous natural mortality of eastern Bering Sea stocks was estimated to be 0.47 (North Pacific Fishery Management Council, 1979). Total mortality (Z) estimates of Straight of Georgia roe herring, using regression techniques, have been calculated to range from 0.45 to 0.57 (Trumble, pers. comm.). Assuming an average annual exploitation rate of 20% (F = 0.22), preliminary estimates of instantaneous natural mortality would be approximately 0.23-0.35. Other stocks in Puget Sound, currently unexploited as adults, have total mortality (Z = M) calculated as 0.5 (Trumble, pers. comm.).

6.2 Stock Units

6.2.1 Biological Determination of Stock Units

Intensive spawning ground surveys have documented the existence of large spawning stocks of herring in San Francisco and Tomales Bays in California and in the Strait of Georgia in Washington. Minor spawning stocks have also been identified in many bays and estuaries along the coasts of northern California, Oregon, southern Washington, and in Puget Sound, Washington. Spawning stocks also exist along the east and west coasts of Vancouver Island close to the U.S.-Canada border.

It is likely that stocks intermingle extensively on the summer offshore feeding grounds and thus are not amenable to single stock management in the

FCZ. Accordingly, three management units have been established which best delineate stock groupings for effective management:

1. Southern Management Area - U.S./Mexico border to Cape Mendocino, California (40°30'N. latitude). Large stocks of herring from San Francisco and Tomales Bays are present in this area which are currently heavily exploited in inshore waters.

2. Central Management Area - Cape Mendocino, California to Cape Elizabeth, Washington (40°30'N. to 47°20'N. latitude). Small stocks are present in and adjacent to embayments in this coastal area. Fisheries are small in this area.

3. Northern Washington - Cape Elizabeth to U.S./Canada boundary (North of 47°20'N. latitude). Spawning stocks from British Columbia and Puget Sound form mixed stock aggregations in the U.S./Canada transboundary area but can be managed by the Council only in the U.S. portion. Stocks in U.S. and Canada are heavily exploited in inshore waters.

6.2.2 Condition of the stocks

The current status of herring stocks can be described from trends in abundance estimates made through direct observations (spawning escapement, catch, hydroacoustic) and from changes of age composition through a series of years (cohort analysis).

Four major geographic areas contribute to herring aggregations in the FCZ. Two of these are Canadian areas (western Vancouver Island and eastern Vancouver Island). Canadian spawning escapement estimates suggest that the herring stocks in these areas are stable. In U.S. waters, stocks in one area (Northern Puget Sound--Strait of Georgia) have shown a declining trend, while in the other (San Francisco Bay) they have been increasing.

Only in Canada are data available to estimate abundance trends for more than eight years. Canadian scientists estimate that present abundance corresponds closely to the peak abundance estimated for the reduction fishery of southern

Vancouver Island during the early 1960's. The western Vancouver Island stock has been estimated at about 108,000 tons and the eastern Vancouver Island stock at about 159,000 tons (W. E. Johnson, pers. comm.). About 2/3 of these two stocks are considered to intermingle with U.S. stocks. During the late 1960's, the Vancouver Island stocks declined to low levels due to overfishing during a period of poor recruitment. Following a four-year ban on reduction fishing from 1968 through 1971, these stocks made a full recovery. The level of decline was apparently not large enough to seriously affect recruitment. Canada reinstituted intense fishing in 1972 with the beginning of the sac-roe fishery. Stocks from the east coast of Vancouver Island which contribute to the offshore herring population in the FCZ are currently healthy and capable of sustaining fisheries in Canada's inshore waters. Stocks on the west coast of Vancouver Island have recently shown indications of depletion and it is becoming increasingly difficult to sustain a roe herring harvest (Humphreys, personal comm).

The Strait of Georgia (northern Puget Sound) herring population which supports the Washington State sac-roe fishery has shown a decline since surveys began in 1973. The estimated population of 14,500 tons in 1973 and 14,000 tons in 1974 dropped to approximately 9,000 tons in 1979 and 1980. Age composition data show apparently strong recruitment prior to and at the beginning of the fishery. The 1969 and 1968 year classes dominated the fishery as four and five year olds beginning in 1973. This period was followed by several years with poor to moderate recruitment. Since 1974, the 1975 year class has shown strength, recruiting into the fishery as 3 year olds in 1978 and the 1978 year class recruiting as 2 year olds in 1980.

Population estimates of Pacific herring stocks in California indicate a 1980 spawning population in excess of 54,000 mt, a catch of 6,000 mt, and a total of 60,000 mt. The San Francisco and Tomales Bay spawning escapements are estimated to be at least 47,000 mt and 5,400 mt respectively; other spawning areas support relatively minor stocks. Catch quotas have been increased gradually since 1976 and currently total about 12% of the resource available. The age structure of the catch has fluctuated from year to year but no year class failures have occurred and older age classes are still represented in the fishery. Harvesting at current levels is conservative and stocks appear in excellent condition.

6.3 Ecological Relationships

6.3.1 Environmental Characteristics

The waters off California, Oregon, and Washington are relatively cool and sub-arctic in origin (Favorite, Dodimead & Nasu, 1976). Major current systems are the Sub-Arctic Current and the California Current. The Sub-Arctic Current System is a massive easterly-flowing body, roughly between latitudes 40 and 50 degrees north. As it approaches the North American continent, it branches northward, joining the Alaska Current, and southward where it becomes the southeastward-flowing California Current. The California Unoercurrent flows northerly, relatively near shore and joins the northerly component of the Sub-Arctic Current. Upwelling and coastal eddies occur seasonally. The water is characterized by high nutrient and oxygen levels. Mean ocean surface salinity is moderate, ranging from less than 32°/oo in the north to 33°/oo in the south. The coastline is relatively even with few major projecting capes or indentations. The continental shelf is relatively narrow but with frequent submerged gullies (Favorite, Dodimead, & Nasu 1976; Trumble, MS).

6.3.2 Biological Characteristics

The eastern North Pacific coastal region is relatively rich in nutrients, accompanied by high productivity of phytoplankton and zooplankton which support substantial populations of higher animals - fish, birds, mammals. Production tends to be richer near shore where upwelling, eddy effects and coastal runoff are strongest. Demersal and semi-demersal species dominate off Washington, Oregon and northern California, whereas pelagic species tend to dominate off southern California. Pelagic species off Washington and Oregon include sandlance, herring, smelt, northern anchovy and salmon. In addition, albacore, saury, Pacific whiting, jack mackerel, and pomfret migrate into northern waters in summer. Off California the dominant pelagic species are northern anchovy and jack mackerel. The abundance of these two species has a complex relationship with Pacific sardine and Pacific mackerel which is poorly understood.

Seals, sea lions, porpoises, and whales are common throughout the region. Substantial numbers of northern fur seals migrate seasonally northward and southward through the region (Fiscus, 1980). Many species of marine birds feed seasonally or year-round in the region and are important consumers of pelagic fish and invertebrates. Dungeness crab are very abundant north of California and their larval and juvenile forms constitute an important part of the food web for both fish and birds.

6.3.3 Ecosystem Characteristics

An ecosystems approach to fisheries management is desirable, particularly where a fishery for a given species has a substantial effect on other desirable species. Such interaction between species undoubtedly occurs in the ecosystems comprising "herring waters" off Washington, Oregon, and California. Involved are complex space-time variable processes, including: environmental phenomena, primary biological productivity, biomass levels, reproduction and growth of the major elements of the food web, interactions of predator-prey relationships, natural and fishing mortality, and vertical and horizontal migrations. Data are not presently available for a sophisticated ecosystems approach to management in the waters of concern.

6.3.4 Feeding Conditions

Herring in offshore waters feed opportunistically on a wide variety of zooplankton and nekton, including crustaceans, molluscs, cephalopods, larval fish and pelagic ova (Wailes, 1936). Food items vary according to size of herring, location, depth and seasonal and annual abundance of major prey species. There is no evidence in the literature that availability of food is a limiting factor in adult herring growth or survival. Periodic reductions in feeding may occur during winter or during spawning activity such as are common to other fish. Murphy (1977), in referring to pelagic clupeoids in general, concluded that "...in post-recruits there is little or no observable response to growth rate or fatness over wide ranges of stock size, again indicating that they are not directly food limited." This conclusion is consistent with the hypothesis of Cushing and Harris (1973) that year class strength for fish is determined during larval drift or early juvenile stages. Mathisen et al. (1979) also presented data which support the concept that food is not limiting to adult fish.

There are suggestions that offshore waters might support substantially larger populations of herring than at present. Results from a dynamic salmon ecosystem model indicate that the "apparent carrying capacity" of the North Pacific in respect to salmon can easily sustain a substantially higher standing stock of adult salmon than at present (provided that salmon are very competitive for food and predation on salmon is not a limiting factor) (Favorite and Laevastu, 1979). Since, at times, herring and salmon feed on many of the same food items (Fresh and Cardwell, 1979), the conclusions of Favorite and Laevastu might be expanded to include pelagic herring as well. However, the fact that the "apparent carrying capacity" has not been reached may suggest that adult salmon or herring abundance is dicated by mortality in the early life history or competition for critical food items at another life stage.

6.3.5 Competitors and Predators

Within the total food web, herring occur as intermediate predators on, and competitors for, smaller prey species, and herring themselves are prey for larger fish, birds and mammals. The general features of the food web in marine waters off Washington, Oregon and California have been discussed by Laevastu and Favorite (1977). This work is at an early stage, and biomass estimates and consumption rates are very approximate. An important conclusion is that most species feed upon a variety of food items so that a substantial change in abundance of a single item will not necessarily have a severe impact on the total food supply. Copepods comprised 71 percent of the diet of herring-like fishes used in this study. It is not known whether this high average copepod consumption is due to preference or relative abundance. It is also unknown whether a shortage of copepods in a given area or season could affect growth, or whether compensatory mechanisms might come into play such as vertical or horizontal migration to richer feeding areas, or more competitive feeding activity for other prey items.

6.3.5.1 Herring-Salmon Interactions

The matter of specific predation on herring by salmon will be dealt with separately because of the long-standing question as to whether herring fisheries either inshore or offshore have adverse impact on salmon growth or survival.

Pritchard and Tester (1944) examined stomachs of chinook and coho salmon off Barkley Sound and off North Vancouver Island in 1939, 1940 and 1941 for the specific purpose of resolving the "supposed conflict between herring and salmon fisheries". Their study was in response to "fears expressed as early as 1938, that herring seining would result in elimination of the salmon through reduction of the food supply." A summary of the range of identifiable stomach contents for the two species for all years and for both areas follows:

Food Item	Stomach contents (% by weight)	
	Coho	Chinook
Herring	13-34%	33-46%
Pilchard	1-5%	9-21%
Sandlance	13-41%	25-41%
Other Fish	1-35%	4-7%
Invertebrates	4-30%	2-6%

Although herring formed a substantial portion of the diet in the combined samples, species composition and dominance varied greatly between monthly periods and between sampling areas. For example, euphausiid formed 30-40% of the diet, sandlance 60-70%, and crab larvae 50-60% in some monthly sample groups.

The range of fish species eaten by salmon included herring, pilchard, sandlance, anchovy, capelin, Pacific whiting, rockfish, sablefish, saury and lanternfish. After analyzing salmon stomach samples, Pritchard and Tester concluded that "we cannot assess the effect of herring supply on salmon troll fishing without knowledge of fluctuations in numbers of salmon and factors affecting availability." They further concluded that the availability of food may cause: (1) concentrations of salmon for the benefit of fishermen, (2) salmon that are full and difficult to take on troll gear.

A direct and seemingly simple method for determining whether herring affect survival of salmon would be to compare the abundance trends of salmon and of herring over a long series of years. However, in view of the limitations in our knowledge of the behavior, distribution, and migration of both salmon and herring, it would be virtually impossible to select appropriate areas, time periods, or stocks for making a meaningful comparison. The assumptions and the conclusions would be subject to serious questions whether the data indicated a relationship or not. A host of other factors, both known and unknown, could be responsible for any apparent positive or negative correlation in abundance. This would be particularly true in comparing the abundance of herring versus salmon in the oceanic environment where stocks from many origins are mixed and free to migrate rapidly and extensively.

Canadian scientists recently conducted a preliminary study on salmon/herring dependency in Georgia Strait for the period 1960-1970 (Healey, 1976). The abstract of Healey's report summarizes his findings as follows:

> "This manuscript considers the importance of herring and the exploitation of herring to the populations of Pacific salmon in Georgia Strait. No relationship was found between the abundance of each species of salmon and the abundance of herring in Georgia Strait between 1960 and 1970, a time when major fluctuations in herring abundance occurred. Available data on food habits indicates that chinook and coho eat mainly fish while the other species eat mainly invertebrates. Herring is only one of several important forage species for chinook and coho. The herring taken by chinook and coho are generally in age-class 1+ to 3+, with few older herring being taken. Estimates of the herring requirements of all species

of salmon in Georgia Strait ranged around 12,000 tons compared with an estimated herring population of 290,000 tons. Commercial harvesting of adult-sized herring, therefore, is unlikely to influence the growth or survival of Pacific salmon in Georgia Strait."

A significant statement by Healey (1976, Page 2) with respect to the validity of his findings follows:

"Although I felt it was important to rule out any obvious direct relationship between the abundance of herring and salmon, I did not expect to find any. Failure to find a correlation over such a short time period could as easily be due to shortcomings in the information as to the real lack of relationship. Any concerted attempt to discover a relationship, whether direct or indirect, will require considerable investment of time and resources. The estimates to follow, of the food requirements of salmon, will serve to put the problem into perspective so that its relevance can be assessed against other needs."

Clearly, the problem is complex and will require a substantial effort to test for the existence or non-existence of a relationship, and is beyond the scope of this management plan. It can be said, however, that in the light of our present knowledge of the life histories of both herring and salmon, it would be highly speculative to postulate that the abundance of herring determines the survival of salmon, but herring abundance may, at times and places affect growth or even migration and distribution of salmon in some limited degree.

The work of Laevastu and Favorite (1977) makes it possible to carry the salmon/herring question one step further. For instance in Table 6.3, salmon abundance in the Washington-Oregon area is estimated at 90,000 mt and as consuming 38,000 mt, whereas their food items, particularly the "sardine" category which includes herring, is estimated at 639,000 mt and with a consumption rate of 1,165,000 mt. Biomass and consumption estimates for zooplankton are not given in Table 6.3 but would be even greater than for any of the fish species.

As shown in Table 6.4, euphausiids comprise 132,000 mt of food for the baleen whale alone, and 2,000 mt for marine birds off Washington and Oregon. Thus, salmon, as a relatively small part of the biomass of the ecosystem, have available to them massive quantities of a variety of food items. Their impact on herring and similar fishes is very small. In this perspective, a small fishery for herring off the northern Washington coast would have only a minor impact on herring considering the total biomass and removals by other ecological groups. The impact on food supply for salmon would also be minimal.

Table 6.3. "Minimum sustainable" biomass and annual consumption of selected fish types off Washington, Oregon & Central and Northern California seaward to 200 mile limit.

Fish Types	Estimates in 10^3 mt			
	Wash/Or.		Cent. & N. Calif.	
	Biomass	Consump.	Biomass	Consump.
Squid	279	455	670	1,077
"Sardine", anchovy, smelt, herring, sandlance 1/	639	1,165	1,505	2,701
Saury, mackerel, lanternfish, pomfret	363	575	877	1,379
Salmon, tuna, bonito	90	38	233	100
Hake, cod, sablefish	387	313	862	697
Rockfish	199	159	363	322
Flatfish	123	92	204	179

1/ Mainly herring & sandlance in Washington/Oregon

Source: Laevastu & Favorite, (1977)

Table 6.4. Estimated consumption by mammals & birds of major ecological groups of food types off Washington, Oregon and Central and Northern California seaward to 200 mile limit. Source: Laevastu & Favorite (1977a).

	Consumption in 10^3 metric tons/year by									
	Baleen Whales		Toothed Whales 2/		Pinni-peds 3/		Marine Birds		TOTAL	
Food Types	Wa/Or	Ca.	Wa/Or	Ca.	Wa/Or	Ca.	Wa/Or	Ca.	Wa/Or	Ca.
Euphausiids	132	526					2.0	1.9	134	528
Copepods	26	105							26	105
Squid	17	68	90	256	13	18	1.1	1.0	121	343
"Sardines" 1/	13	53	90	256	6	8	4.0	3.8	113	321
Saury			63	179					63	179
Other Pelagic			90	256	7	14			97	270
Salmon/Tuna			27	76	2	5			29	81
Roundfish			90	256	82	138	0.6	0.5	173	395
Rockfish					26	44	0.6	0.5	27	45
Flatfish							0.6	0.5	1	1
Benthos							0.6	0.5	1	1
"Others"					5	9	1.1	1.0	6	10
TOTALS	188	752	450	1,279	141	236	10.6	9.7	791	2,279

1/ "Sardines" include herring, sandlance, smelt, anchovy.
2/ Including porpoises & dolphins.
3/ Fur seals & sea lions.

7.0 DETERMINATION OF CATCH LEVELS

7.1 Harvest Strategies

A mathematical model constructed to examine harvest strategies for herring is presented in Appendix II. The model requires information on biological characteristics (growth, mortality, recruitment) and approximate starting biomass of stocks to be considered. For a set of biological parameters, one may compare biomass, harvest levels, and population stability over a long time period for a series of management strategies. Although the model cannot be used to accurately predict the course of events in a given year, it does give an estimate of the long-term consequences of different harvest management strategies.

Several results emerged which are applicable to herring fisheries independently of biomass. Harvesting at a proper constant percentage of the estimated total biomass gives the least fluctuation of biomass and harvest. Constant harvest rates may be high enough to drive the population to depletion, but can be guarded against by setting a minimum population size as a reserve, below which no harvest may occur. This strategy will protect the resource against inadvertent overharvest, but is subject to fluctuating harvest and biomass including several years without harvests. The "surplus stock" strategy which authorizes harvest of all herring in excess of a desired spawning escapement will also maintain a long-term production from the population; however, this strategy is characterized by extreme fluctuations in biomass and harvest. Harvests extend from extremely high to many zero harvests. These strategies are currently used by existing roe herring fisheries in Canada ("surplus stock") and the U.S. ("proportional harvest").

The model predicts that long term average yields in the U.S.-Canada transboundary area could be between 40,000 and 60,000 mt, depending on the management strategies chosen. The predicted range is from 0 to 200,000 mt per year. This quantity may be taken inshore, offshore, or in both areas, and will be shared by the U.S. and Canada. At the present time all fisheries occur inshore and 80 to 90 percent of the fish are harvested in Canada.

Addition of an offshore fishery will add mortality. However, total loss to the inshore population will be less than the amount harvested, because some of the fish would have died even if an offshore harvest hadn't occurred. In the case of an offshore fishery, there will be a relationship between the level of offshore catch and the reduction in inshore biomass, determined by the natural mortality experienced by the stocks on their inward migration. Some of the fish caught by an offshore fishery would die anyway before being able to spawn, even in the absence of an offshore fishery. The longer the time period between the offshore fishery and time of spawning, the more loss will occur due to natural mortality. The herring harvest strategy model (Appendix II) calculates that from the time period of an offshore fishery (July, August, September) to spawning in March, approximately 20% of the herring biomass is lost to natural mortality. Therefore, 20% of the fish caught by an offshore fishery would have died, and 80% of the catch would be lost to the spawning population. An offshore fishery later in the season would experience a lower loss to natural mortality, so more of the offshore catch would be lost to inshore biomass.

The amount of reduction to the inshore fishery depends on the management procedure used to compensate for the offshore harvest. If inshore quotas are based on a constant proportion (i.e., 20%) of observed biomass, then the lost harvest will be 20% of biomass reduction. If management calls for a constant fishing mortality or harvest of all fish above a spawning escapement goal, then the entire inshore biomass reduction is lost to the inshore fishery. Reductions to an inshore fishery will be less than the amount harvested offshore. A U.S. offshore fishery along the northern Washington coast will cause more reduction of inshore Canadian harvest than of inshore U.S. harvest, and would increase the total U.S. catch. A U.S. offshore fishery along central California will cause direct loss to the Californian inshore fisheries.

The United States will have no direct input to management strategy of Canadian inshore fisheries. The biomass of herring will depend to a large degree on the spawning escapement established for Canada. The Canadians harvest all herring in excess of a spawning reserve; this management practice causes the most variable catches and biomass. Therefore, any harvest from management strategy for the U.S. portion of the transboundary area which is tied to biomass will likewise undergo the same large excursions.

7.2 Maximum Sustainable Yield (MSY)

Maximum sustainable yield (MSY) is an average over a reasonable length of time of the largest catch which can be taken continuously from a stock. It should normally be presented with a range of values around its point estimate. Where sufficient scientific data as to the biological characteristics of the stock do not exist or the period of exploitation or investigation has not been long enough for adequate understanding of stock dynamics, the MSY will be estimated from the best information available. These estimates of MSY are based on current fishery practices. Changes in mesh size and/or the season/area distributions of fishing effort would change estimates of MSY for most species.

Although the model can predict a MSY produced by the selected management regime, it is useful only as an indicator of what may be expected, on the average, over many years. MSY has no usefulness in setting ABC or establishing annual management programs. It must be indelibly scored on the mind of all involved in herring management that MSY is simply a predicted long-term average and has no more short-term value than the fact that a stream averages 12 inches in depth to a man in that stream up to his neck in the water.

There is also no single value of equilibrium yield at which population will remain approximately constant. Of far more use to managers and planners is a knowledge of the range of harvest values that may be expected, and the effects that various harvest strategies may have on such fluctuations. Herring is a species which undergoes large variations in annual recruitment, and there are normally only three or four year classes which contribute significantly to the biomass. Two or three successive years of poor recruitment or of strong recruitment will cause wide swings in total abundance.

7.3 Acceptable Biological Catch (ABC)

Acceptable biological catch (ABC) is a seasonally determined catch that may differ from MSY for biological reasons. It may be lower or higher than MSY in some years, because of fluctuating recruitment. ABC may or may not be set at equilibrium yield (EY), which is the harvest that would maintain a stock at its current level, apart from the effects of environmental conditions. It may be set lower than MSY in order to rebuild depleted stocks.

There is presently no procedure to estimate the ABC in the FCZ. The ABC for each fishable population is set each year by state agencies on the basis of prespawning biomass estimates or estimates based on egg deposition. Procedures for setting ABC's in each state are described in the source document. These ABC's actually represent the acceptable annual biological catch from the entire resource which spawns in U.S. waters since all mature herring move inshore to spawn each year. Accordingly, the ABC's developed by each state are considered the best available and will be used in this plan. Whenever necessary, the ABC's shall be combined to form a composite ABC for a management area. For example, the ABC for the Central Management Area will be a composite of ABC's for northern California, Oregon and southern Washington.

A special circumstance exists in the Northern Management Area. Since the major component of the herring biomass in the FCZ spawns in Canadian inshore waters, the ABC of these stocks must be incorporated into the composite ABC. Canadian authorities will be asked to provide annual estimates of ABC. If no estimates are available, the Plan Development Team will estimate the ABC from the best available data, including published and unpublished reports, historical and present catches, age composition estimates and knowledge of abundance and recent trends in abundance.

7.4 Optimum Yield (OY)

Optimum yield (OY) may be obtained by a plus or minus deviation from ABC for purposes of promoting economic, social, or ecological objectives as established by law and public participation processes. Ecological objectives, where they primarily relate to biological purposes and factors, are included in the determination of ABC. Where objectives relate to resolving conflicts and accommodating competing uses and values, they are included as appropriate with economic and/or social objectives. OY may be set higher than ABC in order to produce higher yields from other more desirable species in a multi-species fishery. It might be set lower than ABC in order to provide larger-sized individuals or a higher average catch per unit of effort.

The issues discussed in Chapter 9 (e.g., herring as forage, natural fluctuations) suggest that a cautious management approach is warranted. Therefore, the total harvest (inshore and offshore) should not exceed the ABC for each Management Area, and thus the maximum OY will not exceed ABC.

The OY for each area will be selected by the Council and will conform with objectives of the plan which favor existing fisheries while increasing the diversity of fishing opportunities.

The intent of this plan is to clearly establish a cooperative management arrangement between state agencies and the Council. Under this arrangement, the Council would set the offshore OY component (OY_O) and the states would set the inshore OY component (OY_I).

The Council must first set OY_O. It is expected that this will be a fixed quota which will not vary between years or which will be set by predetermined formula. Any changes in OY_O will require a plan amendment.

Each year the states will determine the ABC's. Inshore quotas (OY_I) will then, by definition equal the ABC less the offshore OY or $OY_I = ABC - OY_O$.

8.0 TOTAL ALLOWABLE LEVEL OF FOREIGN FISHING (TALFF)

The TALFF for Pacific herring under this plan is set at zero. The following considerations clearly demonstrate that there is currently no harvestable surplus of herring and that there will be no surplus in the foreseeable future.

1) At the present time, herring which spawn in U.S. waters are fully utilized. Stocks of herring which occur in exploitable abundance in the FCZ migrate inshore to spawn and reside in inshore waters from six to nine months each year. Harvest of these herring has traditionally occurred during the inshore phase of their annual migration pattern.

2) That fraction of the transboundary stock which spawns in Canadian waters is fully exploited by Canadian fishermen.

3) The U.S. harvesting capacity and market exceed MSY, ABC, and OY for stocks that spawn in the U.S.

4) Herring are a significant source of food for many commercial and recreational fish species. They are also consumed by several species of marine mammals and birds. Any temporary or short-term surplus should accrue to the "forage stock".

5) This plan is intended to diversify and stabilize the markets for herring. It is likely that a decrease in present major markets (e.g., sac-roe) will result in an increased effort of fishermen and processors to produce other herring products (e.g., food or bait).

9.0 MANAGEMENT ISSUES

The purpose of this chapter is to consolidate and summarize the most significant management issues which are discussed in various sections throughout the plan. These issues must be considered during formulation of a management plan for herring, establishment of the acceptable biological catch, and setting of optimum yield levels.

9.1 Mixed Stock Versus Single Stock Management

The best available information suggests that herring from many different spawning areas intermingle freely during the offshore feeding phase of their life history, and thus form mixed stock aggregations. A fishery on a mixture of stocks of differing status significantly complicates effective management. It is virtually impossible in a mixed stock fishery to devise measures which will protect the small or depleted stocks while allowing intensive harvests on large stocks or those which may appropriately be harvested at a higher level.

If an offshore fishery for herring develops in the FCZ, it will in all likelihood fish on mixed stocks. Scientists from Europe, Canada and Alaska attending the 1980 Alaska Herring Symposium concluded "that in a mixed stock fishery, the percentage removal is related to the percentage of mixing of the stocks, and that if management objectives are for a general level of exploitation, then underfishing of the smaller stocks is as likely as overfishing" (Melteff and Wespestad, 1980). Thus, a mixed stock fishery in the FCZ, harvesting healthy stocks at the same rate, cannot be precluded. However, weak stocks which need protection may require reduction or elimination of an offshore fishery.

Herring stocks in most areas covered by the plan are in satisfactory condition. However, the Strait of Georgia (Northern Puget Sound) herring stocks declined in 1980 and 1981 resulting in a complete closure of the sac-roe fishery in 1981. If this stock continues to decline, or does not recover, it will require special consideration during the development of a management regime for coastal waters.

9.2 Herring as a Forage Species

Perhaps the most controversial and emotional issue to be addressed in developing a commercial herring fishery is the role of herring as food for fish, birds, and marine mammals. One viewpoint insists that herring should not be harvested by man, but should be left for exclusive use as food for other animals. This viewpoint holds that any utilization of herring by a commercial fishery will directly impact and reduce the abundance and health of other animal populations. The opposing viewpoint holds that herring is only one of many food organisms in the marine environment and that most predators are opportunistic and will prey on whatever food organism is available. The latter viewpoint contends also that a reasonable level of fishing will have no observable impact on herring recruitment since poorly understood environmental interactions cause wide fluctuations in herring recruitment in the absence of commercial herring fisheries. Refer to section 6.3 for further discussion of the role of herring in the ecosystem.

Currently, many management agencies explicitly or implicitly recognize the importance of herring as a forage item and set conservative exploitation rates. This management concept will be considered when developing the final management regime.

9.3 Regional Management Needs

Three management areas have been considered in recognition of special management requirements. Biological, social, and political considerations vary by area. Since these areas and stocks have unique characteristics, each will be considered separately when developing management measures.

In the northern area, large stocks of herring which spawn in Canada intermingle with stocks of Puget Sound origin. These stocks apparently move freely across the international boundary (see section 9.4). Further, it has been demonstrated, through the experimental fishery, that these stocks can be harvested by trawls on the high seas. Special consideration must be given to existing inshore fisheries as well as to the international implications of an offshore fishery when considering appropriate management measures for this area.

Virtually all of the stocks in the large central area are small and spawn in the embayments and river estuaries along the coastline of southern Washington, Oregon, and northern California. The discrete nature of these small stocks in this large area suggests special consideration is necessary. It is probable that in this extended area less mixing of stocks occurs and an offshore fishery could target on discrete stocks.

Large populations of herring are found in the southern area. These fish spawn primarily in San Francisco Bay and, to a lesser degree, in Tomales and Bodega Bays. At the present time, these herring are fully harvested by an inshore fishery for sac-roe. Virtually nothing is known of the offshore distribution and migration pattern of herring in this area. Development of an offshore fishery will have a direct impact on the inshore roe fishery since offshore fishing would be on the same stocks which subsequently spawn inshore.

9.4 International Implications of Transboundary Stocks

As discussed previously, the large transboundary aggregations of herring which feed in offshore waters during the summer, subsequently move inshore to spawn in Canada and the United States. The best information available indicates that at least 80 percent of the total herring aggregation in the transboundary area is comprised of fish which ultimately spawn in Canadian inshore waters. It follows then that if a commercial fishery developed in this area of the FCZ, a large percentage of herring taken would be of Canadian origin. There are at least two important management implications which arise from the transboundary nature of these stocks.

1. Any U.S. fishery which develops in offshore waters will harvest a high proportion of fish which spawn in Canadian waters. Consequently, the impact of an offshore fishery on U.S. stocks is minimized since, hypothetically, only one out of five fish harvested is destined for U.S. Puget Sound waters. Thus, while such a fishery will increase the value of herring harvested by U.S. fishermen, it will decrease the overall value of herring, because of the larger loss to Canada.

2. There is an obvious international management issue involved in any offshore fishery for herring. This issue is beyond the purview of the plan and must be addressed by the U.S. and Canadian governments.

The management regime developed in this plan will consider the biological and management issues evolving from an offshore fishery as they relate to the impact on inshore U.S. stocks.

9.5 Marketing Issues

In recent years, the vast majority of herring harvested in Washington, Oregon, and California have been sold for sac-roe. Prices for roe herring increased dramatically until late 1979, when they plummeted (see section 5.0). Market conditions for roe herring since that time have been very unstable. During the 1980/81 new year season, Japanese consumers resisted the high-priced herring roe and ex-vessel prices in California subsequently declined from $1,200 to $600-800 per ton from December 1980 to January 1981. There are indications that salted fish and roe are becoming less popular in Japan due to consumers' interest in reducing salt in their diet (Pacific Fishing, February 1981). It is possible that high prices, combined with health concerns, may significantly and permanently decrease demand for herring roe.

In contrast to the concerns over the roe market, interest in fisheries for food and bait have been increasing. These contrasting market conditions were considered when developing management options. It may be beneficial to long-term market stability to broaden the base of utilization from what is now essentially a single-use fishery to a multi-use fishery. High quality herring can be harvested in the FCZ in the summer and early fall. However, adult prespawning herring, which are found in inshore waters, are of low fat content and are less acceptable to the sophisticated food markets of Europe. In order to diversify and broaden the market base, it is likely that an offshore fishery would be necessary.

9.6 Natural Fluctuations of Herring

Herring typically exhibit wide natural fluctuations in abundance. If a large-scale fishery is imposed on a stock or stocks of herring which are at the low point of a natural fluctuation, severe recruitment and abundance problems can result. Consequently, any management regime for herring should consider this aspect of the natural history and establish conservative optimum yield levels to prevent depletion of a resource during years of naturally low abundance.

10.0 MANAGEMENT MEASURES

10.1 General Management Strategy

Results of the herring management strategy model discussed in section 7.0 and Appendix II provide useful insights into impacts of various management strategies and harvest levels. Strategies or harvest rates which drive the population to low levels or extinction are rejected without further discussion.

The concept of a constant annual inshore quota is also rejected because large natural fluctuations would make it necessary to set the quota low enough to prevent overharvest during years of low abundance. The constant quota would thus result in underharvest in all years of average or above average abundance.

Proportional harvest with a minimum biomass necessary before any harvest is permitted and harvest of fish surplus to spawning requirements are viable management strategies. Both protect against overharvest and permit large average catches and prevent long-term depletion of the resource.

10.1.1 Surplus stock concept

The strategy which allows harvest of all fish surplus to spawning requirements produces a high average yield with a large standard deviation, and would result in very large quotas in some years and no quota in many others.

The range in quotas is due to large natural fluctuations in abundance and a prohibition of all fishing at population levels below the prescribed spawning requirement. This concept assumes an "optimum" spawning stock size which will produce optimum recruitment. Since there is no documented relationship between spawning stock and the resulting recruitment except at extremely small stock size, the highly variable quotas appear to be an unnecessary and an undesirable product of this strategy. Further, this management concept reduces the total stock size to the same level each year, and in essence establishes a recruitment fishery.

10.1.2 Proportional harvest concept

Proportional harvest with a minimum biomass before any harvest is permitted, maintains long-term stock stability with much more stable harvest levels. This method is advantageous because of the need to protect stocks which have been reduced to low levels and the uncertainty of a spawner-recruit relationship. At high levels of abundance, this procedure produces catches lower than the "surplus stock" method but provides carry-over of adults into subsequent years, thus spreading harvest of a single year class over several years. This carry-over buffers the impact of years of subaverage recruitment. In conformance with management regimes of the three states, this strategy of harvesting 20 percent of the biomass will be the basic management strategy (see section 7.0). This concept conforms with and enhances achievement of objectives of the plan.

10.1.3 Considerations of an offshore fishery

The proportional harvest strategy is applicable to inshore herring harvest in all areas and is currently the management policy of the state fisheries agencies of Washington, Oregon, and California. If offshore fisheries are to occur, however, the proportional harvest strategy must be modified to accommodate them. Since objectives of the plan favor existing circumstances and because little is known about the ocean segment of herring life history, any initial offshore fishery must be small, but also must be of sufficient magnitude to be economically viable. A small, constant annual quota would allow an offshore fishery. Results of the management model suggest that an offshore quota in addition to an inshore proportional harvest is an acceptable option. Options which include an offshore harvest component are presented below.

10.2 Management Measures for the Fishery as a Whole

The following proposed measures may apply to all management areas or may be selected for each area.

10.2.1 Fishing gear

Seines and pelagic trawls are effective, historically-used commercial gears for herring. Although gill nets are also effective for catching herring, the potential incidental catch of salmon and the prohibition of set nets (a form of gill nets) for other species in the FCZ precludes consideration of this gear for herring (Pacific Fishery Management Council, 1981). No other fishing gear has been proven effective for high seas herring fishing and, thus, only seines and pelagic trawl options are proposed for this fishery.

Option 1 - Pelagic trawls only

Pelagic trawls must conform with the following requirements:

(a) codends must be single walled;

(b) bottom line at trawl mouth must be without protection (rollers, bobbins, or discs) and may not exceed 1.75 inches in diameter, which includes twine necessary for seizing material;

(c) sweeplines, including bottom leg of bridle, must be bare;

(d) no minimum mesh size requirements.

Rationale:
Pelagic trawls are a proven effective fishing gear for herring on a worldwide basis. The limited recent commercial domestic and foreign herring catches in the Pacific Council's FCZ have been taken by pelagic trawls. The trawl description above was modified from that used in the Groundfish FMP and is intended to prevent intentional contact with the bottom to minimize incidental catches of non-pelagic species. Small mesh sizes are necessary to harvest herring. Imposition of any mesh size regulations on the herring fishery designed to protect juveniles of other species would preclude a herring fishery. Further, observers of the experimental offshore herring fishery report a very low incidence of juvenile fish. Accordingly, no mesh size regulations are proposed.

Incidental catch proposals are presented in section 10.2.2.

Option 2 - Pelagic trawls and seines

Seines are an extremely effective gear for herring, and are currently used in the inshore sac-roe fisheries in all Pacific areas. It is entirely possible that seines could be effective for herring fishing in the FCZ. Seines are currently banned from the FCZ in waters adjacent to Washington and Oregon for all species to prevent directed or unavoidable catches of salmon. The use of seines for herring is an acceptable option from a biological perspective if catches are carefully monitored. No minimum mesh restrictions are proposed (see the mesh size discussion under pelagic trawls).

10.2.2 Incidental catch allowances

Incidental catches of other species are governed by other plans.

It is proposed that incidental catches of groundfish[1/] be 15 percent of the catch per trip or 3,000 pounds per trip, whichever is greater.

It is proposed that there be no retention of salmon, crabs, shrimp or other species of finfish or shellfish.

Rationale:
Large catches of groundfish were made during the early stages of the experimental offshore herring fishery. Catches of groundfish decreased as the fishermen gained experience in offshore herring trawling. The proposed incidental limits for groundfish will allow for unavoidable catches, and discourage targeting on groundfish with small mesh nets.

10.3 Area Specific Measures

1/ See appendix III for a complete list of groundfish.

10.3.1 Management Areas

Management areas have been described in section 1.4 and Figure 1.1. The special characteristics of each area are discussed in section 9.3. Briefly, the three management areas are:

Southern Area - U.S.-Mexico border to Cape Mendocino, California (40°30' N. latitude),

Central Area - Cape Mendocino, California (40°30' N. latitude) to Cape Elizabeth, Washington (47°20' N. latitude),

Northern Area - Cape Elizabeth, Washington (47°20' N. Latitude) to the U.S.-Canada boundary.

10.3.2 Southern management area (U.S.-Mexico border to Cape Mendocino)

10.3.2.1 Quotas

Option 1 - Status quo

Herring fisheries will be managed by the State of California. There will be no herring fishing in the FCZ.

Rationale:

Herring stocks are fully exploited in this area. Catches made in the FCZ would cause a commensurate reduction of quotas for inshore fisheries.

Option 2 - Status quo in state waters and a 1,000 - 4,000 mt fixed annual quota in the FCZ

Rationale:

This option would provide flexibility in management in the event of low harvest inshore not due to conservation issues (i.e., market collapse, strikes). A small fishery offshore would also diversify markets and may improve long-term market stability for the overall herring fishery. A harvest in the FCZ would require inshore quota reduction of about 80 percent of the offshore catch. For example, an offshore harvest of 1,000 mt would necessitate about an 800 mt quota reduction inshore to account for the offshore harvest, less what could be accounted for by natural mortality and other life processes. A quota lower than 1,000 mt would probably be insufficient to provide an economically viable fishery.

Option 3 - Status quo in state waters and a variable annual quota in the FCZ of 1,000 to 4,000 mt.

Rationale:
This option is intended to provide a minimum 1,000 mt quota in the FCZ with the ability to increase the quota to a maximum of 4,000 mt without plan amendment. The Regional Director is authorized to increase the quota after consultation with, and approval by, the Council.

The Council will consider the following factors prior to approving an increase.

1) The condition of the herring stocks contributing to the offshore biomass.

2) Current and past inshore harvests.

3) Market conditions for herring harvested inshore and offshore.

4) Other appropriate factors.

Any increase above the minimum 1,000 mt quota must be allotted at least 30 days prior to the start of the fishing season.

10.3.2.2 Seasons

Option 1 - The FCZ will be open all year (Inshore seasons are set by state fishery agencies)

Rationale:
This option provides minimal regulation. Fishermen would be able to fish at any time subject to quota limitations. Since adults move inshore to spawn

during the November-March period, it is likely that an offshore fishery during these months would catch primarily juvenile and sexually immature herring. It is also possible that discrete stocks of late spawning herring would be accesable to harvest in the winter months.

Option 2 - The FCZ will be closed to all herring fishing from November 1 through March 30

Rationale:
This option would protect small and immature herring and those discrete stocks of late spawning adults which may be available. It would also reduce potential enforcement problems in the inshore fishery resulting from misreporting of inshore catches to avoid inshore regulations.

10.3.2.3 Fishing gear

If coastwide uniformity is considered to be unnecessary, an option presented in section 10.2.1 can be selected for this area.

10.3.2.4 Incidental catch allowances

Uniform catch allowances for all areas are proposed in section 10.2.2.

10.3.3 Central management area (Cape Mendocino, California, to Cape Elizabeth, Washington).

10.3.3.1 Quotas

Option 1 - Status quo

At the present time, all herring fisheries are in state waters. The fisheries will be managed by the states. There will be no herring fishing in the FCZ.

Rationale:
Many small discrete spawning stocks are present in this large area, each of which is managed independently. No large stocks or aggregations of herring

have been observed in either coastal waters or the FCZ. Virtually nothing is known about the ocean distribution of herring in this area, nor of the degree of intermingling of spawning stocks.

Since herring stocks in this area are apparently fully utilized, any offshore catches would directly impact inshore quotas, the inshore management regime, and could result in overharvest of individual spawning stocks.

Option 2 - Status quo inshore and a 100-500 mt quota for an offshore experimental fishery. No more than 50-250 mt can be harvested in waters adjacent to a single state.

Rationale:
An offshore experimental fishery with observer coverage could provide valuable information on the distribution and relative abundance of offshore herring aggregations. A small quota, combined with the provision to distribute catches along the entire area (conversely, to prevent the entire quota being taken from a small area) may minimize the impacts on onshore fisheries or on discrete spawning stocks. However, the distribution requirement may be hard to enforce.

10.3.3.2 Seasons

Option 1 - The FCZ will be open all year

Rationale:
This option provides minimal regulation. Fishermen would be able to fish at any time subject to limitations of the experimental fishing permit. Since adults move inshore to spawn during the January-April period, it is likely that an offshore fishery during these months would catch primarily juvenile and sexually immature herring. Discrete stocks may be vulnerable as they move inshore to spawn.

Option 2 - The FCZ will be closed to all herring fishing from January 1 through April 30

Rationale:
This option would protect small and immature herring and discrete stocks of late spawning adults. It would also reduce potential enforcement problems in the inshore fishery resulting from misreporting of inshore catches to avoid inshore regulations.

10.3.3.3 Fishing gear

If coastwide uniformity is considered to be unnecessary, an option presented in section 10.2.1 can be selected for this area.

10.3.3.4 Incidental catch allowances

Uniform catch allowances for all areas are proposed in section 10.2.2.

10.3.4 Northern Management Area (Cape Elizabeth to the U.S.-Canada border)

10.3.4.1 Quotas

Option 1 - Status quo

Rationale:
At the present time, northern Washington spawning stocks are fully exploited in state waters. There will be no herring fishing in the FCZ. Fisheries in state waters will be managed by Washington State.

Option 2 - Status quo inshore and a small offshore quota (1,000-4,000 mt)

Rationale:
This option would provide flexibility in management in the event of a low harvest inshore, which was not a result of conservation issues (i.e., market collapse, strikes). A small offshore fishery would also diversify markets and may improve long-term market stability for the overall herring fishery.

A harvest in the FCZ could result in a smaller inshore catch. For example, if 1,000 tons were harvested in the FCZ, the estimated reduction to Washington stocks would equal 160 mt (see Table 5.3).

Assuming ex-vessel values of $475 per ton, a 1,000 ton fishery would generate $.475 million in income to fishermen. About half of the 160 mt inshore reduction (80 mt) would be to the northern Puget Sound sac-roe fishery. At a 20% harvest rate of observed inshore biomass, this would result in a 16 mt reduced harvest and a 64 mt reduced spawning escapement. At a constant combined harvest rate for inshore and offshore fishing, the full 80-ton reduction would come at the expense of the inshore harvest. The other 80 tons of inshore biomass loss would be proportionally distributed among other Puget Sound stocks. At an average value of $1,000 mt, $16,000 would be lost to the sac-roe fishery in the first case, and $80,000 would be lost in the second case. For a more complete treatment of economic trade-offs. see section 5.4.

<u>Option 3 - Status quo quo in state waters and a variable annual quota in the FCZ OF 1,000 to 4,000 mt.</u>

Rationale:

This option is intended to provide a minimum 1,000 mt quota in the FCZ with the ability to increase the quota to a maximum of 4,000 mt without plan amendment. The Regional Director is authorized to increase the quota after consultation with, and approval by, the Council.

The Council will consider the following factors prior to approving an increase.

1) The condition of the herring stocks contributing to the offshore biomass.

2) Current and past inshore harvests.

3) Market conditions for herring harvested inshore and offshore.

4) Other appropriate factors.

Any increase above the minimum 1,000 mt quota must be allotted at least 30 days prior to the start of the fishing season.

10.3.4.2 Seasons

Option 1 - The FCZ will be open all year (Inshore seasons are set by state fishery agencies)

Rationale:

This option provides minimal regulation. Fishermen would be able to fish at any time subject to quota limitations. Since adults move inshore to spawn during the December-May period, it is likely that an offshore fishery during these months would catch primarily juvenile and sexually immature herring and discrete stocks of herring as they moved inshore to spawn.

Option 2 - The FCZ will be closed to all herring fishing from December 1 through May 31

Rationale:

This option would provide a measure of protection to small and immature fish and discrete stocks of herring moving to spawning areas. It would also reduce potential enforcement problems in the inshore fishery resulting from misreporting of inshore catches to avoid inshore regulations.

10.3.4.3 Fishing gear

If coastwide uniformity is considered to be unnecessary, an option presented in section 10.2.1 can be selected for this area.

10.3.4.4 Incidental catch allowances

Uniform catch allowances for all areas are proposed in section 10.2.2.

LITERATURE CITED

Anthony, V. C., and G. T. Waring, 1980. A review of the herring fisheries, their assessment, and management in the Georges Bank-Gulf of Maine area. In: Melteff, B. R., and V. G. Wespestad (Eds). Proceedings of the Alaska Herring Symposium. Alaska Sea Grant Report 80-4, Univ. of Alaska, Fairbanks.

Barton, L. H., 1978. Finfish resource surveys in Norton Sound and Kotzebue Sound. OCSEAP Final Rpt. (March 1976-Sept. 1978), ADF & G. Comm. Fish. Div., Anchorage.

Blankenbeckler, Dennis, 1980. Gulf of Alaska Herring Management. In: Melteff, B. R., and V. G. Wespestad (Eds). Proceedings of the Alaska Herring Symposium. Alaska Sea Grant Report 80-4, Univ. of Alaska, Fairbanks.

Chapman, W. M., M. Katz, and D. W. Erickson, 1941. The Races of Herring in Washington State. Wash. Dept. Fish. Biol. Rept. No. 38A. 36 p.

Cushing, D. H. and J. G. K. Harris, 1973. Stock and recruitment and the problem of density dependence. Rapp. P.-V. Reun. Cons. Inter. Explor. Mer. 164:142-155.

Day, D. E., 1980. 1978 Gulf of Georgia Sac-roe Herring Fishery Market Sample Data Analysis Prog. Rept. 102 Wash. Dept. of Fisheries. 25 p.

Dornheim, Holger, 1978. Status of the herring stocks fished by the Federal Republic of Germany fleet. Mar. Fish. Rev. 40(4):21-24.

Dragesund, Olav, 1980. A review of management practices and research activities on Norwegian spring spawning herring. In: Melteff, B. R., and V. G. Wespestad (Eds). Proceedings of the Alaska Herring Symposium. Alaska Sea Grant Report 80-4, Univ. of Alaska, Fairbanks.

Dushkina, L. A., 1973. Influence of salinity on eggs, sperm and larvae of low-vertebral herring reproducing in the coastal waters of the Soviet Union. Marine Biology. 19:210-233.

Favorite, F., A. J. Dodimead, & K. Nasu, 1976. Oceanography of the Sub-Arctic Pacific Region. Int. N. Pac. Fish. Comm. Bull. 33. 187 p.

Favorite, F., & T. Laevastu, 1979. A Study of the Ocean Migrations of Sockeye Salmon and Estimation of the Carrying-Capacity of the North Pacific Ocean Using a Dynamical Salmon Ecosystem Model (NOPASA). N.W. & Alaska Fish Ctr. Processed Rpt. 79-16 OCT. 1979, 47 p.

Fiscus, C. H., 1980. Marine mammal-salmonid interactions: a review. In: Himsworth & W.J.McNeil (Eds) Salmonid Ecosystems of the North Pacific Ocean. Oregon State Univ. Press., Corvallis, p 121-132.

Fresh, K. L. and R. Cardwell, 1979. Salmon-Herring Predator/Comp. Interactions (Phase I). Final Rpt. to the Pac. N.W. Regional Commission. Grant No. 10890006 for Period Aug. 4, 1978 - July, 1979.

Galkina, L. A., 1971. Survival of spawn of the Pacific herring (Clupea harengus pallasi) related to the abundance of spawning stock. Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 160:8-11.

Grant, W.S., (in prep.) Biochemical genetic population structure of Pacific herring (Clupea harengus pallasi).

Haegele, S.W., R. D. Humphreys, and A. S. Hourston, 1981. Distribution of eggs by depth and vegetation type in Pacific herring (Clupea haregus pallasi) spawnings in south British Columbia, Canada. J. Fish. Aquat. Sci. 38:381-386.

Harden Jones, F. R., 1968. Fish Migration. Edward Arnold (Publishers) Ltd. London. 325 p.

Hart, J. L., 1973. Pacific Fishes of Canada. Fish. Res. Bd Can. Bull. 180.

Healey, M. C., 1976. Herring in the Diets of Pacific Salmon in Georgia Strait. Fish. Res. Bd. Can. MS Rept. No. 1382. 38 p.

Hourston, A. S., 1980. The biological aspects of management of Canada's west coast herring resource. In: Melteff, B. R., and V. G. Wespestad (Eds). Proceedings of the Alaska Herring Symposium. Alaska Sea Grant Report 80-4, Univ. of Alaska, Fairbanks.

Jones, B. C., 1972. Effect of intertidal exposure on survival and embryonic development of Pacific herring spawn. J. Fish. Res. Bd. Canada 29:1119-1124.

Katz, M., 1948. The fecundity of herring from parts of the North Pacific. Trans. Am. Fish. Soc. 75:72-76.

Laevastu, T., and F. Favorite, 1977. Minimum Sustainable Biomasses of Marine Ecological Groups off Central and Northern California, Oregon, Washington and Vancouver Island Coasts. N.W. & Alaska Fish. Ctr. Processed Report. May, 1977, 60 p.

Lemberg, N.A., 1978. Hydroacoustic assessment of Puget Sound herring, 1972-1978. Wash. Dept. Fish. Tech. Rept., No. 41:43 p.

Macy, P. T., J. M. Wall, N. D. Lampsakis, J. E. Mason, 1978. Resources of non-salmonid pelagic fishes of the Gulf of Alaska and eastern Bering Sea, Part 1, N.W. & Alaska Fish. Ctr. Processed Report, Seattle, WA. 356 p.

Mathisen, O. A., R. E. Thorne, R. J. Trumble, and M. Blackburn, 1978. Foc consumption of pelagic fish in an upwelling area. In R. Boje and M. Tomcz..., (Eds.). Upwelling Ecosystems. Springer-Verlag, Berlin. p. 111-123.

Melteff, B. R. and V. G. Wespestad, (Eds) 1980. Proceedings of the Alaska Herring Symposium, Feb. 1980. Alaska Sea Grant Rept. 80-4. 279 p.

Millikan, A., and D. Penttila, 1973. Puget Sound Baitfish Study, July 1, 1972 - June 30, 1973. Prog. Rept. Wash. Dept. Fish. 34 p.

Millikan, A., D. Penttila, and D. Day, 1974. Puget Sound Baitfish Study, July, 1973 - June 30, 1974. Prog. Rept. Wash. Dept. Fish. 31 p.

Moores, J. A., 1980. The herring resource of eastern Canada. In: Melteff, B. R., and F. G. Wespestad (Eds). Proceedings of the Alaska Herring Symposium. Alaska Sea Grant Report 80-4, Univ. Alaska, Fairbanks.

Murphy, G. I., 1977. Characteristics of Cupeoids. In: J. A. Gulland, Ed. Fish Population Dynamics. John Wiley & Sons. A Wiley - Interscience publication.

Nagasaki, F., 1958. The fecundity of Pacific herring (Clupea pallasi) in British Columbia coastal waters. J. Fish. Res. Board Can. 15:313-330.

New England Fishery Management Council, 1978. Final Environmental Impact Statement/Fishery Management Plan for the Atlantic Herring Fishery of the Northwest Atlantic.

North Pacific Fishery Management Council, 1979. Draft Fishery Management Plan and Environmental Impact Statement for Bering-Chuckchi Sea Herring. 190 p.

Outram, D. N., 1958. Seagulls biggest killers of herring spawn. Western Fisheries 57(1): 38-42.

Outram, D. N. and R. D. Humphreys, 1974. The Pacific Herring in British Columbia Waters. Fish. Res. Bd. Can. Pac. Biol. Stu. Circ. 100:25 p.

Paulson, A. C. and R. L. Smith, 1977. Latitudinal variation of Pacific herring fecundity. Trans. Am. Fish. Soc. 106(3) 244-247.

Penttila, D. E. and M. A. Stinson, (in prep). Juvenile herring studies in southern Puget Sound, Washington, 1976-1977. Wash. Dept. Fish.

Prakash, A., 1962. Seasonal changes in the feeding of coho and chinook salmon in southern British Columbia waters. J. Fish. Res. Bd. Can. 19:851-866.

Pritchard, A. L. & A. L. Tester, 1944. Food of spring and coho salmon in British Columbia Fish. Res. Bd. Can. Bull. 65 pp. 1-23.

Rabin, D. J. and R. A. Barnhart, 1977. Fecundity of Pacific herring, Clupea harengus pallasi, in Humbolt Bay. Calif. Fish Game 63(3). 193-196.

Reid Gerald, M., 1971. Age Composition, Weight, Length, and Sex of Herring, Clupea pallasii, Used for Reduction in Alaska, 1929-66. Natl. Mar. Fish. Serv., Spec. Sci. Rep. Fish. 634. 25 p.

Schumacher, Albrecht, 1980. Management of the North Sea herring fisheries. In: Melteff, B. R., and V. G. Wespestad (Eds). Proceedings of the Alaska Herring Symposium. Alaska Sea Grant Report 80-4, Univ. of Alaska, Fairbanks.

Skrade, Jeffrey R., 1980. Management of Pacific herring in the Eastern Bering Sea. In: Melteff, B. R., and F. G. Wespestad (Eds). Proceedings of the Alaska Herring Symposium. Alaska Sea Grant Report 80-4, Univ. Alaska, Fairbanks.

Spratt, J. D., 1976. The Pacific Herring Resource of Tomales and San Francisco Bays: Its Size and Structure. Mar. Res. Tech. Rpt. No. 33. Cal. Dept. of Fish and Game. 44 p.

Spratt, J. D., (In Press). The current status of Pacific herring (Clupea harengus pallasii) in California to 1980. In preparation.

Taylor, F. H. C., 1963. The stock recruitment relationship in British Columbia herring populations. Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 154:279-92.

Taylor, F. H. C., 1964. The History and Present Status of British Columbia Herring Stocks. Fish. Res. Bd. Can. Bull. 143. 81 p.

Taylor, F. H. C., 1971a. Variations in hatching success in Pacific herring (Clupea pallasi) eggs with water depth, temperature, salinity and egg mass thickness. Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 160:34-41.

Tester, A. L., 1937. Populations of herring (Clupea pallasii) in the coastal waters of British Columbia. J. Biol. Bd. Can. 3:108-144.

Tester, A. L., 1955. Estimation of recruitment and natural mortality rate from age composition and catch data in British Columbia herring populations. J. Fish. Res. Bd. Can. Bull. 143:81 p.

Trumble, R. J., (Unpublished MS). A Literature Survey of Coastal Upwelling. 42 p.

Trumble, R. J., 1977. Effects of Limited-Entry Legislation on Management of Washington State Commercial Herring Fisheries. Wash. Dept. Fish. Prog. Rept. No. 12. 35 p.

Trumble, R. J., 1979. Analysis of Data Relating to Possible Effects of Sac-Roe Herring Fishing on the Abundance of Bait Herring. Wash. Dept. of Fish. Prog. Rpt. 80. 31 p.

Trumble, R. J., 1980. Herring management activites in Washington state. In: B.R. Melteff and V. G. Wespestad, (Eds.). Proceedings of the Alaska Herring Symposium, Feb. 1980. Alaska Sea Grant Rept. 80-4. p. 91-113.

Trumble, R. J. and M. G. Pedersen, 1980. Summary of the 1979 Experimental Offshore Herring Fishery With Results of Observer Coverage of Herring and Groundfish Fishing Activities off the Washington Coast. Wash. Dept. Fish. Manuscript. 22 p.

Trumble, R. J. and D. H. Reid, 1981. Summary of the 1980 Experimental Offshore Herring Fishery, off the Washington Coast. Wash. Dept. Fish. Manuscript.

Trumble, R. J., R. E. Thorne, and N. A. Lemberg, 1981. The Strait of Georgia herring fishery: A case history of timely management by means of hydroacoustic surveys. Submitted to Fish. Bull.

Wailes, G. H., J. Biol. Bd. Can. 1(6) 1936, p. 477-486.

Warner, I. M., 1976. Forage fish spawning surveys, Unimak Pass to Ugashik River. OCSEAP. Quart. Rpt. (July - Sept.): 61-96.

Williams, R. W., 1959. The fishery for herring (Clupea pallasii) on Puget Sound. Wash. Dept. Fish., Fish. Res. Rept. 2(2):5-29.

APPENDIX I

1. Coordinates of the U.S.-Canada Boundary in the ocean waters west of the U.S. and Canada.

48°29'37.19"	N. lat.,	124°43'33.19"	W. long.;
48°30'11"	N. lat.,	124°47'13"	W. long.;
48°30'22"	N. lat.,	124°50'21"	W. long.;
48°30'14"	N. lat.,	124°54'52"	W. long.;
48°29'57"	N. lat.,	124°59'14"	W. long.;
48°29'44"	N. lat.,	125°00'06"	W. long.;
48°28'09"	N. lat.,	125°05'47"	W. long.;
48°27'10"	N. lat.,	125°08'25"	W. long.;
48°26'47"	N. lat.,	125°09'12"	W. long.;
48°20'16"	N. lat.,	125°22'48"	W. long.;
48°18'22"	N. lat.,	125°29'58"	W. long.;
48°11'05"	N. lat.,	125°53'48"	W. long.;
47°49'15"	N. lat.,	126°40'57"	W. long.;
47°36'47"	N. lat.,	127°11'58"	W. long.;
47°22'00"	N. lat.,	127°41'23"	W. long.;
46°42'05"	N. lat.,	128°51'56"	W. long.;
46°31'47"	N. lat.,	129°07'39"	W. long..

2. Coordinates of the U.S.-Mexico Boundary in the ocean waters west of the U.S. and Mexico.

32°35'22.11"	N. lat.,	117°27'49.42"	W. long.;
32°37'37.00"	N. lat.,	117°49'31.00"	W. long.;
32°37'37.00"	N. lat.,	117°49'31.00"	W. long.;
31°07'58.00"	N. lat.,	118°36'18.00"	W. long.;
31°07'58.00"	N. lat.,	118° 6'18.00"	W. long.;
30°32'31.20"	N. lat.,	121°51'58.37"	W. long.

A-4.114

APPENDIX II

A HARVEST STRATEGY MODEL (HMODEL) FOR PACIFIC HERRING

Fishery management plans prepared for regional councils under the FCMA require consideration of maximum sustainable yield (MSY), modifications from MSY for social and economic reasons to provide Optimum Yield (OY), and a mechanism to determine how much fish may be harvested, Acceptable Biological Catch (ABC). Mathematical fishery models are often employed to calculate MSY, or to calculate fishing effort which will produce MSY. Single number solutions, however, cannot describe natural fluctuations inherent in fish populations. As a result, a computer simulation model called "HMODEL" was constructed to reflect year-to-year variations in Pacific herring biomass and to allow an assessment of the effects of harvest strategies. Before describing and discussing the results of this model, the more traditional models will be presented and their major drawbacks discussed.

TRADITIONAL MODELING

The concept of MSY has provided a convenient objective which is still commonly applied (Gulland, 1979), but has numerous deficiencies (Larkin, 1977). The mathematical models used to calculate MSY are usually logistic--surplus production types (Schaefer, 1954) using catch and effort, or the yield-per-recruit equation (Beverton and Holt, 1954) using a variety of population parameters. The models assume an equilibrium in the population associated with a degree of stability in the environment during the time period considered.

Mortality and Recruitment

Because the population models used to calculate MSY are only suitable for long-term averages, they may be marginal for MSY determination of any individual fish species which undergoes large natural fluctuations. These types of models cannot forecast discontinuous events, which is one of the primary problems facing management of herring populations. Many of the fluctuations are caused by various combinations of density-independent and density-dependent mortalities. Two competing density-dependent mortalities are compensatory, which decreases large abundance and increases low abundance to stabilize at an equilibrium point, and depensatory, which increases mortalities at low abundance and decreases mortalities at high abundance.

Competing mortality rates are most clearly reflected in the variability of recruitment experienced by many species of fish. One of the most common characteristics of herring populations is variable recruitment. In some stocks of herring, for example, the range of recruitment may vary by a factor of 100 times as noted for the Atlanto-Scandian herring by Gulland (1972). The strong year classes appear at very irregular and widely spaced intervals, but sustain the population for a number of years until the next strong recruitment occurs. Gulland estimated that 50 percent of the herring harvest from the Atlanto-Scandian stock for a 50-year period (roughly 1920-1970) came from three or four exceptional year classes. This herring stock may be an extreme example.

There is a tendency among clupeoids for longer-lived fish to experience greatest variability in recruitment and, therefore, biomass, while shorter-lived fish show more constancy (Murphy, 1977). Murphy suggests that clupeoid stocks with short life spans cannot withstand very large fluctuations in recruitment because inevitable recruitment failures will occur in consecutive years to reduce the population to a level where depensatory mortality will prevent stock recovery. Fishing necessarily reduces the stock size and the average age of a fish population. Thus, fishing increases relative fluctuation for a stock. Murphy noted that successive low recruitments occur in unfished populations without massive declines; stock collapse has been observed only for heavily fished populations.

For certain species of fish, the abundance of adults (spawners) in a given year has some predictive relationship to the later recruitment of young fish. Therefore, fishery management objectives can include optimum spawning escapement levels which, in turn, should generate the maximum amount of young fish. Salmon are an example of a species regulated for optimum escapement levels for individual runs.

One reason for the lack of a clear spawner-recruit relationship for herring is that large, environmentally-caused fluctuations of abundance occur. Observations on both Atlantic (Clupea harengus harengus) and Pacific herring show that fluctuations in year class strength are normal: eggs and larvae may experience very high natural mortality due to variable environmental conditions at each life stage. At normal levels of adult populations, environmentally-caused mortality of the young stages is far more important in determining the ultimate number of young fish than the actual abundance of spawners. Very heavy fishing pressure, however, may reduce the adult population so low that too few eggs or larvae will be produced to maintain the population (Pope, in press; Ulltang, in press).

Eggs and larvae produced from a depleted population will be susceptible to many of the same mortalities as experienced by the fish when they were more abundant. Poor environmental conditions could have a devasting effect on a depleted population, and very low recruitment would result. Good environmental conditions would increase recruitment, but recruitment would be limited by the very small amount of eggs produced. At low abundance levels, depensatory mortalities may operate. Ulltang (in press) theorizes that under certain conditions, herring populations which have been reduced to very low levels may not be able to recover to normal levels, even in the absence of fishing.

Herring characteristically lay adhesive eggs in shallow water on marine vegetation (Pacific herring) or on the bottom in waters up to several hundred meters deep (Atlantic herring). In both subspecies of herring, increased numbers of egg layers on spawning substrate tend to increase the mortality of eggs (compensatory mortality). Observations by European (Rannak, 1971, Burd and Wallace, 1971), Soviet (Galkina, 1971), Canadian (Taylor, 1971), and U.S. (Penttila and Day, 1975) scientists confirm that hatching success of individual eggs decreases dramatically as egg deposition thickness increases beyond several layers. Mortality of thick egg layers also increases through predation by birds (Cleaver and Franett, 1945) and fish, and from washup on the beaches in rough weather (Hourston and Rosenthal, 1977). If high numbers of larvae result from a particular spawning, predation will increase and the larvae will experience density-dependent mortality (Cushing and Harris, 1973). Large herring populations, which spawn at densities of multiple egg layers, will experience heavy loss of both eggs and larvae as a direct result of the large populations size. Because of high mortality of eggs and larvae, most herring populations can be characterized as possessing a spawning surplus, that is, adult fish whose loss will not affect the reproductive potential of the population.

An average spawner-recruit relationship for herring can be approximated: above a threshold value of spawning escapement, recruitment varies independently of escapement, so that an average recruitment level may be calculated. Below the threshold value, recruitment decreases to zero as escapement decreases to zero. The predictive value of this relationship is poor, however, because of the extreme environmentally-caused fluctuations in recruitment for any value of spawning biomass and because of the difficulty in determining the threshold value.

Examples

Gulland (1970) and Francis (1974) consider models (yield per recruit and logistic) under which preliminary estimates of maximum sustainable yield can be obtained by setting instantaneous fishing mortality (F_{opt}) equal to instantaneous natural mortaility (M). Age composition analysis for some herring populations indicate that $M = 0.4$. Over a year (assuming $F = M$), total deaths equal $1-e^{-(F+M)} = 1- e^{-.8} = 0.55$. One half of the deaths attributable to fishing implies a fishing rate of $0.55/2 = .28$. Reduction of the fishing deaths from 28 percent to a lower harvest level can be justified on the following points:

1. The conclusion that $F_{opt} = M$ applies only under certain conditions not fully met by herring. Herring are known to be susceptible to heavy fishing and recruitment declines at low population levels. Therefore, following Francis (1974), $F_{opt} < M$.

2. Management of herring should recognize that herring are an important forage organism, and require lower fishing mortality than might otherwise be possible.

3. Assessment of stock condition indicates that series of weak year classes frequently enter the fishery, and fishing intensity must be conservative.

These are points which should be considered before using this simplified model to set actual harvest rates.

A simple Beverton and Holt yield per recruit model using isometric growth (Gulland, 1969) was used to examine aspects of fishing pressure and age at entry. The following parameters were used as generally representative of a wide range of herring stocks:

$$W_\infty = 230 \text{ gr.}$$
$$K = 0.5$$
$$t_0 = -0.15 \text{ yrs.}$$

The yield-per-recruit isopleth diagram (Figure 1) shows yield in grams per fish alive at one year. The figure shows that yield per recruit increases continuously as fishing mortality increases and that herring should be fished at a young age. At fishing mortalities less than about 0.2, the yield-per-recruit model suggests fishing on herring as young as possible. At higher fishing mortality, the age at first fishing for maximum yield per recruit increases to a maximum of approximately 2 1/2 years. The age of maturity for most Pacific herring is about three years of age.

The management strategy of fishing very hard, especially on prereproductive fish, to harvest maximum yield per recruit does not take into account potential effects of fishing on recruitment. Reduction of stock biomass and elimination of older age groups from the population caused by heavy fishing may cause recruitment failure if spawning escapement falls below the escapement threshold level. Yield-per-recruit does not take into account potential effects of fishing on recruitment. Reduction of stock biomass and

elimination of older age groups from the population caused by heavy fishing may cause recruitment failure if spawning escapement falls below the escapement threshold level. Yield-per-recruit considerations alone suggest a fishing strategy that is clearly dangerous to the herring populations.

MODEL

No fishery for herring exists in offshore waters of the PFMC region. Research efforts have been limited to a joint U.S.-Canada research cruise in 1979, which provided quantitative abundance estimates in the U.S.-Canada transboundary area, an experimental fishery off the Washington coast on 1979 and 1980, and several Canadian research cruises. Data for the offshore phase of herring life history is very limited. A substantial amount of information has been gatered and analyzed for inshore herring. This information must be applied by inference to offshore areas. This model is a way to consolidate the data and inferences so that a range of management options may be explored. The model specifically separates inshore and offshore harvest as a result of the PFMC objectives to define the effects of an offshore fishery on the inside fisheries.

Two basic philosophies have been developed within Washington, California, and British Columbia to tailor existing fishery harvest rates to observed population size and spawning requirements. The first of these harvest strategies sets an optimum spawning escapement level and permits all additional fish to be considered harvestable surplus. The second strategy requires a harvest proportional to the population size.

Strategy I is currently applied only in British Columbia. A desired spawning escapement is calculated as the amount of fish required to deposit eggs in the intensity expected to produce maximum larval production (Hourston, personal communication); all additional fish are considered harvestable surplus. This permits very strong pulse fishing during years of heavy recruitment. However, by cropping off all available surplus, there are no fish allowed to carry over for subsequent years to balance or compensate for a series of poor year classes. Biomass declines during periods of poor recruitment are enhanced.

Stragegy 2 is based on the philosophy that a harvest schedule should parallel the natural cycles and abundance observed in nature. This allows a portion of strong abundance to remain unharvested so that the population will have a sufficient carry-over to buffer the effect of several years of poor recruitment. As a safeguard, a proportional harvest strategy may include a minimum population biomass below which no harvest is allowed. This minimum abundance should be above the spawning escapement threshold at which reductions in escapement cause reductions in recruitment. This will protect against continued harvest into low population levels where recruitment can be affected by the spawning population size. One drawback to the proportional harvest strategy is that during periods of higher than normal abundance, intensities of spawning may be high to the point that egg mortality will increase. In periods of heavy intensity spawning, increased catches may be made without jeopardizing reproductive potential of the population.

A *third* possible strategy, which is not currently used for management, is a constant quota, independent of biomass. We can examine the effects of any of these strategies applied to inshore or offshore herring fisheries.

Basic Model Concept

The model is based on a traditional fisheries yield-per-recruit model (Ricker, 1975; Beverton and Holt 1957). Each year is divided into time periods to which factors of recruitment, growth, and mortality are applied. Individual fish get larger as age increases (growth), numbers of individuals within a group diminish through time from natural and fishing deaths (mortality), and young fish periodically enter the population (recruitment). Growth, mortality, and recruitment are not constant through a year, so the year must be divided into intervals within which the rates are assumed constant. Standard fishery equations (growth and mortality are applied exponentially; see Ricker, 1975) allow biomass and harvest calculations for each interval. For a given set of biological parameters, one may compare biomass, harvest levels and population stability for a series of management strategies to determine effect on yield.

Limitations to the Model

Simulation models for fish such as herring must be used with caution. As discussed earlier, one of the dominant characteristics of herring population biology is variable recruitment and wide natural fluctuations in population size. Recruitment cannot be predicted in advance, so recruitment in the model is based on a stock recruitment curve plus lognormal error to generate variability. Long-term simulations provide averages that may be representative, but actual management must recognize and protect aginst the possibility of recruitment problems. Recruitment from year to year may be serially correlated, but our model does not incorporate serial correlation, and may not adequately represent the possibility of a series of poor recruitments (i.e., the possibility of depensatory mechanisms affecting mortality). Second to recruitment fluctuations, the most serious limitation is the inability to address the problem of discrete herring stocks mixing in off-shore waters. At best, our model simulation can be conducted for each identified population; however, separate runs for individual populations will not be able to consider interactions between stocks. Stock separation, including information on population parameters and abundance, is very poorly understood. Parameters in the model (e.g., mortality and growth) are the best available, but any errors will be reflected in the model output. These population parameters do not vary greatly between populations and are less than other variables.

Although the model cannot be used to accurately predict the course of events in a given year, it does give our best estimate of the long-term consequences of different harvest management strategies.

Detailed Construction of the Model

Figure 2 shows the time period (I-IV), the monthly instantaneous rates (M, F_o, F_s, G), fishing quota (Q_o, Q_s.), and recruitment (R), which are needed to go through the model's calculations.

While the time intervals can be changed, those used are generally representative of herring in the U.S.-Canada transboundary region. The calculations for each time period proceeds as follows:

Period I

The year starts April 1 with an estimate of spawning escapement (B_s) following the inside sac-roe fishery. For a period following spawning, biomass will decrease due to natural mortality (M), although the decrease will partially be offset by growth (G).

Hence, three months after spawning, $B_o = B_s \exp(-3(M-G))$.

Period II

Additional mortality (F_o) is added if an offshore fishery occurs. The model assumes a late summer-autumn season for offshore fishing.

Hence, after three months of fishing; $B_F = B_o \exp(-3(M+F_o-G))$.

Period III

This period begins with the recruitment of young fish into the fishery. Although young fish and adults coexist in many areas, they tend to be segregated by size into separate schools. The model calculates that recruitment (R) to the adult (spawning) population occurs only after an offshore fishery, on the assumption that the new recruits are smaller than required for human consumption use, and that the schools of small fish would sustain only a minimal harvest.

Hence, $B_I = (B_F+R) \exp(-5(M-G))$.

Period IV

This period of one month contains the inshore sac-roe fisheries. Assuming the monthly instantaneous mortality rate is F_s, $B_s = B_I \exp(-(M+F_s-G))$, and the model returns to Period I.

Stochastic Considerations

In order to simulate variability which occurs in a natural system, stochastic variation is included in three areas of the model. In all cases, variability is included as a lognormal error. This is, variability is "added" to the variable X, by forming

$$y = X\varepsilon \qquad \log(\varepsilon) \sim N(0, \sigma^2).$$

For moderately small values of σ, the bias in y will be small and σ will be the coefficient of variation of y.

Variable recruitment is therefore generated as follows. Because recruitment is primarily of three year olds, the spawning biomass surviving the sac-roe fishery (B_s) from three years previous is applied to the spawner-recruit curve (Figure 2), to get the recruitment value R'. Stochastic recruitment is generated as ($R = R'\varepsilon$), where ε is a lognormal deviate described previously.

Because catch quotas are based on estimated, and not actual population parameters, lognormal errors are placed on these parameters also. The ocean quota is determined by knowing the quantity B_o; but B_o must be inferred from an estimate of B_s; and B_s is, in turn, not actually known, but estimated. In our model, an estimate of B_o, say $\hat{B}_o$, for the purpose of generating quotas, is determined by first "estimating" B_s with $B_s = \hat{B}_s\ \varepsilon$, where ε is a lognormal deviate, and then applying three months of growth and natural mortality: $\hat{B}_o = \hat{B}_s \exp(-3(M-G))$. Similarly, the quota for the inside sac-roe fisheries is determined from an "estimate" of B_I: $\hat{B}_I = B_I\ \varepsilon$.

It is important to realize that the model always "knows" the "true" population sizes B_o and B_I, but the quota formulas must be based on $\hat{B}_o$ and $\hat{B}_I$.

Once the quotas are determined, however, the catches are taken from the true population sizes. These gyrations are only to simulate the effects due to quotas being based on estimates of population size, and not true population levels.

Quota Determination

Because the prinicipal goal of this model is to investigate the implications of various harvest strategies, the model contains a very general formulation for determining a quota from an estimate of population biomass. Generally, for both the offshore and inshore fisheries:

$Q = 0$ if $\hat{B} < \tau$

$Q = \gamma$ if $\tau \leq \hat{B} < \alpha$

$Q = \gamma + \beta\,(\hat{B} - \alpha)$ if $\alpha \leq \hat{B}$

where Q = annual catch

γ = a constant catch level

β = a constant harvest proportion

B = biomass at the start of fishing

α = a threshold (or reserve) population

τ = a switch that sets $Q = 0$ if $B < \tau$, but allows calculations to proceed if $B \geq \tau$

The parameters α, β, γ, τ are set by the manager.

Given $\hat{B}$, and α, β, γ, τ, an allowable Q is thus clearly determined. However, for our model, Q must be converted to an equivalent monthly instantaneous fishing mortality rate (i.e., the exact instantaneous rate which will result in a harvest of Q under the exponential model). This instantaneous fishing rate is determined by solving

$$Q = \frac{BF}{F+(M-G)}\left(1-e^{-(F+M-G)T}\right)$$

where B is the actual population size prior to the fishery, and T is the duration of the fishery in months. This equation is easily solved using iteration.

By setting combinations of α, β, γ, and τ equal to zero, various harvest strategies can be simulated. The three basic strategies are:

1. α stragey (proportion of total biomass which exceeds a thresnold), $\gamma = \tau = 0,\ 0 < \beta \leq 1,\ \alpha > 0 \rightarrow Q = \beta\ (\hat{B} - \alpha)$.

2. β strategy (proportion of total biomass), $\gamma = \alpha = \tau = 0,\ 0 < \beta \leq 1 \rightarrow Q = \beta\ \hat{B}$

3. γ strategy (constant quota), $\beta = \tau = 0,\ \gamma > 0 \rightarrow Q = \gamma$

Any of the three basic strategies may incorporate the switch .

For example, the Washington State strategy (β strategy with switch τ) of harvesting sac-roe herring at 20 percent of the population if the population exceeds 9,000 tons, but prohibiting harvest for lower abundance is simulated by setting

$$\gamma_0 = \beta_0 = \gamma_s = \alpha_s = 0,\ \beta_s = 0.2,\ \tau_s = 9{,}000.$$
$$\rightarrow Q_s = 0.2\ \hat{B}_I \text{ if } \hat{B}_I \geq 9{,}000$$
$$Q_s = 0 \qquad \text{if } \hat{B}_I < 9{,}000$$

A strategy such as used for northern anchovy harvest (α strategy) which allows a catch of one-third of all anchovy in excess of 10^6 tons follows by setting

$$\gamma_0 = \tau_0 = \beta_s = \tau_s = 0,\ \beta_0 = .333,\ \alpha_0 = 10^6$$
$$\rightarrow Q_0 = 0.333\ (B_0 - 10^6).$$

Canadian strategy (α strategy) of harvesting all herring in excess of a spawning escapement goal derives from $\gamma_0 = \beta_0 = \gamma_s = \tau_s = 0,\ \beta_s = 1.0,$

α_s = spawning goal $\quad Q_s = B_I - \alpha_s$ if $B_I \geq \alpha_s$

$Q_s = 0$ if $B_I < \alpha_s$

Results

For results to be useful, there must be confidence that the model responds in a way that is expected from theory. The simplest comparison to consider is the long-term average population biomass expected when no fishing occurs. Theoretically, $\bar{B} = \bar{R}/Z$ (Ricker, 1975), where $\bar{B}$ is average biomass, $\bar{R}$ is average recruitment, and Z is total mortality. For $\bar{R}$ = 100,000 tons, Z = M-G = 0.3, $B = \frac{100,000}{0.3}$ = 333,333 tons. The model calculated an average spawning escapement (B_s) of 337,645 tons for a 100-year simulation. Similar agreements occur for other combinations of $\bar{R}$ and Z. The model simulates average long-term conditions in a manner expected from theory.

The model offers a wide variety of management strategies, but to introduce the types of results possible, initial discussion will concentrate on inshore harvest only. Unless otherwise specified, results are based on the parameters M = 0.4, G = 0.1, Rmax = 100,000 tons, with simulations of 100 years. The coefficients of variation of the three stochastically-influenced variables (R, $\hat{B}_o$, $\hat{B}_I$) are all 0.2.

The model was run for a constant harvest proportion (β strategy, $Q = \beta_s B_I$) ranging from β_s = 0.2 to β_s = 0.6. At β_s = 0.2, the population and harvest were stable for the entire 100 years (Figure 3). Spawning escapement averaged 172,830 tons with a standard deviation of 20,273. Harvest averaged 44,959 tons with a standard deviation of 9,636 tons. An increase of β_s to 0.4 caused a long-term decrease to near zero levels (Figure 4). However, the decline did not occur for over 25 years, indicating that heavy fishing pressure may be maintained if recruitment cycles are favorable, but when an unfavorable recruitment cycle occurs, heavy fishing will drive the population to critically low levels. At β = 0.6, the population trend is inexorably down, to near extinction in just over 10 years (Figure 5).

As a protective mechanism, one may use the τ parameter to prevent harvest at low biomass levels. At β_s = 0.4 but τ_s = 100,000 tons (i.e., R = τ = 100,000 tons), the population is protected against continuous decline (Figure 6). For the first 25 years with β_s = 0.4, the biomass values track in parallel fashion for τ = 0 and τ = 100,000. However, once the critical recruitment problem occurs, the population rebounds off the reserve (τ), but crashes without the reserve. During the 100-year simulation (Figure 6), predicted harvest averages 54,264 tons with standard deviation of 21,624 tons. This harvest is higher than using β = 0.2 (Figure 2), but is also plagued by many years of zero harvest.

A contrasting strategy harvesting all fish above a spawning reserve (α strategy, $Q = \hat{B}_s - \alpha_s$) also shows long-term stability (Figure 7) but with larger year-to-year variation than observed for the β strategy (Figure 2). For α_s = 150,000 tons, catches average 49,043 tons, but with a standard deviation of 41,316 tons. Many years have no harvest or very low harvest, but other years will have extremely large catches.

The conclusion from this set of runs is that a threshold, either a spawning reserve (α) or switch (τ) will protect against too high harvest. But neither of these strategies will be able to prevent large fluctuations in abundance or harvest. The least variation came from a constant proportion of harvest (β strategy). The switch τ is a good companion to the β strategy in case higher than desired harvest inadvertently occurs.

Addition of an offshore harvest can be tested for effects on the inshore fishery. For illustrative purposes, the simplest example is the α strategy and a constant offshore quota (γ_o). Adding γ_o = 3,000 tons to the inshore strategy of α_s = 150,000 and β_s = 1.0, increases the average offshore harvest by 3,000 tons (0 to 3,000), while the average inshore harvest decreases by 2,330 tons (51,608 to 49,278) for a net gain of 670 tons:

Offshore catch =	3,000	(3,000 ton increase)
inshore catch =	49,278	(2,330 ton decrease)
total	52,278	(670 ton increase)

Spawning escapement remains essentially unchanged by the offshore fishery, and the increased catch is possible because of harvesting fish destined to die through natural causes prior to spawning.

For γ_o = 3,000 tons, and β_s = 0.2, the average harvest offshore increases from 0 to 3,000 tons, while inshore harvest decreases by 1,229 tons (from 44,959 to 43,720), for a gain of 1,771 tons:

offshore catch =	3,000	(3,000 ton increase)
inshore catch =	43,720	(1,229 ton decrease)
Total	46,720	(1,771 ton increase)

The increased harvest comes at the expense of spawning escapement because total fishing mortality (F) increases.

For the same strategies with a 10,000 ton constant offshore harvest:

$\gamma = 10,000 \quad \alpha_2 = 150,000 \quad \beta_2 = 1.0$

offshore catch	= 10,000	(10,000 ton increase)
inshore catch	= 43,855	(7,753 ton decrease)
Total	53.855	(2,247 ton increase)

$\gamma = 10,000 \quad \beta_2 = 0.2$

offshore catch	= 10,000	(10,000 ton increase)
inshore catch	= 40,864	(4,096 ton decrease)
Total	50,864	(5,905 ton increase)

A similar set of runs was completed for a simulated population with the approximate characteristics of the Strait of Georgia sac-roe herring: Rmax = 5,000; M = 0.4; and G = 0.1. This is a useful run because the results can be compared to actual observations in the Strait of Georgia for the past eight years. Strategies of: $\beta_s = 0.2$; $\beta_s = 0.2$, $\tau_s = 9,000$; and $\alpha_s = 7,200$ are shown in Figures 8, 9, and 10, respectively.

The three strategies have similar average harvests, but the β strategies give much less fluctuation than does the α strategy. Also, the spawning escapement is considerably higher for the β strategy. For comparison to recent years in the Washington sac-roe fishery, estimated spawning escapement has ranged from 8,000-12,000 tons; catch has ranged from 1,600 to 4,400 tons, and estimated prefishing abundance has ranged from 9,000 to 15,000 tons.

CONCLUSIONS

The following conclusions can be made from the preceding examples of harvest strategies:

1. Of the fish harvested offshore from July through August, 77.5 percent would have returned to spawn if no fishing had occurred (22.5 percent would have died anyway). More would have returned if the offshore fishery were later in the season.

2. If the inshore harvest follows a α strategy, the offshore catch will slightly increase the total harvest without decreasing spawning escapement, through a reduction in the inshore quota. The increase would be smaller as the offshore fishery is later in the season.

3. If the inshore harvest follows a β strategy, the offshore catch will increase the total harvest; however, both inshore harvest and spawning escapement will be lower, and total fishing mortality (F) will increase. Maintaining constant F and constant spawning escapement requires a reduced β_S value, which will reduce the inshore quota further.

4. Because recruitment cannot be predicted prior to offshore harvest, any adjustment in harvest will have to be made in the inshore fishery (through α or τ) to meet spawning requirements.

5. Reduction of B_I to below α or τ, caused by an offshore fishery, will prevent an inshore harvest.

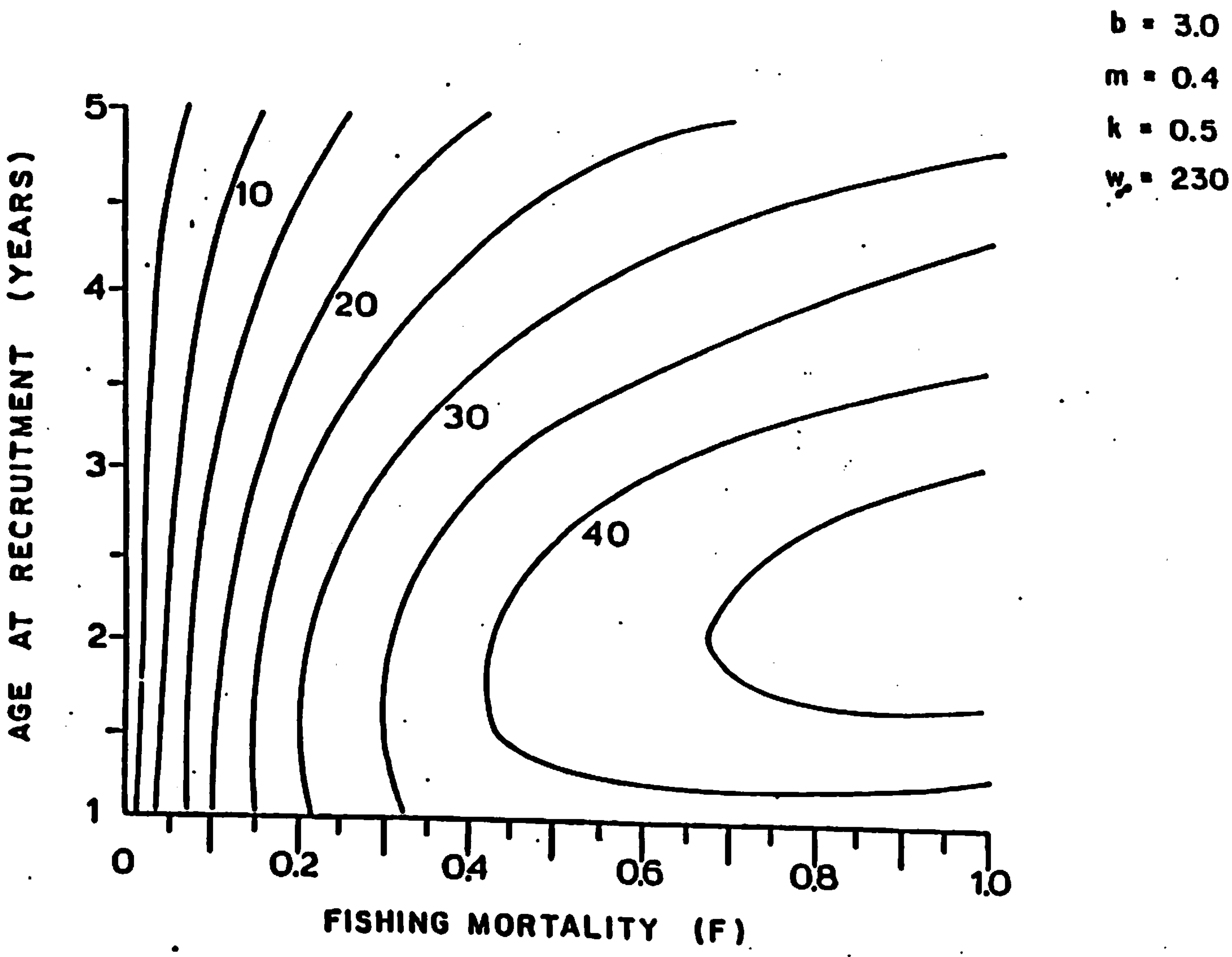
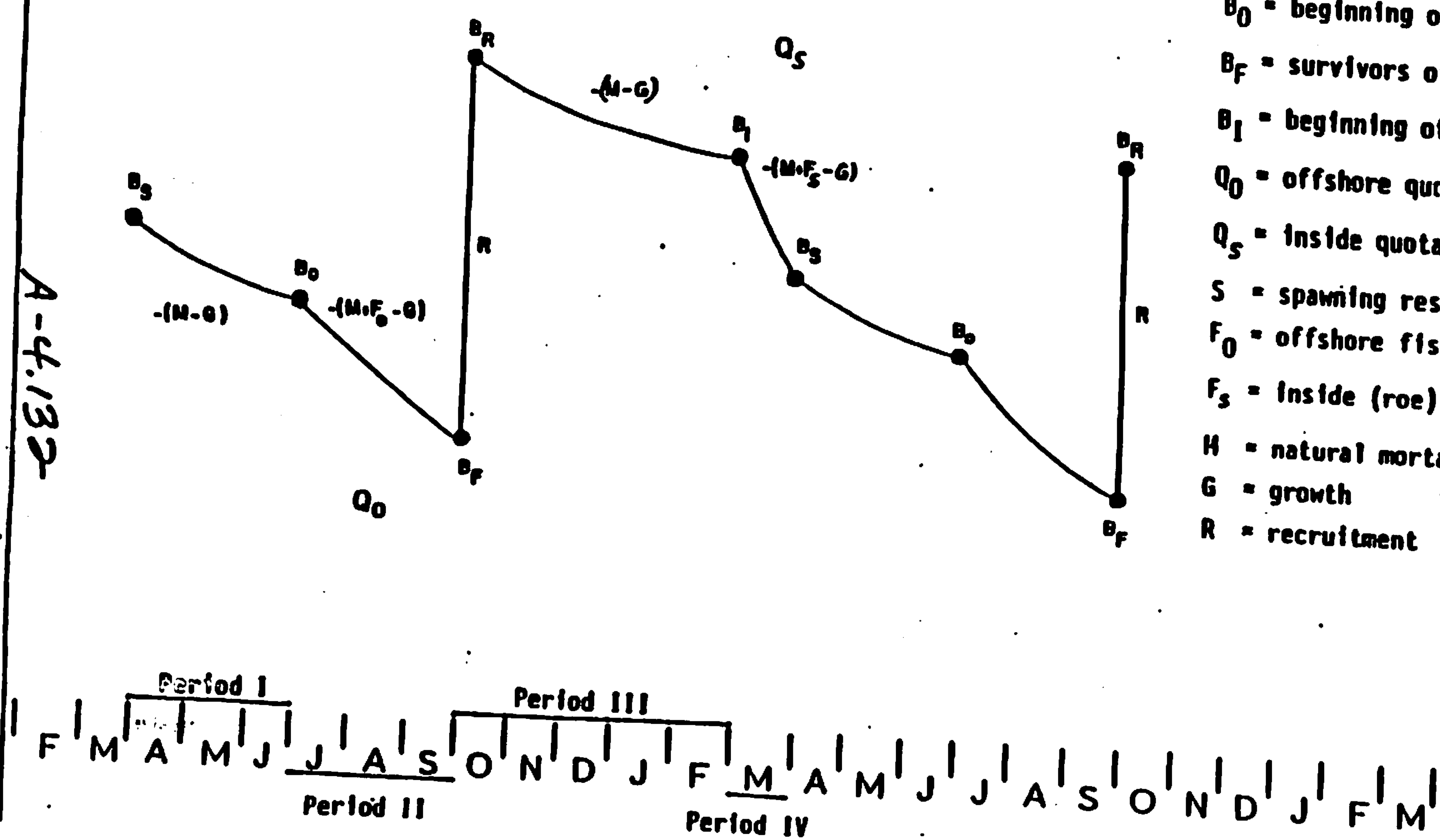


Figure 1. Yield per recruit isoplelhs for Pacific herring



B_S = survivors of roe fishery

B_O = beginning of offshore fishery

B_F = survivors of offshore fishery

B_I = beginning of inside fishery

Q_O = offshore quota

Q_S = inside quota = B_I-S

S = spawning reserve

F_O = offshore fishing mortality

F_s = inside (roe) fishing mortality

M = natural mortality

G = growth

R = recruitment

Figure 2. Basic time periods, rates, and biomass levels for herring harvest simulation.

A-4.132

OUTPUT OF HERRING MODEL

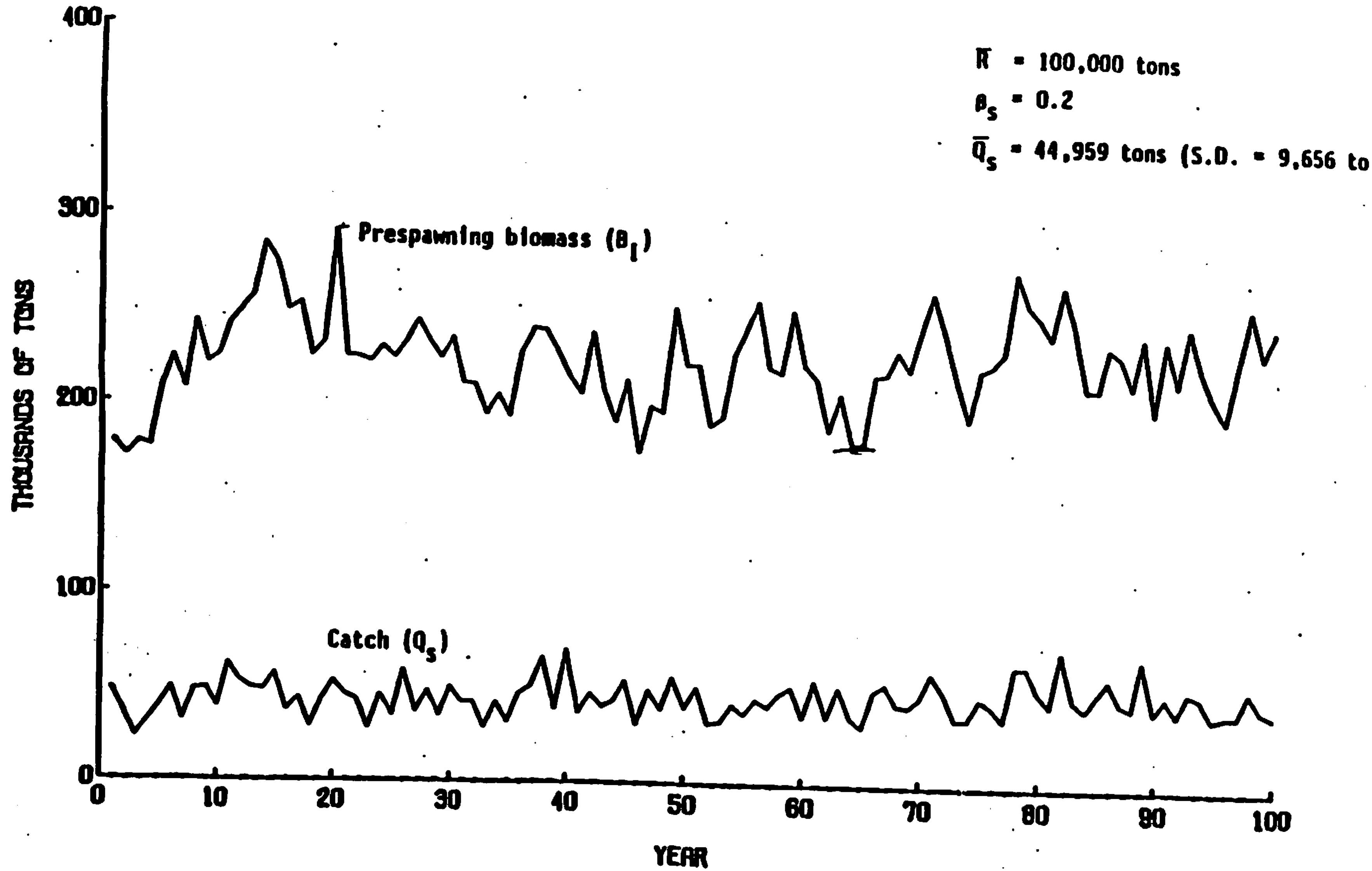


Figure 3. Yearly catch and abundance of herring simulated by HMODEL; harvest rate is 20% of prespawning biomass.

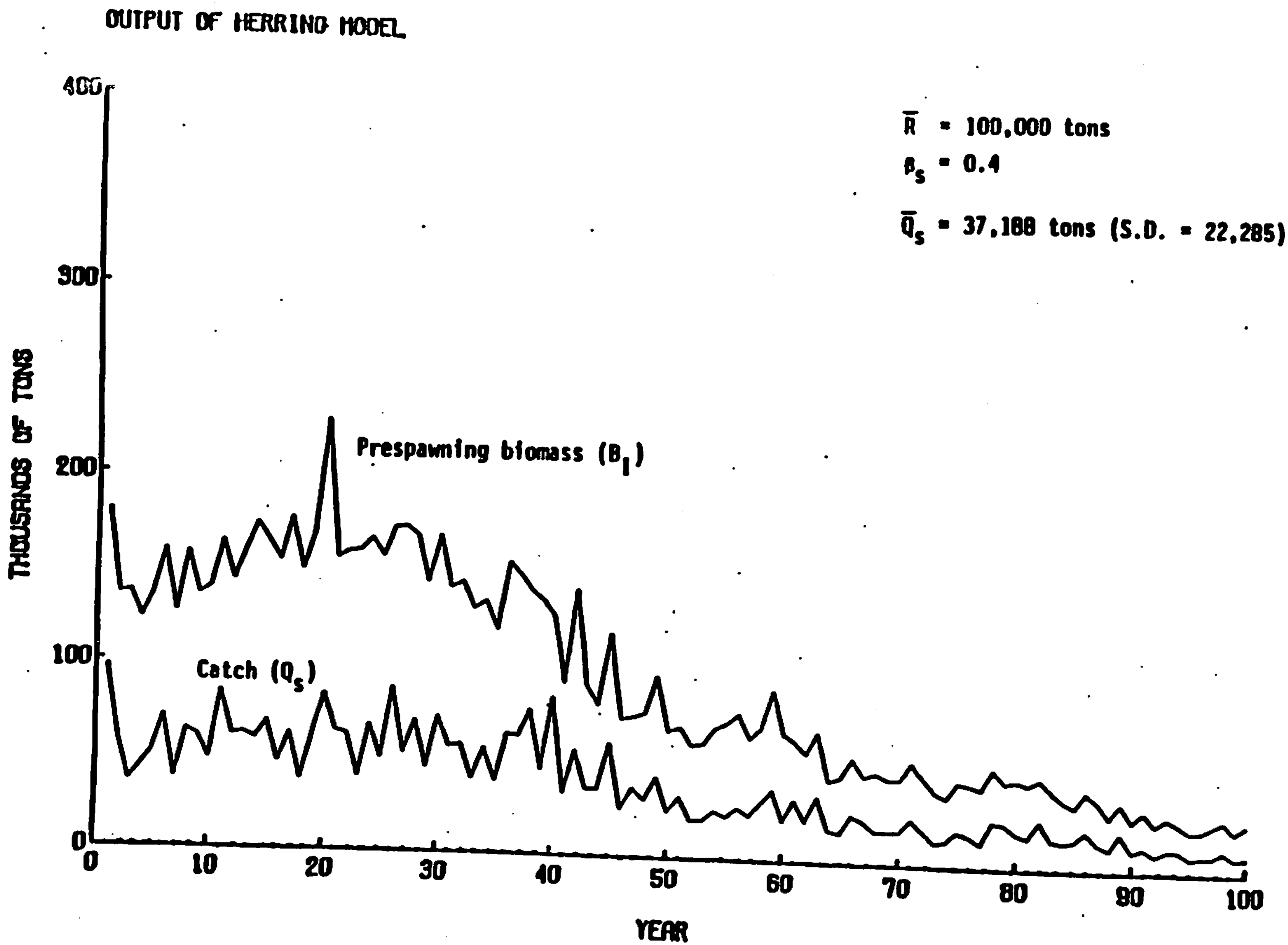


Figure 4. Yearly catch and abundance of herring simulated by HMODEL; harvest rate is 40% of prespawning biomass.

A-4.134

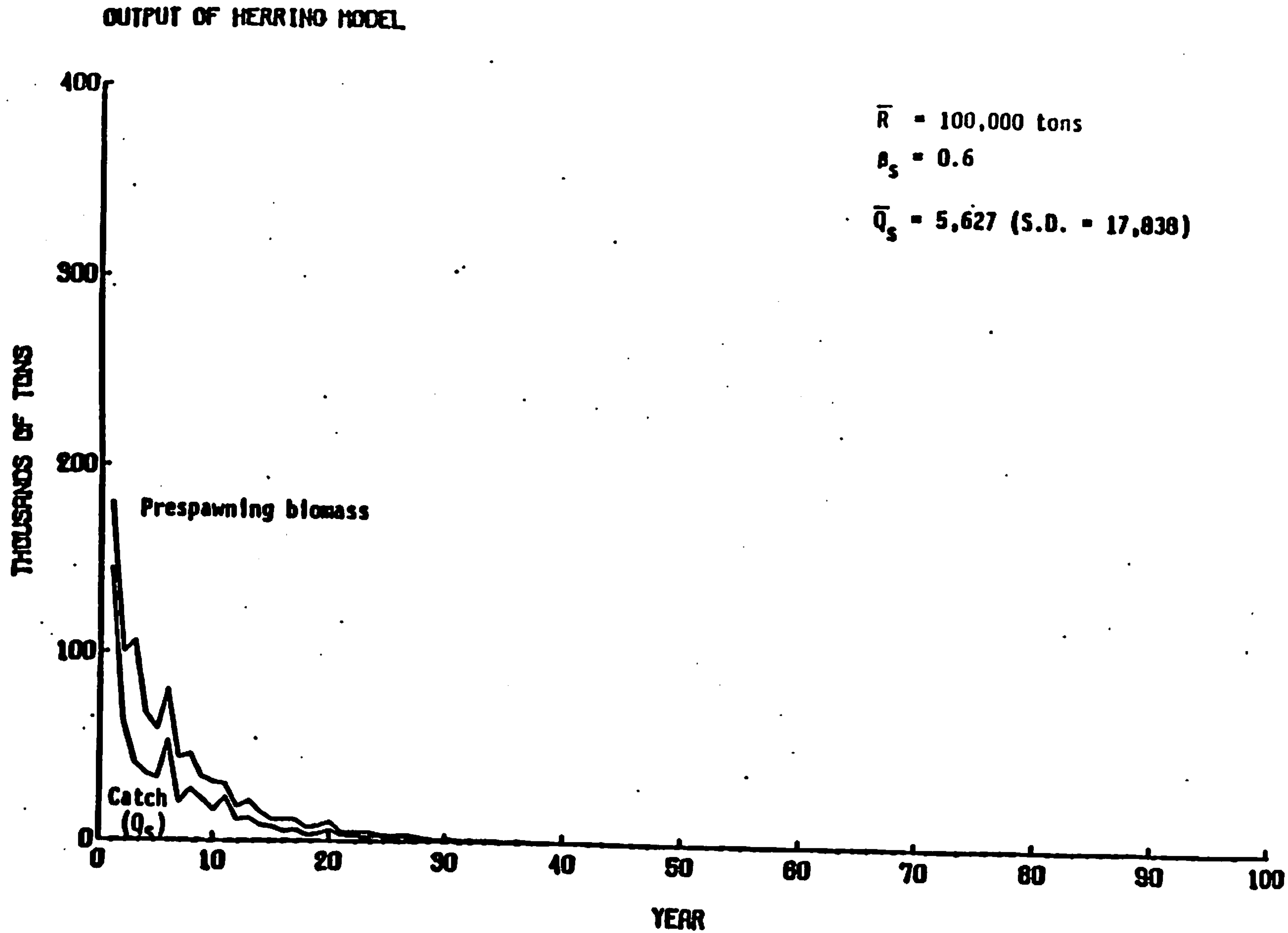


Figure 5. Yearly catch and abundance of herring simulated by HMODEL; harvest rate is 60% of prespawning biomass.

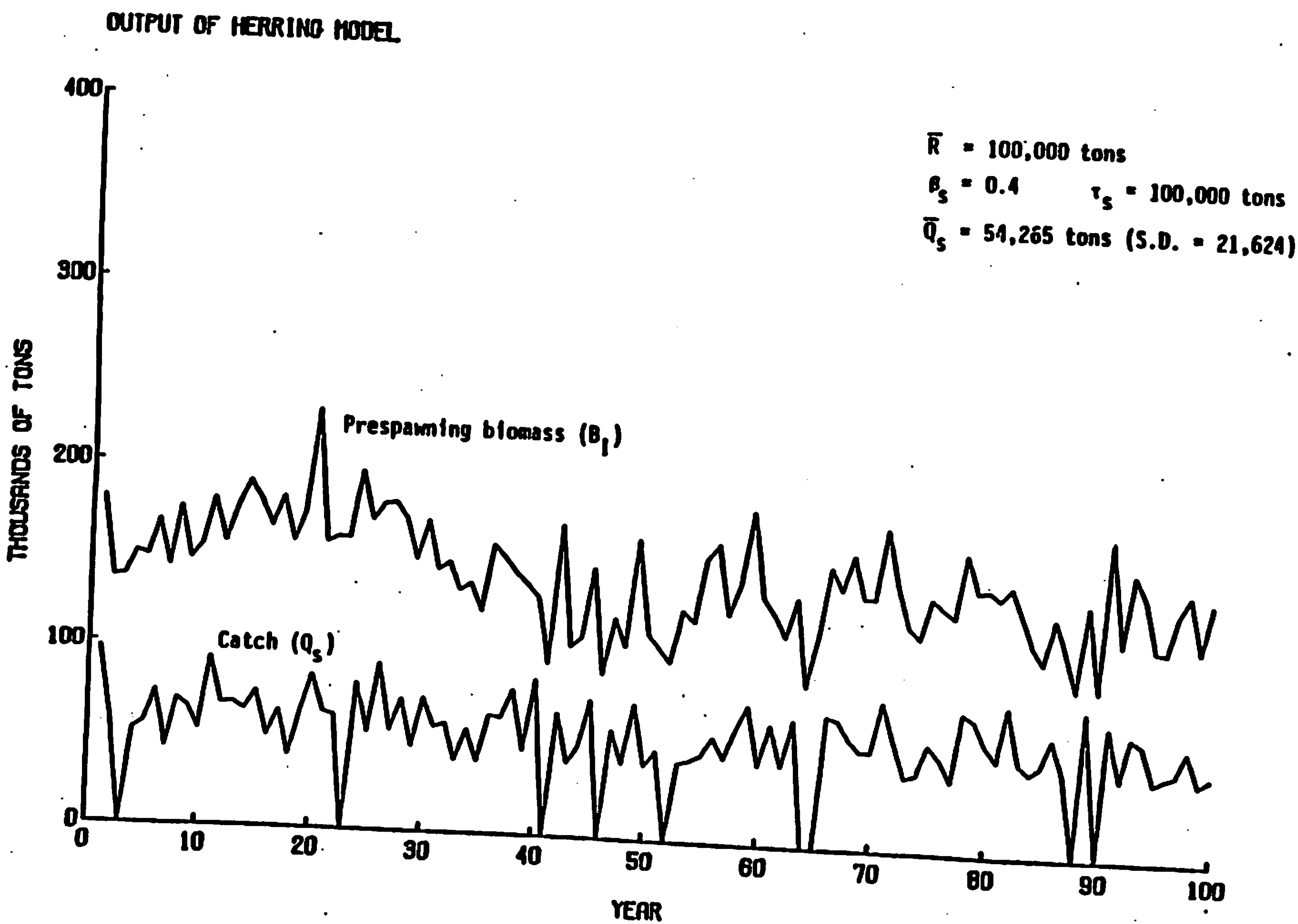


Figure 6. Yearly catch and abundance of herring simulated by IHMODEL; harvest rate is 40% of prespawning biomass if the biomass exceeds 100,000 tons and 0 if [illegible]

A-4.136

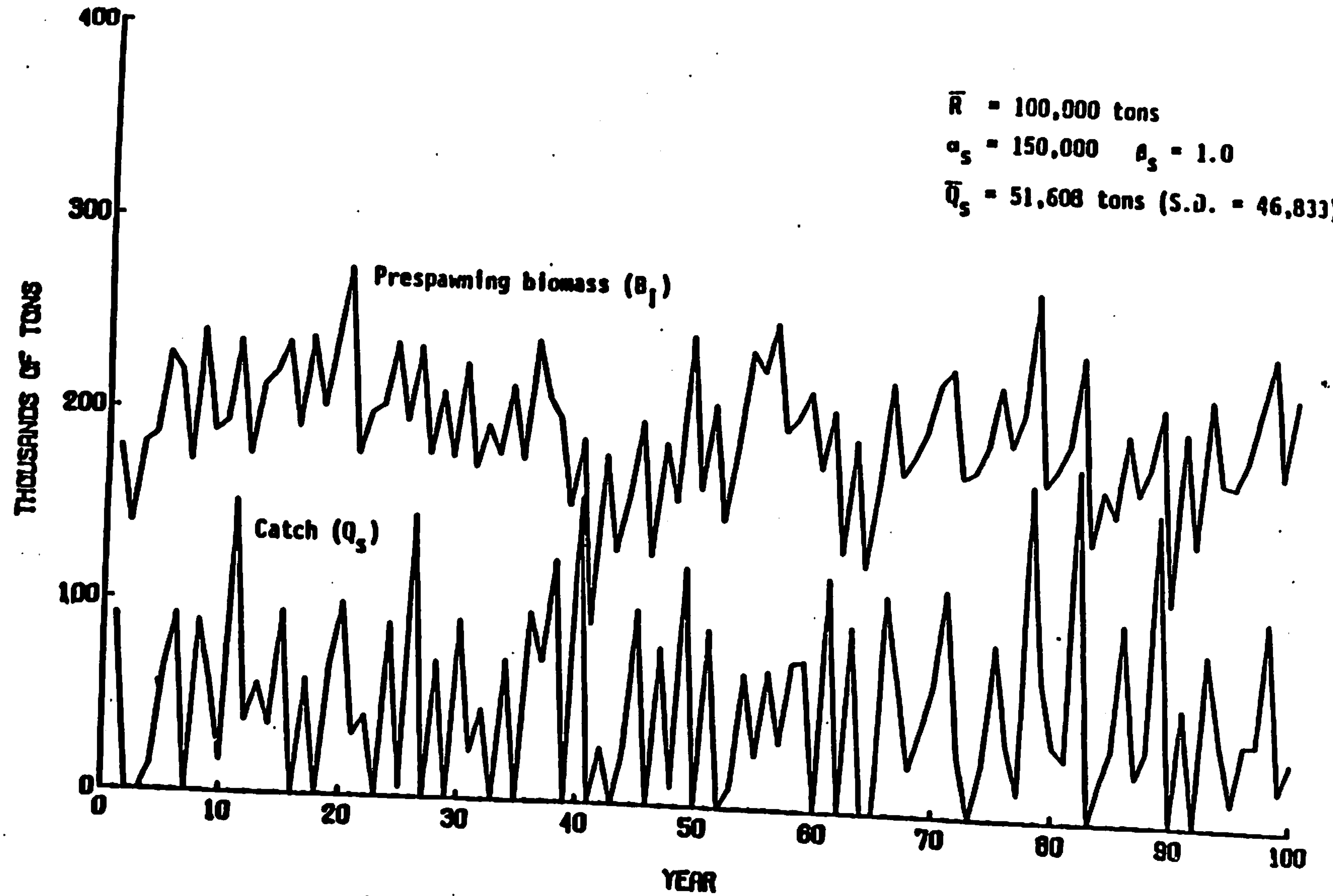


Figure 7. Yearly catch and abundance of herring simulated by HMODEL; harvest rate is all biomass that exceeds a 150,000 ton spawning reserve.

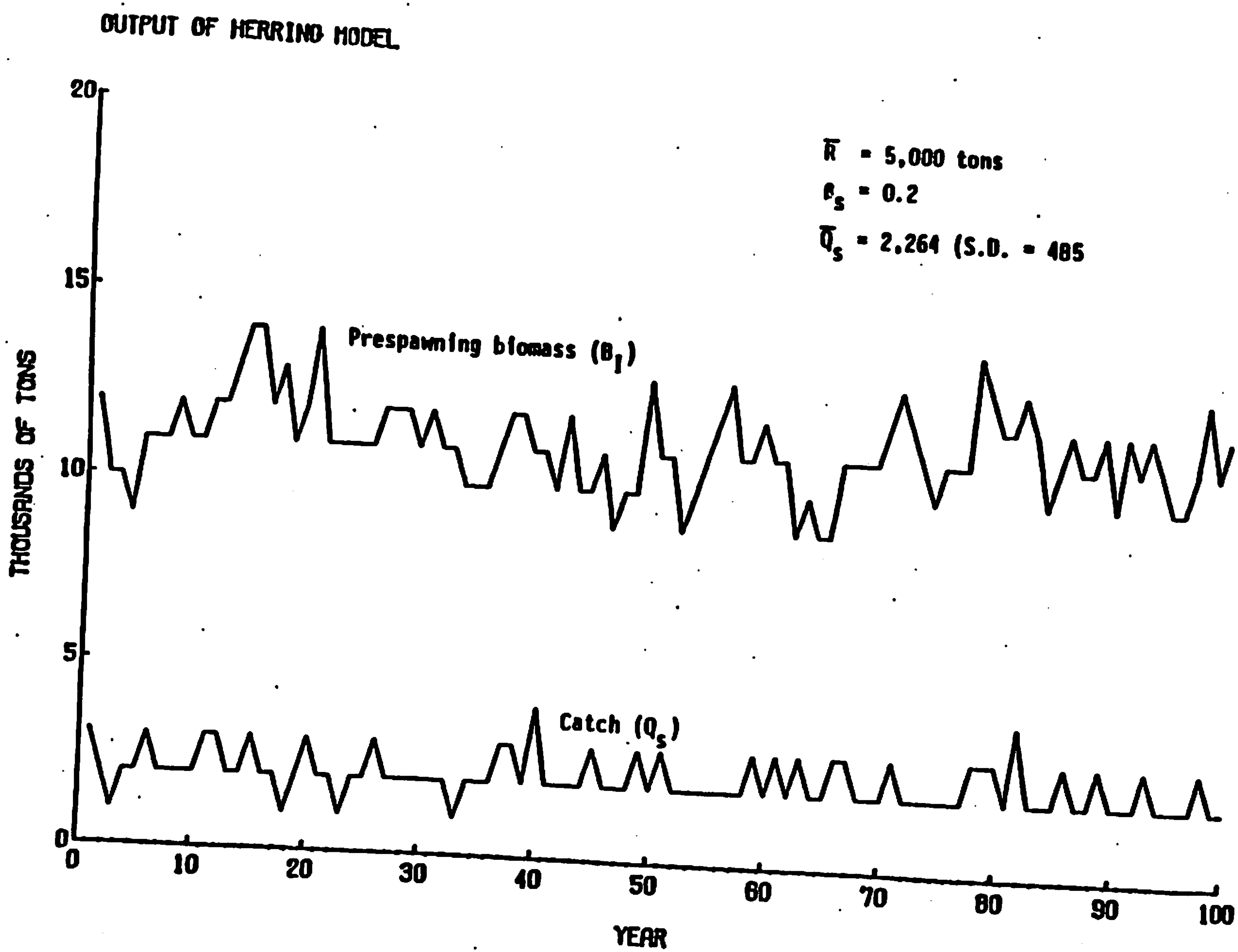


Figure 8. Yearly catch and abundance of herring simulated by IMODEL; harvest rate is 20% of prespawning biomass.

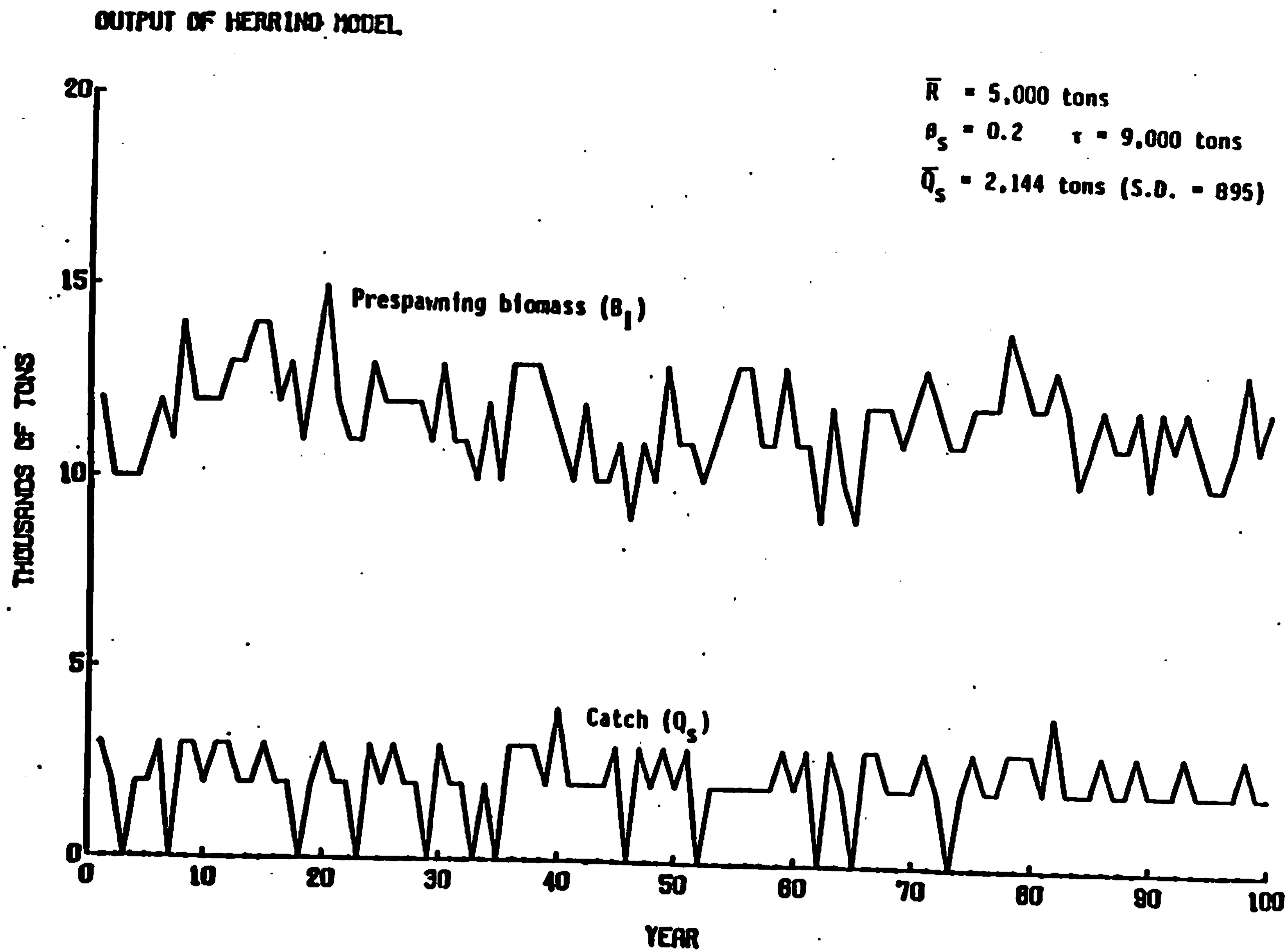


Figure 9. Yearly catch and abundance of herring simulated by HMODEL; harvest rate is 20% of prespawning if the biomass exceeds 9,000 tons, and 0 if biomass is less than 9,000 tons.

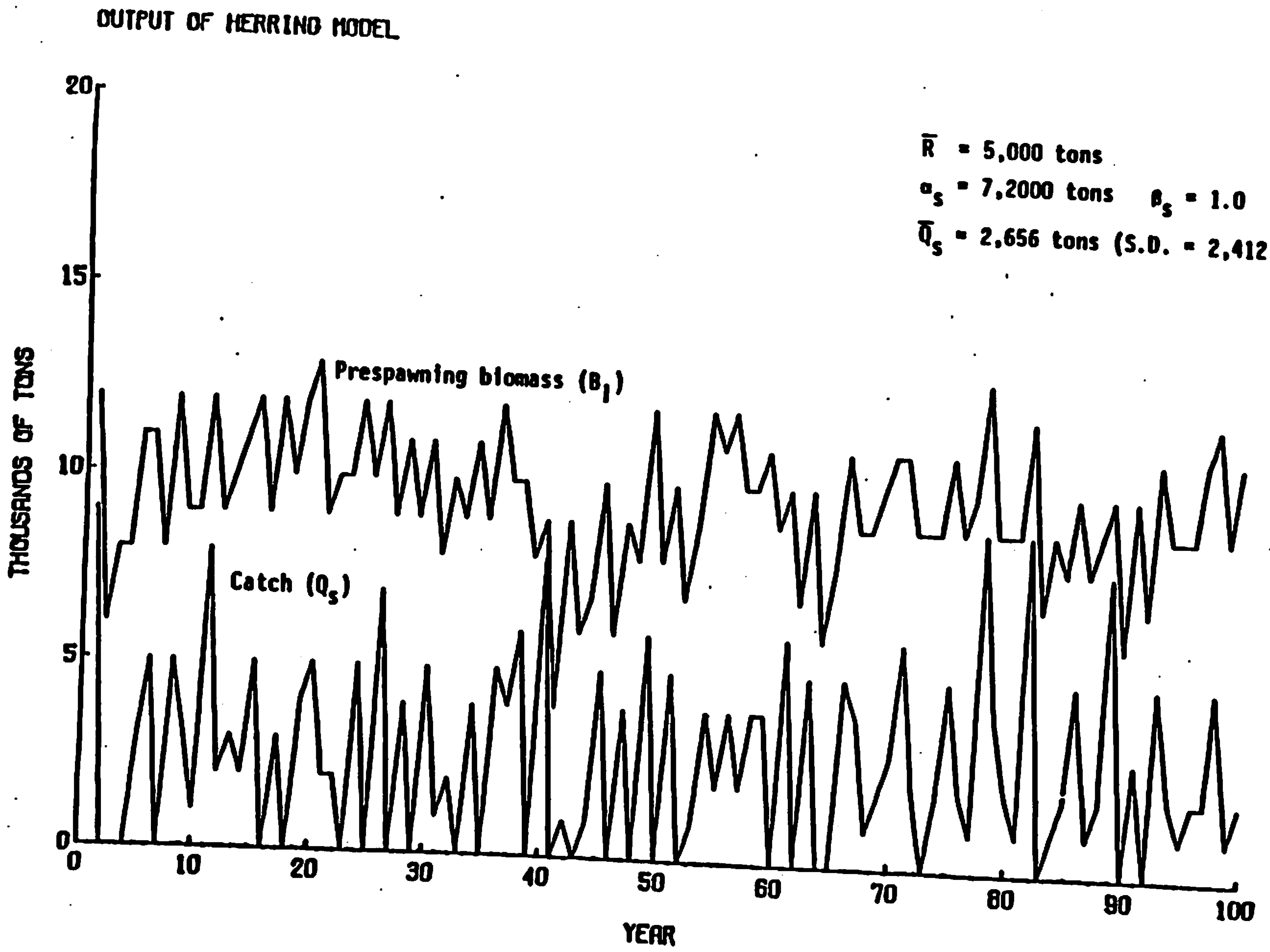


Figure 10. Yearly catch and abundance of herring simulated by IMODEL; harvest rate is all biomass that exceeds a 7,200 ton

A-4.140

APPENDIX III

Common and scientific names of groundfish included in the incidental catch restrictions.

SHARKS	
Leopard shark	*Triakis semifasciata*
Soupfin shark	*Galeorhinus zyopterus*
Spiny dogfish	*Squalus acanthias*
SKATES	
Big Skate	*Raja binoculata*
California skate	*R. inornata*
Longnose skate	*R. rhina*
RATFISH	
Ratfish	*Hydrolagus colliei*
MORIDS	
Finescale codling	*Antimora microlepis*
GRENADIERS	
Pacific rattail	*Coryphaenoides acrolepis*
ROUNDFISH	
Lingcod	*Ophiodon elongatus*
Pacific Cod	*Gadus macrocephalus*
Pacific whiting (hake)	*Merluccius products*
Sablefish	*Anoplopoma fimbria*
ROCKFISH	
Pacific ocean perch (POP)	*Sebastes alutus*
Shortbelly rockfish	*S. jordani*
Widow rockfish	*S. entomelas*
OTHER ROCKFISH 1/	
Black rockfish	*Sebastes melanops*
Blue rockfish	*S. mystinus*
Bocaccio	*S. paucispinis*
Canary rockfish	*S. pinniger*
Chilipepper	*S. goodei*

1/ By definition, the category "other rockfish" includes all rockfish except Pacific ocean perch, shortbelly and widow rockfish.

Copper rockfish	_S. caurinus_
Cowcod	_S. levis_
Darkblotched rockfish	_S. crameri_
Greenspotted rockfish	_S. chlorostictus_
Longspine thornyhead	_Sebastolobus altivelis_
Olive rockfish	_Sebastes serranoides_
Redstripe rockfish	_S. proriger_
Rougheye rockfish	_S. aleutianus_
Sharpchin rockfish	_S. zacentrus_
Shortspine thornyhead	_Sebastolobus alascanus_
Silvergray rockfish	_Sebastes brevispinis_
Splitnose rockfish	_S. diploproa_
Stripetail rockfish	_S. saxicola_
Vermilion rockfish	_S. miniatus_
Yellowmouth rockfish	_S. reedi_
Yellowtail rockfish	_S. flavidus_
Yelloweye rockfish	_S. ruberrimus_

FLATFISH

Arrowtooth flounder (turbot)	_Atheresthes stomias_
Butter sole	_Isopsetta isolepis_
Dover sole	_Microstomus pacificus_
English sole	_Parophrys vetulus_
Flathead sole	_Hippoglossoides elassodon_
Pacific sanddab	_Citharichthys sordidus_
Petrale sole	_Eopsetta jordani_
Rex sole	_Glyptocephalus zachirus_
Sand sole	_Psettichthys melanostictus_
Starry flounder	_Platichthys stellatus_

LITERATURE CITED

Beverton, R. J. H. and S. J. Holt, 1957. On the Dynamics of Exploited Fish Populations. Fishery Investig. Ser. II, Vo. 19. Her Magest's Stationery Office, London. 533 p.

Burd, A. C. and P. D. Wallace, 1971. The survival of herring larvae. Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 160:47-60.

Cleaver, F. C. and D. M. Franett, M.D. The Predation by Sea Birds Upon the Eggs of the Pacific Herring (Clupea pallasii) at Holmes Harbor During 1945. Biol. Rept. No. 46B. Wash. Dept. Fish. 18 p.

Cushing, D. H. and J. G. K. Harris, 1973. Stock and recruitment and the problem of density dependence. Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 164:142-155.

Francis. R. C., 1974. Relationship of fishing mortality to natural mortality at the level of maximum sustainable yield under the logistic stock production model. J. Fish. Res. Bd. Can. 31:1539-1542.

Galkina, L. A., 1971. Survival of spawn of the Pacific herring (Clupe larengus pallasi val.) related to the abundance of the spawning stock. Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 160:30-33.

Gulland, J. A., 1969. Manual of Methods for Fish Stock Assessment. Pt. 1. Fish Population Analysis. FAO Manuals in Fishery Science, No. 4. FAO, Rome. 154 p.

Gulland, J. A., 1970. Preface. In: J. A. Gulland, (Ed.). The Fish Resources of the Oceans. FAO Fish. Tech. Rap. 97:1-4.

Gulland, J. A., 1972. Population Dynamics of World Fisheries. Washington Sea Grant Publication WSG 72-1. 336 p.

Gulland, J. A., 1977. Goals and Objectives of Fishery Management. FAO Tech. Paper No. 166. FAO, Rome. 14 p.

Haegele, C. W., R. D. Humphreys and A. S. Hourston, 1981. Distribution of eggs by depth and vegetation type in Pacific herring (Clupea haregus pallasi) spawnings in South British Columbia, Canada. J. Fish. Aquat. Sci. 38:381-386.

Hourston, A. S. and H. Rosenthal, 1976. Viable Hatch from Herring Eggs Torn Loose from Substrates by Storms. Fish. Mar. Serv. Res. Dev. Tech. Rept. 653. 5 p.

Larkin, P. A., 1977. An epitaph for the concept of maximum sustainable yield. Trans. Amer. Fish. Soc. 106:1-11.

MacCall, A. D., Population models for the northern anchovy (Engraulis mordox). Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 177:292-306.

Murphy, G. I., 1977. Clupeoids. In: J. A. Gulland, (Ed.). Fish Population Dynamics. John Wiley and Sons, New York. pp. 283-308.

Penttila, D. E. and D. E. Day, 1970. Baitfish Management Activities in Washington State from July 1, 1974 to December 31, 1975. Wash. Dept. Fish Prog. Rept. No. 76-02. 40 p.

Pope, J. G. In Press. Some consequences for fisheries management of aspects of the behaviour of pelagic fish. Rapp. P.-V. Reun. Cons. Int. Explor. Mer.

Rannak, L., 1971. On recruitment to the stock of spring herring in the northeastern Baltic. Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 160:76-82.

Ricker, W. E., 1975. Computation and interpretation of biological statistics for fish populations. Fish. Res. Bd. Can. Bull. 191. 382 p.

Schaefer, M. B., 1954. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. Bull. Inter-Amer. Trop. Tuna Comm. 1(2):27-56.

Taylor, F. H. C., 1971. Variation in hatching success in Pacific herring (Clupea pallasii) eggs with water depth, temperature, salinity, and egg mass thickness. Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 160:34-41.

Ulltang, O., (In press). Factors of pelagic fish stocks which affect their reaction in exploitation and require a new approach to their assessment and management. Rapp. P.-V. Reun. Cons. Int. Explor. Mer.

APPENDIX 4

Annual Emission Levels for San Francisco Bay Area Counties

ANNUAL AVERAGE EMISSIONS (TONS/DAY) 1996
SAN FRANCISCO BAY AREA

PM	PM-10	TOG	ROG	No_x	SO_2	CO
618.6	206.0	1,341	760.8	571.7	87.4	3,056

PM = particulate matter
PM-10 = particulate matter <10 microns
TOG = total organics
ROG = reactive organics
NO_x = nitrogen oxides
SO_2 = sulfur dioxide
CO = carbon monoxide