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JUNE 1983

CALIFORNIA MARINE MAMMAL-FISHERY INTERACTION STUDY, 1979-1981

by

Daniel J. Miller, Michael J. Herder, and John P. Scholl

ADMINISTRATIVE REPORT LJ-83-13C

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Daniel J. Miller, Michael J. Herder, and John P. Scholl
Marine Resources Branch
California Department of Fish and Game

June 1983

This report was prepared by Daniel J. Miller, Michael J. Herder, and John P. Scholl under contract No. 79-ABC-00149 for the National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, California. The statements, findings, conclusions and recommendations herein are those of the authors and do not necessarily reflect the views of the National Marine Fisheries Service. Douglas P. DeMaster of the Southwest Fisheries Center served as Chief Official Technical Representative for this contract.

TABLE OF CONTENTS

LIST OF TABLES

List of Tables - Continued

List of Tables - Continued

LIST OF FIGURES

List of Figures - Continued

List of Figures - Continued

ABSTRACT

Two years of data were collected on the direct interaction between marine mammals and all California commercial and recreational ocean fisheries. Both at-sea and shore interview samples were valuable, and in several fisheries, a more representative estimate of interaction was derived from interview data. Marine mammal mortality is infrequent and usually clustered, and for most fisheries, it was not possible to obtain sufficient at-sea trips to estimate mortality. Possible marine mammal mortality caused by fishing activities per year for all fisheries was about 1,900 California sea lions, 117 harbor seals, 25 elephant seals, 15 harbor porpoises, 60 pilot whales, 3 gray whales, and 1 *Balaenoptera* sp. The fisheries most adversely affected by marine mammal depredation were the commercial salmon troll fishery, the California halibut gill net fishery, the Native American gill net fishery in the Klamath River, and the partyboat fishery near San Diego. A total of about $380,000 annual loss in fish and gear was estimated in the salmon fisheries. The gill net fisheries sustained about a $120,000 annual loss in fish and gear. Nearly all the loss in the gill net and salmon troll fisheries was by California sea lions, but only harbor seals were observed depredating the salmon gill nets in the Klamath River. Other fisheries sustaining losses were the Pacific herring, partyboat and skiff salmon fisheries, and the round haul net fisheries for anchovy and mackerel. No interaction was reported or observed in the pier, shore hook-and-line, skindiving, and bottomfish skiff recreational fisheries. In all the fisheries where depredation occurred, only a small portion of the mammals present were involved in the interaction.

Mean value of fish and gear depredated by marine mammals annually was:

	Fish Loss	Gear Loss	Total	1980 Value of Fish to Fishermen (Millions of $)
Salmon Fisheries				
Commercial Troll	$274,000	$12,220	$286,220	13.0
Partyboat	6,000	360	6,360	2.4*
Skiff	2,300	(insig.)	2,300	0.7*
Klamath River Subsistance	74,000	10,000	84,000	0.5*
Total Salmon Fisheries	$356,300	$22,580	$378,880	16.6
Partyboat-Non Salmon (So. California)	$ 27,000	$10,730	$ 37,730	8.1**
Pacific Herring	$ 57,100	$ 4,550	$ 61,650	8.5
Gill Net (non-herring)	$ 63,360	$57,070	$120,430	1.8***
Total All Fisheries	$503,760	$94,930	$598,690	35.0
		Percent of Total		1.4

*No commercial sales permitted; value is as if the same fish were bought at retail price.

**4.5 million fish at $1.80 mean per fish at retail price.

***Minimal assumption - data not collected for 1980.

ACKNOWLEDGEMENTS

In any comprehensive investigation such as this, considerable voluntary assistance is needed, and many federal agencies and Department of Fish and Game employees and fishermen supplied time and information without which we would not have achieved our goals. In the Eureka Department of Fish and Game office, Joseph Lesh instructed his field personnel to collect data for our project and enabled us to obtain good depredation values in the salmon fishery. Lawrence Quirollo supplied mammal interaction data for all recreational fisheries in the northern coastal area. At Menlo Park, Walter Dahlstrom and Edward Finley aided in the collation of herring fishery data, and Jerome Spratt supplied herring fishery data at Monterey. Also at Monterey, James Hardwick, Jack Ames, Frank Henry and Kenneth Boettcher assisted in monitoring the gill net fishery, and Robert Lea assisted in loan of the research boat OPHIODON. Phillip Lehtonan supplied data at the Morro Bay office, and David Ono did likewise at Santa Barbara. In the Long Beach office, Herbert Frey, Robson Collins, Paul Gregory, Eric Knaggs, James Phelan, Dennis Bedford, Richard Klingbeil, Larry Heitz, and Marija Vojkovich are some of the many individuals who gave us generous assistance. National Marine Fisheries Service personnel James Leckey, Dana Seagars, Douglas DeMaster, John Henderson, James Coe, William Perrin, and Nancy Lo assisted in developing sampling programs and in the pilot whale census. Also assisting in marine mammal counts were Donald Patten, Los Angeles, Lyman Fancher, Alviso, and Sarah Allen and Harriet Huber, Pt. Reyes Bird Observatory. To all the above, and many others not listed, our sincere thanks is given for their contribution which often went far beyond what was asked.

INTRODUCTION

This document is the final report of a 2-year study conducted by the State of California to determine the direct marine mammal-fishery interactions in California's ocean waters. The National Marine Fisheries Service contracted with the State early in 1979 (NASO Contract No. 79-ABC-00149), and field investigations were initiated on July 1, 1979. Equal funding was contributed by the Southwest Region Office, Terminal Island and the Southwest Fisheries Center, La Jolla.

The original contract was to extend for one year, but several fishery conditions precluded sufficient coverage. A second year's field program was included, and the sampling regime was adjusted to cover certain unforeseen fishery problems that were not evident at the onset. The analysis and write-up period was extended until the end of the 1980-81 federal fiscal year.

This study is the initial phase of a long range research program designed to (i) establish inter-relationships between marine mammals and the fisheries, (ii) set up research programs to fill information gaps in the population dynamics and life history of marine mammals, and (iii) define optimum sustainable population criteria for at least those mammals that are involved in human interaction. One of the uses of the results will be to determine if the State of California will request return of management of certain marine mammals under the provisions of the Marine Mammal Protection Act of 1972.

Complete findings for each fishery for the 2-year period are presented. There are fishery categories in which the catch is of one species even though more than one gear type may be used. These are the salmon, Pacific herring, and market squid fisheries. Some gear types are used to capture more than one species, and more than one species is often sought and landed at the same time by the same gear in other fisheries. Some fisheries are classified by the structures and habitat used. Fisheries are presented by categories that best define the fishery such as gill net, round haul net, bottomfish commercial passenger fishing vessel (referred to as partyboat in text), bottomfish skiff, pier, shore, trawl, and fish trap.

OBJECTIVES

Direct marine mammal-fishery interactions of all domestic fishing vessels at sea and all shore fishing activities were monitored. The objectives were:

1. Determine incidence of marine mammal interaction in each commercial and recreational fishery in state waters.
2. Determine incidental marine mammal mortality and injury associated with fishing gear and operations.
3. Estimate the depredation of catch and damage to gear, or fishing sites.
4. Determine if gear types cannot be used due directly to marine mammal activity.
5. Record incidences of injury and mortality to marine mammals from lost, untended, or "ghost" fishing gear.

SAMPLING PROGRAM

A detailed sampling methodology for each fishery category will be presented in the description of each fishery.

Sampling Periodicity and Intensity

Many fisheries occur in a restricted period of the year such as the Pacific herring and salmon fisheries. Others may be undertaken throughout the year but usually have strong seasonal peaks of catch and effort. Superimposed upon these sometimes extreme fishing variables are the seasonal fluctuations in abundance and distribution of migratory marine mammals. The first task was to determine an adequate coverage of each fishery under budgetary and equipment restraints. A minimum degree of sampling intensity was chosen and then the sampling effort was apportioned to monitor the fisheries, each with its fluctuating periods of intensity.

At the onset of the study, there had been no comparable multi-fishery interaction study to refer to for methodology. Briggs and Davis (1972) conducted a 6-month salmon fishery-sea lion interaction study in Monterey Bay in 1971. They were able to sample 0.2% of the catch and utilized only at-sea observations. They concluded that the data were not statistically reliable for variance analysis and indicated that possibly a 1% sample may have been adequate (K. Briggs, Univ. of California, Santa Cruz, pers. commun.). Subsequent to the initiation of this program, Everitt et al. (1980) considered that a 5% sample would be desired in the Columbia River when they designed their fishery-mammal interaction study.

Commercial catch records published periodically by the Department of Fish and Game (DFG) and recreational fishery catch and effort surveys (Miller and Gotshall 1965; Miller and Odemar 1968; Pinkas, Thomas, and Hanson 1967) supplied an estimate of the potential effort and catch to be expected in most of the fisheries. By apportioning the known number of field days available, it was determined that probably no more than a one percent at-sea sample of all the fisheries could be obtained, although for some fisheries sampling intensity would be higher when other fisheries were not in operation. It was not possible to establish a purely random sampling regime due to the high unpredictable variability of effort in most fisheries, the likelihood that there would not be access to a randomly drawn boat on a given day, and unforeseen weather and logistic problems.

At-Sea and Interview Sampling

Some fisheries could be covered only with interview or indirect sampling of the fishermen when fish were being unloaded. These were the skiff fisheries for both salmon and bottomfish and in any fishery in which the boats fished overnight in out of state waters. Pier, shore, and jetty areas were covered by direct sampling when the fishermen were actually fishing. The Pacific herring fisheries of central and northern California were observed directly from shore or from DFG research boats, and the market squid fisheries were monitored primarily from the R/V KELP BASS in southern California and the state research boat OPHIODON in Monterey Bay. These samples were considered at-sea because the entire fishing operation of individual boats could be monitored.

The fisheries in which at-sea samples were needed such as in the commercial and partyboat salmon fisheries were planned originally to be covered entirely at sea. It soon became apparent, however, that due to non-cooperation of the commercial fishermen, samplers would not be able to obtain sufficient boat trips. There was also the likelihood that the boat trips they could arrange might fish in different areas than the majority of the fleet were operating and not represent the fishery. As soon as this problem was realized, interview samples of fishermen were made as the fish were being unloaded. This was primarily in the commercial salmon fishery and gill net fisheries of southern California. At-sea samples were still attempted as first choice for all samplers, but if an at-sea trip could not be arranged for a particular day, that day was spent interviewing at landing docks and ramps. During these interviews, attempts were made to arrange for at-sea trips.

Immediate comparisons were made between at-sea and interview data, and in the salmon partyboat fishery, there was a close relationship in the degree of interaction and the catch. Commercial salmon at sea and interview data were more difficult to evaluate because not enough at-sea samples were obtained to permit a valid statistical comparison. It was not possible to obtain sufficient at-sea samples at any one port to make a valid comparison with interview data collected at the same port at the same time. Interview data for the salmon fishery were emphasized in the second year, and the DFG Anadromous Branch added a column to their field sheet to record marine mammal interaction for us. At-sea trips were still arranged because certain data such as behavior of mammals and species identification of mammals and birds could not always be derived from interview data.

Fishermen Attitudes

Difficulties in gathering mammal interaction data from fishermen were encountered in all fisheries. The principal investigator has been collecting assessment data from fishermen for nearly two decades, and the attitudes of many fishermen in all fisheries have become generally reserved or uncooperative within the past several years. There are no simple answers to this problem, but a few distinct attitudes have been revealed.

There are many reasons why observers are not invited aboard, most of them commonly encountered over many years and considered as merely part of the fishing operation. These include the lack of insurance coverage by the boat operator or owner, the common desire to want to be alone and not have to be concerned about someone who may be injured or uncomfortable on a small vessel, that the observer will get sick and create an unpleasant atmosphere and not be able to do the job, and that the boat operator may want to change plans during the trip and would inconvenience the observer if the trip was extended for several days or the boat returned to another port. These are not the attitudes that have created a serious at-sea sampling program in recent years. The main problem now is the distrust of government research which may potentially result in more restrictions on the fishery. Superimposed upon this general attitude is the overall negative attitude towards any government employee, an attitude spawned primarily by political rhetoric of the 1980's.

Two particular events have created an atmosphere of distrust of agency research representatives within the past two years in California.

One was the use of observer data in the tuna-porpoise program for litigation under the Marine Mammal Protection Act of 1972 against fishermen. The other was the formation of the Pacific Fisheries Management Council, which is considered too restrictive by many commercial salmon fishermen. The fear of arrest was a concern to some fishermen if some inadvertant violation would take place when an observer was aboard. This attitude was exacerbated in the central California area where an agency poster was placed on bulletin boards in harbors offering a large reward to anyone giving information leading to the arrest and conviction of anyone violating the MMPA. At the same time, a student from a large university near Monterey Bay related the rules of the MMPA over the radio channel used by commercial fishermen resulting in considerable agitation among the fishermen. The problem is not so much of mistrust of "environmentalists" and the agency personnel who must enforce restrictions on the take of marine mammals, but rather that the environmental protection laws are so powerful and supported by so many of the public that many fishermen felt it was a waste of our time to study a problem on marine mammal interaction when there was no possibility to solve the problem. They were, of course, considering that terrestrial predator management of killing animals to reduce the mammal populations to where interaction would become minimal would be applied to marine problems. Our answer to this was to point out the success of gear development in the tuna-porpoise problem and that other means may be developed if we could get a better idea of the nature and mechanics of the interaction. This approach was not always successful.

One of the paradoxes of fishermen's attitudes was revealed in this study. Even though many fishermen professed openly that they did not trust us or that we were wasting our and their time, they still gave us valuable and accurate interview information. It was rare when a fisherman would out-right refuse to give any information. It was also rare when a fisherman would give obvious erroneous information, and it was noticeable immediately to the interviewer when it did take place. Why then did so few salmon trollers allow an observer aboard? Information obtained from fishermen we have known personally over the years and remarks by new acquaintances in the gill net fishery of southern California revealed that "peer group" inhibition was primarily at play. On several occasions, we would be told that they would like to take us out but that the rest of the fishermen would not like it, possibly resulting in animosity among members of the fishery. Fishermen know that marine mammals and birds occasionally become entangled in nets and that salmon trollers will occasionally shoot sea lions and many fishermen did not want this information to become hard facts. The end result of all this is that we did not receive overt cooperation from those who felt intimidated by other fishermen and friends by allowing us on their vessels, but they were still extremely helpful and honest with us in revealing their catch data, where the fish were taken, how many fish were lost, and all other items they could accurately recall. We accomplished the sampling goals, but not as was originally planned.

SALMON FISHERIES

Introduction

There are four fisheries in which salmon are taken in California. These are the commercial troll fishery, the commercial smolt release and return spawner fishery, the recreational fishery, and the Klamath River Native American subsistence gill net fishery. The commercial troll fishery is made up of several components: large vessels with sleeping quarters and freezer storage which stay out for many days (trip boats), vessels moored in harbors which almost always return the same day (day boats), and skiffs which are launched at ramps. The recreational fishery consists of partyboats or charter boats carrying up to 35 fishermen, small private boats moored in harbors or launched at ramps, and shore, pier, and river bank fishermen in quest of spawning run salmon and steelhead.

The migratory behavior of the two major species taken, king (chinook) and silver (coho), is predictable and anadromous fish research personnel along the coast from several state and federal agencies are aware of the status of the stocks for each major river. The timing and approximate abundance of the spawning runs in the rivers are predictable, however, location of feeding concentrations in the ocean may be quite variable. A highly efficient fishery using acoustic devices, constant experimental fishing, and radio communication readily locate fishable aggregates. Salmon are only occasionally taken south of Monterey (less than 2% of the total catch), and this report will include fishery information from Monterey to the Oregon border.

The historical pattern of fishing has been for the recreational fisheries south of Tomales Bay to start in February with the commercial fishery starting several months later. The spawning adults return to the rivers in summer and fall, and after October, little ocean fishing takes place until next spring. There are spring runs of salmon in some larger rivers, but these do not contribute materially to the river catches.

The regulations for commercial fishing change each year and only the 1980 general rules will be given to relate the nature of the fishery. Regulations concerning seasons, size limits, bag limits, and hold inspections are adopted by the Pacific Fishery Management Council, based on the status of the resources. There is advisory input from management agencies and the industry. The Council, in conjunction with the U.S. Department of Commerce, has management responsibility for the offshore salmon resources within the Fishery Conservation Zone (3-200 miles offshore). The State of California has management responsibility for salmon inside 3 miles. Management of all the commercial and recreational salmon fisheries involves numerous agencies, including the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, Bureau of Indian Affairs, the U.S. Department of Justice, and several state agencies within Washington, Oregon, and California. The result of all the various agency jurisdiction and public interest is a complex, coordinated effort requiring long-term planning by agencies and interests which may have conflicting goals. The general regulations for California in 1980 for the commercial fishery were:

Season: South of Cape Vizcaino (Figure 1) - all salmon except coho from May 1 through May 15; all salmon from May 16 through

May 31 and from July 1 through September 30.

North of Cape Vizcaino - the same schedule as above except the July opening was on July 16 instead of July 1.

Size Limits: chinook - 26 in TL; coho - 22 in TL.

Bag Limits: none in 1980

Limited Entry: first imposed in the 1980 season.

Regulations for the recreation fishery were:

Season: no closed season north of Tomales Point; south of Tomales Point open from February 1 through October 31.

Bag Limit: two fish per person, any species of salmon.

Size Limits: at least 22 in except that one may be no less than 20 in.

Regulations permit the use of hand or troll lines for commercial capture of salmon, but gill nets are allowed only in the Klamath River Native American subsistence fishery. Troll gear consists of one or more lines of braided steel cable wound onto a spool. Hooks with bait or artificial lures are drug at speeds of from 1 to 3 knots and at depths of from 2 to 30 fm. Single, barbless hooks were required prior to May 16 for all artificial lures except salmon plugs. Barbed hooks were permitted for salmon plugs and with natural bait. Baits commonly used were anchovy, herring, and occasionally mackerel. Artificial lures varied with spoon, flashers, "hootchies", and squid skirts being the most common.

Lures and baited hooks are generally tied to a heavy monofilament leader and fastened at "stops" on the steel cable by means of a clip-on device at about 1 fm intervals. Lines are weighted at the bottom with

10 to 40 lb round ball weights, the heaviest closest to the vessel. The lines are suspended on outrigger poles, and the outer line on each pole is attached to a float device, keeping the line some distance behind the vessel and away from the inner lines. Fishermen use from 1 to 4 troll lines on each side, depending upon the size of the vessel. Lines with heavy weights are controlled by hydraulic winches. On smaller skiffs, hand operated winches are used. All the lines are usually attached to springs tied to the poles; the stretch and erratic action of the spring indicating that a fish has been hooked.

Commercial Troll Fishery

Methods

Catch records are kept at each port on a bi-weekly basis throughout the season by the Anadromous Fisheries Branch of the DFG. These data were readily available to the project, and additional information was entered on the anadromous branch forms for our use. Project sampling included more detailed information including number of sublegal fish (shakers) returned, the number of hours spent fishing, the number of hooks and lines used, number of hours spent fishing, amount of gear damage and from what cause, the number of fish lost and from what cause, animal behavior, and where the fish were caught. We also included monitoring of the recreational skiff fishery in the larger northern California rivers (not the Sacramento), fishing from banks at mouths of rivers and in the tidal area of rivers in which sea lions and harbor seals could forage. All the data were digitized for computer collation and analysis.

Initially, we planned to attain most of the interaction data from vessels at sea (direct or field sampling). As mentioned in the introduction section, there was a serious degree of non-cooperation in obtaining at-sea trips. The result was that at some major ports such as Eureka and San Francisco where trip boat landings were dominant, almost no commercial at-sea samples could be obtained in the first month. At other ports such as Fort Bragg and Moss Landing where fishermen's attitudes were somewhat more cooperative towards our research, at-sea samples could be obtained, but still not at the desired statistical level.

The only possible way out of the dilemma was to investigate the reliability of interview data. Instructions to samplers were to continue to attempt to get as many at-sea trips as possible but to remain at unloading stations and launching ramps to gather port-fishing or interview data if an at-sea sample was not available. In the Copper River Delta commercial gill net-harbor seal interaction study (Matkin and Fay 1979), mammal depredation values derived from interview data were a little more conservative (less fish lost) than direct observations made from project boats at the fishing sites. The small amount of possible bias actually turned out to be in the sampling procedure (C. Matkin pers. commun.) due to the choice of random samples being made in areas of the river where interaction was more likely to take place.

Our first comparisons of at-sea and interview data was in the partyboat salmon fishery in San Francisco Bay. When a partyboat returned to port, the sampler would intercept fishermen after they had left the boat and ask each individual or party separately about interaction with mammals during the day. After the fishermen were contacted and had departed, the skipper or a deckhand of the vessel was then interviewed. No discrepancies were encountered between the reports from a boat, and the data proved to be precise. We were able to achieve a higher sampling effort than originally planned and could rely upon Anadromous Branch personnel to collect interview data, releasing more time for project personnel to obtain at-sea trips on commercial vessels.

In the commercial fishery, one person per boat would be contacted. In this case, comparisons of at-sea and interview data at the same port and in the same time frame were needed. Repeated attempts were made to gather valid comparative data for both series but sufficient at-sea samples could not be obtained at a port within a short period of time in order to derive reasonable confidence intervals. In general, depredation values were in the same magnitude and recorded from the same fishing areas,and an obvious bias was not revealed after the first month's data were collated. It was noted that a disproportionate majority of at-sea trips were on day boats and that the major catches were being made by the trip boats. Continuing attempts were made to obtain at-sea trips and as the study progressed, more confidence was placed on interview data.

At-sea trips were still essential to gather data which could not usually be expressed by the fishermen. These parameters were: the behavior of marine mammals during the interaction, identification of mammals and birds sighted, determination of species, size and, if possible, sex of the animals, and other data such as depth, exact location, weather, and other specific data possibly important to evaluate the interaction.

One of the more difficult interpretations was the taking of a salmon off a hook by a marine mammal. We had two categories: definite loss and probable loss. A definite loss would be recorded when a fish was hooked, the action of the line would no longer indicate that a fish was hooked, and then a sea lion would appear at the surface with a salmon. A probable loss would be recorded when a fish was hooked, and a sea lion would be observed diving in the area, but not come to the surface with a fish. It was assumed that the fish may have escaped, or that the fish was small enough to be swallowed under the surface. The mere sighting of a sea lion eating a salmon at sea did not necessarily warrant recording a loss. The fish may have been taken from the line of another boat or may have been a weakened or dying shaker which was discarded earlier in the day. An interaction had to have the elements of a fish lost from the boat, the observer was aboard, and the presence of a sea lion which was observed diving on the lines of the vessel. Loss of fish also takes place when sharks bite fish or when large salmon break the leaders.

General Results

The project was initiated on July 1, 1979, thus missing the month of May, a month of high catch and effort. Throughout July, 1979, samplers on at-sea trips encountered no interaction because nearly all the California sea lions had migrated south. At-sea observations were continued to reveal possible Steller sea lion depredation. Steller sea lions have established rookeries at St. George Reef, Sugarloaf Rock, the Farallon Islands, and at Año Nuevo Island (Figures 1 and 2). Steller sea lions were reported to be the major pinniped species involved in salmon depredation along the northern coastline in the early 1950's (Senate Fact Finding Committee 1960). Throughout the 2-year study, no Steller sea lion interaction with salmon trollers or with partyboat fishing was observed, although one possibly valid report of an interaction was related at Trinidad in 1980. No harbor seals were observed or reported harassing salmon trollers and recreational fishermen, however, this species was the only marine mammal depredating the gill nets in the Klamath River. Elephant seals were not observed or reported removing fish by salmon fishermen or project personnel. Several northern fur seals were reported near boats, but no interaction was reported or observed.

Marine Mammal Mortality

Estimates of mortality are not available for this fishery. Sea lions were shot at only on three of the 149 at-sea trips over the 2-year study. Understandably, few fishermen would shoot at an animal when an observer was aboard.

Interview data did reveal some mortality, with several fishermen guessing that possibly up to 300 sea lions were shot each year by the salmon trollers. Fishermen could obtain seal "bombs" but these do not harm the animal. Many fishermen consider bombs ineffective or do not want to handle them, and prefer to fire shotguns at the animals when fish are hooked. On several occasions, repeated shooting was heard by the observers when the boats were concentrated off Shelter Cove and Jackass Creek (Figure 1). One observer reported that at least 13 animals were shot on one day by listening to the marine radio. Most fishermen do not shoot at or harass sea lions. In fact, interviews with the more efficient fishermen indicate that many "highliners" do not attempt to compete with a following sea lion removing fish from lines. They will pull up their gear and move on until the animal is lost, or leave their gear in the water and cross another vessel's bow and "give" the animal to another fisherman. Once the animal is not following, they will resume fishing.

In Monterey Bay in 1980 and 1981, routine beach surveys were made every 2 weeks covering 8 of the 50 km of sandy beach from Monterey to Capitola. All marine mammals and birds were tallied and estimates were made of the total beached animals by species each month from October 1980 to September 1981. Whenever a marine mammal appeared on the beach during the 2-week interval surveys, a yellow line was tightly wrapped around the animal for identification. The public is not inclined to remove this small piece of line from a rotting marine mammal, and in no case was a line removed. These marked animals were noted for many consecutive weeks with one large male California sea lion carcass remaining on the beach for 2.5 months after which time only the largest bones and some dried skin remained, still entwined with the marking line. Only one of the eight 1-km census zones was within a State Park area where the maintenance crews would pick up or bury the washed-in animals. In this case, the maintenance crew was asked to inform project personnel if an animal had been removed which was not marked. A total of 19 California sea lions, six harbor seals, five sea otters, two elephant seals, and four harbor porpoises were counted in the eight 1-km sections in the 11-month period. A total of 119 dead California sea lions was estimated to have been beached during this period ($19 \times \frac{50}{8} = 118.75$). The sea otter estimate of 30 otters for the 11 months was compared to the actual number reported and picked up by the DFG sea otter project. A thorough coordinated reporting of beached sea otters by county and State Department of Parks and Recreation has been organized by the DFG, and J. Ames (DFG per, commun.) reports that 27 sea otters were reported and picked up during this period in this study area.

The 119 California sea lions estimated to have been beached does not demonstrate a high incidence of mortality due to shooting by salmon trollers. There are other causes of mortality known to take place in the area such as drowning in gill and round haul nets, being attacked by sharks, and other natural causes. Considering that over 1,400 California sea lions were hauling out at the nearby Monterey breakwater in May 1980 and over 2,000 in May, 1981 (see below), these few beached dead animals do not appear to represent a high total mortality for the area. Of the 19 sea lions observed on the beaches, four were large adult males, the remainder were small subadults and yearlings. Only three of the 19 dead California sea lions counted appeared on the beaches during the salmon trolling season, the majority were beached during the winter period.

The maximum guess of around 300 California sea lions being killed each year for all of California offered by commercial salmon fishermen is probably high. Many animals may be shot at, but few are hit.

Commercial Fishery - 1979 Season

Depredation of Hooked Fish. It was possible to obtain 79 at-sea trips in 1979: 34 in July, 36 in August and 9 in September (Table 1).

A total of 635 legal fish was observed caught, yielding a 0.14% at-sea sample of the total recorded landings for the 3-month period. A total of 5,731 legal salmon was recorded in the interview samples, yielding a combined at-sea and interview sample of 1.23% of the total landings (Table 2). Since it was not possible to determine the species of salmon removed by sea lions, the landings and losses reported include both king and silver salmon. Records are kept of the landings by species, however, and when loss values are compared, species composition is utilized.

The greatest depredation occurred near Fort Bragg with 855 (72%) of the total 1,186 salmon considered definitely removed by sea lions in this area (Tables 2 and 3). The high degree of variability of the data is expressed in the range of the 95% C.I. values for the estimated definite loss of 1,186. The lower limit was 350 fish lost, and the upper limit, 2,887.

Probable loss data yield additional depredation values. Upon conclusion of the second year's study, greater confidence was placed on interview data, and salmon reported as probably lost are most likely truly lost fish. Project observers on at-sea trips also came to this conclusion. In several incidents, evidence was so sparse when a fish was lost that the occurrence was not entered as an interaction. With this additional marginal data of which some were probably losses, the data presented are minimal figures, and the probable loss may be considered as real loss. Throughout this discussion, both definite and probable losses will be given.

The combined definite and probable losses for 1979 totaled 1,386 salmon with a lower 95% C.I. limit of 367 fish and the upper limit of 3,290 fish (Tables 4 and 5).

A major factor in computing losses is the number of shakers caught during a day's fishing. It was assumed that sea lion depredation on hooked fish was not biased toward either legal or sublegal fish, and the shaker percentage of the catch was used in computation of loss. Shaker abundance is quite variable, both between areas of the coast and between fishermen fishing in the same area. We depended upon at-sea data to determine shaker composition in 1979 resulting in figures of limited reliability for some ports. Legal fish made up 52.6% of the catches sampled at-sea and where the information was asked during interviews (Table 2). The highest percentage of shakers was off San Francisco (64%), and the lowest percentage of shakers by month was 25% in September.

Anadromous Fishery Branch personnel (J. Lesh, pers. commun.) reported that a minimal mortality of king salmon shakers released at around 15% and 50% for silver salmon released shakers, and that about half of the fish reaching legal size in the ocean will be taken in the fishery. With these values, the number of shakers removed by sea lions which would have lived to be caught can be computed. In 1979, 982 shakers were estimated removed from hooks by sea lions (Table 5). Using the above values of shaker mortality and that half the legal size fish are caught, 450 king salmon and 17 silver salmon were estimated lost to the fishery.

The mean total depredation using projected shaker loss in addition to the definite and probable loss was 1,853 fish in 1979. The average value to the fisherman of a fish was $26, yielding a fish loss value of $48,152 for the July through September period. Using the upper and lower 95% C.I. limits for definite plus probable loss and mean value for shaker loss, the depredation value ranged from $11,292 to $134,780.

Gear Loss. At-sea data only were utilized for this parameter in 1979 (Table 1). During the 79 at-sea days, sea lions were observed following the vessel on 18 days (23% of the total). Gear loss occurred when a sea lion would bite a hooked fish breaking the leader. Sometimes only a hook would be lost, but occasionally the entire set-up of flasher, leader and hook would break away from the steel cable. Most of the time fish were removed without loss of gear. Gear loss was recorded only once at sea for a total of $4 in a catch of 635 legal sized fish. This small sample may not be representative, but by projecting a value of gear loss of $0.0063 per legal fish recorded landed in the fishery, the loss of gear due to sea lion depredation was around $2,900 for the 3-month period.

Gear loss due to sharks was seven times higher than by sea lions, with an estimated loss per legal fish of $0.042, yielding a total value of $19,000 worth of fishing gear lost to sharks in the 3-month period.

Areas of Fishing and Depredation

Catch per DFG block area was determined for all samples, but not for the entire recorded catch. Only one block number was entered for each day's catch. This was the block in which the majority of fish was landed. Block numbers of secondary importance were also recorded and this information was used in the final analysis. Twenty-seven block areas were represented in the at-sea samples, and 16 were reported in the interview data. Fishermen tend to lump their day's catch in one block number, usually the one nearest to a major landmark. The data are useful in determining general locations of the catch between months and years.

The 1979 data are incomplete for the entire season and insufficient in quantity to warrant analysis, and the 1980 data were utilized for catch-interaction relationships (see below). The 1979 data did demonstrate that most of the catches were made at a few locations but that salmon are taken almost throughout the inshore area from Monterey to Oregon.

Commercial Catch - 1980 Season

Depredation of Hooked Fish. Seventy-five at-sea days were obtained in 1980: 35 in May, 16 in July, 6 in August, and 18 in September. A total of 540 legal fish was caught in the at-sea sample (Table 6) yielding a 0.08% sample of the total recorded landings. A total of 52,259 legal fish was recorded in the interview sample, yielding a combined at-sea and interview sample of 8.17% of the total recorded catch for the 1980 season (Tables 7 and 8).

The definite loss was estimated at 6,863 fish with 95% C.E. limits of 3,628 for lower and 10,323 for upper. Depredation including probable loss (Tables 9 and 10) was 9,819 legal fish with 95% C.I. limits of 5,686 and 16,124 for lower and upper, respectively.

Shaker loss to sea lions totaled 6,427 for the 1980 season (Tables 9 and 10). Using the mortality rates for released salmon and 50% utilization rate of legal sized fish given above in the 1979 analysis, 2,515 king salmon and 128 silver salmon were taken by sea lions that would have been taken in the salmon fishery at a later date.

The summation of all fish depredated by sea lions including projected shaker loss and definite plus probable loss was 12,459 legal sized salmon. The average value of a salmon to the fisherman was about $22, yielding a total mean monetary loss of about $274,000 for 1980. The lower 95% C.I. limit value would have been $183,240, and the upper limit, $412,874.

Gear Loss. Gear loss attributable to a sea lion was recorded only when a fish was lost or probably lost to sea lions. Other causes can be from sharks and when exceptionally large salmon are hooked. Weak and substandard gear can also be broken during routine catches of smaller fish.

Gear loss occurred in about 30% of the occurrences when a fish was removed by a sea lion. The average value of gear loss for each fish removed was $0.75. A minimum value per loss would be when only a hook is lost ($0.65), and the maximum is when a flasher, leader and hook are taken ($5). The greatest amount of gear loss occurred in May, followed by September and August (Table 11). The estimated total loss for 1980 was $12,225. This estimate is minimal in that the estimates for San Francisco and Eureka in August and September were extrapolated from minimal loss values of nearby ports due to lack of sufficient data at these two ports.

Gear and Fish Loss Due to Sharks. Gear loss due to sharks was computed for 1980 (Table 12). No fish loss was reported for May at three ports when the sharks, mostly blue sharks, were not yet in the fishing area. A total of $12,606 loss was estimated due to sharks. The greatest losses were recorded during July and August.

There was an estimated loss of 3,115 fish, including legal and shakers, for the 1980 season (Table 13). This estimate is much more subjective than values of sea lion depredation. When sharks are being caught or fish are being retrieved, slashed in half and no sea lions are present, it is assumed that when a leader is cut that a shark was responsible. About half of the losses attributable to sharks were damaged fish, the other half were assumed to be from sharks even though the action could not be directly observed. About half of the estimated loss in fish would have been legal sized fish, resulting in an approximate loss in value of legal sized salmon of $34,000 due to shark depredation.

Catch and Depredation By Block Area. In 1979, the major catch areas were off Pt. Reyes, but this may be due in part to the disproportionately higher sampling effort expended at Bodega Bay. Other principal fishing areas in 1979 were off Shelter Cove and Eureka. In 1980, a more representative sample was taken at each port. The major catch areas in 1980 were off Cape Mendocino in May and in the area from Shelter Cove to Usal in the July to September period.

At-sea and interview data were recorded by DFG catch block areas (Figures 1 and 2). The sample distribution by month probably represents the relative abundance and distribution of the total commercial catch by block. Trip boats travel over an extended fishing area and attempt to fish in the areas where they receive the highest catch for their effort. These boats return to all the major ports where their catch is sampled. Day boats were also sampled at all ports along with the trip boats yielding a record of the catch throughout the coastal fishing area, including block areas where the yield is low.

A complex pattern of fishing success and depredation by California sea lions is revealed when the data are plotted by month. The May catch and depredation reflected the more widespread distribution of the southern moving adult and subadult male sea lions with depredation reported from 32 of the 50 block areas reported as areas of highest yield for each trip. There was a clumping of depredation near the major hauling grounds off Pt. St. George, Klamath Cove, Trinidad Head, Jackass Creek, Bodega Rock, Pt. Reyes, the Farallon Islands, Año Nuevo Island and the Monterey Breakwater (Figures 1 and 2). In May, there was a high degree of depredation between the above hauling areas. However, during July, August and September most of the depredation occurred adjacent to major hauling grounds. The California sea lion has been reported to migrate southward close to shore during the spring movement, foraging in rivers and close to shore as they move south (Ainley et al. 1977).

The post-breeding northern movement was more spread out in time and apparently many of the animals remained more at sea, not entering rivers, and fewer were noted at the nearshore hauling grounds such as the Monterey Breakwater.

During July, depredation was reported from only 8 of the 42 catch block areas where catches were reported. The small amount of depredation was adjacent to major hauling grounds except for the fish loss reported off Fort Bragg. There is no major hauling ground at Fort Bragg, however, there is a small hauling ground about 20 km to the north. It is also possible that a few sea lions may remain off Fort Bragg where they may be attracted by the constant fishing activity by day commercial boats and recreational skiffs and partyboats.

During August as the sea lions were working their way northward, the only depredation was near hauling ground sites, except for the few fish lost off Pt. Arena. During September, the fishery was limited to certain block areas with depredation occurring in 12 of the 21 catch block areas in which catches were reported. As in August, the depredation took place adjacent to major hauling grounds except for the loss recorded off Fort Bragg.

The combination of relatively heavy salmon aggregation during all months in the area from Shelter Cove to Usal and the presence of a major hauling ground at Jackass Creek yielded consistently high depredation values for this area of the coast. The salmon lost to sea lions in this area comprised 33.6%, 45.5%, 67.7% and 64.0% of the total salmon lost in May, July, August, September, 1980, respectively. A total of 43.4% of the fish lost to the fleet in 1980 due to California sea lion depredation took place in the area from Shelter Cove to Usal.

Subsequent to the submission of this report, Beach et al. (1982) had a significant positive relationship between a higher rate of depredation and smaller than average catches of salmon in the Columbia River. This "scratch effect" concept has been reported for years by fishermen in California. However, in our study when the number of fish recorded in the sample by block is plotted against the number of fish depredated in these blocks (Figure 3), there is not a clear-cut relationship between presence of heavy catches and a comparable fish loss to sea lions. The clearest cause and effect relationship appears to be a high depredation when dense fish aggregates are located near hauling grounds.

California sea lion concentrations at the Monterey Breakwater were monitored in the 1980 season and until May, 1981. Counts made by A. Baldridge (Hopkins Marine Station, pers.commun.) revealed a spring peak number of animals in the area during the southern migratory movement, with the highest counts in May. Baldridge's counts were usually of one side of the breakwater but give a valid picture of the approximate number of animals hauling out. The peak number in 1967 was 410, 480 in 1968, and in 1971 around 400. The principal investigator counted sea lions hauled out at the breakwater in 1964 and recorded a peak of 800 in May, 1964. The DFG counts were made from a boat and included both sides of the breakwater plus animals in the water.

Baldridge's counts revealed a wintertime abundance of from 75 to 300 usually hauled out. Our counts in 1980 and 1981 were considerably higher than previous counts, and the numbers are due to an increase in animals, not merely better counting procedures. The spring peak in May, 1980 was 1,521 sea lions (Table 14), and in April and May, 1981 over 2,000 animals were counted. Sixty-four percent of the sea lions counted in May 1980 were juveniles. These young animals had been reported by salmon trollers as being exceptionally tame and curious and would show little fear. Most of the fish loss was attributed to these young animals. The curiosity of these animals was evident when making the counts from the DFG research vessel OPHIDON at the breakwater. Counts had to be made of animals in the water first by traveling continuously around the area and not stopping. If the boat was stopped, the juveniles in the water following close behind would swim ahead of the boat and mix with the uncounted animals. Up to 50 to 60 of these juveniles would remain close around the boat when the counts of hauled animals were made. By July 8, 1980, juveniles were still at the breakwater after most of the adult males had moved south.

The interest in sea lions at the breakwater was to compare numbers of animals present in relationship to the loss of salmon from trolling lines. The highest mean depredation rates for the entire coast for May and September 1980 were recorded for the Monterey Bay fishery (Table 7). The May rate was 3.31% of the legal catch and for September, 7.60%. The numbers of fish lost were higher in May due to the greater fishing effort on presumably a larger concentration of fish. In August, 1980, the mean number of hauled out sea lions at the breakwater was 60 animals with a maximum count of 123. There was a Monterey Bay depredation rate of 4.26% of the legal catch with 500 fish estimated lost to sea lions. In May, there was a foraging rate of 3.31% with about 1,000 fish lost, but with a concentration of over 1,500 at the breakwater. These data indicate that there may not always be a direct relationship of the rate of depredation and the number of sea lions present in the area. There were over 10 times as many sea lions present in May than in September, but only twice as many salmon were lost during May. Possibly, the larger population of adult sea lions could have contributed to the high depredation rates in September.

Catch-Per-Hour

Catch-per-hour values of at-sea data were more variable than interview data because of the small sample size at most ports, however, the overall values were comparable (Table 15; Figure 4). The major differences were where large numbers of shakers were encountered in the at-sea sample, such as during May in the 100 block area. The higher values did correspond to the block areas where the most fish were taken, such as in the 200 block series in May.

The magnitude of the number of hours in relationship to the catch and fish loss tends to minimize the importance of catch-per-hour data. An exceptionally high degree of fishing success change would have to take place to yield significantly different values. The commercial catch averaged 0.028 fish per hook-hour (28 fish per 1,000 hours) for May. At-sea data averaged 0.025 fish per hook hour yet the percentage loss of the total fish caught (including shakers), was 2.70% and 4.07% for the interview and at-sea data respectively. These data may show that the catches are less variable than the losses to sea lions. The data do point out that both series reflect the true nature of the fishery, but that at-sea sampling needed to be expanded to represent adequate interaction information.

Comparisons of catch-per-unit of effort data between seasons and areas reflect the distributional and availability parameters of the salmon population that are known from other studies and catch records. The spring months have historically been the periods of highest catches, and our data indicate a marked decline in fishing success from May to September (Figure 4) in both 1979 and 1980. 1979 values were higher than 1980 catch values except in August 1980 when all the values were about the same. Some of the decline in efficiency of the fleet may also be due to the largest vessels leaving the salmon fishery to try for albacore when this species appears, which usually occurs in late July or August.

Ocean Farming

One operation is extant in California; at Davenport, Santa Cruz Co., silver and king salmon and steelhead are released into the ocean at the beach area and harvested when they return to the catch basin. The return of adults spans over a prolonged period from August through January. A permit to take harbor seals was requested by the operator to alleviate foraging on returning fish. Prior to the permit, the operator estimated that about 15% of the adult salmon entering the return structure were bitten by harbor seals. It is not known how many salmon were eaten. The operator used seal bombs to keep the harbor seals away from the immediate return structures where the salmon were concentrated. There are no estimates of the value of fish lost to the seals.

Partyboat Fishery - Salmon

The partyboat fishery is conducted primarily from San Francisco Bay ports where 95% of the total partyboat caught salmon were landed. Partyboats at Crescent City, Trinidad, Eureka, Fort Bragg and Bodega Bay do not start fishing until May and usually terminate operations in late September. Partyboats operate out of San Francisco Bay throughout the February 1 to October 31 open season. All are day boats, leaving near daybreak and returning usually by 1200 to 1500, depending upon weather conditions and if they have limited out. The average number of anglers per boat in our 1980 sample was 12 (range 3 to 25). Each angler has one pole with one hook.

In 1979 about 8% of the catch was sampled: 2% by project personnel and 6% by DFG Anadromous Fishery Branch personnel by interview (Table 16). The estimated total legal fish loss to California sea lions was 196 salmon, representing 0.47% of the statewide salmon partyboat catch from July through October. All the loss was recorded for San Francisco in July and August.

The 1980 catch was monitored throughout the season with all ports covered (Tables 17 and 18). About 14% of the catch was sampled: about 2% by project personnel and 12% by Anadromous Branch personnel. The estimated loss of legal salmon to sea lions was 202, representing 0.32% of the total salmon partyboat landings for 1980. An additional 88 sublegal salmon were taken off the lines by sea lions, about 50% of which would have probably been caught at a later date. The value of the loss due to sea lion depredation was $6,000, based upon the fish market value of salmon.

The estimated major losses to sea lions were at San Francisco Bay ports with 152 fish (75% of the total), with the remainder lost in Monterey Bay. The heaviest depredation occurred in March and April when 122 fish (60% of the total loss) were estimated taken. It was during this period that the Monterey losses were high due to the large numbers of juvenile California sea lions present in the bay (see discussion above in commercial fishery section). The percentage depredation in Monterey Bay was over 10 times that recorded for San Francisco Bay ports (Table 17). Catch-per-hour values (Table 19) reveal that the abundance of salmon in Monterey Bay was much lower than off San Francisco, but the loss per hook was higher. Both partyboat and commercial fishermen reported they had not before seen such an abundance of sea lions in Monterey Bay following their boats as was observed in 1980.

There was only one shark caught each in 1979 and 1980 in our at-sea samples. There was no fish or gear loss observed due to sharks. Gear loss due to sea lions was not recorded in 1979 (Table 20), but a $14 loss was recorded in the 1980 sample (Table 21). The total gear loss due to sea lions was around $1.25 per fish lost, yielding an estimated total gear loss of $360 for the 1980 season.

Skiff Recreational Fishery - Salmon

Anadromous Fisheries Branch monitors the skiff catch at all ports, and catch estimates are computed for each month. In 1979 project samplers monitored 0.33% of the catch, and Anadromous Branch personnel sampled 2.83% of the catch for total sample for marine mammal interaction of 3.16% of the catch (Table 22). For the entire salmon skiff fishery from Crescent City to Monterey, only 11 fish were estimated lost to sea lions from July to October, 1979. In 1980, 78 salmon were estimated lost to sea lions for a 0.18% loss of the total skiff catch from Crescent City to Monterey. The sample size was 2.47% by project personnel and 26.57% by Anadromous Branch personnel for a total sample of the skiff catch from Crescent City to Monterey of 29.04% (Table 22).

The greatest depredation was at Monterey Bay landing areas where 44 (56%) of the estimated loss was recorded. Nearly all this Monterey loss was during the spring months from February through April, the same period in which the most partyboat depredation occurred in this area. The port area of highest salmon skiff catch was in the San Francisco Bay area where 66% of the skiff catch was landed. There was no gear loss reported in our samples. The value of the salmon lost was about $2,300, if the fishermen were to buy these fish at a market. Some fishermen reported loss from sharks, but not on days on which they were sampled.

Recreational Salmon Fishing in Rivers

The Smith, Klamath, Eel, Albion, Navarro, and Garcia rivers were sampled from July 1979 through March 1980 for interaction of steelhead fishermen and marine mammals. A total of 72 interviews involving 335 hook hours was obtained. Of these, 28 were fishermen sampled on shore and 44 were skiff fishermen (Table 23). Fifteen steelhead were landed in the sample. One skiff fisherman reported losing two fish to a harbor seal in the Eel River in mid-October. No interactions were observed or reported from the other rivers sampled except for the Klamath River. Results of Klamath River recreation fishery study are presented below.

Salmon Fisheries - Discussion

The salmon troll-California sea lion interaction study conducted by Briggs and Davis (1972) was requested and funded by commercial fishery interests in the Monterey Bay area. Since the samplers had full cooperation from the fishermen, they could pick sampling days at random and had little trouble arranging for at-sea trips. They obtained 52 commercial troller at-sea trips in a 6-month period. By contrast, we were able to obtain only 75 at-sea commercial troller days in 4 months in 1980 for all ports from Monterey to Crescent City with seven samplers available. The overall negative response to our at-sea sampling program by the commercial trollers did not preclude obtaining a valid sample of the economic loss caused by marine mammals. Fishermen interviewed, including those who would not take us aboard, related accurate information of their catch and losses to marine mammals.

Most of the interview sample was of trip boats which fished at the areas where the highest yield for their effort was available. These areas may have been far from their home port. Unloading of fish was quite often the nearest port to the fishing area. Regardless of the port of return, the results of the sampling reflected the same specific catch areas and fish losses. Had there been a significant bias or distortion of the facts, these coastwide trends would not have been as uniform and persistent. When the catches dropped in abundance or the fishing areas shifted to other areas as reported on the marine radio, subsequent results of sampling when these boats returned to port a week or two weeks later would reflect these known events. Even though at-sea results were marginal, they did reflect the same specific trends of catch and interaction that were reported by the fishermen during interviews. There was a slightly higher rate of fish loss in the at-sea samples, and had there been a tendency for the fishermen to exaggerate their losses, the interview data would have shown a higher rate than the at-sea. This did not occur, and the conclusion is that the interview data were more useful than the at-sea data in determining economic loss to marine mammals. The trip boats covered the entire fishing area permitting catch block area analysis of marine mammal losses as well as by port. The area of catch was determined from interview and at-sea data and was not derived from the catch block numbers entered on the official landing receipts (pink slip). The block numbers on the pink slips are biased toward port of landing rather than where the fish were actually caught. The one percent sample goal originally desired under the contract was exceeded with the use of interview data with a 8.17% sample achieved. At-sea sampling yielded a 0.08% sample in 1980. Because of the highly variable distribution in time and space of the fish loss to California sea lions, a one percent sample would not have yielded reliable estimates of the value of the fish and gear lost. As was suggested by Everett et al. (1980), a minimum of a 5% sample seems to be adequate if an interaction study would be undertaken in the future. An optimum sampling program would consist of a 5% sample drawn at random by port, and primarily of interview data. At-sea information would still be necessary for mammal identification and behavior.

California sea lions were the only pinnipeds observed removing salmon from commercial trolling gear and in the partyboat and recreational skiff fisheries. One Steller sea lion was reported taking a fish near Trinidad, and no harbor seals were observed interacting with ocean fishing. However, the harbor seal was the only pinniped observed depredating the gill nets in the Klamath River and reported to take steelhead from skiff fishermen in the Eel River. Harbor seals were also the only pinnipeds observed foraging on salmon returning to the ocean farming operation at Davenport, Santa Cruz Co.

Steller sea lions were the pinnipeds reported to be the major species removing salmon from troll lines in the 1960's, but these reports must have been from misidentification. Steller sea lions appear to be at maximum numbers at Sugarloaf Rock, Cape Mendocino and at Pt. St. George, and no Steller sea lion interaction was recorded from boats fishing in these areas. We did observe Steller sea lions as well as California sea lions foraging near the mouth of the Klamath River. These otariids, especially the California sea lion, commonly frequent the river system during the spring Pacific lamprey and eulachon runs but were not observed or reported to be involved in the gill net depredation.

The ocean fishing losses to California sea lions were closely related to proximity to established hauling grounds. The principal hauling areas where fish losses occurred, by relative consistent degree of fish loss, were near Mistake Pt., Pt. St. George, the area between Bodega Rocks and Pt. Reyes, Monterey Coast Guard breakwater, Trinidad Head, and Año Nuevo Island. There were fish losses between these areas in May during the nearshore movement of California sea lions returning to the breeding grounds off southern California, but at a much lower intensity and not consistently during the fall northern movement (except possibly for the area off Fort Bragg).

Monterey Bay depredation rates were most interesting in that despite a relatively low haulout density in August and September compared to May (about 1/20th the number of animals), the fish loss was almost twice the rate per legal fish caught in August and September. The exceptionally large numbers of juveniles involved in the depredation in May and again in August and September indicates that it is not only the "wise" old animals or "rogues" alluded to in the past by fishermen that are responsible for the losses.

Shooting and harassment of sea lions over the past 50 years has not prevented depredation and is one reason why many fishermen do not attempt to kill sea lions as they realize the effort is of limited value, and potentially dangerous. Routine surveys of the 50 km area from Monterey to Capitola in 1980 yielded an estimate of 114 California sea lions washed up dead, from May through September. Of these, an estimate of only 18 appeared during the commercial salmon trolling season. The guess offered by several fishermen of about 300 California sea lions shot is probably high. Due to the sensitive nature of such data, most fishermen would not offer information on this subject nor would most fishermen shoot animals when an observer was aboard. We do not have an estimate of the actual number of California sea lions killed in the commercial salmon troll fishery, but have an estimate of around 30 to 40 harbor seals killed yearly in the Klamath River gill net fishery.

The estimated ocean fishery losses in 1980, the only complete season sampled, could reach as high as $430,000 and as low as $200,000. The mean value was near $300,000. Over 90% of this loss was in the commercial troll fishery, with a mean loss of 12,459 legal fish removed by California sea lions in this fishery. The losses in the partyboat fishery were about $6,000 (202 fish), and in the recreational skiff fishery, 78 fish valued at $2,300 were lost to sea lions. The commercial fishery loss was 1.5% of the total catch, the partyboat loss was 0.32% of the catch, and the skiff loss was 0.18%. Gear loss due to sea lions for all methods was about $13,400. The 1979 losses for the July to September period were considerably lower than that estimated in 1980, indicating that the 1980 losses may be near the maximum value that can be expected. The fishermen certainly expressed the opinion that they had not seen such a high degree of loss in previous recent times as occurred in 1980. An overall maximum annual value of depredation of salmon and gear by pinnipeds in California, including the Klamath River, could possibly reach ½ million dollars during peak years of catch and depredation in a fishery worth around 13 million in wholesale value of fish in 1980.

Possible Management Procedures to Alleviate Losses

Possible gear changes to lessen interaction are not visualized in a hook and line fishery as was possible in changing tuna net construction. Fishermen probably do save a few fish by shooting at and scaring sea lions. Shooting sea lions with rifles is dangerous and is disapproved by most fishermen, especially when the boats are concentrated. Seal "bombs" also may reduce losses, but these explosives are difficult to obtain and are dangerous to handle.

The successful procedure of crossing the bow of another vessel and "giving" a following sea lion to another boat may help one boat, but it is to the possible detriment to another and does not solve the problem. Avoidance of areas of high depredation near the major hauling grounds is also not feasible because in both years studied,it was in these areas that the majority of the fish were caught,and the fishermen must utilize these areas.

The only possible mitigating procedures at this time appear to be to preclude the use of certain hauling grounds to sea lions to lessen the degree of fish loss such as near Mistake Pt. where California sea lions haul out on three beaches, primarily Jackass and Little Jackass Creeks. Experimentation with underwater acoustic harassment (noise aversion) is planned. The former idea has been offered for several years by fishermen at Monterey who have stated they would like to keep the sea lions off the breakwater. Information gathered on this study in Monterey Bay indicates that the reduction in animals present would have to be drastic to possibly effect a real reduction in drepredation.

Also, due to the apparent continual movement of animals up and down the coast, very expensive means would have to be constantly employed to keep sea lions from utilizing any haulout area, if it were indeed possible.

The only other technique known at this time is noise aversion. The Department of Fish and Game is presently undertaking a joint research study with Dr. Bruce Mate, Oregon State University, Corvallis, to explore the potential use of an underwater acoustic device which will keep pinnipeds at a distance from fishing gear and hatchery areas. Our initial experiments will be in the Klamath River to test its effect of keeping harbor seals away from gill nets and at a distance from the DFG seining operation to obtain salmon for upstream marking experiments. Other experimentation includes the interaction of pinnipeds in the round haul fisheries of southern California. The major experimental need at this time is to test possible habituation of animals to the loud irritating noises. Should the first year's experiments prove successful, it is recommended that experiments with salmon trolling gear be initiated.

PARTYBOAT FISHERY - NON-SALMON

Description of Fishery

This section presents the partyboat fisheries for bottomfish such as rockfishes and lingcod and the more surface oriented fishes such as Pacific bonito, Pacific mackerel, and California barracuda.

The California partyboat fishery was established in the early 1920's (Sadler 1928), and in 1925, live bait was reported used by partyboats in southern California (Clark and Croker 1933). The industry expanded rapidly after 1929 and again after WWII in the early 1950's. In central and northern California the seasonal salmon fishery dominates the partyboat effort, however, in more recent years increased bottomfish effort has been expended at all northern California ports. South of San Francisco salmon partyboat fishing makes up a small segment of the effort.

The southern California fishery is more diverse with several fish being target species. Live bait is used from Morro Bay southward. Anchovies are most commonly used as live bait with squid, Pacific mackerel, white croaker, and queenfish occasionally utilized. Half-day boat trips are common in southern California but seldom operated in central and northern California due to the more forceful onshore afternoon winds in the northern part of the state. There is an evening fishery at times in southern California in which case a given boat may take three separate trips in one day.

The southern California partyboat operation includes different types of fishing methods for various habitats and depths for a variety of target species. The surface and mid-depth species are the Pacific bonito, Pacific mackerel, jack mackerel, California barracuda, white seabass, yellowtail, albacore, and marlin. In Baja California waters, additional species are yellowfin tuna, skipjack, and dolphinfish.

The surface species are taken with both live bait and lures, usually in shallow water within 1 km of an insular or mainland shoreline. The boat will lay out a "circle" of live chum to attract the targeted fish and continue to throw out live bait to keep the fish within the range of cast lures or hooks with a live bait attached. When partyboats move between fishing areas, the skipper will sometimes travel slow enough to allow fishermen to troll with lures. Often, when a bonito or other surface fish is caught while trolling, the skipper will stop the boat and try to attract the fish to the boat if there is a large number of them. The skipper will usually anchor the boat when good fishing is underway.

Deep water fishing for rockfishes is usually conducted at offshore banks or in deep waters adjacent to the offshore islands. The fishing poles are heavy duty with large reels and equiped with an extended winding arm to haul in the heavy weight and sometimes large fish. The fish species include bocaccio, chilipepper, cowcod, and lingcod. The water is too deep, up to 100 fm, for anchoring,and the boats will drift over good fishing areas and return up wind again as they drift off the productive grounds. The dead bait used is anchovy, squid, or mackerel.

The shallow water inshore bottomfish fishery is targeted for kelp bass with other species often taken such as sand bass, sculpin, white croaker, halfmoon, California sheephead, California halibut, and ocean whitefish. This fishery is with both live and dead bait and can be at anchor or while drifting. Water depths range from about 10 m to 30 m, and often adjacent to kelp canopies.

Sampling Methodology

At-sea samples were desired for this fishery due to the large number of fishermen aboard and the diversity of species being taken when an aggregate of rockfish and flatfish are being caught. It would be more difficult for the boat operator to relate the catch and loss to marine mammals in this fishery than in the salmon fishery in which only one or two species were being taken among fewer fishermen aboard. Interview data were gathered occasionally when an opportunity arrived such as when going to the harbor to arrange for an at-sea trip or when sampling some other fishery. At-sea data collected were the approximate number of fish by species caught, the number of lines in the water, the block area of catch, a record of all marine mammal activity, and the definite and probable loss of fish due to marine mammal depredation. Other interactions were if fish were frightened away from the boat by marine mammals and when the skipper would move to another area to escape harassment from mammals removing fish from hooks and foraging on the live chum.

There were 36 ports from which partyboats operated in California waters in 1980 (Figure 5), with 317 boats registered statewide. More than half of these boats operated out of southern California ports (Goleta to San Diego) with the greatest concentration at San Diego where 73 boats (23% of the total) were located. Many of these large vessels at San Diego are equiped with bunks and gallies enabling overnight trips of up to 3 or 4 days into Baja California waters.

Sampling in 1979 revealed that there was no interaction with marine mammals from Avila northward on bottomfish partyboats. Consequently, in 1980 at-sea samples were made only on vessels operating from Goleta southward. The 1979 at-sea data also indicated that the only sustained, serious depredation and harassment occurred near San Diego, and a disproportionate sampling intensity was applied to this area. Large numbers of fish were landed at all other southern California port areas, and project sampling and samples of mammal interaction recorded by "intercept" personnel supplied information for these port areas in 1980. The intercept project gathered sport fishing data under contract to the State through the Pacific Marine Fisheries Commission, Oregon.

Total catch by numbers of fish is available for each month by port. These data, which are recorded on mandatory logs for each fishing trip, were supplied to the project by Marine Resources Region personnel. Due to the extreme variability and infrequent occurrence of fish loss due to marine mammals and to our small sample, confidence interval values cannot be computed for this fishery. The economic value of the fish lost was determined by what fishermen would have to pay for the fish at a fresh fish market. Gear loss was determined from at-sea data by projecting the gear loss value per fish lost by species to the total estimated loss of that species.

Results

In 1979, eleven at-sea trips were obtained in central and northern California and three in southern California, and interviews were made of two trips in central California and 10 trips in southern California. These data revealed that no interaction occurred from Avila northward and that depredation was uncommon in southern California except in the San Diego area. Sampling in 1980 was conducted only by interview from Avila northward to ensure that interaction actually did not occur.

Twenty-seven interviews were recorded in 1980 with no loss reported in the central and northern California area.

In southern California, 66 at-sea samples were obtained yielding a 0.32% sample of the total logged daily trips for 1980. Interview samples were obtained from 116 partyboats for an additional sample of 0.57%. Over 20,000 partyboat trips were reported on the mandatory logs for 1980.

Depredation was computed by collating the catch and sampling data by port groupings for the entire season. Insufficient data are available to compute losses by month for each port area. The port groupings are in three areas in which the boats fish for about the same species in comparable habitats. These areas are from Goleta to Port Hueneme, Malibu to Oceanside, and Mission Beach to San Diego (Tables 24 and 25).

The estimated depredation values computed from at-sea and interveiw data revealed the same general trends of interaction. The highest rate of interaction was in the San Diego area and the lowest in the Goleta to Port Hueneme area. The percentage for San Diego when computed from <u>definite</u> loss values was 2.32% for the interview data and 1.88% for at-sea data. The total southern California loss was 0.43% and 0.39% for interview and at-sea data, respectively. When <u>probable</u> loss values are computed, however, there is a wide discrepancy between the at-sea and interview data from some areas. Most of the discrepancy occurred due to an abnormally high report of depredation from one boat at Port Hueneme on two separate days in two different catch block areas.

The estimated losses computed from definite loss values for at-sea data totaled 15,141 fish for southern California. Pacific bonito was the leading species (78% of the total loss) with 11,812 estimated lost, 9,214 of which were estimated for the San Diego area. Interview sample losses were estimated at 18,272 fish using definite loss values. Pacific bonito loss totaled 5,800 fish (31% of the total), all of which occurred at San Diego. The species depredated by California sea lions and harbor seals in southern California were Pacific bonito, Pacific mackerel, kelp bass, California barracuda, and several species of rockfish. The percentage of definite fish lost at San Diego to mammals was 78.8% and 91.7% of the total southern California loss in the at-sea and interview data, respectively.

Partyboats operating out of San Diego fishing in Baja California waters reported a loss of yellowtail, skipjack, and yellowfin tuna. Twenty-two interviews were made from November 1979 through February 1980 of boats fishing in Baja California. During this period, the losses to California sea lions (the only species reported) was 2.72% for yellowtail and 0.59% for yellowfin tuna. Considering that this fishery was outside U.S. territorial waters, sampling was discontinued once it was established that depredation does occur in Baja California and by what species.

The value of the fish loss in southern California computed from definite loss figures was $26,300, estimated from at-sea data and $28,100, estimated from interview data.

Loss-Per-Block Area

The mandatory log catch-by-block data are not available for this analysis and only sample data are used. The samples collected by Intercept project personnel are not complete counts of the total catch for the day because only a sample of 20 or 40 fish per boat trip were usually taken. Our at-sea data includes the total catch by species. Therefore, the block area catch presented (Figure 6) relates the number of fish recorded in the samples and is compared to the losses observed and reported on these trips. The most consistent losses to mammals in both the at-sea and interview data occurred in block #860 off San Diego and in the block areas immediately to the north of this block. There was also consistent losses at Los Coronado Islands, Baja California.

Marine Mammals Involved in the Interaction

All the interaction activity reported in Baja California and all but one interaction in southern California were by California sea lions. The exception was by a harbor seal observed removing a Pacific mackerel from a hook off Santa Barbara in August 1980.

California sea lion hauling grounds are primarily at all the offshore islands including Los Coronados Islands. A few California sea lions haul out on offshore rocks and buoys off Pt. Loma, La Jolla Cove, Laguna Beach, the Los Angeles breakwater, and Pt. Dume (Figure 6). The sea lions harassing the partyboats off San Diego are probably utilizing the local breakwater rocks and buoys as well as Los Coronados Islands, 50 km to the south of San Diego harbor.

Harbor seal hauling grounds along the mainland in southern California are only at La Jolla Cove, Mugu Lagoon, Carpinteria, Goleta, Ellwood, and Pt. Conception. Therefore, the abundance of harbor seals is relatively light and minimal interaction occurs.

A common complaint by partyboat skippers is that the presence of sea lions frightens fish away from the proximity of the vessel. Not only may the presence of sea lions lessen the take, but the skipper may be forced to change fishing locations to lose the sea lions, resulting in additional fuel consumption and loss of fishing time. On several occasions, project personnel have noticed the number of fish being caught to drop off when a sea lion entered the area. In most instances, however, fish continued to bite in the presence of sea lions.

The persistent harassment of the partyboats off San Diego may be due to a combination of modified behavior of the animals and to the year-round presence of a combination of Pacific mackerel and Pacific bonito in a live bait fishery. The high incidence of interaction in this area close to a port and where hauling grounds are available may result in the possibility that fishing activity may modify pinniped activity. Partyboats consistently chum with live bait and utilize the same fishing spots, and samplers have observed partyboat fishermen purposely hand feeding sea lions while fishing was underway. Reports of skippers purposely feeding sea lions to keep them away from fishing lines has probably also intensified the conditioning of these mammals to follow boats to the fishing grounds. California sea lions have been observed following partyboats when fish parts were being tossed overboard. Skippers often cope with the problem by passing close to other fishing vessels in hopes of transferring the animal's interest, as is commonly done in the salmon trolling fishery (see above).

A similar learned behavior of California sea lions at Santa Catalina Island may be taking place. Partyboats arrive at the island during the dark hours of morning to brail squid for live bait using lights to attract the squid. The partyboat skippers claim they are not bothered by sea lions when the commercial squid vessels are operating nearby. Commercial fishermen may legally harass and take sea lions interfering with their fishery by tossing seal "bombs" at them and shooting. When the commercial fishery ends, usually during February or March, partyboat skippers use their own lights to attract the squid without the presence of the commercial boats. Without the negative reinforcement provided by the commercial fishermen, partyboat skippers claim that the sea lions become less cautious near boats causing the squid to disperse. By April, skippers claim the squid are very hard to brail because of the presence of sea lions, although the scarcity of squid at the end of the spawning season is more likely the cause of poor squid fishing.

Adult California sea lions have been the only age group observed removing fish from lines, whereas juveniles were the group remaining close to the vessels to consume live chum. An example of the nature of California sea lion harassment at a partyboat is the following report from an exceptional day at Los Coronados Islands: "Fifteen Pacific bonito and one yellowtail were taken off the hooks by two adult male California sea lions. In most cases, only a portion of each fish was consumed. In addition, 23 juvenile brown pelicans and 16 cormorants were hooked by the fishermen, some of them injured badly." There was as much dislike of the birds as for the sea lions by many of the fishermen. We thus have conflicting attitudes shown by fishermen towards mammals and birds. A study of aesthetic value of marine mammals by partyboat fishermen is being conducted by the DFG. Skippers must be cautious in their treatment of marine mammals because several charter boats participate in "whale tours" in winter when fishing is slow.

There appears to be an increased degree of harassment by pinnipeds. John Baxter (MRR, pers. commun.) has no recollection of skippers complaining about marine mammals from 1950 to 1970. Possibly the recent large numbers of juvenile California sea lions are not conditioned at an early age to avoid close approximation to boats and discover a food supply, possibly under the added stress of increasing population levels. The year-round depredation recorded at San Diego is possibly due to the constant fishing pressure on bonito and Pacific mackerel appearing during all seasons (Table 26; Figure 7). The least depredation occurred during the May to July period when the adult animals were on the breeding grounds. The greatest number of Pacific bonito lost occurred during the fall months when the highest catches were recorded and when the greatest amount of effort was expended.

Gear Loss.

Gear loss occurred only when Pacific bonito were taken, resulting in breaking of leaders and loss of lures and hooks. A total of $33 worth of gear was lost in the at-sea sample of 56 Pacific bonito lost, yielding a value per depredated fish of $0.5893. The estimate of Pacific bonito lost in 1980 was 18,213 fish using at-sea data. An estimated $10,733 worth of gear was lost due to California sea lion depredation.

Discussion

The possibility that much of the California sea lion depredation is the result of learned behavior of animals in the San Diego area

Also, due to the apparent continual movement of animals up and down the coast, very expensive means would have to be constantly employed to keep sea lions from utilizing any haulout area, if it were indeed possible.

The only other technique known at this time is noise aversion. The Department of Fish and Game is presently undertaking a joint research study with Dr. Bruce Mate, Oregon State University, Corvallis, to explore the potential use of an underwater acoustic device which will keep pinnipeds at a distance from fishing gear and hatchery areas. Our initial experiments will be in the Klamath River to test its effect of keeping harbor seals away from gill nets and at a distance from the DFG seining operation to obtain salmon for upstream marking experiments. Other experimentation includes the interaction of pinnipeds in the round haul fisheries of southern California. The major experimental need at this time is to test possible habituation of animals to the loud irritating noises. Should the first year's experiments prove successful, it is recommended that experiments with salmon trolling gear be initiated.

PARTYBOAT FISHERY - NON-SALMON

Description of Fishery

This section presents the partyboat fisheries for bottomfish such as rockfishes and lingcod and the more surface oriented fishes such as Pacific bonito, Pacific mackerel, and California barracuda.

The California partyboat fishery was established in the early 1920's (Sadler 1928), and in 1925, live bait was reported used by partyboats in southern California (Clark and Croker 1933). The industry expanded rapidly after 1929 and again after WWII in the early 1950's. In central and northern California the seasonal salmon fishery dominates the partyboat effort, however, in more recent years increased bottomfish effort has been expended at all northern California ports. South of San Francisco salmon partyboat fishing makes up a small segment of the effort.

The southern California fishery is more diverse with several fish being target species. Live bait is used from Morro Bay southward. Anchovies are most commonly used as live bait with squid, Pacific mackerel, white croaker, and queenfish occasionally utilized. Half-day boat trips are common in southern California but seldom operated in central and northern California due to the more forceful onshore afternoon winds in the northern part of the state. There is an evening fishery at times in southern California in which case a given boat may take three separate trips in one day.

The southern California partyboat operation includes different types of fishing methods for various habitats and depths for a variety of target species. The surface and mid-depth species are the Pacific bonito, Pacific mackerel, jack mackerel, California barracuda, white seabass, yellowtail, albacore, and marlin. In Baja California waters, additional species are yellowfin tuna, skipjack, and dolphinfish.

The surface species are taken with both live bait and lures, usually in shallow water within 1 km of an insular or mainland shoreline. The boat will lay out a "circle" of live chum to attract the targeted fish and continue to throw out live bait to keep the fish within the range of cast lures or hooks with a live bait attached. When partyboats move between fishing areas, the skipper will sometimes travel slow enough to allow fishermen to troll with lures. Often, when a bonito or other surface fish is caught while trolling, the skipper will stop the boat and try to attract the fish to the boat if there is a large number of them. The skipper will usually anchor the boat when good fishing is underway.

Deep water fishing for rockfishes is usually conducted at offshore banks or in deep waters adjacent to the offshore islands. The fishing poles are heavy duty with large reels and equiped with an extended winding arm to haul in the heavy weight and sometimes large fish. The fish species include bocaccio, chilipepper, cowcod, and lingcod. The water is too deep, up to 100 fm, for anchoring,and the boats will drift over good fishing areas and return up wind again as they drift off the productive grounds. The dead bait used is anchovy, squid, or mackerel.

The shallow water inshore bottomfish fishery is targeted for kelp bass with other species often taken such as sand bass, sculpin, white croaker, halfmoon, California sheephead, California halibut, and ocean whitefish. This fishery is with both live and dead bait and can be at anchor or while drifting. Water depths range from about 10 m to 30 m, and often adjacent to kelp canopies.

Sampling Methodology

At-sea samples were desired for this fishery due to the large number of fishermen aboard and the diversity of species being taken when an aggregate of rockfish and flatfish are being caught. It would be more difficult for the boat operator to relate the catch and loss to marine mammals in this fishery than in the salmon fishery in which only one or two species were being taken among fewer fishermen aboard. Interview data were gathered occasionally when an opportunity arrived such as when going to the harbor to arrange for an at-sea trip or when sampling some other fishery. At-sea data collected were the approximate number of fish by species caught, the number of lines in the water, the block area of catch, a record of all marine mammal activity, and the definite and probable loss of fish due to marine mammal depredation. Other interactions were if fish were frightened away from the boat by marine mammals and when the skipper would move to another area to escape harassment from mammals removing fish from hooks and foraging on the live chum.

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Gear Loss.

Gear loss occurred only when Pacific bonito were taken, resulting in breaking of leaders and loss of lures and hooks. A total of $33 worth of gear was lost in the at-sea sample of 56 Pacific bonito lost, yielding a value per depredated fish of $0.5893. The estimate of Pacific bonito lost in 1980 was 18,213 fish using at-sea data. An estimated $10,733 worth of gear was lost due to California sea lion depredation.

Discussion

The possibility that much of the California sea lion depredation is the result of learned behavior of animals in the San Diego area where Pacific bonito is a major part of the catch, leads to the concept that behavioral patterns can be modified to reduce interaction. Partyboat skippers have been requesting that the MMPA be amended to allow them to take marine mammals to reduce interaction. Our results indicate that this procedure is not justified.

Measures other than take may be possible. For instance, skippers should not feed sea lions to keep them from taking fish off hooks, and the fishermen should not feed the juvenile animals when they come close to the boat. It is not recommended that seal bombs and shooting be allowed on partyboats, especially when many of the passengers may become upset with this type of animal treatment.

Possible food or noise aversion methods may be feasible. Bait thrown out that has been injected with lithium chloride may condition the curious juveniles to not expect a foraging bout when the vessels arrive at the fishing grounds. Noise aversion may be applicable if the animals prove to not become habituated to the irritating noises. Both juveniles close to the boat and the adults removing fish at greater distances and depths may be kept out of the range of the hooks. It is recommended that noise aversion experiments be initiated in 1983, followed by food aversion studies should they fail.

PACIFIC HERRING FISHERY

Introduction

Pacific herring are taken during the winter spawning period in San Francisco Bay, Tomales Bay, Bodega Bay, Humboldt Bay, and in Crescent City harbor (Figure 8). There is a small incidental round haul net take of around 25 tons of Pacific herring during the summer period in Monterey Bay.

The spawning herring are taken primarily for the Japanese roe market, with a small amount sold locally for fish bait and fresh fish consumption. The spawning fisheries are controlled by the Fish and Game Commission with season, quota, and number of fishing vessels established in each fishing area (Table 27). Additional restrictions include that no gill net can be longer than 65 fms and that each vessel is allowed no more than two nets in the water at the same time. The gill nets vary from about 2.0 to 2.5 in stretched mesh and must be marked with buoys at each end. The buoys must be lit at night with battery operated flashers. Fishing is conducted during both daytime and at night, however, fishing for all boats (including round haul permits) terminated each week at noon on Friday and resumed at midnight on Sunday.

Gill netting in San Francisco and Tomales Bays is divided between odd and even number groups, each group operating alternate weeks. This is to alleviate overcrowding on the fishing grounds. In 1980-81, 100 new gill net permits were issued for San Francisco Bay. These permittees were allowed to fish from November 30 through December 8, when they reached their quota (Figure 9).

Besides the mandatory fish landing receipts of which the Department receives a copy, there is a mandatory fishing log for each day's operation. Each net set is reported with an estimate of the catch, or if there is no catch. The time of each set is entered along with the location of the set entered on a map of the fishing area which is included in the log.

Methods

Mammal Mortality

Interviews with herring fishermen before the study was initiated revealed that at Crescent City two California sea lions were reported drowned in nets and that rarely a sea lion would be drowned in the round haul net operation in San Francisco Bay. The apparent rarity of drownings precluded scheduling a routine sampling regime which could yield a confidence estimate of mammal mortality. It was assumed that drownings, if any, would become known to the observers or that enough net hauls could be monitored during routine mammal depredation coverage to disclose degree of mortality.

Frightening Fish Schools Out of Round Haul Nets

There is a claim by fishermen that sea lions enter the round haul nets before the bag reaches the boat and frighten the fish out of the net. The principal investigator has observed fish school loss as described above during commercial anchovy aerial observations in clear waters of southern California, and comparable round haul net loss of herring may be taking place. Fish school loss in this manner does not limit the catch if the quota is met. It may mean that more sets would be required to reach the quota or that an individual boat may catch less fish, but the overall fishery may not be affected. If the round haul quota for the year is not met, then this mammal activity could result in a reduction of the catch. There was no methodology available to determine this potential loss because the waters of San Francisco Bay are turbid precluding observation of fish school and underwater mammal activity in the nets.

Marine Mammal Depredation on Gill Nets

The principal emphasis the first year was to document mammal behavior in the fishing areas and to develop standardized sampling regimes for each fishing area. Fishermen interviews were conducted when fish were being unloaded to determine the nature of the fishery and possible interaction under different fishing conditions.

Mammal behavior was determined by recording activity at gill nets during both nighttime and during the day and in lampara and purse seine nets from early morning to late evening when light was adequate. At Crescent City and in Humboldt Bay, observations were sometimes possible at night because of the nearby shore lights, but in San Francisco and Tomales Bays such close-by lighting was not present. In 1979-80, the gill net quota was reached in 34 fishing days, in 10 days for purse seine boats, and in 23 days for lampara boats.

It was thus not possible to gain sufficient interaction information by observing from one boat per night due to the limited number of sampling days. There was also a chance that the boat the sampler was aboard may catch no fish and the entire sampling day would be lost. In Crescent City harbor and Humboldt Bay, fishing effort was limited enough to permit single net sampling either from a Department skiff or by being aboard a gill net boat. For San Francisco and Tomales Bays, however, daytime sampling of many boats per day was required to obtain a representative sample. Observations were made from a Department boat and from high vantage points on shore. In this way, observations could be made of mammal interaction at several nets at a time and several areas could be covered in one day. Also, net hauls of many sets per day could be observed for net damage, entanglement of mammals, and quantity of herring being caught.

Behavioral patterns and foraging intensity data collection from shore was made during extended periods of time, varying from 1 to 5 hours at each site. Counts of animals by species at and near the nets were made in a zone in which accurate accounts of all behavior could be monitored. The maximum distance of the study area from shore was around 600 meters from a high observation point. Whenever an animal would appear at the surface, the time and activity category was entered on a map of the observation zone. The position of each gill net was drawn on this map. The mammal activities were foraging, traveling, or resting. Foraging activity is when an animal remains in the general area slowly and deliberately diving and surfacing. Surfacings within about 10 m of a net were considered "at" the net and were considered foraging on fish gilled in the net. Foraging dives farther from the net than about 10 m were considered "near" the net if within the study zone.

Only on four occasions was an animal observed eating a fish after surfacing at gill nets or inside lampara nets. The report (Spalding 1964) that pinnipeds consume herring under water was confirmed in this study. Fancher (1979) also reports that harbor seals in south San Francisco Bay rarely brought forage items to the surface. Thus, it was not possible to know whether fish were actually being eaten at the nets, but from their behavior it is assumed that they were.

Depredation values were made by using the activity observations recorded at 15 min intervals in the study zones. Data recorded were the number of nets in the zone and the number of animals that were foraging, traveling, or resting. The tally was made over about a 3-minute period to allow for searching the entire zone and observe animals at the surface if diving was taking place. Fancher (1979) noted that the average diving time of harbor seals near the Dumbarton Bridge was about 4.8 minutes under the water and about 35 seconds on the surface between dives. Our first observations of harbor seals and California sea lions at herring nets disclosed a different foraging behavior. The range of dives at nets by California sea lions and harbor seals was from 1 to 6 min with an average of 2.33 min per dive. However, continuous observations were made between counts, and the approximate number of animals and their location were known when the 15 min tally was made, limiting the chance of over or under counting of animals known to be in the area.

The number of nets being fished at each 15 min interval was totaled, yeilding a summation of net units. This summation was then divided into the sum of the number of animals recorded during the same 15 min interval yielding an index of foraging frequency. This index was then multiplied by the total number of net sets recorded on the daily fishing logs yielding the total number of mammal foraging units in each fishing method for the season (Table 28). These mammal foraging units were considered as mammal foraging days for the sake of this analysis.

There is little information as to the length of foraging bouts in the wild for pinnipeds. Fancher (1979; and pers. commun. 1981) relates that the maximum foraging bout for harbor seals in pursuit of bottomfish such as staghorn sculpin was a little over one hour with the average somewhat less. Foraging at herring gill nets in which fish are captured for the animal probably requires less effort (as indicated by the shorter diving times), and that an assumed foraging bout of one hour per day is probably realistic. If so, then the mammal foraging units are the same as mammal foraging days.

There are several other untested assumptions and information gaps in this estimate. The index used here assumes that all slow-action dives at and near nets are foraging dives, that there is the same degree of foraging effort at night as during the day, and that the daily consumption rates for wild animals is the same as for captive animals that are on a maintenance diet.

An evaluation of the above assumptions indicates that the estimates are useful, but only as a general indication of potential depredation. The assumption that all dives at and near nets are foraging dives is probably accurate, but not all fish eaten may be taken from the nets and all fish taken may not be herring. Foraging dives at nets amounted to about 70 percent of the total foraging dives recorded (Tables 29-30). Fishermen claim that many herring free themselves from the net but are weakened and can be easily picked up by a foraging animal. Foraging near nets by California sea lions and harbor seals (Figures 10 to 13) in San Francisco and Tomales Bays indicates that either weakened fish or spawning, schooling fish are being eaten other than out of nets.

Under this assumption, net depredation estimates would be high.

The assumption that daytime and nighttime foraging intensity is the same is based upon the data presented by Fancher (1979) that there was little difference between night and daytime foraging but that the tidal height had a definite influence in foraging behavior in San Francisco Bay. Our data indicate a slightly higher evening and nighttime foraging intensity in Humboldt Bay but the data are not sufficient to detect significant differences. The fact that herring are netted and are readily available whenever a run is being fished throughout the day and night may interfere with any "natural" non-net foraging strategies.

The assumption that consumption rates for captive and wild animals is the same would result in a conservative value. Several captive animal feeders contacted (Sea World, Inc. San Diego; Peter Howorth, Santa Barbara; Mark Weber, Fort Cronkite) feel that wild animal consumption would be higher. The feedings in captivity are for either display or rehabilitation and are maintenance diets rather than full consumption per day intake. A maintenance rate of about 15-20 percent of body weight was reported for young fast growing animals and about 5-10 percent for adult animals. Harbor seals consume slightly less per percent of body weight than sea lions. These consumptive rates were used in this analysis.

Gear Damage

Interviews of fishermen at the onset of the study indicated that net damage and tangling by mammals was greater when the nets were allowed to drift. This fishing activity was terminated after 1978-79 and less fish depredation and net damage was reported. Net holes can be made when a mammal bites a fish in the net and when an animal may become temporarily tangled. Net damage due to bottom snags were also reported, and the cause cannot always be determined. One of the methods to determine damage in the Humboldt Bay and Crescent City areas was to ask the fishermen to keep an additional log for the project in which they recorded animal depredation and net damage. This was not done for the areas to the south. Nets were inspected during unloading with comments recorded from the fishermen as to the probable cause of the damage.

Results

San Francisco Bay

Marine Mammals Present in Area

There have been several studies on harbor seals in San Francisco Bay and along the coast north to Bodega Bay, and an apparent pattern of seasonal distribution has been established (Bartholomew 1949; Paulbitski and Maguire 1972; Fancher 1979; Fancher, pers. commun. 1981; Risebrough et al. 1980). There are nine known areas where harbor seals haul out inside San Francisco and San Pablo Bays (Figure 19). Rookery areas are at Castro Rocks, Mowry Slough and Greco Island. The Mowry Slough pupping concentration is the largest with a maximum of 331 animals counted in May, 1980 (Table 31). Two of the hauling grounds, Strawberry Spit and Greco Island, are available to harbor seals only during high tide.

There is an apparent movement of harbor seals out of the south bay during the September to January period with some of the animals apparently moving to Strawberry Spit and others relocating outside the bay area to the north, possibly into Bolinas Bay (Fancher 1979;

Risebrough et al. 1980; and Sarah Allen, pers., commun.). Thus during the herring spawning season, there is not an increase of harbor seals entering the bay to forage upon herring as some fishermen believe but a scattered movement not necessarily oriented to the herring spawnings.

California sea lion haul outs are at Seal Rock (Land's End), San Francisco and at the southernmost tip of Angel Island. Fancher reports he has not observed California sea lions south of near the Oakland-San Francisco Bay bridge during aerial coverage of the bay. The maximum counts made in the two seasons were around 200 at Angel Island, around 175 "jugging" near Treasure Island during a heavy fishing operation, and around 200 at Seal Rocks. These animals were counted on different days, and the Treasure Island and Angel Island animals may have been the same.

Mark Weber (Marine Mammal Rescue Center, Fort Cronkite, pers. commun.) counted a minimum (one side of the rocks) of 425 California sea lions and four Steller sea lions at Seal Rocks on May 19, 1979. Wintertime counts at Seal Rocks reported by Weber were 157 in November 1978 and 105 in November 1979. Project maximum count at Seal Rocks was 202 California sea lions in December 1980.

There have been around 500 California sea lions hauling out at the Farallon Islands (Ainley et al. 1977), but it is not known if these animals travel into San Francisco Bay to forage. California sea lions follow the herring schools and are directly involved in foraging upon spawning herring. Our studies demonstrated nearly constant presence of California sea lions near the fishing operations, but we seldom observed harbor seals foraging at gill nets and none entered the round haul nets (see below).

The only cetacean seen in the fishing area was a subadult California gray whale observed in Richardson Bay on February 22, 1981. The whale passed within about 300 m of two gill nets, entered the shallow muddy area of Richardson Bay and was subsequently lost from view.

Marine Mammal Mortality

Gill nets tallied in the activity study areas in 1979-80 totaled 194, 78 of which were observed being retrieved (Table 32). Forty-nine gill nets were in the study area in 1980-81 with 47 observed being retrieved. A total (Table 33) of 106 round haul sets was observed in the two seasons. No marine mammals were observed tangled in gill nets or drowned in round haul nets. On a skiff census of pinnipeds during the herring season from Treasure Island to off Richmond, one subadult sea lion was floating dead (bloated) on the surface. Cause of death was not known.

The Herring Fishery in 1979-80 and 1980-81

The fishery in San Francisco Bay in 1979-80 reached quotas for all net categories relatively quickly with only 34 days of fishing effort (Figure 9). The fishery in 1980-81 started out with exceptional catches during the November 30-December 8 period, but most of the remaining heavy spawnings occurred during closed season periods and during the fishermen's strike for price. Only the purse seine boats reached their quota in 1980-81. Seventy-five days of fishing effort was expended in 1980-81 (Figure 9).

The spawning biomass (J. Spratt, California Department of Fish and Game, pers. commun.) in 1979-80 and 1980-81 was approximately

53,000 and 65,000 tons respectively. The catch was 9.8 percent and 12.2 percent of the spawning biomass in these two seasons respectively.

Net Damage

Holes most likely made by pinnipeds biting herring out of the gill nets were observed in nearly all nets that were fished. These holes were about 5 to 10 in in diameter, but the damage did not preclude use of the net and the holes were seldom mended. Most fishermen interviewed did not consider net damage as important and did not view it as a loss in dollars. Most of the nets were owned by the fish buyers and not by the fishermen, and mending takes place primarily during the off season. Large holes caused by sea lions becoming entangled and breaking loose were not observed in San Francisco Bay as at Crescent City (see below).

Foraging Activity at Nets

Gill Nets. Behavior studies disclosed that foraging activity by pinnipeds in San Francisco Bay is slow and deliberate and usually by only one or at the most for four animals per net. It was difficult to follow the activity of individual animals, but when possible, the animal would move from one net to another often making foraging dives some distance from a net, then move to another nearby net (Figures 10-13). There was no intraspecific competitive interaction when more than one animal was at a net, in fact, there were several occasions when two California sea lions (usually subadults) would travel and often dive together at the nets. When herring spawning runs were heavy and fishing activity conducted throughout the day and night, there were always a few California sea lions foraging but many more were resting in view of the observer, usually outside the area of boat activity. Most of the traveling animals were single or in pairs and there was no directional pattern of movement evident. The maximum number of California sea lions feeding in the fishing area which could include up to 150 nets was about 30 animals.

Total California sea lion foraging tallies at gill nets were 162 and 171 in 1979-80 and 1980-81, respectively (Tables 29 and 30). Plotting of surface activity from shore (Figures 10-13) disclosed that about 70 percent of the foraging dives by California sea lions was within about 10 m of the nets. There was more clustering at the nets on days when the catches were low (Figures 7 and 12; Tables 32 and 33). Harbor seals were observed only on three of the 15 days spent on activity patterns during both seasons with 11 out of 12 (92%) of surfacings within 10 m of the nets.

Catch-per-set values were derived from the daily catch logs. The total estimated catch reported by gill net fishermen in San Francisco amounted to 90.8 and 90.0 percent of the total catch recorded at the weighing stations in 1979-80 and 1980-81, respectively. A general comparison of individual boat log estimates and landing receipts indicates that most of the difference in catch between the two sources was due to non-reporting of daily logs. It is assumed for this analysis that there was no difference in non-reporting between heavy and light load sets.

Foraging frequencies per gill net (Figure 15) appeared to decline as the catch per set increased, however, when no or very little catch was made, the foraging rates varied from no foraging to high levels. Catches were considered "heavy" when the take was 1,000 pounds per set or over. The foraging frequency index was 0.30 at nets when heavy loads were recorded and 1.10 during light catches. There was a large disproportionate take of herring during the heavy runs with over 97 percent and 89 percent of the total landings in 1979-80 and 1980-81, respectively landed on days when the average catch per set was over 1,000 pounds. During these heavy catches, 0.37 percent of the catch was possibly removed from the nets by pinnipeds compared to 15.71 percent of the catch removed per set during periods of light fishing in 1979-80 (Table 28). In 1980-81 these values were 0.39 and 7.21 percent for heavy and light fishing success, respectively.

Reasons for higher foraging frequency values recorded during light fishing are probably related to the high fluctuation in number of nets in relation to the relatively more constant number of mammals present. When gill nets are taking heavy loads, the animals are spread among more nets with less concentration per set. When only a few nets are being fished when the runs are light, mammals concentrate at these nets if fish are being gilled. The mammals may not remain in the area if no fish are being gilled, although on one occasion when no herring were in the area, jacksmelt were being gilled and foraged upon by harbor seals. Another factor in decline of foraging frequency during heavy take is that the animals may be satiated by foraging on free swimming masses of spawning fish and do not need to forage at the nets. Also, there may be a general saturation of feeding when spawning runs are large and the foraging time is shorter.

The maximum poundage of herring foraged by pinnipeds at and near gill nets determined from foraging frequency indices was 0.71 and 1.10 percent of the total catch in 1979-80 and 1980-81, respectively (Table 28). This represents about 42,000 and 59,000 pounds, respectively.

When these estimates are corrected for percentage of foraging activity only at the net and adjustment for non-reporting on the daily logs (Table 34), these values are reduced to 0.56 and 0.73 percent depredation for 1979-80 and 1980-81, respectively. During the 1979-80 season, the quota was met and this maximum amount of possible depredation did not reduce the catch. In 1980-81 when the quota was not reached, the maximum amount of herring (44,000 pounds) that could have been consumed out of the gill nets would have been worth about $25,000.

Round Haul Net Fishery. The round haul net fishery is involved in a different type of interaction with marine mammals. These boats rely upon recording and flashing electronic devices to locate the herring and can thus fish in daytime as well as at night. These boats will maneuver about the bay area to trace herring and will set on the schools if the amount of fish is considered sufficient and is near the surface. After the bag reaches the boat and the fish are "dried up", the fish may be tested for roe content. If the percentage of roe is considered adequate, the fish are either brailed aboard or pumped into the hold with a suction hose. The word is given over marine radio that fishable schools are present and other boats will come to the area. The activities of these vessels attracts California sea lions, and within 15-20 min, up to eight sea lions per set can be observed swimming over cork lines to forage on the trapped fish. Only California sea lions were observed in round haul nets.

A total of 106 round haul sets was observed in the two seasons surveyed. California sea lions entered 53 (50%) of these sets. A total of 92 individual sightings were recorded in the nets yielding a foraging frequency of 0.87 mammals per set (Table 35). The maximum amount of herring consumed in the nets, assuming that the total daily requirement of energy was taken while in the net, would amount to about 0.43 and 0.84 percent of the total poundage caught by lampara nets, and 0.27 and 0.23 percent by purse seines in 1979-80 and 1980-81, respectively (Table 34).

The lampara boats in 1979-80 and the purse seine boats in both seasons landed their quotas, and the fish consumed by pinnipeds in nets did not affect these particular catches. The lampara catch did not reach quota in 1980-81, and a possible maximum loss to the fishery from pinniped foraging in the nets would have been around 22,000 pounds (Table 34) valued at around $8,000.

Seventeen of the 92 California sea lions observed in sets remained in the net until the set was completed (Table 35). These animals could not escape on their own once the fish were dried up, and they had to be maneuvered over the cork line before brailing could be initiated. California sea lions are becoming more accustomed to these fishing vessels, especially in the bays where they are not harassed by the fishermen. On one instance, a large California sea lion adult male leaped into the net over the cork line which was extended about 0.5 m above the water from the lighter skiff to the boat (Figure 16) while the fish were being brailed. The animal proceeded to wallow in the mass of fish, and the brailing operation was delayed until the animal could be maneuvered back over the lowered cork line. This event was observed from shore at a distance through a telescope, and the fishermen were not aware of being watched. At no time was there an attempt to harm the animal during the removal operation.

<u>Possible Foraging Effect</u>. Approximately 30 harbor seals and 300 California sea lions frequented the herring spawning areas each year in San Francisco Bay. There were 23 heavy spawning days in 1979-80 and 40 in 1980-81 (Figure 9). Assuming that these animals consumed their entire energy from spawning herring during these days, a total of 112 and 180 tons of herring were consumed in San Francisco Bay in 1979-80 and 1980-81, respectively. The total spawning biomass during these seasons was around 53,000 tons and 65,000 tons in these seasons respectively. Thus, the total pinniped consumption amounted to 0.1 and 0.5 percent of the total herring spawning biomass in these two seasons. The pinniped consumption from nets amounted to around 0.46 and 0.62 percent of the catch and 0.05 percent of the spawning biomass in 1979-80 and 1980-81.

Tomales Bay

Marine Mammals in the Area

There is a more dynamic and apparently closer relationship between the pinnipeds and the spawning herring than witnessed in San Francisco Bay. The population of harbor seals is larger,and the California sea lions apparently move into Tomales Bay during each spawning run. Harbor seals remain inside Tomales Bay throughout the year (Table 36) with a maximum spring pupping season count recorded in May 1981 of 225 animals including 25 pups (Sarah Allen, pers. commun.). During the herring spawning season, a maximum of 285 harbor seals were counted (Lyman Fancher, pers. commun.) with an average of 126 recorded hauled out by Department of Fish and Game herring project personnel from January 23 to March 14, 1980.

There are other large concentrations of harbor seals in other nearby bays and along the outer coastline near Tomales Bay (Figure 8; Table 37). The fluctuating numbers between these hauling grounds indicate that harbor seals may be moving between these areas (L. Fancher and S. Allen, pers. commun.).

California sea lions haul out at Bodega Rock, 8 km north of Tomales Bay and at Pt. Reyes, 12 km to the south. During fall of 1979, 135 California sea lions were counted at Bodega Rock and about 60 at Pt. Reyes. A maximum of about 75 California sea lions were observed active inside Tomales Bay during the herring spawning season. California sea lions are seldom seen inside Tomales Bay when herring are not spawning.

Both harbor seals and California sea lions forage throughout the bay and frequent the herring spawning grounds both night and day. Resting animals of both species often remain in the water near the fishing operation (Figures 14 to 17). Fishermen watch the actions of the pinnipeds to locate new runs of herring entering the bay.

Marine Mammal Mortality

Forty-nine nets were observed in the study areas in Tomales Bay with 24 of these watched while they were being pulled in. No marine mammals were entangled. Fishermen interviews reported some shooting at animals at night, and Sarah Allen (pers. commun.) reported several dead pinnipeds seen in the bay during the herring season. We have no estimate of the possible number which may have been killed, but it appears to be a rare event.

The Herring Fishery in 1979-80 and 1980-81

Only gill nets are allowed in Tomales Bay, with the exception of one beach seine permit. The quota has been taken only once in 5 years, in 1978-79 when the quota was half of the 1980-81 season quota. Fifty and 56 fishing days were expended in 1979-80 and 1980-81, respectively. Fishing takes place in the bay from about Hog Island south to off Marconi Cove (Figure 22). The area between Toms Point and the mouth of Tomales Bay is closed to fishing. Fishing also takes place outside the bay in Bodega Estero. In some years, possibly more than half the catch for this area is taken outside the bay.

The Tomales Bay spawning biomass was 6,013 and 5,128 tons for 1979-80 and 1980-81, respectively (J. Spratt, Department of Fish and Game, pers. commun.). The commercial catch was 596 and 452 tons, respectively representing a take of 10 and 9 percent of the spawning biomass in these two seasons.

Net Damage

As in San Francisco Bay, little concern was given to the holes made by foraging pinnipeds and most of the nets remained unmended throughout the season.

Foraging Activity at Nets

We observed nine sets in 1979-80, and 40 sets in 1980-81 for a 1.0 and 5.0 percent sample of the total sets for each season, respectively. Harbor seals were involved in 52 percent of the 225 foraging dives observed at and near set gill nets. There were usually slightly more California sea lions present in the fishing areas, although on one occasion harbor seals dominated the foraging activity. There did not seem to be interspecific avoidance or aggressive behavior when both species were foraging at the same net although it did appear that the harbor seals returned to the surface farther from the net than did the California sea lions. There were too many animals present at the same time to permit following individual animals to record diving and surface times. The general foraging pattern appeared to be comparable to San Francisco with most dives around 1 or 2 min.

Foraging frequencies per set ranged from 0.0 to 2.0 for both species combined. The foraging frequency rate during heavy fishing was about 0.9 animals per set and for light fishing about 1.3 animals per set. This compares with 0.3 and 1.1 foraging frequency values respectively for San Francisco Bay. Possible reasons for the greater foraging rate in Tomales Bay is that there are more animals present per set, especially harbor seals, and that the herring runs are in a more confined area.

A total of around 30,000 and 25,000 maximum poundage of herring was estimated removed from the gill nets by pinnipeds in the 1979-80 and 1980-81 seasons, respectively. This amounted to 2.57 and 3.09 percent of the catch in these two seasons, respectively. After adjustments for non-reporting of logs and for foraging away from nets (Table 34), the maximum poundage taken was estimated to be around 25,000 and 23,000 pounds for 1979-80 and 1980-81, respectively. The value of these fish would have been around $16,000 and $15,000, respectively. The quota was not reached in either season and foraging probably did result in a minor loss to some fishermen.

Possible Foraging Effect

A ballpark figure of possible pinniped interaction with the herring population and fishery is offered using a concentration of 200 harbor seals and 80 California sea lions present in the spawning area inside Tomales Bay. There were 12 known spawning days in 1979-80 and 11 days in 1980-81, with an estimated spawning biomass of 6,013 and 5,128 tons, respectively. If it is assumed that all the animals present received all their energy requirements from spawning herring during the runs, a total of 44 tons and 41 tons of herring would have been consumed by pinnipeds in each season, respectively. Thus, the total pinniped consumption amounted to 0.7 and 0.8 percent of the total herring spawning biomass in these two seasons. The pinniped consumption from nets amounted to around 2.1 and 2.5 percent of the catch and 0.2 percent of the spawning biomass in 1979-80 and 1980-81, respectively.

Humboldt Bay

Marine Mammals Present

There are permanent harbor seal hauling grounds scattered inside Humboldt Bay with counts ranging from 600 during the April-May pupping season to 200 during the wintertime herring spawning period. The hauling grounds are primarily in south Humboldt Bay but occasionally large concentrations are observed in north Humboldt Bay (Figure 24). The nearest harbor seal hauling ground outside Humboldt Bay is at the Eel River, 11 km to the south, where over 300 harbor seals have been observed.

California sea lions do not haul out inside Humboldt Bay and the nearest hauling ground for this species is 29 km to the north at Flatiron Rock, off Trinidad Head.

Marine Mammal Mortality

Eighteen sets were observed in the two seasons surveyed out of a total of 215 sets reported on the daily logs for a sample size of 8.3 percent. No marine mammals were observed tangled, and none were reported by the fishermen.

The Herring Fishery in 1979-80 and 1980-81

The four permittees reached the quota of 50 tons in 1979-80 in 15 days of fishing. Most of the fishing was at night but during heavy runs daytime catches were also made. In 1980-81 fishing was conducted on 23 days, but the catch was 7 tons short of the quota. The fishery takes place in the north portion of the bay near Gunther and Indian Islands and to the north about ½ km (Figure 18).

Net Damage

Net damage logs kept for the project indicated a higher degree of net damage than in San Francisco and Tomales Bays. The four permittees in Humboldt Bay listed mending time in dollar values totaling about $600 for the 1979-1980 season. Much greater damage occurred in 1980-81 with each of the four permittees claiming that each had to replace one of their nets due to excessive tearing. Each net cost $650 for a total of $2,600. The fishermen claimed that California sea lions were most responsible for the damage.

Foraging Activity at Nets

The foraging data for Humboldt Bay are not directly comparable to the 15 min interval activity observations collected in San Francisco and Tomales Bays. Twenty of the 30 counts in 1979-80 and all 24 counts in 1980-81 of pinniped activity at nets were recorded during nighttime and the range of vision was much more limited than in the surveys to the south. The periodic count of surfacings and dives extended over a longer period of time (up to 6 or 7 min), and it was possible that more than one dive per animal could have been recorded if the animal was traveling underwater in the direction of the count. During daytime counts, the approximate number of animals and their location are usually known before each count which takes only about 1 to 3 min (see above). Therefore, the count of numbers of animals present may be high. Nevertheless, considering the small magnitude of the fishery and cooperation of the fishermen to relate fishery-mammal interactions, the data do indicate valid comparisons with interactions in San Francisco and Tomales Bays.

Harbor seals were the only pinnipeds observed at (within 10 m) the nets in both seasons (Table 38). Four California sea lions were observed in the netting area but they remained outside the 10 m distance from nets. In the 30 counts on eight nights and days in 1979-80, 124 harbor seals were tallied, yielding a foraging frequency rate of 4.13 mammals per set. A much higher rate of depredation occurred in 1980-81 with 33.4 harbor seals per net recorded. Daily logs of effort and catch reported 102 sets made in 1979-80 with an average of 877 pounds per set. Comparable data for 1980-81 were 113 sets for an average of 723 lbs per set. About 13,000 pounds of herring could have been foraged from the nets by harbor seals in 1979-80. There is no correction for animals foraging near instead of at the nets in that all animals recorded were within 10 m of the net. Reporting of daily logs amounted to 91.3 percent and 95.0 percent of the recorded catch on the landing receipts in 1979-80 and 1980-81, respectively. Correcting for non-reported logs, the maximum poundage foraged by harbor seals in 1979-80 was about 11,500 pounds or 11.7 percent of the catch. The high estimated foraging rate for 1980-81 could be exaggerated by as much as 100 percent in that much longer time was needed to count all the animals present, resulting in possible counting more than one foraging dive per animal.

The length of time at the surface per animal on the average was from 3 to 4 minutes, and if 8 minutes were taken to make one count, the tally could be twice what it should be. With this large error in mind, an estimate of from 34.2 to 53.6 percent of the herring may have been removed from the nets by harbor seals. In 1979-80, there was no loss to the fishermen because the quota was met, but in 1980-81, the loss could have amounted to seven tons of fish valued at about $9,100 for the four fishermen.

There are no spawning herring biomass estimates for Humboldt Bay, and a rough estimate of the degree of interaction by harbor seals is not possible. However, if the maximum number of 200 harbor seals ate nothing but herring during the 23 days fished, in 1980-81 a total of about 58 tons would have been consumed. This is about the magnitude of the commercial take.

Crescent City

Marine Mammals in the Area

The nearest haulout area for California sea lions and harbor seals is at Castle Rock, 6 km north of the harbor area. An average of 88 California sea lions and 64 harbor seals were counted at Castle Rock in three censuses made in January 1980. Steller sea lions utilize the St. George Reef area 12 km north of Crescent City harbor, but this species has not been observed foraging at gill nets.

Marine Mammal Mortality

Prior to the study, drowning of two California sea lions was reported to the Department. No marine mammals were observed entangled in the 6 sets (15% of the total sets) observed in 1979-80.

Net Damage

Considerable net damage was reported and observed in this area. California sea lions were present during all observations and at nighttime, these few nets are involved in occasional entanglements in which the animals break loose, leaving considerable damage. Possibly, one net per permittee needs to be replaced each year as in Eureka. The cost to replace three nets is $1,950.

Herring Fishery in 1979-80

Only one season was covered due to the small fishery and distance and expense to sample this area from Eureka. The three permittees are allowed a quota of 30 tons total. Twenty-six tons were landed in 1979-80; in 1980-81, only 9 tons were reported. The fishery takes place inside Crescent City Harbor.

Six days were spent sampling this fishery in 1979-80 (Table 39) with a total of 14 counts made of pinniped depredation and activity. California sea lions dominated the interaction with from 2 to 14 animals per net, yielding a foraging frequency value of 7.86 California sea lions per set. Harbor seals were present at two of the six sets, yielding a foraging frequency value of 0.79 per set. Forty-two sets were reported on the daily logs, totaling 25 tons of herring. The recorded catch was only two percent more than the log estimate, and this may have been due to underestimation of the catch rather than non-reporting of logs. A total of 9,900 and 830 pounds of herring was estimated consumed from the nets by California sea lions and harbor seals, respectively in 1979-80, assuming that all of the food requirements for the day were taken from the nets. This 5.4 tons of fish amounted to 16 percent of the herring caught, however, since the quota was almost met, the assumed foraging depredation did not affect the fishery. There are no spawning biomass herring data available to determine total possible marine mammal interaction with the herring population.

Discussion

The herring fishery is a controlled fishery with only permittees allowed to fish and quotas allowed amounting to about 10 percent of the spawning biomass. Marine mammal mortality rarely takes place. This can occur by becoming entangled in the gill nets (Crescent City), by occasional shooting (Tomales Bay), and possibly by drowning in round haul nets (San Francisco Bay). These potential mortalities are of California sea lions; harbor seals have not been reported killed.

Since the fishery is on a quota system, the amount of herring removed from the nets by pinnipeds does not affect the fishery in terms of total catch unless the quota is not met. This happened in San Francisco Bay in 1980-81 in the gill net and lampara fisheries, in Tomales Bay in both seasons, and in Humboldt Bay and Crescent City in 1980-81. The maximum amount possibly foraged was determined by use of foraging frequency indices, yielding a potential consumption of fish, assuming that the energy requirement of the pinnipeds involved was taken from the nets. The greatest depredation occurred when few fish and nets were present and the mammals were concentrated on small number of nets.

The estimates are based on data for which there are no confidence intervals computed because of the untested assumptions used in the calculations. The "worst case" depredation (Table 40) amounts to an insignificant portion of the value of the fishery. The herring catch in 1979-80 was worth about 8.5 million to the fishermen with a maximum possible mammal depredation value of $16,000 worth of fish amounting to a 0.18 percent loss. In 1980-81, when the quotas were not met, the depredation value was about $57,000 in a fishery worth about 8.0 million. Gear damage was probably no more than $5,000 per year for all fishing areas.

GILL NET FISHERIES

Introduction

The Pacific herring and Klamath River Native American subsistence gill net fisheries* have been described separately. The gill net fisheries presented here are shark, California halibut, white seabass, rockfish, white croaker, California barracuda, Pacific bonito, flyingfish, and inshore aggregate. The inshore aggregate includes species such as jacksmelt, Pacific pompano, opaleye, halfmoon, surfperches, and miscellaneous flatfishes.

Having the most diverse catch of all local fisheries, this gear use is rapidly expanding. A significant increase has been observed over the past 5 years with the addition of more fishermen and new kinds of netting and net pulling technology. The most recent expansion has been in the white croaker fishery of Monterey Bay and the thresher and bonito shark fishery of southern California.

Historically, the term "gill net" was first used about 1920 in the California Fish and Game Code, but this gear was known long before as a "set net". Because the gill net has been adaptable to many habitats and is selective to certain sizes and species of fish, conflicts have grown with other inshore fisheries in competition for certain species. Past disputes concerning the use of coastal resources and the gill net have led to gill net gear restrictions and several area closures to this type of gear.

The more recent concern about incidental netting of swordfish brought about comprehensive management surveillance of the gill net fishery in the form of the Kapiloff Bill enacted by the State legislature. For several years, a small drift net fleet has operated in

*Herder, M. 1982

southern California to take sharks. In 1979, mesh sizes larger than 10 in were brought into use in this fishery in attempts to avoid unwanted fish generally caught in smaller mesh. An incidental gill net take of swordfish subsequently occurred south of Pt. Conception. The new fishery expanded rapidly and the incidental take of swordfish rekindled the pressure of special interest groups for an end to all gill netting. As a consequence, lobbying and political influence were brought about through sportfishing and harpoon fishermen associations to place controls on the gill net segment of the shark fishery in which swordfish were being taken. After several attempts by the California Fish and Game Commission and legislative committees, Assemblyman L. Kapiloff, San Diego, submitted a bill to attempt to settle the disputes.

Under this legislation, funds were available to effect three basic controls on gill net fishermen, one of which applies to all gill netters. All gill net fishermen entering the fishery must now pass a proficiency test before receiving a permit. These permittees must now submit a log of their activities in most of the gill net fisheries. Another restriction is a quota system allowing drift gill netters to land up to 25% of the total landings of swordfish taken simultaneously in the harpoon fishery. Another requirement of the bill allows Department of Fish and Game personnel to place an observer aboard a vessel using a drift gill net.

If a vessel has both a drift gill net and a harpoon permit, it is considered a "dual permit" vessel. Dual permit vessel skippers have been accused of catching swordfish in the net, bringing the fish aboard, and then harpooning the fish after the fact counting these as harpooned fish. Because of this, almost all observer time has been expended on dual permit vessels. The Kapiloff Bill was scheduled to be re-evaluated on January 1, 1983.

Immediately after field sampling was terminated on this project, increased public outcry was aimed at the drift gill net fishery in southern California, partly because of the increased numbers of marine mammals being reported entangled and drowned. These included California gray whales, pilot whales and California sea lions. This additional information has been supplied to the project and is included in this report.

General Description of Fisheries

Central California. Gill netting in central California is mostly for white croaker, sharks, California halibut, surfperch, rockfish, and several miscellaneous species of flatfish. The vessels vary from small skiffs launched at ramps to boats up to about 40 ft in length. The fishery is almost always by day boats, retrieving the nets in early morning and replacing them to fish the remainder of the day and overnight. Due to conflict between partyboat fishermen and gill netters in Monterey Bay, gill nets are restricted in some areas to take rockfish. The catch is referred to as landings which are a daily record by boat of the total catch listed by species.

Southern California. Southern California gill netting is much more diverse and specialized to various fish species. However, 62.2% of all gill net effort in southern California in 1980 was expended on the shark and California halibut fisheries (Tables 41 and 42). The typical gill net vessel is 20 to 50 ft in length, has a crew of from

1 to 3, and may remain on California fishing grounds up to seven days before returning to port. Trips into Baja California waters for white seabass may extend up to a month. Set gill nets are picked up each day, weather permitting. The nets range in length from 100 to 2000 m and are retrieved by means of hydraulic gurdies.

The mesh size is measured by stretching any two adjacent knots or intersections of the mesh apart until tight and measuring the stretched distance between intersections. Gill net mesh sizes range from 1 7/8 in to 26 in stretched (Table 43), depending upon the size and kind of fish sought. Once used in gill net webbing, cotton twine has been replaced by either nylon braided twine or monofilament line. Nylon webbing is considered to be more flexible, easier to mend, and to have a greater overall holding strength than the same size of monofilament. However, nylon webbing may be more visible, is more expensive, does not last as long, and picks up and holds unwanted debris in the net compared to monofilament.

Gill net webbing is sold in 50 fm "pieces" or shackles which are joined to form the total net, sometimes referred to as a "gang" of net in southern California. Shackles of different sizes of net may be fastened together when more than one target species is sought, such as using both trammel net (see below) for halibut and gill net for shark in the same set. Most fishermen have two or three different kinds of fishing nets to be used seasonally as the different target species appear. Nets used year-round are trammel nets for California halibut and gill nets for shark, rockfish, white croaker, and inshore aggregate species. Seasonal activity is for the more warmer subtropical species which enter the southern California area during summer and fall such as white seabass, California barracuda, Pacific bonito, and flyingfish. When several nets are left in the water by one boat, most of the fisherman's day is spent pulling and resetting the nets in the same spots. However, some fishermen have reported that when "seals" start bothering the nets they may move their gear to new locations.

Trammel nets are a three-layered net with 8 in. mesh in the center sandwiched by large mesh up to 24 in. Fish that are difficult to gill such as flatfish will swim through the outside layer of large mesh, push against the 8 in mesh and form a pocket or entrapping sac when trying to swim through the layer of large mesh on the other side. California halibut is the target species for this type of gear, but most other species will also become entangled. Sharks, skates, rays, lingcod, and occasionally salmon will become tangled in these nets in Monterey Bay. Salmon cannot be possessed on a gill or trammel net boat and must be thrown back when captured. The take of salmon, however, is minimal and does not present a fishery problem.

Regulations are complex, varying between fisheries and areas of the coast. There are several total closures to gill nets such as District 15 in Monterey Bay and District 19A in Santa Monica Bay. There are no bag limits or quotas on fish species taken in gill nets except that gill net caught swordfish may not exceed 25% of the take by harpooners. There are minimum size limits on fish species taken in gill and trammel nets such as the 22 in TL minimum size for California halibut. There is a closed season for white seabass in California from March 15 through June 15 and for surfperch from May 1 to July 15.

White seabass may be taken in Baja California waters during the California closed season and landed in California ports to sell, however, the minimum size limit is still enforced. Mesh size restrictions are imposed on the take of California barracuda, white seabass, rockfishes, flyingfish, and yellowtail (Table 43). All trammel net interior mesh must be at least 8 in stretched.

Sampling Methodology

At-sea samples were desired for this fishery due to the subjective evaluation of fish loss and gear damage in gear which is usually not attended and cannot be observed when in the water. When fish are removed from a gill net, there may be no trace of depredation, but often only a portion of the fish is eaten or the head of the eaten fish may remain in the net. Since these fish often die in the net and are near or on the bottom in set nets, crabs and starfish may enter the webbing and eat on the gilled fish. Fishermen can usually distinguish between crab and starfish depredation and mammal damage, but it is difficult to distinguish shark and other large predatory fish damage to gilled fish from mammal activity. The project observers learned from the fishermen to distinguish the cause of depredation, but in many cases it was not certain. Therefore, only definite losses were used in this fishery to compute losses. Probable losses were recorded but did not contribute significantly to the sample.

Interview samples were eventually obtained once their reliability was determined. As will be shown below, reliable data on fish loss, area of fishing, and catch was gathered from interview data except in the drift gill net fishery where no mammal mortality was reported and no incidental take of swordfish was admitted. In Monterey Bay, at-sea data were obtained by use of DFG boats, observing the catch and possible fish damage as the nets were being retrieved in the early morning. Interview data were not possible in the Indochinese refugee fishery due to a language barrier.

The shark drift gill net fishery was monitored at-sea by DFG Marine Resources Region personnel upon passage of the Kapiloff bill, and project samplers could then emphasize sampling of the other fisheries. Also, daily logs are required in the drift gill net fishery, and these proved to be valuable in determining the location and amount of catch. Logs required for the white seabass fishery also supplied catch and location data for our computation of fish losses.

Data recorded were the mesh size, length and depth of the net, whether it was a set net or drift net, time fished (soak time), depth of water, catch, and loss attributed to marine mammals. All mammal activity near the nets was recorded. Interview data also included the number of days fished per trip.

Total catch records compiled by the DFG are not at this time available for most of the fisheries for 1979 and 1980. A hand tally of all landing receipts was made at the end of the survey to determine the effort expended in each of the gill net fisheries. Our project sample was then expanded to the total effort to compute total loss of fish and mammal mortality. The southern California area was divided into two subsections, from Long Beach to Pt. Conception and from Long Beach south to San Diego. Due to the error bound sources of catch data and to the subjective nature of both at-sea and interview to determine losses, confidence intervals could not be computed for these fisheries.

Results

Results will be given by the 10 target species groups (Table 44). In 1981, there were 274 gill netters who had received general permits with an additional 78 drift gill net fishermen. The most common listed target species was in the gill net shark fishery followed by halibut and white seabass (Table 41).

Shark Drift Gill Net Fishery

This fishery was initiated in 1977. The catch tripled within four years with the 1980 landings recorded at 3,280,301 pounds. The most sought species is the common thresher followed by the bonito shark. Other species caught in the drift fishery are the soupfin, bigeye thresher, and blue sharks. Under the new general gill net permit system, 167 fishermen have received drift gill net permits.

The most commonly used mesh size is 14 in stretched mesh (range 6.5 to 18 in) made of #18 nylon twine. The nets range from 200 to 1000 fms in length and from 3 to 13 fms in depth. The top of the net is usually 2 to 3 fms below the surface when in operation.

Since September 1980, 177 at-sea observer days (7.3 percent of total) were recorded, 26 by project personnel and 151 by MRR personnel. Mandatory logs have been submitted of 2,420 days of fishing during the period from September 1980 through September 1981 (Figures 19-23). A testing of non-reporting of logs has revealed that not all logs were submitted and that the percentage of non-reporting is less than 10% of the total. It is assumed that there is not a bias in the non-reported data as to area fished. This is the only fishing parameter usable from log data for our analysis. There is a place on the logs to report entangled marine mammals, however, no entanglements were reported indicating total non-compliance of the fishermen on this subject.

The drift gill net fishery extends over almost the entire southern California Bight area from Pt. Conception into Baja California and to the offshore Tanner and Cortez banks (Figures 19-23). There are several areas where consistently more effort is expended such as off Laguna Beach, the area between San Diego and San Clemente Islands, off Pt. Dume, and near Santa Catalina Island. Little effort was expended near San Miguel and San Nicolas Islands.

One of the reasons why the Laguna Beach and San Diego areas are popular is that incidental catches of swordfish are more likely to occur in these areas, attracting the shark gill netters who can bring in these high priced swordfish.

Fifty-two marine mammals were observed tangled in drift gill nets in the 144 at-sea days sampled. Of these, two were pilot whales off Laguna Beach, one was a baleen whale off Santa Catalina Island, and 49 were California sea lions. The California sea lions were taken in 17 different catch block areas with the majority recorded from the upper Channel Islands (Figures 19-23). Thirteen California sea lions were taken singly, on six occasions, two were drowned in the same net, and there was one occurrence each of 4, 5, and 15 drowned in the same net.

The mean catch per net day of California sea lions in the at-sea data was 0.28 animals. No entangled mammals were reported in the 2,420 logs submitted by the drift gill netters, however, when interviewed by project personnel at the docks, four California sea lions and one gray whale were reported entangled out of a sample of 88 days of fishing, yielding 0.05 California sea lions taken per net day. Thus, in the three series of data, entanglement values for California sea lions were 0.28, 0.05, and 0.00 animals per net day for at-sea, interview, and log data, respectively. In the 49 interviews, no swordfish were reported whereas in the at-sea samples, swordfish was the dominant species taken.

Using the mean value of 0.28 California sea lions taken per net, a non-random estimated 678 California sea lions were entangled and drowned during the September 1980 through September 1981 period. This is probably a minimal figure in that no sampling was conducted during the low level fishing period in January, February, and March 1981, and possibly as many as 10% of the logs may not have been submitted.

Another series of data yield another computation of mammal mortality. The total number of shark landings (Table 42) for southern California in 1980 was 2,483. These landings included all receipts which listed shark as a major species taken. These totals include both drift and set gill net (see below) catches, and include the non-reporting segment of the drift net fishery on the logs. The average days per shark fishing trip were 1.765, yielding a total of 4,382 net days. Using the 0.28 animals per net day in the drift net fishery, the estimated total annual mortality of California sea lions would be 1,227. This figure would be high in that the number of days per trip is slightly lower in set nets than in drift nets. Therefore, the best approximation of annual mortality of California sea lions in the drift and set net shark fisheries is between 600 to 1,200 animals.

Looking to the future, the recent method of hanging gill nets so that the wall of webbing is not stretched tight along the cork line but is "bunched" forming a loose mass of webbing which will result in a higher pinniped mortality in the set gill nets for shark and California halibut. This wall of loose webbing tends to tangle fish as well as gill them.

Fish and Gear Lost to Marine Mammals

Sharks were not reported or observed being eaten by marine mammals in the drift gill nets. In one at-sea sample, 10 pounds out of 285 pounds of Pacific Mackerel were taken by sea lions. Swordfish depredation was 125 pounds out of 10,675 taken in the sample. The Pacific mackerel catch was not reported and is quite small and no loss projection is warranted. The loss of swordfish occurred in more than one sample, and amounted to 1.2% of the sample. The total take of swordfish in drift gill nets from December 1980 through November 1981 was about 24,000 pounds, yielding an estimated loss of swordfish to California sea lions of 290 pounds valued at $840. Gear Loss averaged about $2.50 per set, yielding a total value of $600 for 1980.

Shark Set Net Fishery

Fishing for sharks with gill nets set on the bottom has been a common practice for many years along the California coast south of Bodega Bay. The species vary in different habitats and include the soupfin, common thresher, bonito, Pacific angel, spiny dogfish, leopard, white, blue, smoothhound, and horn sharks. Blue sharks have not been popular in the past due to their strong flavor, however, new methods of processing have created recent markets for this species.

All shark fishing in central California is by set net but is of small magnitude compared to the southern California take. Of the total 45 gill set nets sampled at-sea in central California, only three were for sharks; however, sharks were commonly taken as incidental species in the California halibut, miscellaneous flatfish and white croaker fisheries.

In southern California, 6 out of 20 at-sea trips made by project personnel were of set nets, and 2 of the 51 interviews were of set net shark fishermen, the remainder were of drift netters. Thus, in our sample which did not target either the drift or set nets, 11% of the effort for sharks was by set nets. Total effort and catch is not known for this fishery at this time. Because of the small sample, not much can be determined about marine mammal interaction except to indicate that angel sharks are apparently the only shark that is eaten by marine mammals in gill nets. California sea lions were near the net where this loss was noted and, in fact, five sea lions were drowned in this net. No gear loss was reported in our sample, but $810 was reported in the interviews.

California Halibut Gill and Trammel Net Fisheries

California halibut are taken by gill and trammel nets from Monterey Bay into Baja California with principal areas being in Monterey Bay, off Estero Bay and Pismo Beach, and in southern California near Santa Barbara and between Newport and San Diego. Flatfish are difficult to gill in the typical single wall of gill net, and trammel nets have been commonly used for this species. In recent years, gill nets placed in shallow water in Monterey Bay have taken large numbers of halibut. These nets are set in shallow water parallel to the coastline just outside the breaker line to take halibut entering the area for spawning and foraging during the July through September period. These gill nets and the trammel nets also used in Monterey Bay and in southern California are set overnight and retrieved in the early morning. California halibut are favorite targets of depredating pinnipeds, crabs, and starfish, and the nets are retrieved each day, weather permitting, to avoid losses.

The 2,125 California halibut landing receipts (Table 42) for southern California were second to shark landings in 1980. All landings were of one-day trips in central California, but up to 6 days per trip were recorded in southern California. The average days per trip on southern California was 1.19.

Monterey Bay Trammel and Gill Net Fisheries

Trammel Net. This fishery has consisted of from four to six boats over the past several years and is centered primarily in the northern portion of the bay. California halibut, starry flounder, lingcod, several species of miscellaneous flatfish, skates, rays, and sharks have been the usual catches.

A total of 349 days of trammel net effort was expended in Monterey Bay from June 1980 through May 1981. The catch during this period for trammel netters was 1,615 pounds of halibut. In the 5 trammel net at-sea days in our sample and in four MRR samples, no halibut were observed depredated by pinnipeds. Fishermen claim that halibut are eaten, but it did not occur in our small sample. Lingcod were observed eaten in such as manner that the damage could have been done by a pinniped.

There was a high degree of net damage, with $65 worth of damage attributed to sea lions by the skippers yielding a gear loss value of $13 per trip. However, it was not possible to determine if the net damage occurred on the day of the sample, and no projection of loss can be made from this sample.

Gill net. The Monterey Bay gill net fishery for California halibut is being conducted by about 25 small boats, most of them operated by Indochinese refugees. These nets are of 8 in monofilament line and range in length from 0.5 to 1.5 miles. The nets are about 2 fms in depth and are set on the bottom in from 3 to 12 fms of water. The nets are retrieved early in the morning and reset soon after the fish are removed. The soak time is about 20 to 22 hours per day. About 20% of these boats have both halibut and smaller mesh white croaker nets (see below) that are fished at the same time, but usually in different depths and areas.

The total California halibut gill net days expended in Monterey Bay from June 1980 through May 1981 were 517. The California halibut catch was 3,034 pounds. Our sample consisted of 20 at-sea trips (3.9% of total) in which no interaction with pinnipeds was noted. Some fish were eaten upon by crabs and starfish. Large holes were observed in the nets, but since it was not possible to determine the cause of the holes and that these holes were seldom mended, no gear damage values attributable to pinnipeds could be determined.

No marine mammal mortality was observed in the 20 gill net and 5 trammel net at-sea samples. However, in June 1980 and June 1981, MRR personnel observed marine mammals entangled in the gill nets. In June 1980, 3 California sea lions, 1 harbor seal and 1 harbor porpoise were entangled in 3 out of 5 nets watched. The total number of net days fished in June 1980 was 76, yielding an estimate of about 45 California sea lions, 15 harbor seals, and 15 harbor porpoises taken in these nets.

No marine mammals were observed tangled the rest of the year. In June 1981, MRR personnel observed two California sea lions and two harbor seals drowned in two out of seven at-sea samples. The net days in June 1981 totaled 77, yielding an estimate of around 22 harbor seals and 22 California sea lions taken. The pinnipeds in 1980 and 1981 were juveniles.

Results of our 2-week beach census of eight 1 km areas of the Monterey Bay beaches adjacent to this fishery indicate these at-sea estimates are high or that not all dead pinnipeds, especially harbor seals, released from the nets come ashore. During June and July 1981, four California sea lions were tallied in the beach section, yielding and estimate of 24 California sea lions. Two harbor seals were tallied, yielding an estimate of 12 for the June-July period. The estimates of net mortality (see above) were 22 California sea lions and 22 harbor seals for June. One possible error is that if the four animals in the June MRR at-sea sample had been put back into the water and came ashore in the study areas, the estimates would have been higher. If all four dead animals had been released and appeared in our sample areas, the estimate of beached California sea lions would have been 36 and of harbor seals 24. Six beached dead harbor porpoises were estimated from the beach samples but none was observed in the at-sea sample. The cause of mortality of the beached animals was not determined.

Southern California Trammel Net Fishery

All California halibut fishing in southern California was with trammel nets. Most of the effort was recorded from Oceanside to San Diego (Tables 41 and 42; Figure 31). Forty-two at-sea trips were obtained, totaling 52 days of fishing. An additional 46 trips were interviewed in which 54 fishing days were reported. Fishing took place in two areas, from Santa Barbara westward to Pt. Conception and from about Laguna Beach to San Diego. The catches were made in shallow water and in all months of the year. The peak catches were from June through August near Santa Barbara, but there was fairly continuous effort from January through October in the southern area with a peak in September.

Fishermen in the trammel net fishery submitted accurate information during interviews including how many fish were lost, fish landed, and mammal mortality. The at-sea and interview data were similar in each of these three parameters. The percent of California halibut removed by pinnipeds was 12.0% and 8.2% in the at-sea and interview data, respectively, and the number of mammals entangled per trip were 0.17 and 0.14 animals per net in the at-sea and interview data, respectively. California sea lions and harbor seals were observed and reported in each series in addition to one elephant seal reported by a fisherman. The area off Pt. Loma (catch block #860) was the area of highest mammal interaction. The other major losses occurred about 10 km west of Santa Barbara.

Estimates were made by combining the at-sea and interview data, yielding a 4.0% sample of the total 1980 effort. The poundage of

California halibut in the combined sample was 10,354 pounds, with an additional 1,166 pounds depredated by pinnipeds for a 10.1% loss rate. Projecting the 4.0% sample to total catch, 29,150 pounds of halibut were removed by pinnipeds, yielding a value of loss of about $46,640. Other species of fish eaten in the nets were Pacific mackerel, Pacific bonito, rockfishes, and Pacific hake. The total estimated value of this loss was around $1,360.

An estimated 220 California sea lions, 73 harbor seals, and 24 elephant seals were drowned in this fishery in one year in southern California.

Gear loss due to mammal entanglement and damage amounted to about $16 per trip, resulting in a total estimate of $34,684 for one year.

White Seabass Gill Net Fishery

The Department of Fish and Game requires a permit to land white seabass in California. There are 197 permittees of which 144 (73%) are gill netters. There is a closed season in California between March 15 and June 15. During the closed season, an incidental take of two white seabass is allowed for each landing. California landings of white seabass caught in Baja California are allowed during the closed California season.

All the reported and observed trips in southern California were by set nets placed near kelp beds. The primary fishing areas were off Santa Barbara, Pt. Vicente, near San Diego, and at Santa Rosa and San Nicolas Islands (Figure 25). The mesh size varies from 4.5 to 7 in , with 6 in mesh most commonly used. There is a minimum white seabass size limit of 28 in. Nets are usually from 500 to 1000 fm in length. In California, the boats are mostly day boats, picking up the nets in early morning and resetting them to fish the remainder of the day and through the night. The average days per trip when fishing in Baja California waters is 9.1. Mandatory logs are required, and catch effort data are available for our analysis.

A total of 40,511 pounds of white seabass was caught in state waters from March 15, 1980 to March 14, 1981. The Baja California catch in this same period was 750,100 pounds. Our sample consisted of 10 at-sea trips, 23 interview samples of vessels fishing in California waters, and 23 interview samples of boats fishing in Baja California. Our sample of 1,635 pounds of white seabass in the combined interview and at-sea samples amounted to 4.0% of the total 1980-81 California catch. An additional 189 pounds were eaten by pinnipeds in our sample for a 10.4% depredation rate. An estimated 4,683 pounds of white seabass taken by pinnipeds, yielding a loss of $7,480 for the 1980-81 season for California. No marine mammals were observed at the nets, and it is not known if California sea lions or harbor seals were the pinnipeds responsible for the depredation.

The Baja California catch was 750,100 pounds of white seabass, 235,500 pounds of which were sampled during the March to June 1980-81 season, representing a 31.4% sample of the total landings. The depredation rate was 10.2% in Baja California for all our samples starting in 1979 but was only 4.4% during the 1980-81 season analysis. Using the 1980-81 data, 24,523 pounds of white seabass were depredated by pinnipeds valued at $39,200 in Baja California waters.

Incidental take of Pacific mackerel and jack mackerel was recorded in three of the at-sea California samples, but since no take of this species was sold, estimates of total loss are not possible. These losses would be negligible. Baja California incidental take of yellowtail represented 12.4% of the take but since the total take landed by Baja California vessels is not known, an accurate estimate of total loss cannot be made. However, by using our 31.4% sample and assuming that the landings of yellowtail in our sample were representative of the entire effort, a total of 20,670 pounds of yellowtail were depredated, valued at $10,300 for the period from November 1979 through August 1980. A thorough sampling of Baja California effort and catch was not made due to the restriction of conducting a study on fisheries outside the United States borders, but the sample above was collected to relate in general that depredation does occur in Baja California and at about the same rate as in California.

Gear loss was minimal in California with only $200 observed lost in the at-sea samples and none reported in the interviews. The $200 lost in our 4.4% sample yielded a rough estimate of $4,545 of gear lost per year in the white seabass fishery in California due to pinniped depredation.

Marine Mammal Mortality. No marine mammals were observed or reported drowned in these nets in California waters although one fisherman at San Diego stated that around eight California sea lions per year are drowned in his seabass nets. However, there was no certainty whether these drownings took place in California or Baja California waters.

In Baja California, three California sea lions were reported entangled in the 23 samples.

Rockfish Gill Net Fishery

Rockfish are sought by gill netters from central California into Baja California with the principal effort off the southern California islands and offshore banks (Figure 26). There is a mainland shore fishery off San Diego and at several areas in central California near Monterey and Santa Cruz. Interviews made at the onset of the survey indicated no loss of fish from nets due to pinnipeds in the central California area, and our sampling effort was directed to cover southern California ports only.

Rockfish gill nets are set nets, often in water up to 100 fm. The mesh size is usually around 4.5 in and is of nylon twine. The nets are set overnight and retrieved in the morning. The buoys and flags are found by using Loran C in the offshore areas where landmarks are not present. The fishery is undertaken year-round, weather permitting.

We obtained eight at-sea trips totaling 15 days of fishing for a 0.7% sample. Sixty-eight interview trips totaling 187 fishing days were obtained for a 6.0% sample. In the at-sea sample, 11,760 rockfish were caught with a loss of 143 fish attributable to California sea lions. This amounts to a loss rate of 1.20%. Interview samples collated a catch of 344,617 fish with a reported loss of 5,718 fish for a 1.63% loss to California sea lions. The California sea lion was the only pinniped observed near these nets during the net lifting operations in both the at-sea and interview samples.

Total losses were estimated by collating the at-sea and interview data. Projecting our sample size to the total trips reported in the commercial catch receipts, a total of 8,550 rockfish valued at $2,600 was removed by California sea lions.

Marine mammal mortality did not occur in the at-sea samples, but one California sea lion and one elephant seal were reported drowned in the interview sample. These reports project about 15 animals of each species killed in these nets, although the estimate for elephant seals is probably too high. In the 76 trips recorded in the at-sea and interview samples, pinnipeds were sighted on 50 (66% of the trips), but no elephant seals except for the one entanglement. Therefore, the estimate of mammals entangled will include 15 California sea lions and consider that only one elephant seal and no harbor seals were taken.

Gear Loss

An average of $20 of gear per trip was reported lost to pinnipeds in the at-sea sample and $12.27 per trip in the interview sample. Using the collated value, $13.61 per trip for the 1,136 trips, an estimate of $15,460 of gear was damaged by marine mammals. This is a high figure in that some of the damage could have been caused by sharks and snagging on the bottom and some tears could have been from previous trips. These are data derived from the fishermen and are presented as possible damage.

White Croaker Gill Net Fishery

New markets for this underutilized species has led to rapidly increased catches over the past three years. There is a continuous fishery in Monterey Bay, primarily by the Indochinese refugee fishermen. In southern California, mostly around Santa Barbara, fishing has increased for this species as markets become more available. Most of the fish caught near Santa Barbara is trucked to San Pedro.

The nets used are monofilament gill nets of 2.25 to 2.50 in stretched mesh and are set in depths ranging from 2 to 20 fms. These fish frequent sandy and mud bottoms and are often densely schooled, resulting in frequent heavy catches of over a ton in one net. The nets range from 0.5 to 1.5 miles in length.

From July 1980 through June 1981, 32 at-sea trips were made in Monterey Bay using DFG research and patrol vessels. No interaction with marine mammals was observed,and no damage of fish that could be attributed to mammals was noted.

The southern California fishery was subject to marine mammal depredation. Three at-sea and nine interview samples were obtained, yielding a 1.8% sample (Figure 27). The depredation rate was 12.9% in the at-sea sample and 3.6% in the interview sample. The high loss in the at-sea sample was due to the small sample with a high loss reported in only one sample. The combined at-sea interview loss was 7.1%. The estimated loss was 7,430 pounds valued at around $2,978 for 1980.

No marine mammals were observed at the nets, and it is not known if California sea lions or harbor seals were the pinniped responsible for the depredation. Gear damage averaged $1.25 per trip, yielding a value of around $1,000 for 1980.

California Barracuda Gill Net Fishery

This is a specialized drift gill net fishery conducted only during the summer months. The 3.5 to 3.75 in mesh nets are attended during the night by the net boat to which one end of the net is attached. One-hundred and four landings were recorded in 1980, all of which were in the area between Oceanside and San Diego (Figure 28). Our sample consisted of two at-sea trips and five interview samples for a 6.5% sample. The incidental catch of Pacific mackerel exceeded the catch of barracuda in the sample with Pacific bonito a minor incidental species. Of the 1,265 pounds of barracuda in the sample, 28 pounds were removed by pinnipeds for a 2.2% loss. The loss of Pacific mackerel was 0.07%. The estimated total barracuda loss was 416 pounds valued at $330. The Pacific mackerel estimated loss was 45 pounds valued at $20. There was no gear loss or mammal mortality. It is assumed that California sea lions were the species removing fish in that only this species was observed near the nets. Seven California sea lions were observed and reported near the nets on three of the trips sampled.

Pacific Bonito Gill Net Fishery

The Pacific bonito gill net fishery is conducted at night with drift nets. The fishery is primarily during the winter months when more preferred species are not available. The nets are small and usually of 3.75 in stretched mesh. In our sample of 2.6% of the total effort, all the trips were in block numbers 718, 739, and 822; areas close to shore off Newport and Oceanside (Figure 29). The depredation rate for the combined at-sea and interview samples was 6.5%. Projecting this value to the 229 landings recorded in 1980, a loss of 6,336 pounds of Pacific mackerel was estimated, valued at $1,270. Pacific mackerel was the only incidental species in the sample.

Gear loss averaged $1.67 per trip, yielding an estimate of $382 gear damage due to pinnipeds in a year. California sea lions were observed or reported in all samples, totaling 19 animals in six trips near the nets. Fishermen report that Pacific bonito heads commonly remain in the net when a fish has been eaten by a sea lion, resulting in fairly accurate depredation values.

Flyingfish Gill Net Fishery

The gill nets are set on the bottom in about 10 fm of water at night with the boat attending at all times. The nets are pulled every 2 to 3 hours. Up to nine sets per night have been observed.

Our sample of four at-sea trips were at Santa Catalina and San Clemente Islands. Flyingfish were reported and observed lost during all samples, resulting in a 6.4% loss due to pinnipeds. All the landings for this fishery were evidently not available in our catch receipt search because only 22,500 pounds were tallied in our sample. The catch in 1976, the latest total catch figures available for this fishery, was 98,000 pounds. If the 1980 catch is around 80,000 pounds as indicated by fishermen interviews, 500 pounds were eaten by California sea lions. The value would be around $200 to the fishermen. No marine mammal mortality was observed or reported.

Inshore Aggregate Gill Net Fishery

There are several dozen small boats and skiffs equipped with small nylon and monofilament gill nets ranging from 2.5 to 4.5 in stretched mesh that fish for surfperch, opaleye, halfmoon, jacksmelt, small sharks, and other miscellaneous species in shallow water. These nets are usually set near kelp beds or in harbors such as Tomales Bay. These boats are known to operate in Tomales Bay, Monterey Bay, and out of most of the southern California ports. In southern California, there were 121 trips recorded in 1980 allotted to this fishery. Our sample was insufficient to permit analysis on interaction with only two at-sea trips arranged. Opaleye and leopard shark were the only species encountered in these trips; but on one trip, 39 pounds of barracuda were determined taken by California sea lions. No gear loss or mammal entanglement were observed. No estimates are made of the losses due to the small sample and unknown take of the boats at the various ports.

Discussion of Gill Net Fisheries

The gill net fisheries of the State present the most serious possible impact upon marine mammals. The shark drift gill net fishery of southern California entangles from about 700 to 1,200 California sea lions and probably as many as 30 pilot whales and an occasional large baleen whale, including gray and finback whales. For all gill net fisheries, including the Klamath River salmon fishery, at least 1,000 California sea lions, 100 harbor seals, and possibly as many as 25 elephant seals and 30 pilot whales are drowned each year in gill and trammel nets statewide.

Our sample for the total ocean gill and trammel net fisheries was around 3.5% of the total effort. By fishery, the highest fish depredation rates were a little over 10% for the California halibut and white seabass fisheries followed with between 6 and 7 percent depredation in the white croaker, Pacific bonito and flyingfish gill net fisheries. The large rockfish fishery experienced only a 1.6% depredation (Table 45).

The highest loss of fish by value was in the California halibut fishery with nearly $47,000 lost per year followed by the white seabass loss in California of $7,480. The white seabass loss to sea lions in

Baja California was almost $40,000. The total approximate value of the fish removed by pinnipeds in the California gill net fisheries was about $64,000. An additional $57,000 worth of fishing gear was reported lost to marine mammal interaction. Most of the gear loss occurred in the California halibut fishery, followed by the losses of drift gill nets entangled by whales.

The above figures are tentative values until the commercial catch is collated and published by the statistical unit at Long Beach, which is not expected for at least 2 years.

SQUID FISHERY

The fishery for market squid in California takes place in Monterey Bay and in several locations in southern California. The fishery is continuing to expand due to increased fresh market, restaurant, and bait demands. The stocks are considered to be underutilized (Gulland 1971; Kato and Hardwick 1975).

Historically, the largest annual California catch of 19,000 tons was made in Monterey Bay in 1946. From 1870 to 1960, 99% of the market squid landed in California waters was from Monterey Bay. In 1965, southern California catch exceeded that of Monterey and again in 1970, 1973-77 and in 1980.

At Santa Catalina Island, the spawning season occurs from November through March with a peak usually in December or January (Figure 30). In the Santa Barbara area the peaks of spawning may be during December or in spring from March through May (Figure 30). The Monterey Bay spawning may occur during all months with spring and fall peaks (Figure 31), however, commercial quantities of squid are usually not present during the December through March period.

Squid are taken by two methods, round haul catches by lampara and purse seine nets and by dip net at lights suspended over the side of the fishing vessel. Lampara nets are used in the shallow waters off Monterey and Pacific Grove, whereas all methods are used in southern California. The take by dip nets at lights amounted to 56.7% of the total southern California catch for 1980. Purse seine nets landed 99% of the round haul take in southern California. Purse seine boats occasionally try to locate squid near Santa Catalina Island during the summer months, May-September, during other fishery operations. About nine percent of the purse seine catch in southern California was during this summer period.

Monterey Bay Fishery

Squid concentrate at night and in the morning hours near the surface during spawning. The egg masses are attached to sandy bottom in from 2 to 20 fms of water, usually in about 8 fms. Squid concentrations are located with use of sonic recording devices or during the dark period of the moon at night by the bioluminescence caused by the squid moving through the water. Lampara net sets can be made in a short period of time, ranging from 10 to 30 min per set,depending upon weather conditions and amount of squid caught. Timing of eight complete sets revealed that the average time to lay out the net and start hauling the wings was 7.5 min. The opened bag was brought to the boat in about 13 min and brailing was initiated in about 20 min. If no squid are caught, another set can be started within 5 or 10 min.

Our survey was made from the DFG research boat OPHIODON. The observer arrived in the fishing area just before daylight and remained until all boats had returned to unload their catch. Fishing sometimes continued until 1100. One day was sampled in 1979 and 14 days in 1980. A total of 95 lampara boats making 98 sets was observed for marine mammal interaction (Table 46). No California sea lions or other marine mammals were observed entering the net during the sets. On five occasions, California sea lions were sighted in the water near the nets. These animals were traveling from offshore to the hauling grounds at the Monterey Breakwater which is within sight of the squid fishing area (Figure 32).

California sea lions have been only occasionally observed foraging in the squid spawning area during daytime,but no observations were made at night when some foraging takes place. The California sea lions apparently were not in need of entering the squid nets to obtain food as the sea lions did in the herring lampara and purse seine nets in San Francisco Bay. Squid die after they spawn and supply a ready meal for any mammal, fish,or bird that may be present. Sea otters commonly forage on these dying squid off Monterey and Pacific Grove. Sea otters will bring several squid to the surface at one time and proceed to unhurriedly eat them. Possibly California sea lions may also take advantage of these weakened forage items and can consume their daily energy requirements in a few minutes during the night and,therefore,do not need to harass the commercial fishermen. However, on several occasions while observing gill net boats near the breakwater, large pods of sea lions were observed entering the hauling grounds at the Monterey Breakwater from well offshore of the squid spawning area, indicating that some other prey species may have been preferred over the close by squid food supply. Counts of California sea lions at the breakwater are presented in the commercial salmon trolling section relating the high spring peak of numbers.

It is tempting to assume that the California sea lion spring peak of abundance at the breakwater is in response to the presence of spawning squid. However, the fall concentration of sea lions is about 1/20 in numbers of the spring peak,and there is about the same (more in some years) of spawning squid in the immediate area. This lack of direct relationship, plus the fact that some of the sea lions present during the spring concentration travel outside the squid spawning areas to forage does not substantiate that the mammal concentrations are directly in response to the squid.

Pilot whales were not observed or reported near the squid spawning areas during the 2 years of study.

Southern California Fishery

The majority of squid in southern California are taken at Santa Catalina Island by dip net light boats. The seaward side of the island provides the majority of the catch and is the area where the California sea lion haulouts (Figure 33) are located and where the greatest concentrations of pilot whales are found. In this case there appears to be a direct relationship between concentrations of these mammals, squid and fishing activity during the squid spawning peak from November through March. Even though there are concentrations of up to 200 California sea lions hauling out on Santa Catalina Island, fishermen prefer to take squid there rather than at other offshore islands where squid is known to spawn such as San Nicolas Island where over 7,000 California sea lions are present during the winter months. There is also a fuel savings by fishing at the island nearest to port.

Because of the frequent shooting at animals and throwing of seal bombs, fishermen were reluctant to take observers aboard the vessels while fishing. Our observers did obtain two trips,but these were not sufficient to adequately describe marine mammal interaction. Six overnight observations were made by project personnel on the R/V KELP BASS. The combined observations in addition to interviews of fishermen after the season gave us a valid picture of the interaction.

Fishermen tend to regard pilot whales and sea lions as competitors for biomass of squid and will shoot at them at times even if they are not "scaring" squid from the light. A real problem does exist of both pilot whales and California sea lions frightening squid away from the light and possibly causing squid to escape from the round haul nets before the bag can be closed.

Sea lions have been observed swimming rapidly through schools of squid under the lights. When squid are dispersed in this manner, perhaps after waiting several hours for the school to surface within the reach of the brails, fishermen become quite irritated at the presence of any marine mammal. The operation of the light fishermen is to locate schools of squid on depth recorders in deeper water and attract them to the surface. This surfacing process may take several hours, and occasionally the school may not "float" to the surface.

Some fishermen claim that sea lions learn to avoid squid fishing vessels as the spawning season progresses and the animals become wary of firearm and seal bomb sounds. Observation from the R/V KELP BASS indicates that these scare tactics are used throughout the season. One fisherman reported using an average of $600 worth of ammunition each season. Rifles and shotguns are used more than seal bombs. One vessel in February 1981 used seal bombs set off in plastic containers to deter flocks of California gulls from feeding on surface squid. Occasionally, dead sea lions have been observed floating in the vicinity of the fishing areas or washed up on the beaches, but the number is quite small compared to the number of shots fired. Most squid fishermen claim they fire to scare the animals rather than kill them, as was commonly reported by salmon trollers off northern California.

Our research vessel observations (Table 47) revealed that California sea lions were observed at the lights during 20% of the 15 min duration observation periods from November through February with the highest incidence observed during November. Pilot whales were more erratic in their presence, varying from not present in January to being present near the lights during 35% of the 15 min observation periods on December 10, 1980. Heavy gunfire was noted during December with 156 shots recorded during 15.2 hours of observations.

Pilot Whale Observations

Observations at sea from fishing vessels and aerial censuses indicate that pilot whales occur regularly nearshore at Santa Catalina Island throughout the squid spawning season. The greater concentrations occur on the seaward side (Figure 33), near the squid spawning areas. The peak numbers of pilot whales occurred in December, January, and February. The numbers during this period were over three times the number observed in October and four times the number counted in March, indicating a concentration related to squid spawning behavior. Risso's dolphins remained more offshore of the pilot whales and peaked in numbers during December.

Many dip net fishermen interviewed felt that the presence of pilot whales around lighted fishing vessels at night was to the fisherman's advantage. Pilot whales often remained outside the perimeter of the vessel lights and possibly this behavior tended to "herd" the squid concentrations closer to the vessel enhancing brailing activity. As pointed out before, however, some fishermen were upset by the presence of any marine mammal in the vicinity of their vessels when fishing.

Questions such as "How much does a pilot whale or sea lion eat in a day?" indicate they are more concerned about potential competition for biomass than direct interaction.

Reports of pilot whales being shot have occurred, but rarely. If more vessels enter this expanding fishery, the feeling of competition will probably become more acute. On one occasion, a fisherman blamed a 10-ton loss of squid on pilot whales when the animals repeatedly bumped into the vessel causing the squid to disperse.

Pilot whales appear to be having the greatest losses when interacting with round haul nets. Both purse seine and lampara boats have been observed making sets in the vicinity of dip net vessels. During a R/V KELP BASS cruise in December, a purse seine boat was observed slowly maneuvering around a lighted dip net vessel at 0100. The purse seiner, probably metering the area for squid, continued moving in the vicinity of the light vessel until 0130 at which time the seiner set the net, wrapping the dip net vessel with squid underneath. As the anchor of the dip net vessel was pulled and the net pursed, lights on the dip net boat were shut off and the dip net vessel drifted over the cork line of the purse seine. By 0330 the seiner had finished brailing.

When a dip net vessel allows a purse seiner to take the squid attracted at his light, there is usually an agreement before the vessels leave port of the amount of profit the dip net will receive in this operation. A report is that a third of the take will be given. There have been other reports the net boats will harass light boats by creating heavy boat wake which will preclude use of the lights causing the dip net boats to leave the area. As the effort for squid increases and competition between fishing methods becomes greater, these fishery interactions may become more intense.

Pilot whales are occasionally wrapped in the purse seine nets and cannot escape. One purse seine skipper complained that pilot whales are much more numerous now than they were 3 years ago, and tend to remain in the area year round compared to previous years. Another purse seine fisherman claimed that pilot whales are extremely "dumb" and won't go over the corkline when it is pushed down to facilitate escape. Tangling of whales in the nets is time consuming and costly, and no attempt is made to capture them. Some fishermen claim to wait for 15 min or so when about to make a set to make sure no whales will be wrapped, however, other fishermen claim this is not always the case, especially when daybreak is coming and the boat has not caught squid that night.

Nine pilot whales were observed dead on the seaward side of Santa Catalina Island on two flight days in the DFG census. Investigation of three of these animals by NMFS personnel revealed net marks on the body and stomach contents were of squid. Two of the whales observed from the plane had the flukes severed indicating capture in purse seine nets. Twelve pilot whales were observed and reported possibly killed in this manner in the 1980 season. There were no comments made by the purse seine fishermen interviewed as to the number of California sea lions taken in the nets, but reports indicate that this does happen.

Discussion

An increase in the effort by purse seine vessels is expected in this fishery and interaction with marine mammals will increase. The

12 pilot whales considered entangled in 1980 is a conservative figure. By projecting the known dead pilot whales in our flights and those reported to the total time of the fishing period, the take could have been about three times that amount. The maximum observed on any one day in our aerial observations was six. A series of strip-transects (½ NM) were made from Skymaster 337 at 164 m height in 1980-81 (Table 48; Figure 33) which resulted in a tentative estimate of a maximum of 316 pilot whales that frequented the Santa Catalina Island area during the squid spawning season. A manuscript is being prepared of the techniques and analysis of the pilot whale census by NMFS and DFG. There could have been from 4 to 12 percent of the pilot whales present killed in the squid fishery at Santa Catalina Island.

There is no simple solution to this mortality or to the problem of possible frightening of squid from the lights or out of the nets. Shooting and bombs have not solved the problem. In early 1982, the acoustic harassment device was turned on over and near pilot whales with essentially no response.

ROUND HAUL NET FISHERIES

Description of Fishery

Round haul nets are used in California waters to take anchovies for live bait and reduction, and for jack mackerel, Pacific mackerel, bluefin tuna, Pacific herring, and market squid for marketing and canning.

The lampara net was introduced from Europe in the late 1800's and is probably the forerunner of the purse seine. Each net type has its particular advantage under different fishing conditions. When the markets were more limited and there were dense schools of fish close to port, the lampara net was simpler and quicker to operate with a smaller crew. The purse seine became more efficient for many pelagic species when greater tonnage per set of fish farther from shore in deeper water were sought.

The southern California lampara fleet consists of 22 vessels. There are about 20 lampara boats operating in central California for live bait at Morro Bay and for herring, squid, anchovies and mackerel in the Monterey Bay and San Francisco Bay areas. The boats range in length from 40 to 60 ft with a crew of from 4 to 6, and except for a portion of the squid and herring fishery of central California, the operation is almost entirely at night.

The length of lampara nets range from 100 to 300 fms including the wings. The wings make up the bulk of the net and form a "wall" of webbing between the boat and the smaller meshed bag as the wings are being retrieved by hydraulic gurdies. The bag is of 11/16 in mesh for anchovies and 1-3/8 in mesh for mackerel. Entrapped fish can escape by swimming under the wings before the bag mesh reaches the vessel. It is during the wing pulling operation that sea lions can frighten encircled fish out of the net.

About 90% of the lampara net effort in southern California is for live bait using small "bait nets" constructed on the lampara pattern. Daytime sets are possible under some conditions but most of the round haul sets are made between midnight and dawn. Daytime operations in deeper water for mackerel and anchovies are made in conjunction with aerial spotters who find the schools from the air and direct the netting operation around the school by radio while circling above. The nets used in this operation are usually purse seines.

Purse seines are made of the same size mesh throughout, using the same size mesh as in the lampara net bag, 11/16 in for anchovies and 1-3/8 in for mackerel. The nets range from 210 to 350 fms in length and can reach to 50 fms in depth in the larger nets. Purse seines have been used in California since about 1884. In 1920, at the beginning of the intensive fishery for sardines, 125 purse seine vessels were registered in California (Scofield 1951). Presently, about 30 purse seine vessels are operating out of San Pedro and there are another 4 or 5 out of Monterey. These vessels range from 45 to 90 ft. in length and can hold from 30 to 100 tons of fish. This study did not survey the large tuna purse seine fleet operating out of southern California ports.

The setting of the purse seine is more complex than the lampara, requiring close coordination of the 9 to 12 crew members. A skiff (also used by most lampara boats) is used to retain one end of the net as the net vessel makes the circular net layout. The net is set when the vessel returns to the skiff. The skiff can then be used to aid in keeping the net from collapsing or to keep the vessel from drifting into the net if the set was made "uphill", i.e., against the current. Pursing the net is done by retrieving the cable which is passed through heavy metal rings attached along the bottom of the net. When this mass of pursed rings reaches the vessel, the net is closed on the bottom and the fish cannot now escape unless there is a hole in the webbing.

There are several methods employed to try to keep encircled fish in the lampara and purse seine nets before the bag is secure. These include banging on metal structures on the boat such as a fair-lead or davit. Noise near the boat tends to keep the fish in the bag area of the net away from the vessel. Dye "rocks" are used in daytime. These are rock-like objects containing dyes which are dissolved into the water when thrown overside, creating a curtain of intense water color under the vessel. This curtain is considered important in keeping fish schools in the net. A "drop line" or electric light source is sometimes suspended over the vessel into the water at night in hopes to keep the fish away from the vessel.

Fish often escape out of the nets without presence of sea lions foraging on the entrapped fish. However, when California sea lions enter these nets at the beginning of the set, there is a much greater chance of the fish being frightened and escaping near the vessel as the net is being retrieved. Sea lions are accustomed to being harassed by use of firearms or seal bombs and remain in the net as far from the vessel as they can thereby negating attempts by the fishermen to keep the fish away from the vessel.

When the last portion of the bag approaches the vessel, the foraging sea lions usually swim out of the net over the corks. Occasionally a sea lion will remain in the net and will be brailed in the darkness without the fishermen aware of it until the fish and sea lions are dumped into the hold. The animals are usually drowned by this time, however, live sea lions have ended up in the hold creating a serious and dangerous problem of removing it. When the animals are still in the net along side the vessel, attempts are made to release them by holding the cork line down and allowing the animal to swim away. Dead animals are difficult to handle,and it is dangerous to shoot animals close to the boat and fishermen in the skiff. The practice of releasing animals in this manner was noted several times in the herring lampara fishery in San Francisco Bay (Figure 16).

A lampara fisherman reported that off San Diego in May 1981 a 20 ft gray whale was found inside the net at 0600 with the anchovy catch. The whale plunged through the webbing without apparent harm to the animal. This type of escape occurrence was reported by other skippers. No whale entanglements were observed in our round haul net sampling. Pilot whales have been observed floating dead with the tail flukes removed. It has been reported to us that pilot whales dive and will not swim over the corks lowered for them when they are trapped in round haul nets. Occasionally, the tail of the whale will become entangled in the webbing and as the net is being retrieved by a power block, the animal appears tail first, suspended in the air. At this point, the flukes are cut off, allowing the whale to slip out of the webbing and is later dumped out at the end of the set.

Interaction

Our at-sea sample was on six lampara and three purse seine boats for anchovies, two lampara and two purse seine boats for Pacific mackerel, and one purse seine boat for jack mackerel. No mammal mortality was observed on these 14 at-sea trips.

Our interview sample was six lampara boats and two purse seine boats for anchovies, nine lampara boats and three purse seine boats for Pacific mackerel, and 12 lampara boats and three purse seine boats for jack mackerel. One California sea lion mortality was reported in these 35 interviews. The at-sea samples are too few to arrive at an estimate of mortality, especially when no mortality was observed.

Fish loss cannot be estimated for these fisheries. The amount of fish eaten by sea lions when foraging in the nets is unknown. Considering that sea lions were observed inside the nets in only 17% of the sets monitored and the number of animals usually ranged from one to 5, the extremely small amount that may have been eaten compared to the tonnage landed cannot be considered as a significant loss to the fishery. The 1980 catch of anchovies taken was 5,424 tons for live bait and 48,169 tons for reduction. The 1980 catch of jack mackerel was 22,195 tons, and for Pacific mackerel, 32,334 tons (tentative mackerel data).

Fishermen do not complain about the amount eaten by sea lions in the nets but are concerned about the amount of fish chased out of the nets during the set. Some estimates by fishermen claim about 30% of the fish caught are chased out of the nets. Our at-sea and interview samples indicate a much smaller interaction: none for anchovies, 0.9%

for Pacific mackerel, and 0.1% for jack mackerel. Even if a school was actually frightened out of a net by a sea lion, this could not positively be considered a loss to the fisherman or the fishery because the school or individual fish in it may be caught at a later date.

In fisheries in which there is a quota, if the quota is not met, no loss to the fishery can be considered. An individual fishing boat could suffer a loss.

California sea lions were the only marine mammals observed interacting with the lampara and purse seine fisheries. In the anchovy fishery, California sea lions were observed near the net operation on 26.7% of the samples with none entering the net during the set. California sea lions were present during 56% of the jack mackerel round haul samples, with 31.1% of the trips in which sea lions entered the net during the set. For Pacific mackerel round haul sets, sea lions were present in the area during 68.8% of the trips, with sea lions entering the net on 37.5% of the samples.

HOOK-AND-LINE COMMERCIAL FISHING FOR BOTTOMFISH

Rod-and-reel fishing and long line gear are lumped into this category as they are not separated on the fish landing receipts. Long line gear consists of heavy nylon line wound on "baskets" with hooks attached at about 1 m intervals on this line. The hooks are baited with either squid or herring pieces, and the entire line which may be up to several hundred feet long is laid on the bottom, usually in rocky substrate. The gear is usually set out overnight and retrieved in the morning.

Our sample consisted of seven interviews in central California and 22 interviews in southern California (Table 49). Most of the effort was for rockfishes, with some surfperch and flatfish also recorded. In our 29 total samples, 3,565 pounds of rockfish were reported with a definite loss of 13 rockfish and a probable loss of 3 rockfish.

The southern California effort was tallied off the landing receipts for 1980. These data are minimal and represent a majority of the catch, but until the final computer reports are available, the exact effort and catch will not be known. For the sake of our tentative analysis, 2,068 landings were tallied in which rockfish were the major catch. The only loss to California sea lions was of rockfish, amounting to 0.36% definite loss and 0.08% probable loss of the sample. Projecting this percentage of loss for 29 landings for southern California to the total sample of rockfish trips (Table 49), about 1,141 pounds of rockfish were taken off the hooks by California sea lions in southern California. No loss was recorded or related by the fishermen for central California.

COMMERCIAL TRAWL FISHERY

Trawl or drag nets are used in four basic types of fisheries: rockfish and deep water flatfish on the bottom, California halibut on the bottom in southern California, hake and widow rockfish are taken middepth, and shrimp on the bottom. The mid-depth trawls are used in northern California and are a new form of trawl operation.

The trawl net is an elongated conical net with a cod end of mesh no larger than 4.5 in stretched except for the shrimp mesh. The net is held open as it is being towed under the water by two heavy doors which cause friction in the water keeping the net mouth open. Cables are attached to the doors for letting the net out and retrieving it after the several hour tow. The shrimp trawl is attached to a metal frame to which the net is attached and is drug on the muddy bottom.

Fishermen report that occasionally California sea lions will attempt to take fish out of the cod end when it is on the surface ready to be lifted aboard. The losses are not of concern to the fishermen. Sea lions will almost always be following draggers to pick up smaller fishes passing through the webbing and to forage on soft-bodied fish descarded such as small Pacific hake. The fishermen also report that occasionally sea lions will be found in the net, apparently entering the trawl while fishing and be unable to swim out of the net. Most have been drowned, but some were still alive and returned to the water.

Our sample consisted of six at-sea samples and 7 interview samples of commercial trawlers and one report from DFG research cruise using a small mid-water trawl net for sampling anchovies. One California sea lion was observed drowned in a California halibut trawl net off

Santa Barbara and one was drowned in the DFG experiment (Table 50). One California halibut boat skipper reported that a total of eight "sea lions" were caught in his net in one week in October 1980. One of these animals had been caught and thrown back the day before. We do not know the total effort of this fishery at this time and cannot make an estimate of the total number of animals caught. This is one fishery in which mortalities were not expected and did not occur until at the project in spring 1981 when it was too late to give the fishery more attention. Up to 12 fishing boats are involved in the halibut trawl fishery, and the total mortality cannot be of large numbers, possibly no more than 20 animals per year.

PIER FISHING

Recreational fishermen on piers complain about seals and sea lions frightening the fish away from the area resulting in poor catches. In 1979 we monitored 23 different piers from Crescent City to Oceanside (Table 51) totaling 66 days of effort. In 1980, MRR personnel sampled three piers in northern California totaling 42 days of effort. No evidence of marine mammals interacting with the fishermen were noted. California sea lions were observed near the piers on 4 days, and harbor seals were sighted on 2 days. Of the 1,862 anglers interviewed in this sample, none reported being harassed by marine mammals.

RECREATIONAL FISHING FOR BOTTOMFISH FROM SKIFFS

Most of this sample was collected when sampling salmon skiff fishermen by both project and MRR personnel. Ten ports were sampled in this fishery with 237 skiffs, totaling 607 fishermen interviewed.

Contact with southern California fishermen indicated no harassment by marine mammals occurred, and this area was not routinely sampled. No interaction was reported in the central and northern California sample. The ports sampled were Crescent City, Trinidad, Eureka, Fort Bragg, Bodega Bay, Berkeley, Princeton, Santa Cruz, Moss Landing, and Monterey.

SUMMARY

Methodology

Marine mammal depredation ranged from 0 to 13% of the effort for all fisheries and is usually clustered in certain geographic areas, primarily near hauling grounds. Clustering may occur also because of prey species aggregations and marine mammal migratory movements. Because of the dynamic nature of the small number of interactions, a program of stratified sampling effort by port requires a relatively high degree of sampling, especially since the samples most likely cannot be picked at random. Our data indicate that a 5% sample of the total effort or catch may be sufficient to monitor interactions. Random at-sea sampling of boats was not possible due to lack of cooperation in several fisheries.

The at-sea trips that were available did reveal important parameters of interaction but were inadequate to compute confidence limits around the estimates except for the salmon troll fishery. Interview data proved to be important and reliable for all fisheries except for the drift gill net fishery of southern California. Interview data are readily available at all ports,and a greater cross section of the fisheries can be obtained which encompasses all the fishing areas. At-sea data are necessary to record life history data and behavioral activity of the marine mammals involved, to estimate mortality of marine mammals, and to obtain an objective evaluation of gear loss and damage to fish and gear caused by sharks or other species.

Recording the data by <u>definite</u> and <u>probable</u> categories was important. The definite category enables the observer or the fisherman to relate positive losses and yields a minimal loss. When <u>probable</u> interaction parameters are recorded, a maximum estimate of interaction is available. The subjective interpretation of events remembered over several days becomes clearer to the fisherman when losses are divided into these two categories.

Catch-per-unit of effort data proved valuable and should be collected by catch block area or at least recorded in such a way as to record interaction in relation to hauling grounds and areas of human disturbance.

Commercial Salmon Troll Fishery

This fishery sustained the highest depredation rate with a mean number of 12,459 salmon estimated taken off the hooks by California sea lions in 1980. The value of the fish was $274,000 with 95% limits at $183,000 and $413,000. An additional $12,225 worth of fishing gear was removed by sea lions. Only one probable loss by a Steller sea lion was reported in an interview. There was no interaction observed or reported involving harbor seals, northern fur seals, or elephant seals in the troll fishery.

Our sample consisted of 154 at-sea trips yielding a direct sample of 0.08% of the total catch. Including the interview samples, 8.17% of the total catch was sampled. The interview sample was more valuable for fish loss estimates because a more representative sample of both trip and day boats could be obtained and all fishing areas could be monitored. At-sea samples confirmed the loss values derived from interview data and gave necessary information on species, sex and relative size of the mammals involved. Behavioral data were collected which may lead to application of remedial measures.

The geographical area of highest incidence of depredation occurred within 20 miles either side of Mistake Point, the area between Shelter Cove and Usal. In 1980, 43.7% of all fish lost to sea lions from Monterey to Oregon occurred in the Shelter Cove to Usal area.

The number of sea lions shot could not be estimated from our at-sea samples. Few fishermen would discuss this matter but those that did indicated that possibly as many as 300 California sea lions may be shot each year. Our shore survey to compute the total number of beached mammals on Monterey beaches revealed 19 sea lions appearing in our census zones, only 3 appeared during the commercial season.

A series of California sea lion counts at the Monterey Coast Guard breakwater indicates that only a few of the total sea lions in the area were involved in depredation and that considerable decrease of sea lions may not reduce depredation. Present methods of frightening sea lions with firearms and seal "bombs," and stopping fishing and moving to lose a following sea lion save some fish, but these methods do not prevent major losses.

Salmon Partyboat Fishery

Interview data were highly reliable because of the nature of the fishery. Estimates of depredation between at-sea and interview data were close. The combined interview and at-sea data yielded a 14% sample of the total 1980 catch with a depredation loss of 0.32%. The value of the fish removed by sea lions, if the fishermen had to buy the fish at a market, would have been $6,000. An additional $360 worth of fishing gear was lost due to sea lion activity.

In 1980, 75% of the losses were in the San Francisco port area, however, some of the highest depredation rates were recorded in Monterey Bay. The 1979 July to November data also showed a small loss to sea lions, with all of the loss occurring off San Francisco.

Salmon Recreational Skiff Fishery

From July through November 1979, the combined project and Anadromous Fisheries Branch personnel sample was 3.16% of the catch yielding a depredation rate of 0.02%. In 1980, a 29.04% sample was obtained, yielding a depredation rate of 0.18% of the total recreational skiff salmon catch. The value of fish lost to sea lions in 1980 was about $2,300 with no gear loss reported. California sea lions were the only marine mammals involved in the interaction. Fifty-six percent of the total estimated statewide skiff salmon loss occurred in Monterey Bay.

Recreational Salmon and Steelhead Fishing in Rivers

Steelhead and salmon anglers rarely lose fish to pinnipeds when fishing from river banks or from skiffs. Over 5,100 interviews were conducted by DFG samplers in the Klamath River. Five fish were taken by harbor seals in a catch of 1,398 fish for a 0.10% depredation rate. Two steelhead were reported taken in the Eel River by a skiff fisherman in a sample of 72 interviews taken in six northern California rivers other than the Klamath. Total estimates of loss cannot be made because the total effort of river anglers is unknown.

Partyboat Fishery for Bottomfish (Non-salmon)

The fishery in California consists of several types of fishing including rockfish and lingcod in the rocky areas, halibut and other sandy bottom species including other flatfishes and white croaker, and surface and midwater foraging fishes such as Pacific bonito and Pacific mackerel. There is a large partyboat fishery out of San Diego utilizing Baja California waters in pursuit of yellowtail, tunas, Pacific bonito, California barracuda, dolphinfish, and groupers.

No interaction was observed or reported in the central and northern California partyboat fishery for rockfishes and lingcod. In southern California, all partyboat fisheries experienced some degree of interaction. The vessels fishing for Pacific bonito sustained the highest depredation.

The total of 79 at-sea trips was obtained, 69 of which were in southern California. Interviews totaled 128 statewide, 116 of which were in southern California.

A total of 15,141 fish was estimated as definitely removed from hooks by pinnipeds in southern California in 1980 using at-sea data. Pacific bonito was the leading species sought by pinnipeds comprising 78% of the loss. Interview data yielded an estimated loss of 18,272 fish, 31% of which were Pacific bonito. The value of fish lost in California using definite loss values was $26,300 and $28,100 computed with at-sea and interview data, respectively.

The most consistent losses to mammals in both the at-sea and interview data occurred in the area off Pt. Loma where, using combined definite and probable losses, a total of over 18,000 Pacific bonito valued at about $35,000 were depredated by California sea lions. Gear loss was estimated at $10,733 in the Pacific bonito catch which is a live bait fishery and attracts sea lions. Gear loss was not reported or observed in other partyboat fisheries.

Except for one harbor seal removing Pacific mackerel from hooks off Santa Barbara, all the depredation was by California sea lions. Partyboat operators occasionally moved to new locations when these animals harassed the fishing operation. The highest incidences of harassment and fish loss occurred off Pt. Loma and La Jolla and at Los Coronados Islands.

Vessel operators fishing in Baja California waters were interviewed, and those fishing south of Los Coronados Islands were treated separately. Yellowtail was the most depredated species with 2.72% of the yellowtail caught reported taken by California sea lions. Depredation on tuna was about 0.6% in Baja California waters.

Pacific Herring Fishery

There were varying degrees of interaction with harbor seals and California sea lions in each of the four herring fishing areas in San Francisco Bay, Tomales Bay, Humboldt Bay, and in Crescent City harbor. Nearly all the interaction was by California sea lions foraging on gill nets and entering round haul nets in San Francisco Bay. In Tomales Bay there was about an equal number of California sea lions and harbor seals foraging on the nets, in Humboldt Bay only harbor seals were observed at the nets, and at Crescent City, California sea lions were the major problem.

The Pacific herring catch is limited by quotas in each fishing area. If the quota is met for a season, any depredation contributed to pinnipeds cannot be considered as a loss to the fishery although an individual fisherman may catch less fish. The quota was not met in San Francisco Bay for most of the gill netters and the lampara boats in 1980-81. The quota was also not met in Tomales Bay.

Activity patterns of pinnipeds were recorded, and a foraging frequency index was computed for each fishery. This index was then projected into an estimate of maximum amount of herring the counted number of pinnipeds present could consume had they taken all their daily energy requirements from the nets. In the 1980-81 season when the quota was not met in San Francisco Bay, a maximum of about 44,000 pounds of herring worth $25,000 could have been consumed from the nets by pinnipeds in the 1978-80 and 1980-81 seasons, respectively. The assumption was used that all the pinnipeds present ate nothing but herring out of these nets, which is not a true assumption but at least this estimate reveals the absolute maximum depredation that could occur. The statewide herring fishery was worth about $8.5 million to the fishermen in 1980-81.

California sea lions were observed trapped in the lampara and purse seine nets at the end of the set, but all animals observed escaped or were aided in their escape by pushing the cork lines down for them to swim over. Possibly some mammal mortality takes place, but it would be negligible.

About 23,000 pounds of herring could have been foraged from the gill nets in Tomales Bay in the 1980-81 season in the "worst case" scenario of pinniped consumption. This amounts to about 3.09% of the catch and was worth about $15,000 to the fishermen. There was higher depredation when herring runs were light and the pinnipeds were concentrated at the fewer number of nets being fished.

The Humboldt Bay losses were much higher per net due to the large number of harbor seals present and to the fact that only four permittees were fishing. In this case, possibly as much as 30% of the netted fish may have been eaten by harbor seals, resulting in a loss value of $9,000. The quota was met in 1979-80 but fell short by 7 tons in 1980-81.

Crescent City fishermen problems are primarily with California sea lions which haul out nearby at St. George Reef. Considerable damage was reported to nets amounting to an estimate of around $1,950 for the 1979-80 season. About 16% of the fish could have been foraged from the nets, however, since the quota was met, the fishery was not affected.

Gear loss for the entire fishery, including all the small holes to be mended and loss of large sections of netting at Crescent City, may reach about $5,000 per season.

Gill Net Fisheries

The gill net fisheries in central California are subject to a small degree of depredation, especially in the California halibut fishery of Monterey Bay, but the losses are negligible compared to the fish losses and number of animals entangled in the various gill net fisheries of southern California.

Drift and Set Gill Netting for Shark

The most serious interaction occurs in the recently developed shark drift gill net fishery. Entangled thresher and bonito sharks are not depredated by pinnipeds, however, swordfish caught in these nets are at times eaten, resulting in a loss in 1980-81 of about $840 to the fishermen. The major concern of these drift and set gill nets for shark is not the loss of fish but the number of marine mammals entangled. A non-random estimated 678 to 1,227 California sea lions were drowned in these nets in 1980-81. Two pilot whales and one large whale (*Balaenoptera* sp) were observed drowned in our at-sea sample. Considerable assistance was given to our project by the DFG observers aboard some of these gill net vessels.

California Halibut Gill and Trammel Net Fisheries

The California halibut fisheries experienced about a 10% depredation rate based upon our 4.0% at-sea sample of the total effort. The value of these halibut would be around $46,640 to the fishermen. An estimated 220 California sea lions, 73 harbor seals, and 24 elephant seals were drowned in this fishery in one year in southern California. An additional 22 California sea lions, 22 harbor seals, and 15 harbor porpoises were estimated to be drowned in Monterey Bay.

White Seabass Gill Net Fishery

The majority of the white seabass catch and losses to marine mammals takes place in Baja California. California losses were estimated at $7,480 for the 1980-81 season based on a 4.0% depredation rate of gilled fish. California sea lions were the only species observed depredating these nets. Possibly as much as $39,000 worth of white seabass were removed from the nets in Baja California by California sea lions where a 10.2% depredation rate was reported by the netters during interviews. Gear losses were minimal in California amounting to about $200. Gear loss in Baja California may have been as much as $4,545 in 1980. Mammal entanglements were not observed in the at-sea samples, and only one gill netter reported taking California sea lions in a white seabass net.

Rockfish Gill Net Fishery

The combined at-sea and interview pinniped depredation amounted to about 1.4% of the total catch. These fish were valued at about $2,600. An estimate of 15 California sea lions and one elephant seal were drowned in these nets in 1980. Gear loss amounted to about $15,460, but this figure is probably much too high in that it is not easy to determine the cause of holes and tears in the net when setting on rocky areas.

White Croaker Fishery

There is an extensive white croaker fishery in Monterey Bay, but no losses were observed in 32 at-sea trips. In southern California, however, we recorded a 12.9% loss in the at-sea sample and 3.6% loss in the interview data. The combined depredation rate was 7.1%, yielding a loss valued at $2,978 for 1980. Gear damage may have been as much as $1,000, and there was no mammal mortality observed or reported in these small mesh nets. Both California sea lions and harbor seals were observed near these nets.

California Barracuda Gill Netting

This fishery is conducted only during summer months and the nets are attended at all times. The estimated barracuda loss was $330, and there was a minimal loss of Pacific mackerel taken incidentally in these nets. Only California sea lions were observed near these nets, and no gear loss was reported or observed.

Pacific Bonito Gill Netting

This wintertime fishery is limited to the area from Newport to San Diego. In our sample of 2.6% of the total effort, the depredation rate was 6.5%, yielding a loss value of around $1,270 for 1980. There was an estimated gear loss of $382. No marine mammal mortality was reported.

Flyingfish Fishery

This specialized fishery occurs in the summer and fall months and is conducted near kelp beds at the offshore islands. A depredation rate of 6.4% was observed, but the loss amounted to only about $200 for 1980.

Inshore Aggregate Gill Netting

Small gill nets are used in shallow water for various shallow water species. These boats operate at many ports from Tomales Bay to San Diego but do not represent a major fishery. No valid estimates are available of fish and gear loss due to the scattered nature of the fishery and small sample we could obtain.

Market Squid Fishery

The squid fishery in Monterey Bay is by lampara net only, and no interaction was observed during 98 observed sets. Fishermen report that California sea lions enter the nets from about 0300 to dawn but do little damage. No pilot whales have been observed at the squid spawning areas in Monterey Bay as is common in southern California.

The southern California squid fishery is by both lampara and purse seine nets and by dip netting of squid attracted to a light suspended over the side of the vessel. Fishermen claim that sea lions and pilot whales will frighten the squid from the light and prevent fishing. This was observed several times from our research vessel observations. Due to the common practice of shooting at both sea lions and pilot whales, it was difficult for project personnel to obtain at-sea trips.

Pilot whales are entangled in the round haul nets. Twelve were known to be entangled, and possibly as many as 30 were estimated killed in 1980. Our tentative estimates of the population of pilot whales frequenting the Santa Catalina Island area during the squid spawning season is around 300.

There is considerable harassment of marine mammals during this nighttime fishery with one fisherman claiming that he spent over $600 in ammunition last season. There was no way of substantiating the amount of squid which may have been frightened out of nets by foraging sea lions.

Round Haul Net Fishery for Anchovy and Mackerels

As in the squid round haul net problem, it is not possible to attain an estimate of the loss of fish that are assumed to be frightened out of the net by marine mammals. There is a quota in the anchovy fishery, and if the quota is met, there is no loss to the fishery even though an individual boat crew may take less fish because of the interaction. California sea lions are the species involved,and several are drowned each year when they cannot escape during the brailing operation. We were not able to obtain sufficient trips to compute an estimate of mortality. Additional sampling is being done in the 1981-82 contract to arrive at this estimate. Acoustic harassment experiments will be conducted in 1982 to determine if the sea lions can be kept out of the nets. Gray whales were reported taken in lampara nets,but these large animals broke through the mesh without apparent injury.

Hook-and-Line Commercial Fishery

Long line and rod-and-reel fishermen in southern California claim a small amount of depredation by California sea lions. There was a 0.36% definite loss and a 0.08% probably loss in our sample of 29 interviews. Projecting this loss to the total effort recorded on the logs, about 1,141 pounds of fish valued at $1,500 was depredated by California sea lions. All the fish removed from the hooks were deep water rockfishes. No losses were reported by central California long-line fishermen.

Commercial Trawl Fishery

The deep water trawling operation rarely encounters marine mammals in the nets, but occasionally a California sea lion will enter the net and end up in the bag with the mass of fish. Most of these animals are drowned. The numbers are small, probably not more than 10-20 per year.

There is a specialized trawl fishery for California halibut off Santa Barbara in which California sea lions are involved at a greater degree than in the deep water rockfish and flatfish operations. One halibut trawler reported that a total of eight "seals" were taken in his net in one week in 1980. At least 10 but possibly 20-30 California sea lions are drowned each year in this fishery.

Even though California sea lions will attempt to pull fish out of the bag when it reaches the surface, no real loss takes place. Most of the sea lion activity is foraging on small fish that pass through the 4.5 in webbing of the bag or on the soft-bodied fish discarded in the sorting process.

Pier Fishing

Of the 1,862 anglers interviewed at 23 piers from Crescent City to Oceanside in 1979 and 1980, no interaction was observed or reported.

Recreational Fishing for Bottomfish from Skiffs

Ten ports were covered for this fishery with 237 skiffs sampled totaling 607 angler days. No interaction was reported.

Pinniped - Fishery Interaction in the Klamath River System

Harbor seals remove salmon from gill nets and forage on weakened fish caught for tagging purposes by the DFG. About 13.2% of the netted salmon are damaged or eaten by harbor seals amounting to a monetary loss of over $2,400 for each Native American subsistence gill netter in the river if the fish were bought at the market. The total depredated value of salmon was $74,000 at retail market prices. Gear damage was difficult to assess because the cause of net tears is not easily determined, especially in a river with rocky bottom and numerous log snags. Also, as in other gill net fisheries, the holes are not patched continuously and the damage observed may have been made over a month period and cannot be assigned to the sampling day. If one net was destroyed each year for each fisherman by harbor seals as claimed by the fishermen, then about $24,600 worth of damage is done each year.

There was a 0.9% depredation of netted salmon by river otters in one area of the river. In that area, Hector's Hole, river otters damaged fish almost at the rate of that caused by harbor seals. King salmon depredation rates were 1.4% by harbor seals and 0.9% by river otter; silver salmon sustained a 3.4% depredation rate by harbor seals but none by river otters; steelhead sustained a 5.3% depredation rate by river otters only.

Only a small number of the harbor seals hauling out at the river mouth were involved in the upriver depredation. Of the 150 to 200 animals hauling out, no more than seven to 19 could be accounted for foraging at the nets during any one night. At least twenty-two of the 29 harbor seals found dead in the river were killed in the gill net operation in 1980. Seven California sea lions were found dead in the river. At least five of these were killed in a fishing operation.

No direct loss due to California sea lion activity was observed in the fishery. All three species of pinnipeds in the area, harbor seals, California sea lions and Steller sea lions enter the river during lamprey runs and indirectly, the catch of lampreys may be affected by this foraging activity. California sea lions are shot during this time, and the mortalities observed were most likely by fishermen from the shore attempting to keep the animals from their fishing areas.

There was a 0.9% depredation of redtail surfperch fishing at the mouths of rivers in northern California. No direct interaction was observed in the surf smelt fishery near mouths of rivers.

Marine Mammal Discussion

Reliable estimates of mammal mortality due to fishing operations were difficult to achieve. The primary problem was that most fishermen did not want to reveal this information in interviews or would either not shoot at animals when an observer was aboard or would not take our personnel to sea if it was felt that marine mammals may be killed in the operation. The principal areas of non-cooperation were in the round haul net fisheries for anchovy, mackerel, and squid and in the gill net fisheries. Even when we did have cooperation, the occurrences of mammal mortality were so infrequent that computation of confidence limits of the limited data were not justified.

We did gather enough field data to at least gain an understanding of the approximate degree of mammal mortality and harassment in most of the fisheries. Mandatory regulations on the drift shark fishery included the ability to place observers aboard these vessels and in this fishery, a realistic estimate of mortality was computed. Even in this case, the catch statistics are as yet tentative and a firm estimate is not available. A continuing survey of mortality in the round haul net fisheries is being made by the DFG under the present NMFS contract, and the DFG personnel present during netting operations in the drift net shark fish are supplying us with further information (observation program was terminated September 15, 1982).

California Sea Lion

The California sea lion was the major species involved in fish and gear loss and was the species most harassed and killed in the fishing operations. Of the total tentative estimate of mammal mortality of slightly over 1,700 marine mammals killed annually in California in the fisheries, the California sea lion comprised about 90% of the total with near 1,500 estimated taken in all fisheries (Table 52). In the California sea lion mortality, about 1,160 (60% of the total) were estimated taken in the drift and set net shark fisheries. Most of these animals were small in size, with up to 15 animals taken in one set.

The waves of male California sea lions migrating to and from the southern California rookery areas that have been reported in published censuses for many years were manifest in the computations of interaction in the salmon trolling fishery. The greatest losses to commercial salmon trollers were during the May southern movement when the animals were more spread out and were encountered in all fishing areas as the animals passed through. The highest spring concentration of California sea lions recorded since the 1950's at the Monterey Breakwater was tallied during April and May 1981, when over 2,000 animals were observed. In May 1980, 1,521 sea lions were present, 914 of which were yearlings, many of which remained about two weeks in the area after the adult males had departed. Ainley et al. (1977) noted this occurrence of young animals for the first time at the Farallon Islands in 1971 and has observed this phenomenon in subsequent years. The large numbers of yearlings at the breakwater in 1980 were noted by the fishermen as being the greatest number of these small animals they had ever encountered in Monterey Bay.

The northern movement of California sea lions is more spread out in both time and space and not as noticeable from periodic counts as is the more concentrated spring movement. Interaction with commercial salmon trollers during the late August through October period occurs primarily near the major California sea lion hauling grounds such as the Farallon Islands, Pt. Reyes, and Jackass Creek. The juxtaposition of the hauling areas near Mistake Point Creek and the usual final ocean concentration of maturing salmon between the Usal and Shelter Cove area results in significant losses of salmon from trolling lines. Over 43%

of all the salmon taken off hooks along the California coast occurred in this area during our study.

A general observation of the degree of interaction with fisheries and the number of marine mammals present indicates that only a few of the interacting individual animals present are involved. During the intensive salmon trolling taking place in Monterey Bay in May 1980, there was not a pattern of large numbers of California sea lions leaving the hauling grounds in the morning and traveling to the fishing grounds with the boats. In fact, nearly all the sea lions had returned from their nighttime foraging bouts and were returning to the breakwater as the fishing boats were departing. On any given day when complaints were being voiced over the marine radio about sea lion problems, no more than about a dozen interactions could be accounted for, and some of these could have been repeated occurrences by the same animals.

During the spring migration of California sea lions off the Klamath River, about 80 to 120 were noted hauling out at Klamath Cove, immediately north of the river mouth. Of these, seldom more than six were observed in the river at any one time in search of lampreys and eulachon. Areas in which a more substantial number of the sea lions present took part in the interaction was in the herring fisheries of San Francisco and Tomales Bays.

There were several areas along the coast and at the offshore islands where fishermen avoided the area due to excessive capture of marine mammals or disturbance to the fishing operation. One of these is at Año Nuevo Island where gill net fishermen report that "nets full" of sea lions are captured if they place their nets within several miles of the area. Gill netters do not utilize this area. Other areas are near the principal hauling grounds at San Nicolas and San Miguel islands off southern California. Squid fishermen favor the Santa Catalina Island area because of the fewer number of sea lions present compared to other offshore island areas where squid is known to spawn and could be caught. Fishermen cannot economically operate when marine mammals commonly entangle in their gear or are harassed to the point that the fish or squid are chased out of the fishing gear. They also do not what to kill these animals and for that reason alone, most fishermen avoid areas of high marine mammal interaction. It has been mentioned in the text about the "high liner" commercial salmon trollers who pick up their gear and move to another trolling area nearby to lose the following sea lion rather than attempt to kill it, a process which they consider ineffective and dangerous to other fishermen nearby.

California sea lion harassment of partyboat fishermen near San Diego and Los Coronados Islands is of primary interest because the interaction appears to be increasing as more young California sea lions are being conditioned to forage on the live bait chum. Partyboat operators increasingly move to new fishing locations to avoid the taking of fish off lines by adult sea lions and feeding upon live bait chum near the boats by the subadults. Some of the fishermen purposely feed these animals with chum for the enjoyment of it to the dismay of the skippers and other fishermen.

The California sea lion population in California numbers about 45,000 with another 45,000 reported breeding off Baja California. The probable mortality of this species due to fishing operations is around

1,800 annually or about 4% of the California population. It is likely that some of the mortality is of Baja California breeding animals since it has been established that some males from Baja California winter in southern California. A "worst case" scenario would be that all the mortality was of animals of the California breeding stocks and that our estimates of mortality were low by 20%. In this case, the annual mortality would be around 2,200 animals of 45,000 for a 5% fishery mortality which would be well within the assumed acceptable take in a mammal population which is near carrying capacity and at or near its optimum sustainable level.

Harbor Seal

About 100 harbor seals were estimated killed in the ocean gill net fisheries and another 29 harbor seals were observed dead in the Klamath River, most likely killed in the subsistence salmon gill net fishery. There are around 18,000-20,000* harbor seals in California waters and if the total take in all fisheries is 200, then a maximum of about 1% of the population is taken annually in the fisheries.

There are no areas avoided by fishermen due to harbor seal activity, and most fishermen are never concerned about their activities. There has never been a report or observation of harbor seals removing salmon from trolling lines in California. This species does forage on netted herring and occasionally on other filled fish in the ocean fisheries. Only rarely does a harbor seal enter round haul nets during a fishing operation, and they do not harass partyboat fishermen. There have been reliable reports of harbor seals stealing fish off of skindiver's fish strings, especially in Carmel Bay where an individual harbor seal has been doing this on occasion for several years. One

*Results of unpublished 1982 harbor seal censuses conducted in June, 1982.

harbor seal was found in a fish trap in Carmel Bay in 1979 (P. Kolb, DFG, pers. commun.).

The potential problems of harbor seals are more of disturbance of rookery and hauling sites. In 1979, about 20 newborn pups were killed by dogs near Cypress Pt., Monterey County, and there have been numerous reports of hauling site disturbance by joggers, hikers, bird watchers, abalone pickers,and all others who are interested in low tide organisms. Sarah Allen (pers. commun.) reports disturbance in the Pt. Reyes National Seashore at the large hauling site at Double Point. An educational program is being undertaken by Park personnel to protect this important rookery and hauling site. The hauling site at Strawberry Spit, San Francisco Bay is not utilized during the daytime due to human disturbance. The few animals now using the area do so only at nighttime at high tide.

The Klamath River study indicates that only a small portion of the harbor seals utilizing the river mouth area for hauling are involved in the gill net depredation upriver. Of the 100 to 300 harbor seals near the mouth, no more than 19 on a given night were estimated to be upriver involved in gill net depredation. The killing of 29 harbor seals did not terminate net depredation,but it may have limited some losses. Usually no more than eight harbor seals at a time have been observed daily capturing weakened released tagged salmon at the DFG salmon seining sight about 3 miles upriver.

Steller Sea Lion

Steller sea lions were reported to be involved in taking hooked salmon in the 1950's. This is quite surprising in that the population of Steller sea lions was less than now and, except for one possible interaction at Trinidad, no Steller sea lions were involved in interaction with any fishery in our study. This species does forage at and near the mouths of rivers for anadromous species such as salmonids, lampreys, and possibly eulachon, and the presence of these large and impressive animals may have lead to the belief that this was the same species involved in the salmon trolling interaction in the past. Interviews of fishermen who have been fishing for 20 to 30 years indicate that the fish loss then was by California sea lions and not by Steller sea lions.

No mortality was observed or reported for this species which has not returned to former numbers south of Año Nuevo Island. There are rookeries at Año Nuevo Island, the Farallon Islands, Sugarloaf Rock near Cape Mendocino, and at St. George Reef. Thus, this species was known to be present during the periods of salmon fishing, but little or no interaction with salmon trollers and other fisheries was observed or reported. The rookery areas are protected and no human disturbance has been reported.

Northern Fur Seal

No interaction was reported or observed in any of the fisheries with the northern fur seal. This species was observed by trawlers and some salmon trollers offshore, but no loss of fish was reported. The rookery at San Miguel Island is protected and is under scientific surveillance.

Northern Elephant Seal

An estimated 25 elephant seals, all subadults, were entangled in gill nets in southern California. This species does not take fish off salmon trolling gear or sport hook and line, although it was once reported years ago that an elephant seal was caught on a commercial long line hook and entangled in the gear in central California. Trawler fishermen reported that rarely an elephant seal may appear in the net. The number taken annually would be insignificant from a population ranging from 45,000 to 60,000 in the California and Baja California populations.

Pilot Whale

Pilot whales were involved in the squid fishery interaction at Santa Catalina Island and in the shark drift gill net fishery off southern California. A maximum of about 30 pilot whales were assumed killed annually in each of these fisheries. Little is known of the pilot whale population along California. Our aerial census conducted over a 4-day period in each of 4 consecutive months, yielded a maximum estimated population of 316 pilot whales within 5 nautical miles of Santa Catalina Island during the squid spawning peak from December 1980 through March 1981. No other pilot whale censuses were made off southern California during this time,and the total southern California population distribution and abundance is not known.

Pilot whales were observed each season at Santa Catalina, apparently attracted by the concentrated spawning squid. These animals occasionally are wrapped in purse seine nets and may be drowned or have their flukes severed when they become entangled in the webbing as they are being brought aboard by power blocks. Fishermen attempt to keep away from the whales and will often wait until they are out of range before setting the net. The fishery is at nighttime,and it is difficult to observe the whale's presence. Dip net fishermen using lights to attract the squid to the surface will at times shoot at the pilot whales as well as California sea lions.

The pilot whales tangled in drift gill nets are a new problem with the recent development of the drift net fishery for thresher sharks and swordfish. Actually only two pilot whales were observed tangled, but projection of this sample to the entire fishery yields about 30 animals taken in this manner. Since it is only one sample, the reliability of the estimate is uncertain. The National Marine Fisheries Service is initiating a nearshore cetacean census off southern California,and more may be determined of the impact of these fisheries on the population..

Harbor Porpoise

About 15 harbor porpoises were estimated taken in gill nets in Monterey Bay in 1980. A few were reported taken several years ago in round haul nets for anchovies,but none were reported in this fishery during our study. The Monterey Bay harbor porpoise population was considered to be around 300 to 400 animals by V. Morejohn (Moss Landing Marine Laboratory, pers. commun.) several years ago. An estimated 24 harbor porpoises washed up on Monterey Bay beaches between Monterey and Capitola in 1980,but the causes of death were not known. Hearsay reports from fishermen over the years indicate that not all harbor porpoises killed in fishing gear may be returned to the water in that the flesh is reputed to be excellent in flavor and is taken home by some fishermen.

A law is presently being prepared to curtail the Monterey Bay halibut gill net fishery to deeper waters because of marine bird and mammal mortalities. Should this legislation pass, it is expected that there will be fewer harbor porpoise and pinniped mortalities in Monterey Bay.

California Gray Whale

Three California gray whales were reported killed by gill nets in 1980. Two of them came ashore near San Francisco and the third in southern California. Possibly three to five gill nets are destroyed each year by migrating whales, usually during the northern movement in April. All entanglements have been of subadult animals.

Baleen Whales

One whale, provisionally identified as a finback whale, was observed tangled in a drift gill net.

General Remarks

No other pinniped or cetacean other than those listed above were involved in direct fishery interaction in California. There were several reports of sea otters chewing on halibut gilled in Monterey Bay and of river otters depredating salmonids gilled in the Klamath River.

Disturbance of rookery areas appears to be the most potentially harmful impaction by human activities on pinnipeds as the use of coastal shorelines and waters increases. Future studies should include a more definitive evaluation of human disturbance on harbor seal and sea lion rookery sites, including research activities at areas where several species of pinnipeds are in competition for optimum hauling areas. The areas are San Nicolas and San Miguel islands in southern California and Año Nuevo Island in central California. Should the disturbance of

California sea lions during research on elephant seals or other pinnipeds result in displacement of several thousand California sea lions to other hauling grounds, the impact on the populations could be significant as well as the impaction on nearby fisheries should such an event take place. A careful review of pinniped censuses and counts in both the published and gray literature may reveal better documentation of shifts of population numbers as has been indicated by Ainley et al. (1977). A complete delineation of California harbor seal rookery sites is being conducted by the DFG under the renewed NMFS contract for 1981-82.

Mitigating measures are presently not effective in materially decreasing fishery-marine mammal interaction. Shooting of animals has not solved the problem although the losses may be lessened to some degree. Seal bombs are reported to be more efficient but are dangerous and hard to acquire.

The only promising potential solution to some interaction problems is with the use of noise aversion or acoustic harassment. The device developed by Charles Greenlaw and Bruce Mate of Oregon State University has been tested in the Columbia River, Netarts Bay, and the Klamath River, and the first experiments are encouraging. It may be possible to keep pinnipeds at a distance from certain operations until the fish are safely aboard. It may also be possible to keep harbor seals from passing upstream in narrow rivers during peaks of salmon runs and gill netting such as in the Klamath River. Fisheries in which this device may be feasible are the Klamath River gill netting, the California sea lion frightening of fish away from lights in the squid fishery of southern California, keeping California sea lions at a distance from salmon trolling lines and partyboat hooks, keeping pinnipeds at a distance from intake structures of ocean farming and hatchery establishments, and keeping California sea lions from entering the purse seine and lampara nets in the Pacific herring, anchovy, and mackerel fisheries. The DFG in cooperation with Oregon State University is planning to investigate the feasibility of this device in the squid, anchovy and mackerel fisheries in early 1982.

COMMON AND SCIENTIFIC NAMES OF SPECIES IN TEXT

Common Names	Scientific Names
Invertebrates	
Squid, market	*Loligo opalescens*
Shrimp	*Crago* spp.
Vertebrates - Pisces	
Albacore	*Thunnus alalunga*
Anchovy, northern	*Engraulis mordax*
Barracuda, California	*Sphyraena argentea*
Bass, giant sea	*Stereolepis gigas*
kelp	*Paralabrax clathratus*
sand	*Paralabrax* spp.
Bocaccio	*Sebastes paucispinis*
Bonito, Pacific	*Sarda chiliensis*
Cabezon	*Scorpaenichthys marmoratus*
Chilipepper	*Sebastes goodei*
Cowcod	*Sebastes levis*
Croaker, white	*Genyonemus lineatus*
Dogfish, spiny	*Squalus acanthias*
Dolphinfish	*Coryphaena hippurus*
Eulachon	*Thaleichthys pacificus*
Flatfishes	Bothidae and Pleuronectidae
Flounder, starry	*Platichthys stellatus*
Flyingfishes	Exocoetidae
Grouper	*Mycteroperca* spp.
Hake, Pacific	*Merluccius productus*
Halfmoon	*Medialuna californiensis*
Halibut, California	*Paralichthys californicus*
Herring, Pacific	*Clupea harengus*
Jacksmelt	*Atherinopsis californiensis*
Lamprey, Pacific	*Lampetra tridentata*
Lingcod	*Ophiodon elongatus*
Mackerel, jack	*Trachurus symmetricus*
Monterey Spanish	*Scomberomorus concolor*
Pacific (chub)	*Scomber japonicus*
Marlin (billfishes)	Istiophoridae
Opaleye	*Girella nigricans*
Pompano, Pacific	*Peprilus simillimus*
Queenfish	*Seriphus politus*
Ray, bat	*Myliobatis californica*
Rockfishes	Scorpaenidae
Rockfish, blue	*Sebastes mystinus*
vermilion	*Sebastes miniatus*
widow	*Sebastes entomelas*
Salmon, king (chinook)	*Oncorhynchus tshawytscha*
silver (coho)	*Oncorhynchus kisutch*

Sardine, Pacific	*Sardinops sagax*
Sculpin (California scorpionfish)	*Scorpaena guttata*
Sculpin, staghorn	*Leptocottus armatus*
Sculpins	Cottidae
Seabass, white	*Atractoscion nobilis*
Shad, American	*Alosa sapidissima*
Shark, blue	*Prionace glauca*
bonito (shortfin mako)	*Isurus oxyrinchus*
horn	*Heterodontus francisci*
leopard	*Triakis semifasciata*
Pacific angel	*Squatina californica*
soupfin	*Galeorhinus zyopterus*
white	*Carcharodon carcharias*
Sheephead, California	*Semicossyphus pulcher*
Skates	Rajidae
Skipjack (skipjack tuna)	*Euthynnus pelamis*
Smelt, surf	*Hypomesus pretiosus*
Smoothhounds	*Mustelus* spp.
Steelhead (rainbow trout)	*Salmo gairdneri*
Sturgeon, green	*Acipenser medirostris*
white	*Acipenser transmontanus*
Surfperch, redtail	*Amphistichus rhodoterus*
Surfperches	Embiotocidae
Swordfish	*Xiphias gladius*
Thresher (thresher shark)	*Alopias vulpinus*
Tomcod, Pacific	*Microgadus proximus*
Trout, cutthroat	*Salmo clarki*
Tuna, bluefin	*Thunnus thynnus*
yellowfin	*Thunnus albacares*
Whitefish, ocean	*Caulolatilus princeps*
Yellowtail	*Seriola lalandei*

Vertebrates - Mammalia

Dolphin, Risso's	*Grampus griseus*
Otter, sea	*Enhydra lutris*
Porpoise, harbor	*Phocoena phocoena*
Seal, harbor	*Phoca vitulina*
northern elephant	*Mirounga angustirostris*
northern fur	*Callorhinus ursinus*
Sea lion, California	*Zalophus californianus*
Steller (northern)	*Eumetopias jubatus*
Whale	*Balaenoptera* spp.
gray	*Eschrichtius robustus*
pilot	*Globicephala macrorhyncha*

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TABLE 1. Summary of At-Sea Data in the 1979 Commercial Salmon Troll Fishery.

	Number Days at-sea	Number Legal caught	Number Legal Lost	Number Days Followed by Sea Lions	Number Days with Gear Loss	Value of Gear Loss to sea Lions	Number sharks caught	Fish Damaged by sharks	Value of Gear loss to Sharks
July									
Crescent City	2	105	0	0	0	0	0	0	0
Trinidad	2	35	0	0	0	0	0	0	0
Eureka	2	50	0	0	0	0	0	0	0
Fort Bragg	8	155	0	0	0	0	6	0	0
Bodega Bay	4	43	0	0	0	0	0	0	0
Santa Cruz	5	14	0	0	0	0	0	0	0
Moss Landing	3	11	0	0	0	0	0	0	0
Monterey	8	6	0	0	0	0	0	2	0
Total July	34	419	0	0	0	0	6	2	0
August									
Crescent City	3	15	0	0	0	0	0	0	0
Trinidad	2	11	0	0	0	0	0	1	0
Eureka	1	3	0	1	0	0	0	0	$10
Fort Bragg	8	95	2	3	0	0	0	0	0
Bodega Bay	6	16	6	2	1	$4	1	0	0
Oakland	2	4	0	0	0	0	0	0	0
Princeton	1	8	0	1	0	0	0	0	0
Santa Cruz	4	10	0	1	0	0	1	0	0
Moss Landing	5	5	0	3	0	0	0	0	$14
Monterey	4	4	1	4	0	0	0	0	0
Total August	36	171	9	15	1	$4	2	1	$24
September									
Crescent City	1	13	0	0	0	0	0	0	0
Fort Bragg	4	32	1	0	0	0	0	0	$ 3
Moss Landing	2	0	0	2	0	0	0	0	0
Monterey	2	0	0	1	0	0	0	0	0
Total September	9	45	1	3	0	0	0	0	$ 3
Total 1979	79	635	10	18	1	$4	8	3	$27

TABLE 2. Estimate of Legal Salmon Definitely Lost to California Sea Lions By Port Area in the Commercial Salmon Troll Fishery, 1979.

	Total Catch (incl. Shakers)	Percent Legal	Recorded Landings	Catch Sampled (legal)	Percent Sampled	Estimated Definite Loss: Percent of Legal Catch	Number	95% C.I. Lower	upper
Crescent City									
July	104,508	72.4	75,664	116	0.15	0.00	0	0	0
Aug.	106,158	19.0	20,170	33	0.16	0.00	0	0	0
Sept	6,022	32.5	1,957	13	0.66	0.00	0	0	0
Total	216,688	45.1	97,791	162	0.17	0.00	0	0	0
% of Total	25.35		21.17	2.83			0.00		
Eureka									
July	85,859	61.8	53,061	2,086	3.93	0.12	63	0	164
Aug.	87,281	46.2	40,324	326	0.81	0.14	57	0	304
Sept	not sampled		(12,140)	-	-	-	-	-	-
Total	173,140	60.9	105,525	2,412	2.29	0.11	120	0	468
% of Total	20.25		22.84	42.09			10.12		
Fort Bragg									
July	138,307	68.3	94,464	274	0.29	0.00	0	0	0
Aug.	71,620	74.2	53,142	233	0.44	0.31	169	0	623
Sept	28,589	74.4	21,271	647	3.04	3.12	686	350	1023
Total	238,516	70.8	168,877	1,154	0.68	0.50	855	350	1646
% of Total	27.90		36.56	20.14			72.09		
San Francisco									
July	159,451	31.9	50,865	1,618	3.18	0.10	50	0	189
Aug.	30,150	33.3	10,040	321	3.19	0.52	52	0	190
Sept	12,843	100.0	12,843	6	0.05	0.00	0	0	0
Total	202,444	36.4	73,748	1,945	2.63	0.14	102	0	379
% of Total	23.68		15.96	33.94			8.60		
Monterey									
July	17,936	66.7	11,994	34	0.28	0.00	0	0	0
Aug.	4,020	75.0	3,015	20	0.66	3.49	109	0	394
Sept	2,028	50.0	1,015	4	0.39	0.00	0	0	0
Total	23,984	66.8	16,024	58	0.36	0.68	109	0	394
% of Total	2.81		3.47	1.01			2.90		
Total California	854,772	52.6	461,965	5,731	1.23	0.26	1,186	350	2,887

TABLE 3. Estimate of Legal Salmon Definitely Lost to California Sea Lions By Month in the Commercial Salmon Troll Fishery, 1979.

	Total catch (incl. shakers)	Percent Legal	Recorded Landings	catch sampled (legal)	Percent Sampled	Estimated Number Lost
July	506,061	56.5	286,048	4,128	1.55	113
Percent of Total	59.20		61.92	72.03		9.53
August	299,229	42.3	126,691	933	0.74	387
Percent of Total	35.01		27.42	16.28		32.63
September	49,482	74.9	49,226	670	1.81	686
Percent of Total	5.79		10.66	11.69		57.84
Total July-Sept.	854,772		461,965	5,731		1,186

TABLE 4. Estimated Number of Definite Plus Probable Lost Legal Salmon Depredated by California Sea Lions in the 1979 Commercial Troll Fishery by Port.

	Number Lost	95% C.I. of Legal Lower	95% C.I. of Legal Upper	Percent of Legal Catch	Estimated Shakers Removed
Crescent City					
Jul	0	-	-	-	-
Aug	0	-	-	-	-
Sep	0	-	-	-	-
Total	0	-	-	-	-
Percent of Total	0.00	0.00	0.00	0.00	0.00
Eureka					
Jul	63	0	164	0.12	38
Aug	57	0	304	0.14	67
Sep	not covered	-	-	-	-
Total	120	0	468	0.11	105
Percent of Total	8.66				10.69
Fort Bragg					
Jul	0	0	0	0.00	0
Aug	336	0	975	0.63	117
Sep	709	367	1,051	3.23	244
Total	1,045	367	2,026	0.62	361
Percent of Total	75.40				36.76
San Francisco					
Jul	50	0	189	0.10	67
Aug	62	0	213	0.62	413
Sep	0	0	0	0.00	0
Total	112	0	402	0.15	480
Percent of Total	8.08				48.88
Monterey					
Jul	0	0	0	0.00	0
Aug	109	0	394	3.61	36
Sep	0	0	0	0.00	0
Total	109	0	394	0.68	36
Percent of Total	7.86				3.69
Total California	1,386	367	3,290	0.30	982

TABLE 5. Estimated Number of Definite Plus Probable Lost Legal Salmon Depredated by California Sea Lions in the 1979 Commercial Troll Fishery by Month.

	Number Lost	95% C.I. of Legal		Percent of Legal Catch	Estimated Shakers Removed
		Lower	Upper		
July					
Crescent City	0	0	0	0.00	-
Eureka	63	0	164	0.12	38
Fort Bragg	0	0	0	0.00	0
San Francisco	50	0	189	0.10	67
Monterey	0	0	0	0.00	0
Total July	113	0	353		105
Percent of Total	8.15				10.69
August					
Crescent City	0	0	0	0.00	0
Eureka	57	0	304	0.14	67
Fort Bragg	336	0	975	0.63	117
San Francisco	62	0	213	0.62	413
Monterey	109	0	394	3.61	36
Total August	564	0	1,886		633
Percent of Total	40.69				64.46
September					
Crescent City	0	0	0	0.00	0
Eureka	not sampled	-	-	-	-
Fort Bragg	709	367	1,051	3.23	244
San Francisco	0	0	0	0.00	0
Monterey	0	0	0	0.00	0
Total September	709	367	1,051	3.23	244
Percent of Total	51.16				24.85
Total July-Sept.	1,386	367	3,290		982

TABLE 6. Summary of At-sea Data in the 1980 Commercial Salmon troll Fishery

	Number Days at Sea	Number Legal Caught	Number Legal Lost	Number Days Followed by Sea Lions	Number Days with Gear Loss	Value of Gear Loss to Sea Lions	Number Sharks Caught	Fish Damaged by Sharks	Value of Gear Loss to Sharks
May									
Crescent City	4	22	7	2	1	$ 3	0	0	0
Trinidad	1	23	0	0	0	0	0	0	0
Eureka	5	89	7	4	2	$ 52	0	0	0
Fort Bragg	10	66	2	3	1	$ 3	0	0	$ 2
Bodega Bay	6	41	1	2	0	0	1	0	0
Sausalito	3	10	0	0	0	0	0	0	0
Moss Landing	6	19	0	4	0	0	0	1	0
Total May	35	270	17	15	4	$ 58	1	1	$ 2
July									
Crescent City	1	2	0	0	0	0	0	0	0
Trinidad	2	39	0	0	0	0	0	0	0
Fort Bragg	13	171	0	1	0	0	5	0	$ 4
Total July	16	212	0	1	0	0	5	0	$ 4
August									
Trinidad	2	13	1	1	1	$ 2	0	0	0
Fort Bragg	4	3	0	0	0	0	0	0	0
Total August	6	16	1	1	1	$ 2	0	0	0
September									
Trinidad	2	2	1	2	1	$ 5	0	0	0
Fort Bragg	5	37	4	3	1	$ 3	1	0	0
Moss Landing	11	3	1	9	0	0	2	0	0
Total September	18	42	6	14	2	$ 8	3	0	0
Total 1980	75	540	24	31	7	$ 68	9	1	$ 6

TABLE 7. Estimate of Legal Salmon Definitely Lost to California Sea Lions by Port Area in the Commercial Salmon Troll Fishery, 1980.

	Total Catch (incl. shakers)	Percent Legal	Recorded Landings	Catch sampled Legal	Percent sampled	Estimated Definite loss: Percent of Legal Catch	Estimated Definite loss: Number	95% C.I. of Legal: lower	95% C.I. of Legal: upper
Crescent City									
May	26,511	74.4	19,724	1,361	6.90	3.30	767	532	1,001
Jul	21,601	64.6	13,954	1,992	14.28	0.10	14	0	38
Aug	21,284	41.9	8,918	451	5.06	1.00	90	0	219
Sep	23,280	32.5	7,566	465	6.15	2.15	166	0	341
Total	92,676	54.1	50,162	4,269	8.51	2.03	1,037	532	1,599
% of total	7.07		7.76	8.09			15.11		
Eureka									
May	99,907	92.1	92,014	12,023	13.10	0.59	547	413	680
Jul	42,399	76.2	32,308	3,101	9.60	0.10	32	0	73
Aug	29,193	51.8	15,122	2,567	16.98	0.28	43	0	86
Sep	21,886	61.5	13,460	61	0.45	6.18	887	0	1,934
Total	193,385	79.1	152,904	17,752	11.61	0.98	1,509	413	2,773
% of total	14.76		23.66	33.62			21.99		
Fort Bragg									
May	24,530	77.5	19,011	7,804	41.05	2.34	457	383	531
Jul	149,603	63.8	95,447	11,343	11.88	0.10	97	25	168
Aug	32,248	50.0	16,124	2,343	14.53	1.45	237	125	350
Sep	28,881	45.5	13,141	2,124	16.16	1.90	254	139	369
Total	235,262	61.1	143,723	23,614	16.43	0.72	1,045	672	1,418
% of total	17.96		22.23	44.72			15.23		
San Francisco									
May	111,654	65.6	73,245	3,394	4.63	2.04	1,525	1,087	1,963
Jul	322,733	35.6	114,893	1,071	0.93	0.00	0	0	0
Aug	25,430	38.8	9,867	123	1.25	0.00	0	0	0
Sep	207,769	13.0	27,010	25	0.09	0.00	0	0	0
Total	667,586	33.7	225,015	4,613	2.05	0.67	1,525	1,087	1,963
% of total	50.97		34.81	8.74			22.22		
Monterey									
May	46,569	65.9	30,689	2,002	6.52	3.31	1,016	719	1,312
Jul	51,707	57.7	29,835	155	0.52	0.00	0	0	0
Aug	15,558	72.8	11,326	265	2.34	4.26	505	177	834
Sep	7,117	38.6	2,747	129	4.70	7.60	226	28	424
Total	120,951	61.7	74,597	2,551	3.42	2.29	1,747	924	2,570
% of total	9.23		11.54	4.83			25.45		
Total California	1,309,860	49.3	646,401	52,799	8.17	1.05	6,863	3,628	10,323

TABLE 8. Estimate of Legal Salmon Definitely Lost to California Sea Lions by Month in the Commercial Salmon Troll Fishery, 1980.

	Total catch (incl. shakers)	Percent Legal	Recorded Landings	catch sampled (legal)	Percent Sampled	Estimated Number Lost
May	309,171	75.9	234,683	26,584	11.33	4,312
Percent of Total	23.60		36.31	50.35		62.83
July	588,043	48.7	286,437	17,662	6.17	143
Percent of Total	44.89		44.31	33.45		2.08
August	123,713	49.60	61,357	5,749	9.37	875
Percent of Total	9.44		9.49	10.89		12.75
September	288,933	22.12	63,924	2,804	2.34	1,533
Percent of Total	22.06		9.89	5.31		22.34
Total California	1,309,860	49.3	646,401	52,799	8.17	6,863

TABLE 9. Estimated Number of Definite Plus Probable Lost Legal Salmon Depredated by California Sea Lions in the 1980 Commercial Troll Fishery by Port.

	Number	95% C.I. of Legal lower	95% C.I. of Legal upper	Percent of Legal Catch	Est. No. Shakers Removed
Crescent City					
May	905	652	1,158	4.59	312
Jul	90	28	152	0.64	49
Aug	218	22	414	2.44	303
Sep	216	18	414	2.85	448
Total	1,429	720	2,138	2.85	1,112
% of total	14.55	12.66			17.30
Eureka					
May	1,347	1,139	1,556	1.44	116
Jul	32	0	73	0.10	10
Aug	64	10	117	0.36	59
Sep	1,120	0	2,272	7.68	701
Total	2,563	1,149	4,018	1.65	886
% of total	26.10	20.21			13.79
Fort Bragg					
May	746	653	838	3.78	216
Jul	102	29	175	0.11	58
Aug	396	253	539	2.40	396
Sep	401	259	543	2.96	481
Total	1,645	1,194	2,095	1.13	1,151
% of total	16.75	21.00			17.91
San Francisco					
May	2,037	1,535	2,539	2.71	1,068
Jul	0	0	0	0	0
Aug	62	0	286	0.62	97
Sep	140	0	2,252	0.52	935
Total	2,239	1,535	5,077	1.00	2,100
% of total	22.80	27.00			32.67
Monterey					
May	1,176	858	1,493	3.69	608
Jul	0	0	0	0	0
Aug	534	197	870	4.50	199
Sep	233	33	433	7.32	371
Total	1,943	1,088	2,796	2.54	1,178
% of total	19.79	19.13			18.33
Total California	9,819	5,686	16,124	1.50	6,427

TABLE 10. Estimated Number of Legal Definite Plus Probable Lost Salmon Depredated by California Sea Lions in the 1980 Commercial Troll Fishery by Month.

	Number Lost	95% C.I. Of Legal lower	upper	Percent of Legal Catch	Estimated Shakers Removed
May					
Crescent City	905	652	1,158	4.59	312
Eureka	1,347	1,139	1,556	1.44	116
Fort Bragg	746	653	838	3.78	216
San Francisco	2,037	1,535	2,539	2.71	1,068
Monterey	1,176	858	1,493	3.69	608
Total May	6,211	4,837	7,584	2.57	2,320
Percent of total	63.26	85.07			36.10
July					
Crescent City	90	28	152	0.64	49
Eureka	32	0	73	0.10	10
Fort Bragg	102	29	175	0.11	58
San Francisco	0	0	0	0	0
Monterey	0	0	0	0	0
Total July	224	57	400	0.08	117
Percent of total	2.28	1.00			1.82
August					
Crescent City	218	22	414	2.44	303
Eureka	64	10	117	0.36	59
Fort Bragg	396	253	539	2.40	396
San Francisco	62	0	286	0.62	97
Monterey	534	197	870	4.50	199
Total August	1,274	482	2,226	3.50	1,054
Percent of total	17.98	8.48			16.40
September					
Crescent City	216	18	414	2.85	448
Eureka	1,120	0	2,272	7.68	701
Fort Bragg	401	259	543	2.96	481
San Francisco	140	0	2,252	0.52	935
Monterey	233	33	433	7.32	371
Total of September	2,110	310	5,914	3.20	2,936
Percent of total	21.49	5.45			45.68
Total California	9,819	5,686	16,124	1.50	6,427

TABLE 11. Computation of Gear Loss Due to California Sea Lion Depredation in the Commercial Salmon Troll Fishery in 1980.

	Gear Loss in Sample $	Total Salmon lost in Sample	Gear loss per fish $	Total Estimate fish lost	Estimated Total Gear loss
May					
Crescent City	178	88	2.023	1,217	2,462
Eureka	148	194	0.763	1,463	1,918
Fort Bragg	272	411	0.662	962	637
San Francisco	67	148	0.453	3,105	1,407
Monterey	126	121	1.041	1,784	1,857
Total May	$791	962	$0.822	8,531	$8,281
July					
Crescent City	0	20	0.000	139	0
Eureka	4	4	1.000	42	42
Fort Bragg	16	19	0.842	160	135
S.F.-Monterey	0	0	0.000	0	0
Total July	$20	43	$0.465	341	$177
August					
Crescent City	14	27	0.519	521	270
Eureka	22	21	1.048	123	129
Fort Bragg	101	118	0.856	792	678
S.F.-Monterey	0*	19*	(0.500)	892	446
Total August	$137	166	$0.825	2,328	$1,523
September					
Crescent City	2	42	0.048	664	32
Eureka	0*	9*	(0.500)	1,821	910
Fort Bragg	74	147	0.524	882	462
S.F.-Monterey	0*	32*	(0.500)	1,679	840
Total September	76	189	0.402	5,046	2,244
Total 1980	$1,024	1,360	$0.753	16,246	$12,225

* Insufficient sample. Minimum values of nearby ports used in computations.

TABLE 12. Gear Loss to Sharks in the 1980 Commercial Salmon Troll Fishery

	Gear loss in sample in $	Expansion Factor to total catch	Estimated total Loss in $
May			
Crescent City	0	14.49	0
Eureka	0	7.65	0
Fort Bragg	9	2.44	18
San Francisco	0	21.58	0
Monterey	2	15.33	31
Total May	$11		$49
July			
Crescent City	73	7.01	512
Eureka	0	10.42	(750)*
Fort Bragg	242	8.42	2037
San Francisco-Monterey	0	118.05	(1447)*
Total July	$315		$4746
August			
Crescent City	54	19.77	1067
Eureka	0	5.89	(1904)*
Fort Bragg	303	6.88	2085
San Francisco-Monterey	2	54.62	109
Total August	$359		$5165
September			
Crescent City	12	16.27	195
Eureka	0	220.66	(738)*
Fort Bragg	152	6.19	941
San Francisco-Monterey	4	193.22	772
Total September	$168		$2646
Total May-September			$12,606

* Insufficient sample. Minimum values of nearby ports used in computations.

TABLE 13. Salmon Loss to Sharks in the 1980 Commercial Salmon Troll Fishery.

	Recorded Landings	Legal catch Sampled	Expansion Factor	Number Fish Lost in Sample	Total Estimated Fish Loss (legal)
May					
Crescent City	19,724	1,361	14.49	0	0
Eureka	92,014	12,023	7.65	0	0
Fort Bragg	19,011	7,804	2.44	2	5
San Francisco	73,245	3,394	21.58	0	0
Monterey	30,689	2,002	15.33	2	31
Total May	234,683	26,584	8.83	4	36
July					
Crescent City	13,954	1,992	7.01	23	161
Eureka	32,308	3,101	10.42	0	(139)*
Fort Bragg	95,447	11,343	8.42	53	446
San Francisco-Monterey	144,728	1,226	118.05	0	(579)*
Total July	286,437	17,662	16.22	76	1,325
August					
Crescent City	8,918	451	19.77	12	237
Eureka	15,122	2,567	5.89	0	(519)*
Fort Bragg	16,124	2,343	6.88	53	365
San Francisco-Monterey	21,193	388	54.62	0	(85)*
Total August	61,357	5,749	10.67	65	1,206
September					
Crescent City	7,566	465	16.27	3	49
Eureka	13,460	61	220.66	0	(63)*
Fort Bragg	13,141	2,124	6.19	8	50
San Francisco-Monterey	29,757	154	193.22	2	386
Total September	63,924	2,804	22.80	13	548
Total July-September	646,401	52,799		158	3,115

* Insufficient sample. Minimum values of nearby ports used in computations.

TABLE 14. Counts of California Sea Lions at the Monterey Coast-Guard Breakwater, May 19, 1980 to May 1, 1981.

Date	Adult Males	Subadults	Yearlings	Total	Time Count Started
1980					
19 May	87	520	914	1,521	0600
11 Jun	92	524	514	1,130	0830
14 Jun	37	103	320	460	0820
18 Jun	13	20	391	424	0740
24 Jun	4	6	347	357	0810
25 Jun		(not determined)		423	0630
8 Jul	1	0	113	114	0800
16 Jul	2	0	0	2	0800
7 Aug	16	5	4	25	0615
11 Aug	24	6	4	34	0600
15 Aug	31	10	15	56	1030
20 Aug	42	74	7	123	0945
12 Sep	32	——(131)——		163	1045
19 Sep	17	8	5	30	1145
30 Sep	115	163	19	297	1015
8 Oct	150	123 (+ 108 not determined)	11	392	0810
13 Oct		(not determined)		423	1000
31 Oct		(not determined)		501	0900
24 Nov		(not determined)		554	1040
10 Dec	109	——(416)——		525	0800
1981					
8 Jan	13	5	25	43	0900
23 Mar	295	——(1,322)——		1,617	1100
15 Apr		(not determined)		2,000 +	1100
1 May		(not determined)		2,000 +	1100

TABLE 15. Comparison of Block Number Values of Percent Loss of Total Catch by Sea Lions and Catch-per-Hour of At-Sea and Interview Data for the 1980 Commercial Salmon Troll Fishery.

	Legal Catch	Shakers	Total catch (incl. shakers)	Fish Loss (incl. shakers)	percent loss of total Catch	Catch per 1,000 Hook Hours: Legal Catch	Catch per 1,000 Hook Hours: (incl. shakers)
May							
100 Block Series							
Interview	1,929	520	2,449	101	3.96	26	33
At-Sea	22	53	75	7	8.54	16	54
200 Block Series							
Interview	18,357	2,968	21,325	550	2.51	30	35
At-Sea	155	53	208	9	4.15	25	34
400 Block Series							
Interview	4,661	2,444	7,105	202	2.76	27	41
At-Sea	51	46	97	1	1.02	35	67
500 Block Series							
Interview	1,395	593	1,988	58	2.83	22	31
At-Sea	19	2	21	0	0.00	20	22
Total May							
Interview	26,342	6,525	32,867	911	2.70	28	36
At-Sea	247	154	401	17	4.07	25	40
July							
100 Block Series							
Interview	1,078	818	1,896	4	0.21	53	93
At-Sea	41	14	55	0	0.00	52	70
200 Block Series							
Interview	10,434	6,184	16,618	14	0.08	32	50
At-Sea	153	184	337	0	0.00	20	45
400 Block Series							
Interview	5,721	3,301	9,022	8	0.09	40	63
At-Sea	18	14	32	0	0.00	44	77
Total July							
Interview	17,233	10,303	27,536	26	0.09	35	56
At-Sea	212	212	424	0	0.00	24	49
August							
200 Block Series							
Interview	3,497	4,948	8,439	129	1.51	26	62
At-Sea	3	1	4	0	0.00	8	7

TABLE 16. Computation of Total Legal Salmon Loss to California Sea Lions in the Partyboat Catch, July-October, 1979.

	Total Catch (incl. shakers)	Percent Legal	Recorded Landings	Number Sampled (Legal and Shakers) Project At-sea	Project Inter-view	Anadromous Inter-view	Total	Sample Total Loss	Percent Total Loss	Total Estim-Loss	Legal Estim-Loss
July											
Crescent City	355	100.0	355	2	-	-	2	0	0.00	0	0
Eureka	175	87.5	153	32	-	-	32	0	0.00	0	0
Fort Bragg	108	91.3	980	23	-	-	23	0	0.00	0	0
San Francisco	29,711	55.0	16,341	271	64	-	335	0	0.00	0	0
Monterey Bay	15	100.0	15	0	-	-	0	0	0.00	0	0
Total	30,364	61.0	17,844	328	64	-	392	0	0.00	0	0
August											
Crescent City	1,682	33.3	560	6	-	36	42	0	0.00	0	0
Eureka	116	100.0	116	2	-	18	20	0	0.00	0	0
Fort Bragg	706	100.0	706	21	-	53	74	0	0.00	0	0
San Francisco	16,906	56.5	9,552	138	173	906	1,217	12	0.99	166	94
Monterey Bay	14	100.0	14	-	-	-	-	0	0.00	0	0
Total	19,424	61.7	10,948	167	173	1,013	1,353	12	0.89	166	94
September											
Crescent City	1	100.0	1	-	-	-	-	-	0.00	0	0
Eureka	46	100.0	46	-	-	-	-	-	0.00	0	0
Fort Bragg	16	100.0	16	3	-	-	3	-	0.00	0	0
San Francisco	11,292	77.4	8,740	297	-	2,091	2,388	7	0.29	33	26
Monterey Bay	1	100.0	1	-	-	-	-	-	0.00	0	0
Total	11,356	77.6	8,804	300	-	2,091	2,391	7	0.29	33	26
October											
Eureka	21	100.0	21	-	-	-	-	-	0.00	0	0
San Francisco	4,672	75.0	3,504	-	-	926	926	20	2.16	101	76
Total	4,693	75.1	3,525	-	-	926	926	20	2.16	101	76
July-October Tot.	65,837	62.5	41,121	795	237	4,030	5,062	39	0.77	300	196
Percent of Catch				1.21	0.36	6.12	7.69				0.47

TABLE 17. Computation of the Total Legal Salmon Loss to California Sea Lions in the Partyboat Catch, February-June, 1980.

	Total Catch (incl. shakers)	Percent Legal	Recorded Landings	Number Sampled (Legal and Shakers) Project At-sea	Project Inter-view	Anadro-mous Interv.	Total	Sample Total Loss	Percent Total Loss	Total Esti. Loss	Legal Esti. Loss
February											
San Francisco	4,818	94.0	4,529	-	220	671	891	0	0.00	0	0
Monterey	36	46.7	17	-	14	-	14	3	17.65	6	3
Total	4,854	93.7	4,546	-	234	671	905	3		6	3
March											
San Francisco	10,467	73.2	7,662	135	370	1,501	2,006	6	0.30	31	23
Monterey	188	72.0	135	-	90	-	90	8	8.16	15	11
Total	10,655	73.2	7,797	135	460	1,501	2,096	14		46	34
April											
San Francisco	9,382	75.1	7,046	301	559	1,141	2,001	15	0.74	69	52
Monterey	541	89.3	483	-	25	-	25	2	7.41	40	36
Total	9,923	75.9	7,529	301	584	1,141	2,026	17		109	88
May											
Crescent City	3	-	3	-	-	-	-	-	-	0	0
Eureka	9	-	9	-	-	-	-	-	-	0	0
Fort Bragg	109	-	109	-	-	-	-	-	-	0	0
San Francisco	11,787	57.3	6,754	55	49	807	911	3	0.33	39	22
Monterey	62	-	62	-	-	-	-	-	-	0	0
Total	11,970	57.9	6,937	55	49	807	911	3		39	22
June											
Crescent City	108	-	108	-	-	-	-	-	-	0	0
Eureka	122	-	122	-	-	-	-	-	-	0	0
Fort Bragg	525	-	525	-	-	-	-	-	-	0	0
San Francisco	15,927	80.6	12,837	84	221	4,051	4,356	12	0.28	44	35
Monterey	179	-	179	-	-	-	-	-	-		
Total	16,861		13,771	84	221	4,051	4,356	12		44	35

TABLE 18. Computation of the Total Legal Salmon Loss to California Sea Lions in the Party Boat Catch, July-October, 1980, and Totals for 1980.

	Total Catch (incl. shakers)	Percent Legal	Recorded Landings	Number Sampled (Legal and Shakers) Project At-sea	Project Interview	Anadromous Interv.	Total	Sample Total Loss	Percent Total Loss	Total Estim- Loss	Legal Estim- Loss
July											
Crescent City	448	71.5	320	7	-	-	7	0	0.00	0	0
Eureka	172	92.9	160	14	-	-	14	0	0.00	0	0
Fort Bragg	493	100.0	493	4	-	-	4	0	0.00	0	0
San Francisco	22,430	47.7	10,699	83	8	842	933	1	0.11	25	12
Monterey	66	-	66	-	-	-	-	0	-	0	0
Total	23,609	49.7	11,738	108	8	842	958	1		25	12
August											
Crescent City	230	100.0	230	3	-	-	3	0	0.00	0	0
Eureka	108	-	108	-	-	-	-	0	-	0	0
Fort Bragg	127	100.0	127	4	-	-	4	0	0.00	0	0
San Francisco	15,958	40.0	6,383	85	-	1,492	1,577	2	0.13	21	8
Monterey	15	-	15	-	-	-	-				
Total	16,438	41.8	6,863	92	-	1,492	1,584	2		21	8
September											
Eureka	63	-	63	-	-	-	-	0	-	0	0
Fort Bragg	4	-	4	-	-	-	-	0	-	0	0
San Francisco	5,702	50.4	2,874	11	-	741	752	0	0.00	0	0
Total	5,769	50.4	2,941	11	-	741	752	0		0	0
October											
San Francisco	2,343	66.4	1,556	-	-	693	693	0	0.00	0	0
Total 1980*	102,422	62.2	63,678	786	1,556	11,939	14,281	52	0.36	290	202
Percent of Total				0.76	1.52	11.66	13.94				0.32

* Includes February - June monthly totals from Table 17.

TABLE 19. Interview and At-Sea Catch-per-Hook Hour Values of the Partyboat Salmon Catch at San Francisco and Monterey, February-April and May-July, 1980.

	Hook Hours	Total Catch	Catch Per Hook Hour	Fish Loss	Percent Loss
Feb-April San Francisco					
Interview	8517	1604	0.188	9	0.56
At-Sea	3998	436	0.109	3	0.69
Monterey Bay (Int)	1706	129	0.076	12	9.30
May-July San Francisco					
Interview	3509	534	0.152	1	0.19
At-Sea	865	222	0.257	3	1.35

TABLE 20. At-Sea Data of the Salmon Partyboat Catch, July-September, 1979.*

	Days at sea	Legal Catch	Shakers	Fish Loss	Number Days Followed by sea lion	Sharks Caught
July						
Crescent City	1	2	0	0	0	0
Eureka	4	28	4	0	0	0
Fort Bragg	4	21	2	0	0	0
Sausalito	3	62	77	0	0	1
Berkeley	1	20	12	0	0	0
Oakland	2	37	11	0	0	0
San Francisco	1	30	22	0	0	0
Total July	16	200	128	0	0	1
August						
Crescent City	1	2	4	0	0	0
Trinidad	2	2	0	0	0	0
Fort Bragg	3	21	0	0	0	0
Bodega Bay	1	15	0	0	0	0
Sausalito	1	18	27	0	0	0
Berkeley	2	15	13	0	1	0
San Francisco	2	30	20	0	0	0
Total August	12	103	64	0	1	0
September						
Fort Bragg	1	3	0	0	0	0
Bodega Bay	1	3	0	0	0	0
Sausalito	4	71	26	3	2	0
Oakland	3	66	10	0	0	0
Berkeley	2	50	18	0	0	0
San Francisco	2	40	13	0	0	0
Total September	13	233	67	3	2	0
Total July-Sept	41	536	259	3	3	1

*No gear loss reported caused by sharks or sea lions

TABLE 21. At-Sea Data of the Salmon Partyboat Catch, March-August, 1980.

	Days at Sea	Legal Catch	Shakers	Fish Loss	Number Days Followed by Sea Lions	Value of Gear Loss
March						
Sausalito	6	68	16	0	2	0
Berkeley	4	28	23	2	1	0
Total March	10	96	39	2	3	0
April						
Sausalito	7	71	16	0	0	0
San Francisco	3	56	25	0	2	0
Berkeley	5	87	42	1	1	$6
Emeryville	1	1	3	0	0	0
Total April	16	215	86	1	3	$6
May						
Sausalito	4	45	10	2	1	$8
June						
Sausalito	3	48	11	1	1	0
Berkeley	1	21	4	0	0	0
Total June	4	69	15	1	1	0
July						
Crescent City	2	5	2	0	0	0
Trinidad	1	13	1	0	0	0
Fort Bragg	2	4	0	0	0	0
Sausalito	3	25	18	0	0	0
Berkeley	1	22	21	0	0	0
Total July	9	69	42	0	0	0
August						
Crescent City	1	3	0	0	0	0
Fort Bragg	1	4	0	0	0	0
Sausalito	2	20	28	0	0	0
Berkeley	2	12	14	0	0	0
Total August	6	39	42	0	0	0
Total March-August	49	533	234	6	8	$14

TABLE 22. Estimated Loss of Salmon in the Recreational Skiff Fishery, July-October 1979 and Total 1980 Season. (Catch data from Anadromous Fisheries Branch).

	Estimated catch	Percent Shakers	Sample Project	Sample Anadromous	Total	Loss in Sample	Estimated Total Legal Loss
1979 July-October							
Crescent City	9,300		4	503	507	0	0
Eureka	12,115		90	172	262	0	0
Fort Bragg	6,779		0	268	268	0	0
San Francisco	21,508		89	623	712	1	11
Monterey	5,736		1	0	1	0	0
Total 1979	55,438		184	1,566	1,750	1	11
Percent of Total			0.33	2.83	3.16		0.02
1980							
Crescent City							
June	2,244	10.5	51	793	844	0	0
July	5,614	61.5	45	1,573	1,618	0	0
Aug	1,754	0	3	226	229	0	0
Sept	264	-	-	-	-	-	-
Season Total	9,876		99	2,592	2,691	0	0
Percent of Total C.C.	-		1.00	26.25	27.25	-	-
Eureka							
June	2,998	0.00	17	1,325	1,342	1	2
July	11,920	9.37	87	4,195	4,282	3	7
Aug	1,332	25.00	4	461	465	0	
Sept	82		0	11	11	0	0
Season Total	16,332	6.00	108	5,992	6,100	4	9
Percent of Eureka	-	-	0.66	36.69	37.35		0.06
Fort Bragg							
May	5	0.00	5	0	5	0	0
June	648	5.67	134	0	134	0	0
July	1,514	24.24	50	0	50	0	0
Aug	141	-	-	0	0	0	0
Sept	13	-	-	0	0	0	0
Total Fort Bragg	2,321		189	0	189	0	0
Percent of F. Bragg			8.14	0	8.14		0.00

TABLE 22. Cont.

	Estimated Catch	Percent Shakers	Sample Project	Sample Anadromous	Total	Loss in Sample	Estimated Total Legal Loss
1980 (cont) San Francisco							
Feb	778	8.89	41	134	175	0	
Mar	3,418	50.75	33	417	450	0	
Apr	606	44.70	0	91	91	2	7
May	682	22.22	14	69	83	3	18
Jun	1,639	0.00	0	317	317	0	
Jul	3,336	45.46	42	731	773	0	
Aug	591	-	0	136	136	0	
Sep	511	0.00	0	98	98	0	
Oct	306	-	0	73	73	0	
Total San Francisco	11,867		130	2,066	2,196	5	25
Percent of S. Francisco			1.10	17.41	18.51		0.21
Monterey							
Feb	460	31.68	69	0	69	3	13
Mar	503	27.82	179	159	338	9	19
Apr	569	17.56	108	191	299	6	9
May	52	32.79	41	0	41	0	0
Jun	936	3.70	130	466	596	2	3
Jul	532	21.43	22	75	97	0	0
Aug	28	0.00	0	10	10	0	0
Sep	8	-	0	3	3	0	0
Total Monterey	3,088		549	904	1,453	20	44
Total 1980 Season	43,484		1,075	11,554	12,629	29	78
Percent of Total			2.47	26.57	29.04		0.18

TABLE 23. Marine Mammal - Steelhead Fishery Interaction in Northeast Rivers, July 1979 - March 1980.

	Number Interviews	Hook Hours	Catch	Fish Loss
Shore				
Smith River	2	5.5	0	0
Eel River	26	62.7	4	0
Total Shore	28	68.2	4	0
Skiff				
Smith River	25	200.8	3	0
Eel River	6	14.3	0	2
Albion River	4	20.0	5	0
Navarro River	7	24.5	3	0
Garcia River	2	7.0	0	0
Total River	44	266.6	11	2

TABLE 24. Total Catch and At-sea Sampling Data for the Southern California Partyboat Fishery by Fishing Port Groupings, 1980.

Port Grouping	Recorded Catch: Species	Recorded Catch: Number	Number Sampled	Observed Loss to Marine Mammals: Definite Loss: Number	Definite Loss: % of Total	Definite Loss: Estimated Loss	Definite Plus Probable: Number	Definite Plus Probable: % of Total	Definite Plus Probable: Estimated Loss	Percent Loss of Total Catch, Definite Plus Probable	Percent Loss of Total Catch, Definite Only
Goleta to Port Hueneme	P. bonito	3,506	0	0	0.00	0	0	0.00	0		
	P. mackerel	98,203	160	1	0.62	610	2	1.23	1,220		
	Rockfishes	811,637	971	0	0.00	0	0	0.00	0		
	Total	913,346	1,131	1		610	2		1,220	0.13	0.07
Malibu to Oceanside	P. bonito	415,726	320	2	0.62	2,598	5	1.54	6,494		
	P. mackerel	885,276	0	0	0.00	0	0	0.00	0		
	Rockfishes	981,324	416	0	0.00	0	1	0.24	2,361		
	Total	2,282,326	736	2		2,598	6		8,855	0.39	0.11
Mission Beach to San Diego	P. bonito	143,331	622	40	6.04	9,214	51	7.58	11,719		
	P. Mackerel	302,209	642	3	0.47	1,412	5	0.77	2,222		
	Rockfishes	177,776	408	3	0.73	1,307	3	0.73	1,307		
	Total	623,316	1,672	46		11,933	59		15,248	2.39	1.88
Total Southern California	P. bonito	562,563	942	42	2.06	11,812	56	3.14	18,213		
	P. mack.	1,285,688	802	4	0.16	2,022	7	0.27	3,442		
	Rockfishes	1,970,737	1,795	3	0.07	1,307	4	0.19	3,668		
	Total	3,818,988	3,539	49		15,141	67		25,323	0.66	0.39
Total Catch All Species		4,867,597								0.52	0.31

TABLE 25. Total Catch and Interview Sampling Data for the Southern California Partyboat Fishery by Fishing Port Groupings, 1980

Port Grouping	Recorded Catch: Species	Recorded Catch: Number	Number Sampled	Observed Loss to Marine Mammals: Definite Loss: Number	Definite Loss: % of Total	Definite Loss: Estimated Loss	Definite Plus Probable: Number	Definite Plus Probable: % of Total	Definite Plus Probable: Estimated Loss	Percent Loss of Total Catch: Definite Plus Probable	Percent Loss of Total Catch: Definite Only
Goleta to Port Hueneme	P.Bonito	3,506	0	0	0.00	0	0	0.00	0		
	P.Mackerel	98,203	440	0	0.00	0	(149)	(25.30)	(33,260)*		
	Rockfishes	811,637	780	0	0.00	0	0	0.00	0		
	Kelp Bass	41,515	211	0	0.00	0	0	0.00	0		
	Barracuda	104	0	0	0.00	0	0	0.00	0		
	Total	954,965	1,431	0		0	(149)		(33,260)	0.00 (3.15)*	0.00
Malibu to Oceanside	P. Bonito	415,726	1,582	0	0.00	0	1	0.06	263		
	P. Mackerel	885,276	1,237	0	0.00	0	0	0.00	0		
	Rockfishes	981,324	916	0	0.00	0	0	0.00	0		
	Kelp Bass	214,743	1,344	6	0.44	959	6	0.44	959		
	Barracuda	13,937	37	0	0.00	0	0	0.00	0		
	Total	2,511,006	5,116	6		959	7		1,222	0.04	0.05
Mission Beach to San Diego	P. Bonito	143,331	593	24	3.89	5,800	29	4.66	7,009		
	P. Mackerel	302,209	2,813	92	3.17	10,252	192	6.39	20,627		
	Rockfishes	177,776	1,540	9	0.58	1,039	10	0.65	1,154		
	Kelp Bass	93,087	419	1	0.24	222	2	0.48	444		
	Barracuda	11,320	6	0	0.00	0	10	(62.50)	(18,867)**		
	Total	727,723	5,371	126		17,313	243		29,234	3.86	2.32
Total Southern California	P. Bonito	562,563	2,175	24	1.02	5,800	30	1.36	7,272		
	P. Mackerel	1,285,688	4,490	92	0.79	10,252	341	7.06	20,627		
	Rockfishes	1,970,737	3,236	9	0.05	1,039	10	0.31	1,154		
	Kelp Bass	349,345	1,974	7	0.34	1,181	8	0.40	1,403		
	Barracuda	25,361	43	0	0.00	0	10	(18.87)	(18,867)**		
	Total	4,193,694	11,918	132		18,272	399		30,455	0.72 (1.93)***	0.43
Total Catch, All Species		4,867,597								0.62	0.37

* The probable loss was most likely fish frightened away rather than taken off the hooks.
** One data point, insignificant data.
*** Percent total loss if questionable data included.

TABLE 26. Combined At-sea and Interview Sample and Loss of Pacific Bonito and Pacific Mackerel and Total Catch in the San Diego Area, November 1979 through November 1980.

	Pacific Bonito				Pacific Mackerel				Total
Month	Catch	Sample	Loss	Percent Loss	Catch	Sample	Loss	Percent Loss	Trips
Nov	5,349	115	4	3.36	11,781	290	4	1.36	283
Dec	153	0	0	0.00	8,026	333	50	13.05	193
Jan	275	120	0	0.00	5,318	146	0	0.00	141
Total	5,777	235	4	1.70	25,125	769	54	6.56	617
Feb	52	0	0	0.00	5,687	1,211	87	6.70	152
Mar	1,068	0	0	0.00	19,880	515	25	4.63	219
Apr	2,165	120	0	0.00	24,149	40	2	4.76	306
Total	3,285	120	0	0.00	49,716	1,766	114	6.06	677
May	15,540	0	0	0.00	37,185	0	0	0.00	548
Jun	13,815	24	0	0.00	29,999	215	30	12.24	676
Jul	16,645	152	4	2.56	20,819	32	0	0.00	927
Total	46,000	176	4	2.22	88,003	247	30	10.83	2,151
Aug	32,149	74	0	0.00	62,916	125	0	0.00	981
Sep	25,841	618	65	9.52	30,775	277	1	0.36	561
Oct	15,755	161	3	1.83	22,905	495	2	0.40	372
Nov	7,461	20	8	28.57	18,812	0	0	0.00	241
Total	81,206	873	76	7.25	135,408	897	3	0.33	2,155
Total	136,268	1,404	84	7.51	298,252	3,679	201	5.18	5,600

TABLE 27. Season Dates, Number of Permits, and Quota (Tons) for Pacific Herring Gill Net, Lampara, and Purse Seine Boats in the 1980-81 Season.

	San Francisco Bay	Tomales-Bodega	Humboldt Bay	Crescent City	Totals
Gill Net					
Season	30 Nov-Dec 19 Jan 4-March 31	Dec 14-Dec 19 Jan 4-March 31	Jan 4- March 31	Jan 4- March 31	-
Permits	323	70	4	3	400
Quota	4,250	1,200	50	30	5,530
Lampara					
Season	Jan 11-March 31	none	none	none	-
Permits	29	-	-	-	29
Quota	1,500	-	-	-	1,500
Purse Seine					
Season	Jan 11-March 31	none	none	none	-
Permits	24	-	-	-	24
Quota	1,500	-	-	-	1,500
Totals:					
Permits	376	70	4	3	453
Quota	7,250	1,200	50	30	8,530

TABLE 28. Computation of Pacific Herring Foraged From Gill Nets by Pinnipeds in San Francisco and Tomales Bays, 1979-80 and 1980-81 Seasons.

San Francisco Bay 1979-80	Daily Log Data: Number Sets	Daily Log Data: poundage in thousands	Total fish weighed (poundage in thousands)	Percent Return of Logs	Foraging Frequency Index	Foraging Days	Maximum Foraged: pounds	Maximum Foraged: % of log catch
Gill Net								
Heavy	2,203	5,341	-	-	0.30	661	19,830	0.37
Light	681	143	-	-	1.10	749	22,470	15.71
Total Gill Net	2,884	5,484	6,040	90.8	-	1,410	42,300	0.71
Lampara	523	3,205	3,933	81.4	0.88	460	13,800	0.43
Purse Seine	299	2,895	2,887	100.3	0.88	263	7,890	0.27
Totals 1979-80	3,706	11,584	12,860	90.1	-	2,133	63,990	0.55
1980-81								
Gill Net								
Heavy	2,057	4,786	-	-	0.30	617	18,510	0.39
Light	1,230	563	-	-	1.10	1,353	40,590	7.21
Total Gill Net	3,287	5,349	5,954	90.1	-	1,970	59,100	1.10
Lampara	591	1,834	2,620	70.0	0.88	521	15,630	0.85
Purse Seine	217	2,952	3,088	95.6	0.88	191	5,730	0.19
Totals 1980-81	4,095	10,135	11,662	86.9	-	2,682	80,460	0.79
Tomales Bay 1979-80								
Heavy	576	952	-	-	0.9	518	12,960	1.36
Light	520	209	-	-	1.3	676	16,900	8.09
Total	1,096	1,161	1,192	97.4	-	1,194	29,860	2.57
1980-81								
Heavy	324	586	-	-	0.9	292	7,300	1.25
Light	531	209	-	-	1.3	690	17,258	8.26
Total	855	795	904	87.9	-	982	24,558	3.09

* Heavy loads average 1,000 pounds or more per set; Light loads are under 1,000 pounds.

TABLE 29. Number of Net Units and Foraging Activity of California Sea Lions (Z) and Harbor Seals (P) in San Francisco and Tomales Bays, 1979-80.

	Net Units (NU)	Foraging At Net						Foraging Near Nets						Total Foraging						Percent of Nets Foraged
		Z	Z/NU	P	P/NU	Z+P	Z+P/NU	Z	Z/NU	P	P/NU	Z+P	Z+P/NU	Z	Z/NU	P	P/NU	Z+P	Z+P/NU	
San Francisco Bay																				
16 Jan	44	7	0.2	1	T	8	0.2	7	0.2	1	T	8	0.2	14	0.3	2	0.1	16	0.4	50
17 Jan	172	34	0.2	0	0.0	34	0.2	23	0.1	0	0.0	23	0.1	57	0.3	0	0.0	57	0.3	60
18 Jan	49	34	0.6	1	T	35	0.6	14	0.3	0	0.0	14	0.3	48	1.0	1	T	49	1.0	71
29 Jan	40	1	T	0	0.0	1	T	1	T	0	0.0	1	T	2	0.1	0	0.0	2	0.1	33
30 Jan	314	22	0.1	0	0.0	22	0.1	0	0.0	0	0.0	0	0.0	22	0.1	0	0.0	22	0.1	100
30 Jan	3	6	2.0	0	0.0	6	2.0	0	0.0	0	0.0	0	0.0	6	2.0	0	0.0	6	2.0	100
4 Feb	5	1	0.2	0	0.0	1	0.2	0	0.0	0	0.0	0	0.0	1	0.2	0	0.0	1	0.2	100
6 Feb	5	0	0.0	9	1.8	9	1.8	0	0.0	0	0.0	0	0.0	0	0.0	9	1.8	9	1.8	50
Total San Francisco	632	105	0.2	11	T	116	0.2	45	0.1	1	T	46	0.1	150	0.2	12	T	162	0.3	73
Tomales Bay																				
21 Jan	52	28	0.5	22	0.4	50	1.0	10	0.2	7	0.1	17	0.3	38	0.7	29	0.6	67	1.3	74
22 Jan	21	0	0.0	38	1.4	38	1.4	0	0.0	4	0.2	4	0.2	0	0.0	42	2.0	42	2.0	91
22 Jan	12	1	0.1	0	0.0	1	0.1	0	0.0	0	0.0	0	0.0	1	0.1	0	0.0	1	0.1	100
Total Tomales Bay	85	29	0.3	60	0.7	89	1.0	10	0.1	11	0.1	21	0.2	39	0.5	71	0.8	110	1.3	81

TABLE 30. Number of Net Units and Foraging Activity of California Sea Lions (Z) and Harbor Seals (P) in San Francisco and Tomales Bays, 1980-81.

	Net Units (NU)	Foraging At Net						Foraging Near Nets						Total Foraging						Percent of Nets Foraged
		Z	Z/NU	P	P/NU	Z+P	Z+P/NU	Z	Z/NU	P	P/NU	Z+P	Z+P/NU	Z	Z/NU	P	P/NU	Z+P	Z+P/NU	
San Francisco Bay																				
19 Jan	77	28	0.4	0	0.0	28	0.4	8	0.1	0	0.0	8	0.1	36	0.5	0	0.0	36	0.5	78
20 Jan	41	39	1.0	0	0.0	39	1.0	21	0.5	0	0.0	26	0.5	60	1.5	0	0.0	60	1.5	65
21 Jan	41	1	T	0	0.0	1	T	0	0.0	0	0.0	0	0.0	1	T	0	0.0	1	T	100
27 Jan	57	43	0.8	0	0.0	43	0.8	27	0.5	0	0.8	27	0.5	70	1.2	0	0.0	70	1.2	61
28 Jan	1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
5 Feb	1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
12 Feb	9	4	0.4	0	0.0	4	0.4	0	0.0	0	0.0	0	0.0	4	0.4	0	0.0	4	0.4	100
Totals San Francisco	227	115	0.5	0	0.0	115	0.5	56	0.2	0	0.0	61	0.3	171	0.8	0	0.0	171	0.8	67
Tomales Bay	79	28	0.4	28	0.4	56	0.7	10	0.1	15	0.2	25	0.3	38	0.5	43	0.5	68	0.9	82

TABLE 31. Harbor Seal Counts in San Francisco Bay, December 1979 to June, 1981. (Data sources: LF = Lyman Fancher, Alviso; AF= Alcorn and Fancher, 1980; DFG = Department Count).

	Mowry Slough & nearby S. Bay Sites	Castro Rocks	Richardson's Bay	Angel Island	Yerba Buena Ist.	Data Source
1979						
Dec 5	21					AF
Dec 14	46					AF
1980						
Jan 21	25					LF
Jan 31	28					LF
Feb 8	20		20*			LF
Mar 12	72	22				LF
May 4	232	44				LF
May 15	331					LF
June 25	187	27				LF
July 28	144					LF
Nov 4	41	73				LF
Dec			7*			LF
1981						
Jan			28	2	2	DFG
May 2	173					LF
May 8	169	26				LF
June 29			10			DFG

TABLE 32. Number of Gill Net Sets and Catch Reported on Daily Logs, Total Nets Studied for Mammal Interaction, Total Nets Observed Pulled, and Number of Mammals Entangled in San Francisco and Tomales Bays, 1979-80.

	Daily Log Data		Pounds-per-set	Foraging Frequency	Total Nets in Area	Total Sets Pulled	Mammals Tangled
	No. Sets	Catch in lbs					
San Francisco Bay 1980							
16 Jan	165	367,174	2,225	0.4	113	34	0
17 Jan	188	399,888	2,127	0.3	23	13	0
18 Jan	123	187,134	1,521	1.0	11	4	0
29 Jan	5	0	0	0.1	6	6	0
30 Jan	138	252,840	1,832	0.1	34	15	0
30 Jan	3*	0	0	2.0	3	3	0
4 Feb	32*	0	0	0.2	3	2	0
6 Feb	47	18,660	397	1.8	1	1	0
Totals San Francisco	701	1,225,696	1,748	0.3	194	78	0
Tomales Bay							
21 Jan	4*	T	T	1.3	4	1	0
22 Jan	4*	T	T	2.0	4	4	0
22 Jan	1*	T	T	0.1	1	1	0
Totals Tomales Bay	9	T	T	1.3	9	6	0

* Study area not in zone where heavy catches were made on these dates.

TABLE 33. Number of Gill Net Sets and Catch Reported on Daily Logs, Total Nets Studied for Mammal Interaction, Total Nets Observed Pulled, and Number of Mammals Entangled in San Francisco and Tomales Bays, 1980-81.

	Daily Log Data		Pounds-per-set	Foraging Frequency	Total Nets in Area	Total Sets Pulled	Mammals Tangled
	No. Sets	Catch in lbs					
San Francisco Bay 1981							
19 Jan	173	169,255	978	0.5	10	12	0
20 Jan	79	56,479	714	1.5	11	12	0
21 Jan	51	2,242	44	T	13	8	0
27 Jan	11*	500	45	1.2	10	10	0
28 Jan	1*	0	0	0.0	1	1	0
5 Feb	1*	0	0	0.0	1	1	0
12 Feb	4*	0	0	0.4	3	3	0
Totals San Francisco	320	228,476	714	0.8	49	47	0
Tomales Bay 1980							
19 Dec	52	32,526	626	0.9	40	18	0

* Study area not in zone where heavy catches were being wade.

TABLE 34. Adjustment for Mammal Foraging Only at Gill Nets and for Non-reporting of Daily Logs in the San Francisco and Tomales Bay Catch, 1979-80 and 1980-81.

	Days of Effort	Poundage Foraged	Adjustment for Non-Reported Logs: % Reported	Adjustment for Non-Reported Logs: Adj. Lbs.	Adjustment for Net Foraging: % at Nets	Adjustment for Net Foraging: Estimated Poundage	Recorded Catch in Thousand lbs	% of Total Caught
San Francisco Bay								
1979-80								
Gill Net	34	42,300	90.8	46,590	73.0	34,010	6,040	0.56
Lampara	23	13,800	81.4	16,950	100.0	16,950	3,933	0.43
Purse Seine	10	7,890	100.0	7,890	100.0	7,890	2,887	0.27
Totals 1979-80	34*	63,990	90.0	71,430	(82.4)	58,850	12,860	0.46
1980-81								
Gill Net	75	59,100	90.0	65,670	67.0	44,000	5,954	0.73
Lampara	35	15,630	70.0	22,330	100.0	22,330	2,620	0.84
Purse Seine	12	5,730	95.6	6,000	100.0	6,000	3,088	0.23
Totals 1980-81	75*	80,460	86.9	94,000	(78.1)	72,330	11,662	0.62
Tomales Bay								
1979-80	50	29,860	97.4	30,660	81.0	24,830	1,192	2.04
1980-81	55	24,558	87.9	27,940	81.0	22,630	904	2.44

* Number of Total days on which daily effort logs were submitted for the season.

TABLE 35. Pacific Herring Lampara and Purse Seine Interaction with California Sea Lions (z) in San Francisco Bay for the 1979-80 and 1980-81 Seasons.

	Number Sets observed	Number sets with z entrapped at Boat	Number z Entrapped	Number Sets Foraged	Number z Foraging	Mean mammals Foraging per set
1979-80 Season						
17 Jan	29	1	1	6	6	0.2
18 Jan	4	0	0	1	1	0.3
Total 1979-80	33	1	1	7	7	0.2
1980-81 Season						
15 Jan	6	0	0	1	1	0.2
5 Feb	23	3	4	14	26	1.1
10 Feb	5	2	4	5	9	1.8
11 Feb	20	5	8	10	15	0.8
16 Feb	19	6	11	16	34	1.8
Total 1980-81	73	16	27	46	85	1.2
Totals 1979-80 and 1980-81 Seasons	106	17	28	53	92	0.87

TABLE 36. Harbor Seal Counts in Tomales Bay, 1980 and 1981. (Data source: DFG=Department of Fish & Game; LF=Lyman Fancher; SA=Sarah Allen).

Date	Data Source	Adult and Subadult	Pups	Total
1980				
23 Jan	DFG	210	0	210
24 Jan	DFG	86	0	86
28 Jan	DFG	180	0	180
29 Jan	DFG	70	0	70
8 Feb	DFG	95	0	95
12 Feb	DFG	212	0	212
13 Feb	DFG	94	0	94
14 Feb	DFG	133	0	133
25 Feb	DFG	121	0	121
28 Feb	DFG	100	0	100
12 Mar	DFG	158	0	158
12 Mar	LF	285	0	285
14 Mar	DFG	47	0	47
May	SA	199	23	222
4 May	LF	159	36	195
25 June	LF	36	0	36
4 Nov	LF	125	0	125
1981				
25 Jan	LF	179	0	179
8 May	LF	94	0	94
May	SA	200	25	225
June	SA	145	21	166
18 June	DFG			160
July	SA	84	23	107

TABLE 37. Counts of Harbor Seals at Hauling Grounds from Bolinas Bay to Bird Rock, Tomales Point, 1980 and 1981.

	1980				1981		
	12 Mar	4 May	25 Jun	4 Nov	25 Jan	8 May	19 Jun
Bolinas Bay	7	38	88	52	45	39	46
Duxbury Reef	48	1	79	99	38	0	65
Double Pt.	132	190	176	60	291	312	351
Drakes Estero	169	661	573	278	416	549	525
Bird Rock	79	0	333	35	169	212	71
Tomales Bay	285	195	36	125	179	94	160
Total	720	1,085	1,285	649	1,138	1,206	1,218
Source:	LF	LF	LF	LF	LF	LF	DFG

LF = Lyman Fancher; DFG = Dept. of Fish and Game

TABLE 38. Number of Net Units, Foraging Frequency Indices, and Data on Daily Fishermen's Logs for Humboldt Bay, 1979-80 and 1980-81 Seasons.

	Net Units (NU)	Z	P	Z+P	Z+P / NU	Sets Reported on logs	catch in lbs	pounds-per-set
1979-80								
9 Jan	3	0	15	15	5.0	5	6,912	1,382
10 Jan	3	0	20	20	6.7	10	15,785	1,578
11 Jan	1	0	2	2	2.0	12	4,425	368
12 Jan	3	0	17	17	5.7	6	21,023	3,503
14 Jan	3	0	17	17	5.7	10	5,821	582
18 Jan	4	0	0	0	0.0	1	188	188
20 Jan	3	0	19	19	6.3	(no logs)		
23 Jan	10	0	34	34	3.4	10	4,633	463
Totals 1979-1980	30	0	124	124	4.13	54	58,787	1,089
1980-81								
7 Feb	11	0	295	295	26.8	8	5,360	670
9 Feb	8	0	346	346	43.2	12	11,280	940
21 Feb	5	0	161	161	32.2	10	7,080	708
Total 1980-1981	24	0	802	802	33.4	30	23,720	791

TABLE 39. Number of Net Units and California Sea Lion (Z) and Harbor Seal (P) Activity At Pacific Herring Gill Nets at Crescent City, 1979-80.

	Net units (NU)	Z	Z/NU	P	P/NU	Z+P	Z+P/NU
8 Jan	1	6	6.0	0	0.0	6	6.0
10 Jan	5	61	12.2	8	1.6	69	13.8
14 Jan	3	18	6.0	3	1.0	21	7.0
15 Jan	2	5	2.5	0	0.0	5	2.5
20 Jan	1	9	9.0	0	0.0	9	9.0
25 Jan	2	11	5.5	0	0.0	11	5.5
Totals	14	110	7.9	11	0.8	121	8.6

TABLE 40. Depredation Values by Pinnipeds on the Herring Fishery, 1979-80 and 1980-81.

	Maximum Potential Poundage Foraged		Value of Loss Of Herring		Value of Net Damage	
	1979-80	1980-81	1979-80	1980-81	1979-80	1980-81
San Francisco						
Gill Net	34,000	44,000	0	$25,000	-	-
Lampara	17,000	22,000	0	$8,000	-	-
Purse Seine	8,000	6,000	0	0	-	-
Tomales Bay						
Gill Net	25,000	22,000	$16,000	$15,000	-	-
Humboldt Bay						
Gill Net	11,500	14,000	0	$ 9,100	$ 600	$2,600
Crescent City						
Gill Net	10,700	(not covered)	0	(not covered)	$1,950	(not covered)
Total	106,200	108,000	$16,000	$57,100	$2,550	$2,600

TABLE 41. Number of Landings by Gill and Trammel Net Boats by Major Species Caught in 1980 from Santa Barbara to Long Beach.

Month	Shark	California Halibut	Rockfish	White Croaker	Inshore Aggegate	Pacific Bonito	California Barracuda	Totals
Jan	19	37	22	67	4	4	0	153
Feb	8	36	32	66	0	0	0	142
Mar	14	31	8	30	7	0	0	90
Apr	25	50	34	15	4	0	0	128
May	44	46	18	1	1	0	0	110
Jun	57	97	18	3	3	0	0	178
Jul	75	73	13	11	3	0	1	176
Aug	167	139	43	26	8	0	0	383
Sep	170	47	45	70	7	0	0	339
Oct	50	32	17	44	8	4	0	155
Nov	4	10	10	19	0	1	0	44
Dec	38	17	17	5	0	0	0	77
Total	671	615	277	357	45	9	1	1,975

TABLE 42. Number of Landings by Gill and Trammel Net Boats by Major Species Caught in 1980 from Long Beach to San Diego.

Month	Shark	California Halibut	Rockfish	White Croaker	Inshore Aggregate	Pacific Bonito	California Barracuda	Totals
Jan	69	105	108	79	1	11	0	373
Feb	34	162	100	46	6	15	0	363
Mar	52	116	71	90	10	31	0	370
Apr	170	97	84	51	8	7	1	418
May	196	118	70	51	10	9	4	458
Jun	169	110	59	11	10	61	58	478
Jul	264	161	73	28	25	58	37	646
Aug	348	157	68	36	26	5	0	640
Sep	277	197	83	46	11	3	0	617
Oct	174	153	99	19	3	20	0	468
Nov	31	73	22	4	6	0	0	136
Dec	28	61	22	8	1	0	3	123
Total	1,812	1,510	859	469	117	220	103	5,090
Total Southern California	2,483	2,125	1,136	826	162	229	104	7,065

TABLE 43. Mesh Sizes Used in Gill Nets for Various Species

Species	Optimum Size	Range in Size Used	Remarks
California Barracuda	3.50	3.50-3.75	3.50 in minimum required by law.
Pacific Bonito	3.75	2.75-5.25	
White Croaker	2.75	2.00-3.00	
Flyingfish	2.00	1.875-2.125	These sizes are the minimum and maximum sizes allowed by law.
California Halibut	8.00	8.00-10.50	This mesh is the inner mesh size of a trammel net. There is a minimum of 8.00 in required by law. The outer layers are usually 24.00 in.
Inshore Agrregate	3.75	2.17-5.00	
Pacific Mackerel	2.75	2.50-3.75	
Pacific Butterfish (pompano)	2.50	2.50-3.50	
Rockfish	4.50	4.125-6.00	4.125 is the smaller mesh sized allowed for rockfish.
White Seabass	6.50	5.00-8.00	5.00 in is required minimum mesh size.
Shark	8.00	6.50-26.00	
Swordfish	16.00	6.50-26.00	

TABLE 44. Target Species Listed by Fishermen Registered for General Gill Net Permits, Statewide, 1981.

	General Gill net permits	California Halibut	White Sea-bass	Barracuda	White Croaker	Set gill net shark	Drift* gill net shark	Rock fish	Inshore Aggregate	Pacific Bonito
Long Beach	113	86	83	40	32	92	94	38	19	16
San Diego	59	28	46	16	1	34	55	43	-	-
Monterey	43	40	10	1	28	22	-	17	-	-
San Francisco	33	26	4	-	13	32	-	29	11	-
Santa Barbara	21	15	16	4	-	19	14	2	-	-
Morro Bay	5	4	3	-	1	4	4	-	-	-
TOTALS	274	199	162	61	75	203	167	129	30	16

* Drift gill net for shark. Anyone fishing under this catagory is not required to have a general gill net permit. Seventy-eight (47%) of the fishermen in this catagory were found not to have general gill net permits bringing the total gill net fishermen statewide to 352.

TABLE 45. Summary of Fish loss and Marine Mammal Mortality in the Gill Net Fishery.

Fishery	Sample Percent	Fish Depredated: Species	Percent	Pounds	Value	Gear Loss	Mammal Mortality: Species	Number
Shark	6.0	Swordfish	1.2	290	$ 840	10,000	Zalophus	900
		Angel shark	unknown	-	-		Globicephala	30
							Eschrichtius	3
							Balaenoptera sp	1
California Halibut	4.0	Calif. Halibut	10.1	29,150	46,640	34,684	Zalophus	242
							Phoca	95
							Mirounga	24
							Phoecoena	15
White Seabass								
California	4.0	White Seabass	10.4	4,683	7,480	4,545	Zalophus	unknown
Baja Calif.	31.4	White Seabass	10.2	24,523	39,200		Zalophus	unknown
Rockfish	0.7	Rockfish	1.63	8,550	2,600	15,460	Zalophus	15
							Mirounga	1
White Croaker	1.8	White Croaker	7.1	7,930	2,970	1,000	0	-
California Barracuda	6.5	Calif, Barracuda	2.2	416	330	unknown	-	-
		Pacific Mackerel		45	20			
Pacific Bonito	2.6	Pacific Bonito	6.5	6,336	1,270	382	-	-
Flyingfish	20 +	Flyingfish	6.4	500	200	-	-	-
Totals Gill Net and Trammel (California only).				57,900	$63,360	$57,071	Zalophus	1157
							Phoca	95
							Mirounga	25
							Globicephala	30
							Eschrichtius	3
							Balaenoptera sp	1

TABLE 46. Number of Boats Fishing, Number of Sets Observed, and California Sea Lions Observed in the Monterey Squid Fishery, 1979-1980.

	Number Boats Fishing	Number sets observed	Number Calif. Sea Lions sighted in water Near Nets	Number California sea Lions in Nets
1979				
19 Jul	1	1	0	0
1980				
11 Jun	11	13	0	0
18 Jun	18	30	0	0
24 Jun	13	8	0	0
11 Aug	1	1	0	0
15 Aug	1	1	0	0
22 Aug	3	3	0	0
29 Aug.	3	3	0	0
3 Sep	6	6	1	0
9 Sep	2	2	0	0
12 Sep	13	13	0	0
19 Sep	2	2	0	0
30 Sep	1	1	0	0
13 Oct	18	12	4	0
31 Oct	2	2	0	0
Total	95	98	5	0

TABLE 47. Number of Firearm and Seal Bomb Reports Heard and Presence of Marine Mammals Near Squid Fishing Boats at Santa Catalina Island, 1980-81, by 15-min Intervals.

	Number 15 min periods	Boats Not Brailing	Boats Brailing	Sound Reports		Marine Mammals Near Boats	
				Firearm	Seal Bomb	Zalophus	Globicephala
11 Nov. 80	38	59	18	13	2	18	5
$\bar{x}$ per 15 min period		1.6	0.47	0.34	0.05	0.47	0.13
12 Nov. 80	27	36	0	8	0	1	5
$\bar{x}$ per 15 min period		1.3	0.00	0.30	0.00	0.04	0.19
10 Dec. 80	43	172	37	69	25	12	15
$\bar{x}$ per 15 min period		4.0	0.86	1.60	0.58	0.28	0.35
11 Dec. 80	24	56	10	87	0	2	2
$\bar{x}$ per 15 min period		2.3	0.42	3.63	0.00	0.08	0.08
21 Jan. 81	23	52	2	5	2	0	0
$\bar{x}$ per 15 min period		2.3	0.09	0.22	0.09	0.00	0.00
22 Jan. 81	11	21	0	2	0	1	0
$\bar{x}$ per 15 min period		1.9	0.00	0.18	0.00	0.09	0.00
10 Feb. 81	34	180	26	29	11	5	0
$\bar{x}$ per 15 min period		5.3	0.76	0.85	0.32	0.15	0.00
Totals	200	576	93	213	40	39	27
Mean per 5-min period		2.9	0.47	1.07	0.20	0.20	0.14

TABLE 48. Estimated Number of Pilot Whales by Transect at Santa Catalina Island, December 1980 - February, 1981.

Transect Number	December				January				February			
	15	16	17	18	13	15	16	17	23	24	26	27
1	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
11	7	7	0	0	0	0	0	0	0	0	0	0
16	16	2	0	0	0	0	0	0	10	0	21	10
2	0	0	0	25	0	0	18	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
12	2	48	0	0	0	0	0	0	0	20	0	0
17	0	34	2	0	0	0	0	0	24	42	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	5	0	0	0	0	0
18	0	0	0	0	0	0	37	0	0	0	0	0
19	0	0	0	13	0	21	0	27	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
14	5	68	128	2	31	0	37	0	0	0	57	0
20	77	62	83	30	157	0	146	0	0	0	64	0
5	0	0	0	0	0	0	0	0	0	0	0	21
10	0	0	0	0	0	0	0	0	0	0	0	0
15	0	15	2	0	11	0	73	0	40	0	0	22
21	0	0	13	0	40	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	10	35	72	0	0
23	0	6	0	0	0	0	0	0	24	61	0	0
Total	107	242	228	70	239	21	316	37	133	195	142	53

Table 49. Catch and Loss of the Hook-and-Line Commercial Catch at Nine Ports in the 1980 sample.

Port	Month	Number Boats	Catch Species	Catch Pounds	Loss Definite	Loss Probable	Loss Total
San Francisco	Mar	1	Surfperch	30	0	0	0
Princeton	Mar	1	0	0	0	0	0
Monterey	Mar	1	Rockfish	340	0	0	0
	May	1	Rockfish	32	0	0	0
	Jun	1	Rockfish	50	0	0	0
Santa Cruz	Mar	2	Rockfish	116	0	0	0
Santa Barbara	Jul	6	Rockfish	850	0	3	3
Ventura	Sep	1	Rockfish	280	0	0	0
Long Beach	Jul	8	Rockfish	1,780	13	0	13
	Aug	11	Rockfish	505	0	0	0
Newport	Jul	2	Flatfish	35	0	0	0
Oceanside	Jan	1	Rockfish	150	0	0	0
Totals		36	Rockfish	4,103	13	3	16
			Surfperch	30	-	-	
			Flatfish	35			
Total So. Calif.		29	Rockfish	3,565	13	3	16
			Flatfish	35			
					0.36%	0.08%	0.44%

TABLE 50. At-Sea and Interview Data For the Trawl Fishery, 1979-1981.

	Fishery	Date	Catch Species	Catch Pounds	California Sea Lion Interaction Mortality	California Sea Lion Interaction Following
At-Sea						
	Rockfish	25 Jul 79	Rockfish	7	0	2
	Cal. Halibut	11 May 81	Cal. Halibut	260	0	4
	Cal. Halibut	12 May 81	Cal. Halibut	230	0	2
	Cal. Halibut	13 May 81	Cal. Halibut	195	0	4
	Cal. Halibut	14 May 81	Cal. Halibut	175	1	3
	Shrimp	30 May 80	Shrimp	200	0	1
**DFG Research Vessel		4 Feb 80	Anchovy	36	1	0*
Interview						
	**Hake	8 Apr 80	Hake	4,330	0	0
	**Hake	9 Apr 80	Hake	12,081	0	0
	**Hake	17 Apr 80	Hake	27,000	0	0
	Cal. Halibut	18 Aug 80	Seabass	80	0	0
	Cal. Halibut	20 Oct 80	Cal. Halibut	100	0	0
	Shrimp	22 Jul 80	Shrimp	1,000	0	0***
	Shrimp	12 Sep 80	Shrimp	500	0	0

* Non-random sample reported to us by anchovy research project.
** Mid-depth trawl.
*** One seal attempted to climb aboard when catch was loaded.

TABLE 51. Number of Months, Days, and Anglers Sampled, Number of Mammals Observed, and Fish Loss at 23 California Piers, 1979-1980. (Z=*Zalophus*; P=*Phoca*).

	No Months	Days	Anglers	Mammals Observed	Loss to Mammals	Data Source
1979						
Crescent City	5	9	58	1P	0	Intercept
Trinidad	1	1	11	0	0	Intercept
Eureka	5	20	118	0	0	Intercept
San Francisco Muni.	2	3	106	0	0	Project
Fort Mason	2	10	5	0	0	Project
Fort Baker	1	1	17	0	0	Project
Oakland	1	1	10	0	0	Project
Berkeley	1	1	31	0	0	Project
Pacifica	2	2	487	0	0	Project
Princeton	1	2	45	0	0	Project
Santa Cruz	1	3	200	1P;1Z	0	Project
Moss Landing Jetty	1	2	23	1Z	0	Project
San Simeon	1	1	0	0	0	Project
Cayucos	1	1	49	0	0	Project
Morro Bay	1	1	10	0	0	Project
Port San Luis	1	1	10	0	0	Project
Avila	1	1	36	0	0	Project
Pismo Beach	1	1	26	0	0	Project
Kings Harbor Jetty	1	1	7	1 Z	0	Project
Belmont Pier	1	1	144	1 Z	0	Project
Seal Beach	1	1	81	0	0	Project
San Clemente	1	1	26	0	0	Project
Oceanside	1	1	54	0	0	Project
Total 1979	-	66	1,554	2P; 4Z	0	-
1980						
Crescent City	5	10	66	0	0	Intercept
Trinidad	1	1	3	0	0	Intercept
Eureka	3	31	239	0	0	Intercept
Total 1980		42	308	0	0	-
Totals 1979 + 1980	-	108	1,862	2P; 4Z	0	-

TABLE 52. **Assumed** Marine Mammal Mortality in California Fisheries for 1980.

Species	Fishery	Number
California Sea Lion	Commercial Salmon trolling	300
	Klamath River Gill Netting	7*
	Ocean Gill Netting	1,157
	Squid Round Haul Net	10
	Anchovy-Mackerel Round Haul	20
	Trawl Fishery	10
	Total:	1,494
Harbor Seal	Klamath River Gill Net	22*
	Ocean Gill Net	95
	Round Haul Nets	+?
Elephant Seal	Ocean Gill Netting	25
Harbor Porpoise	Ocean Gill Netting	15
	Round Haul Nets	+?
Pilot Whales	Squid Round Haul Nets	30
	Ocean Gill Netting	30
California Gray Whale	Ocean Gill Netting	3
Large Baleen Whale	Ocean Gill Netting	1
	Total All Mammals:	1,715

* - Actual Count, no estimate made.

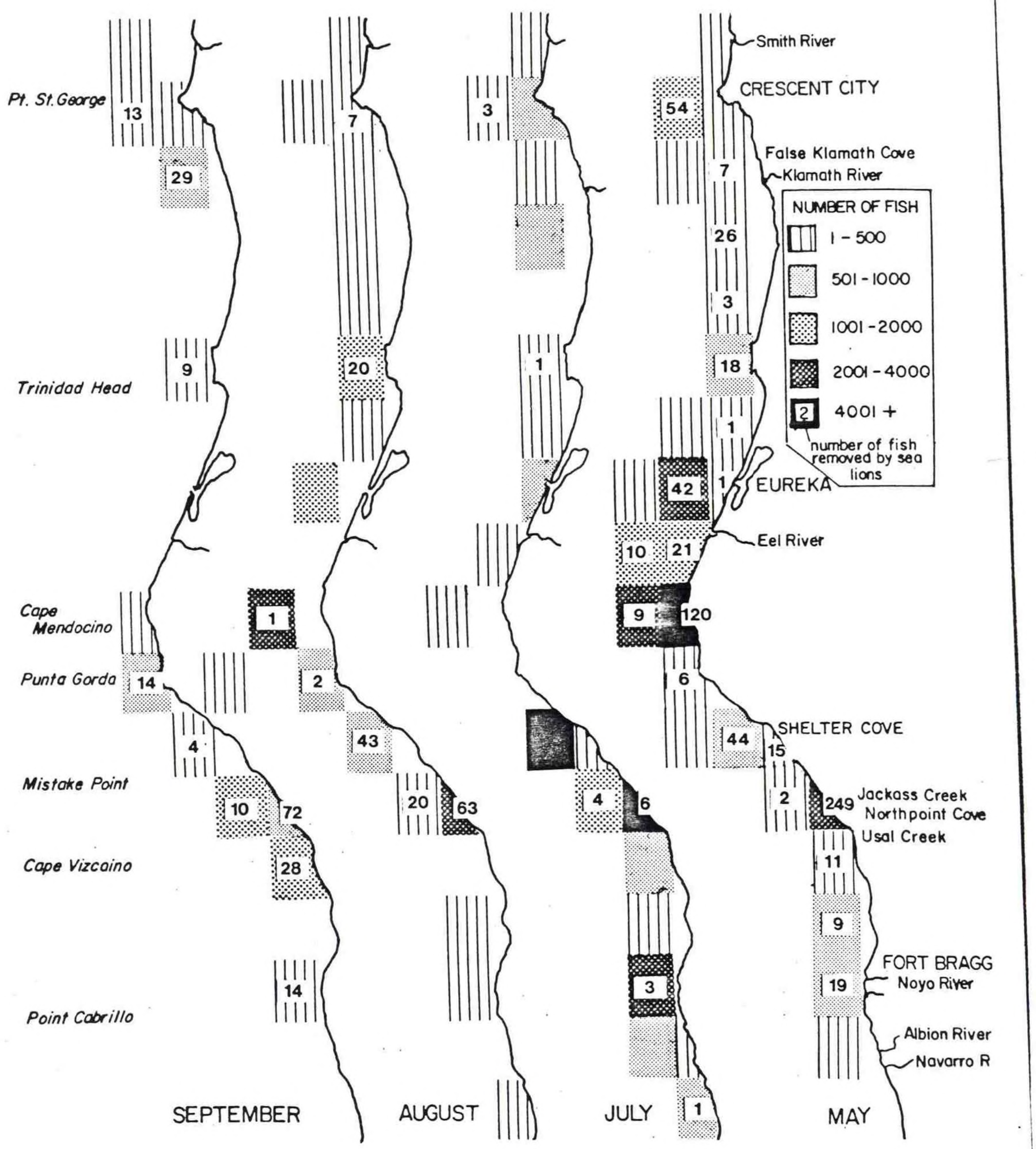

Figure 1. Commercial salmon troll catch and number of salmon taken off the hooks by California sea lions by catch block areas from the Oregon border to Pt. Arena in the combined at-sea and interview samples, 1980.

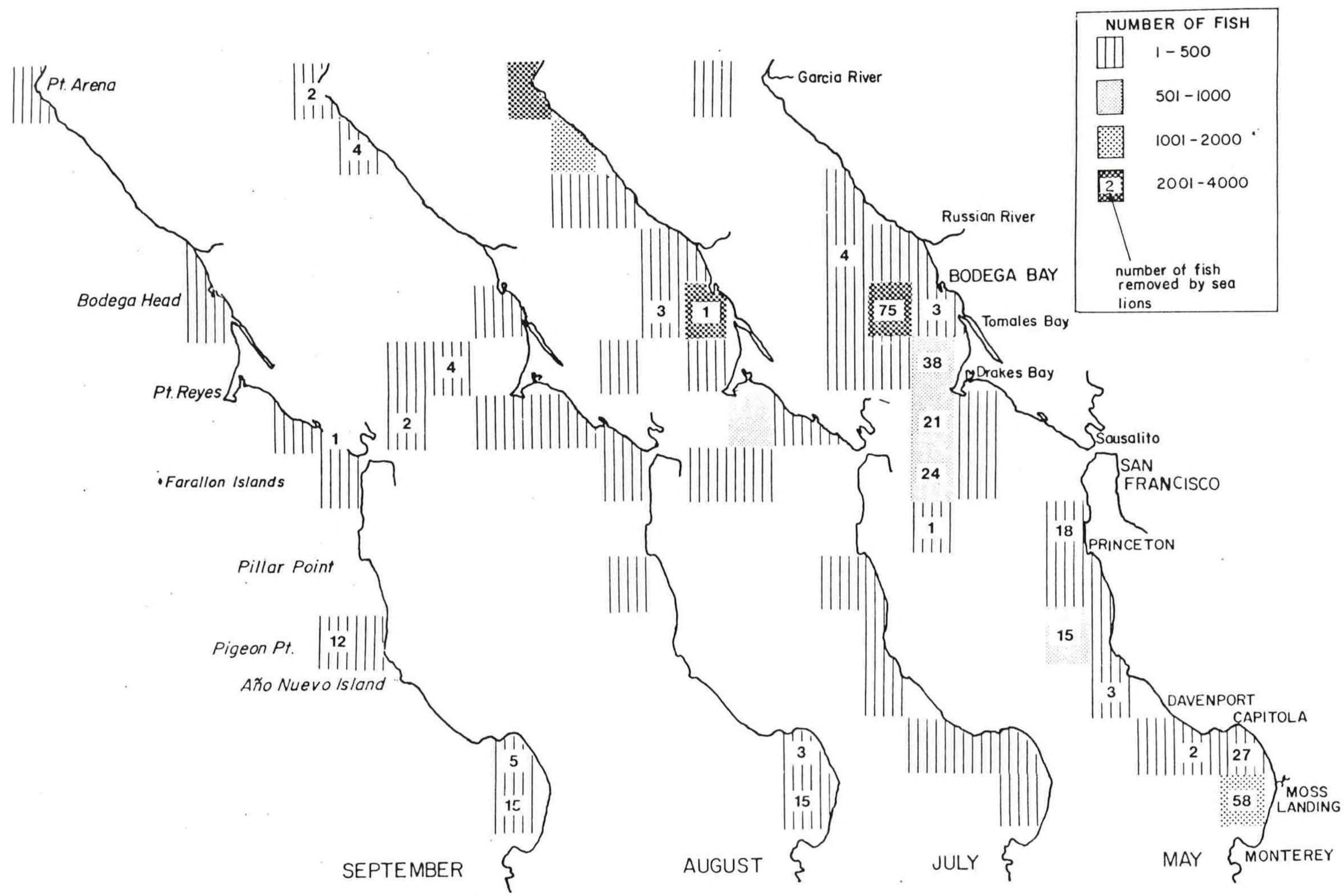

Figure 2. Commercial salmon troll catch and number of salmon taken off the hooks by California sea lions by catch block areas from Pt. Arena to Monterey in the combined at-sea and interview samples, 1980.

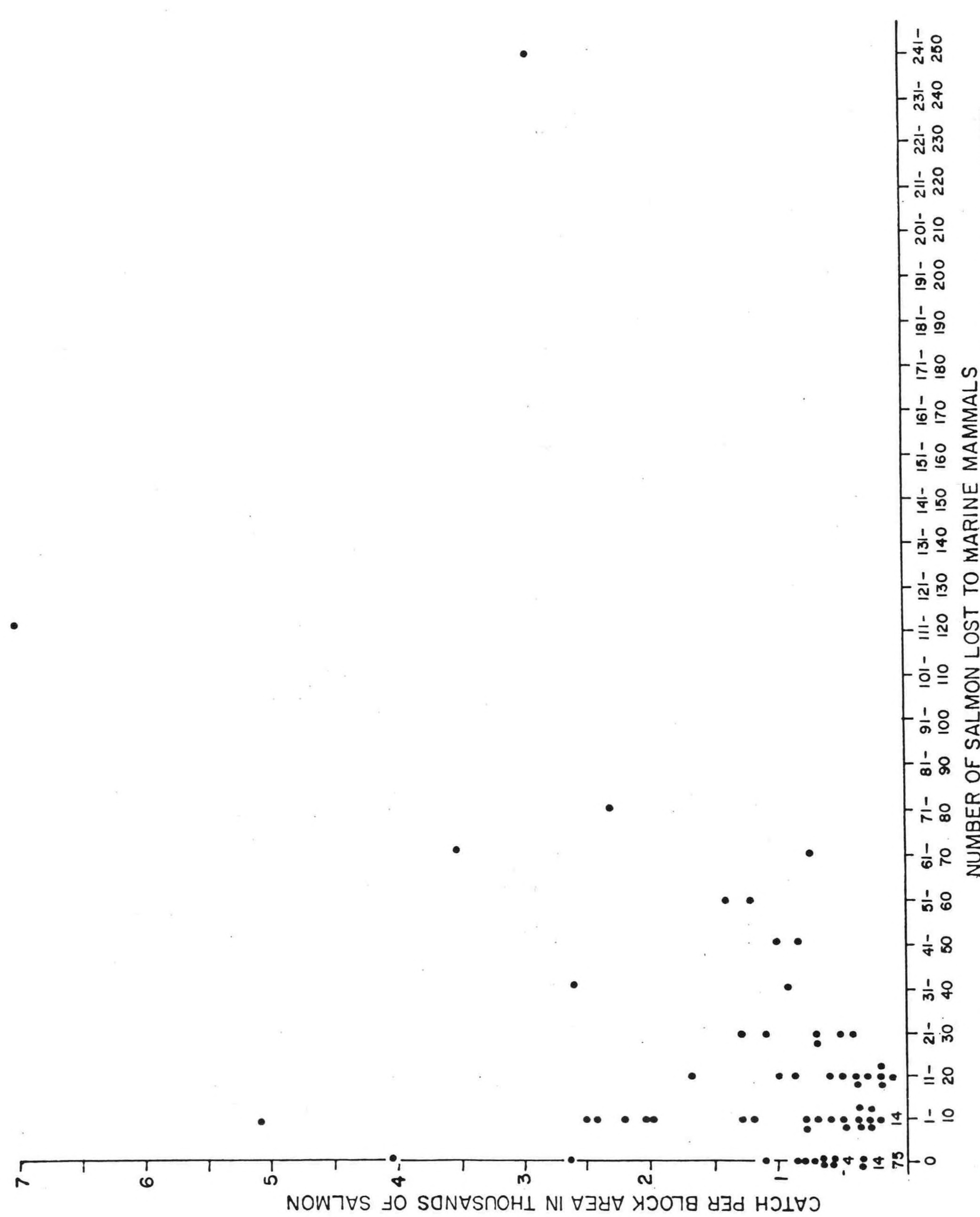

Figure 3. Relationship between commercial salmon catch by block area and number of salmon lost to marine mammals, 1980.

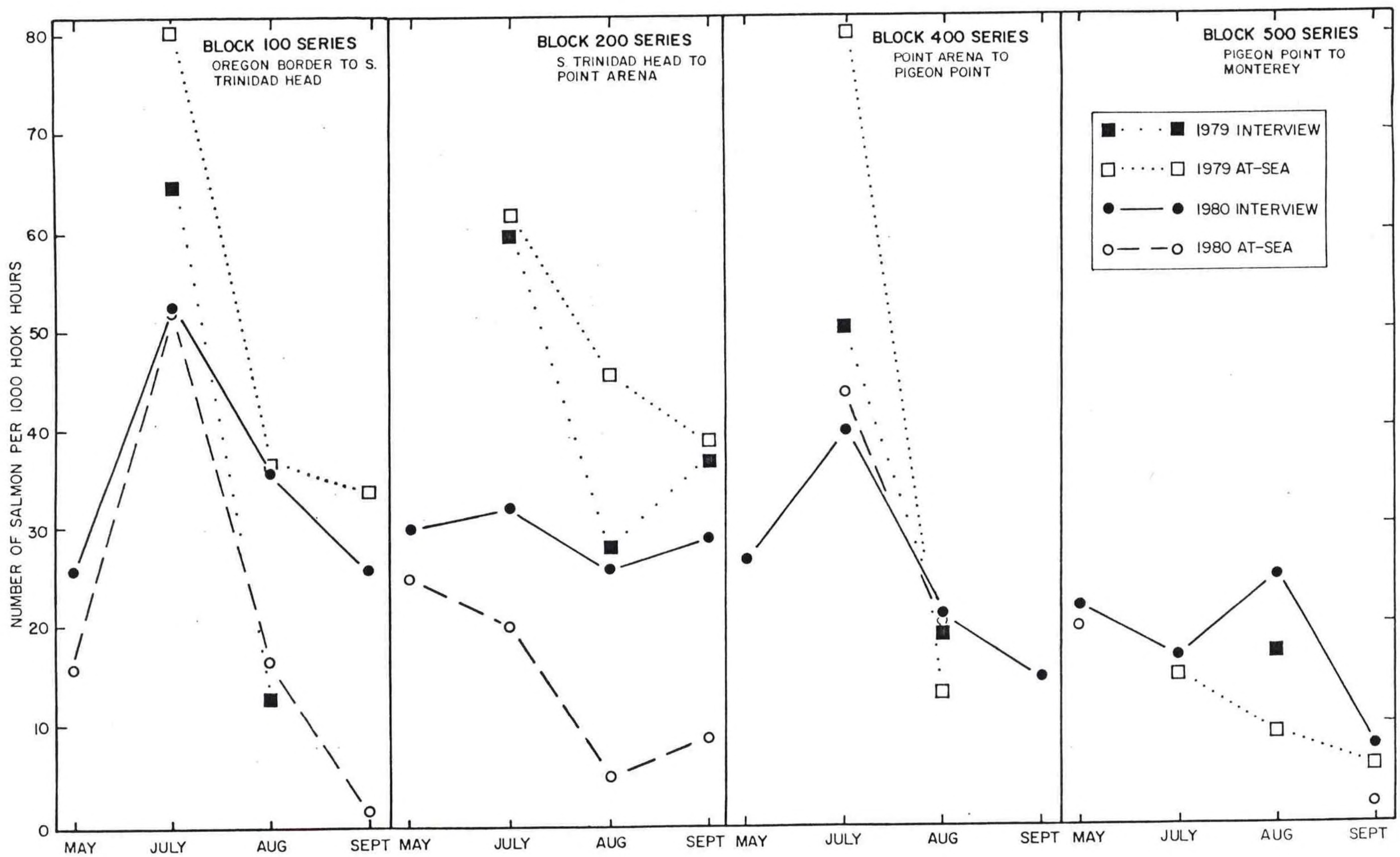

Figure 4. Comparison of number of salmon caught per 1000 hook hours in the at-sea and interview data series in four areas of the California coastline in the 1979 and 1980 seasons.

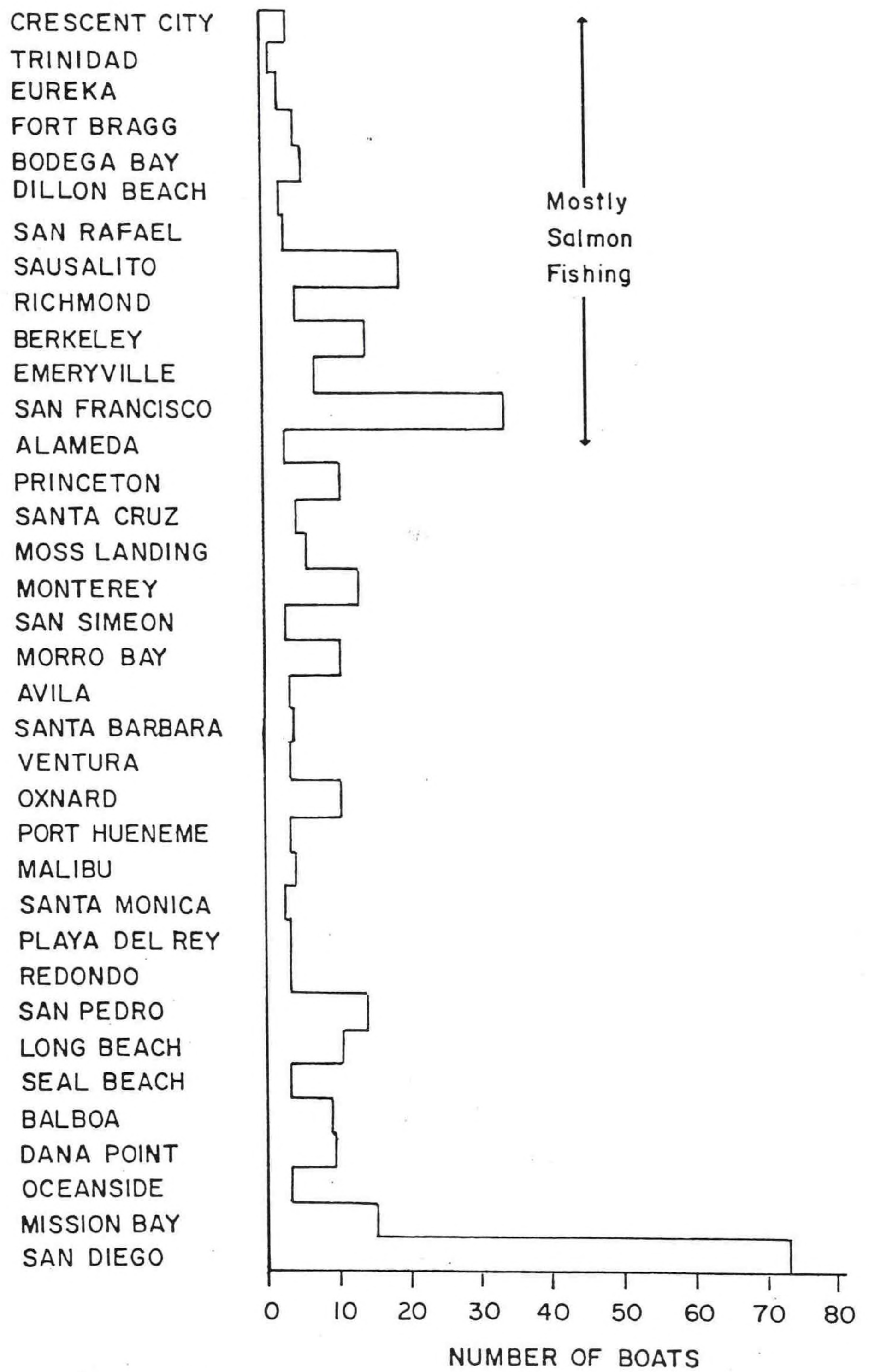

Figure 5. Number of partyboats registered at 36 California ports.

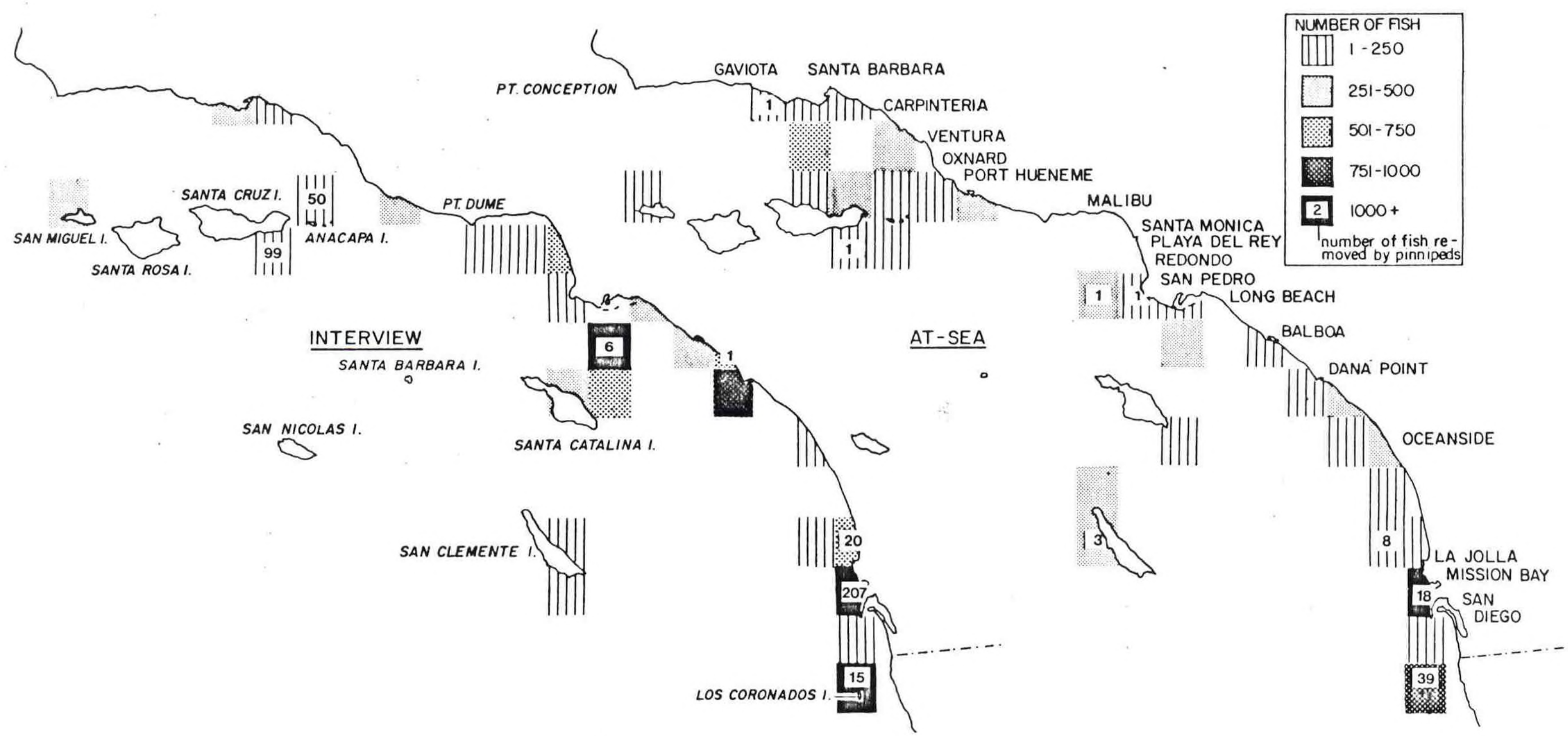

Figure 6. Partyboat catch and number of fish lost to marine mammals in the at-sea and interview samples by catch block area, southern California 1980.

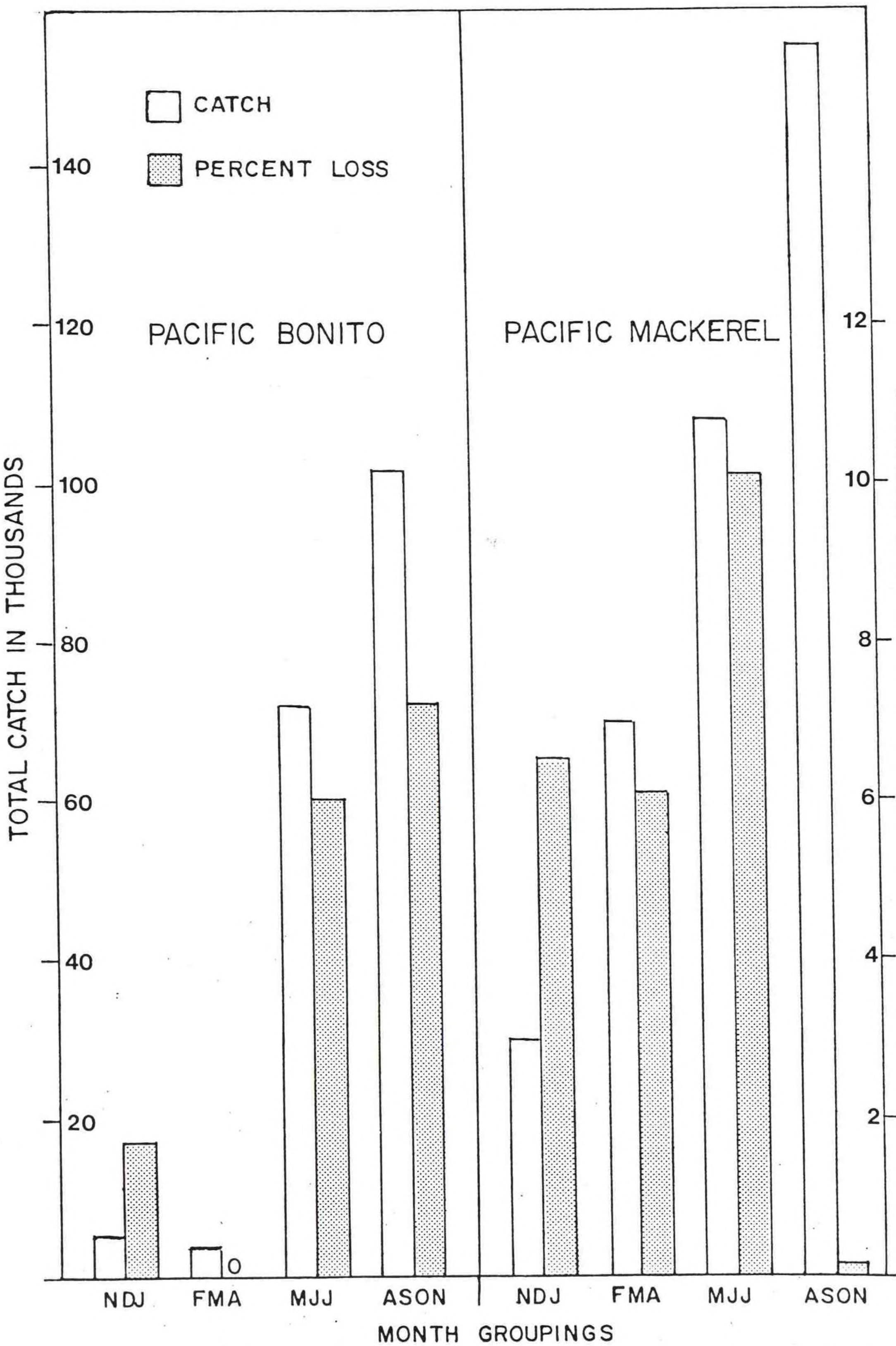

Figure 7. Comparison of Pacific bonito and Pacific mackerel catches with percent loss to California sea lions off San Diego, 1979-1980.

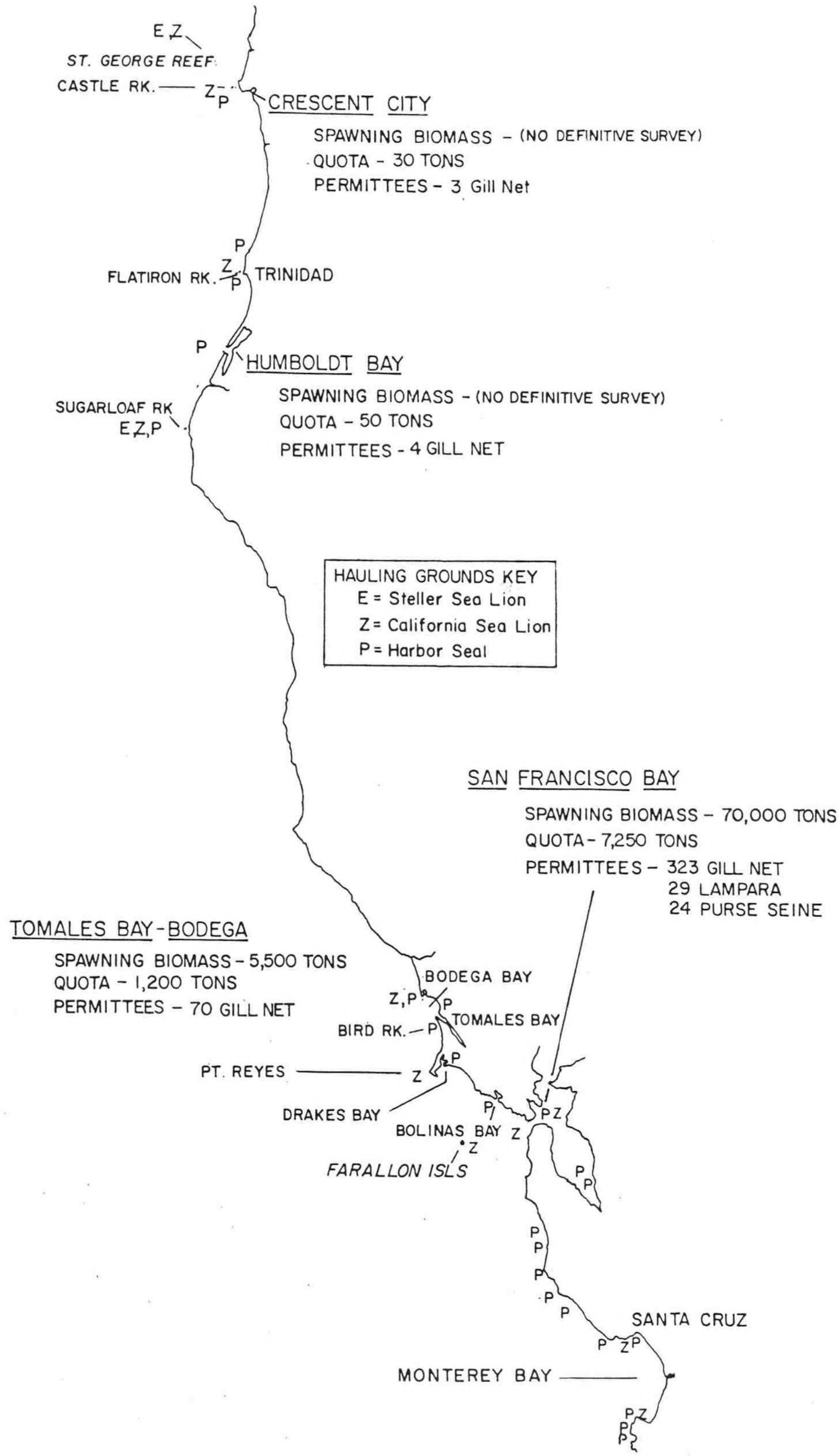

Figure 8. Pacific herring fishing areas in central and northern California and major hauling grounds of harbor seals and California sea lions nearest to the herring fishing areas.

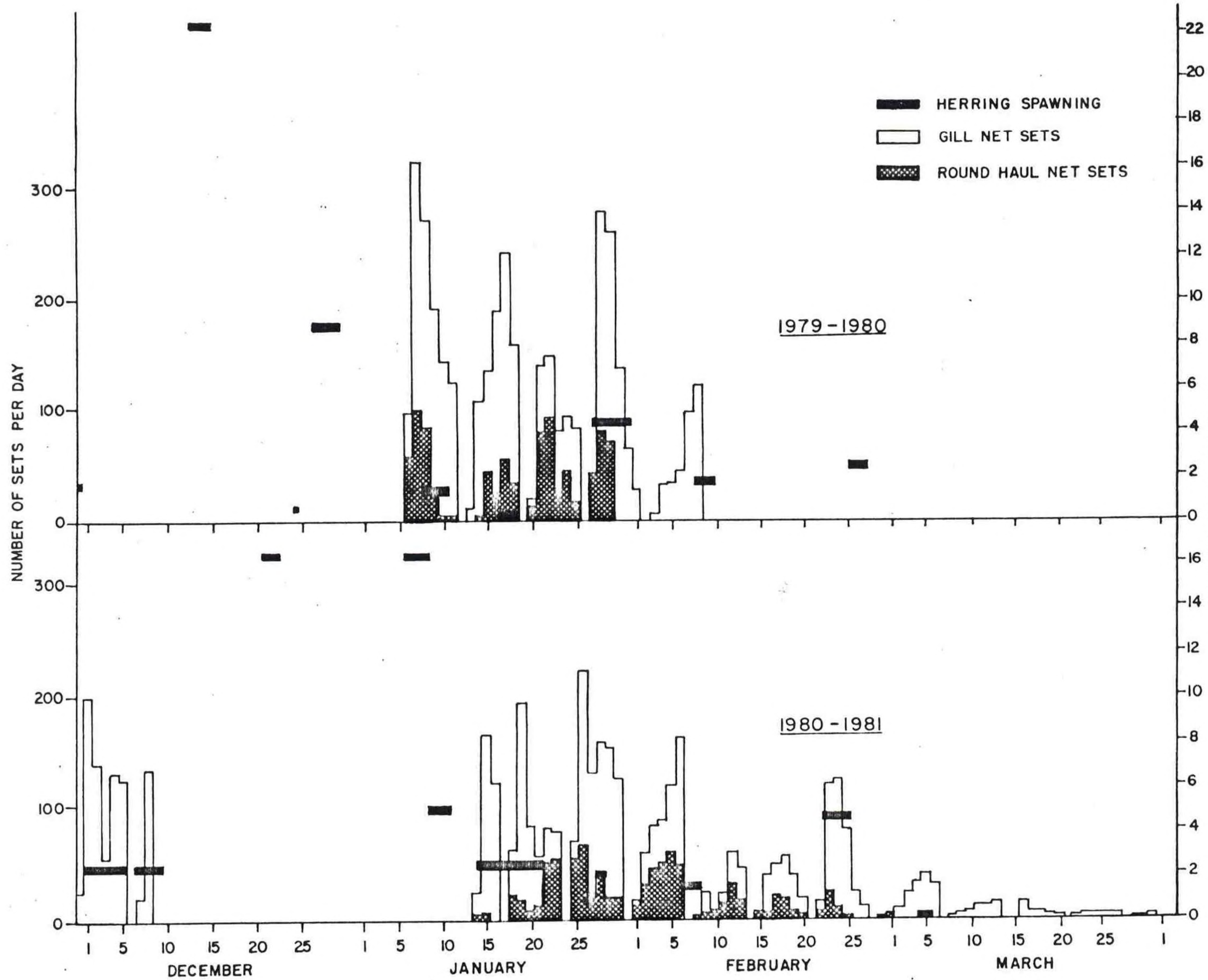

Figure 9. Spawning biomass estimates for each Pacific herring spawning and gill net and round haul net effort by day in San Francisco Bay for the 1979-1980 and 1980-1981 seasons.

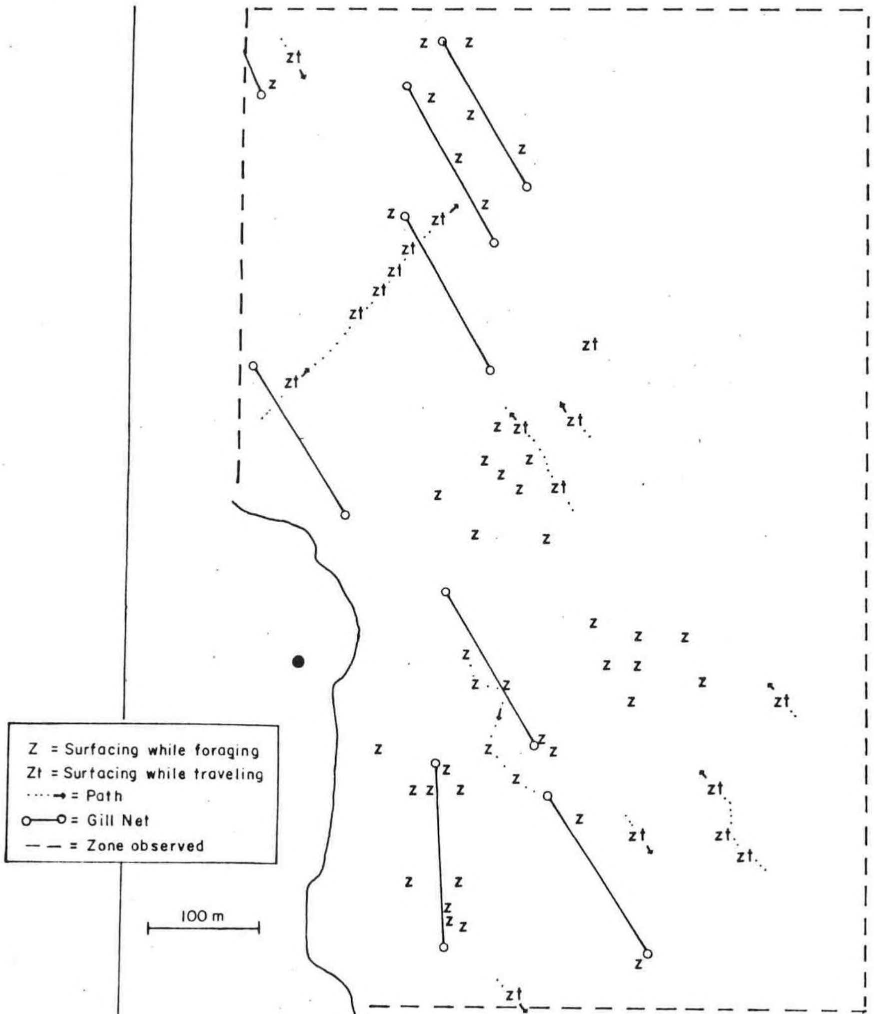

Figure 10. California sea lion (Z) surfacings at and near Pacific herring gill nets at Sausalito, 1300-1610, 17 Jan 80.

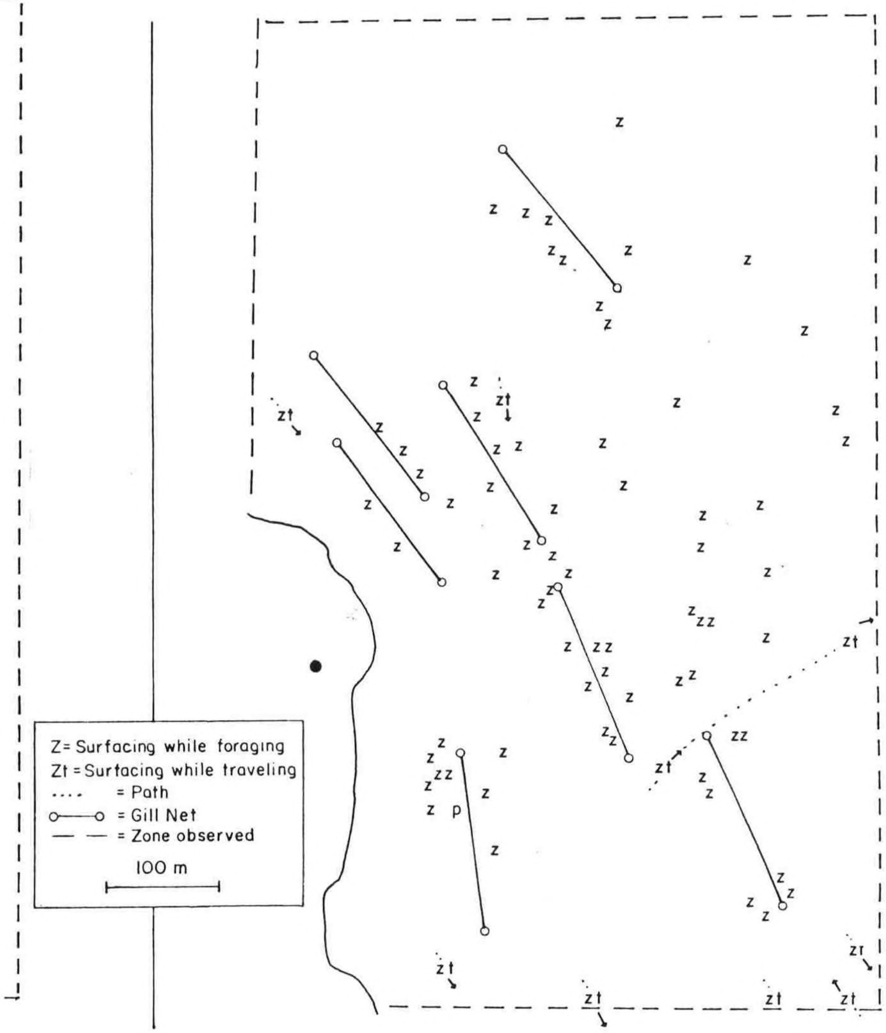

Figure 11. California sea lion (Z) and harbor seal (P) surfacings at and near Pacific herring gill nets at Sausalito, 0800-0945, 18 Jan 80.

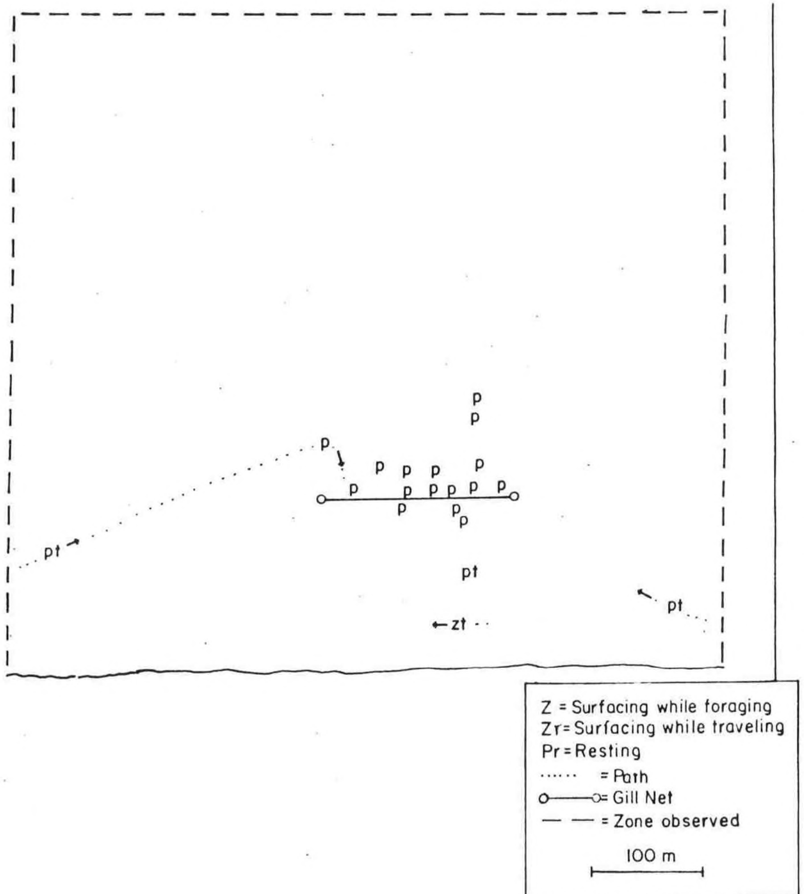

Figure 12. California sea lion (Z) and harbor seal (P) surfacings at and near Pacific herring gill nets at Sausalito, 1645-1745, 6 Feb 80.

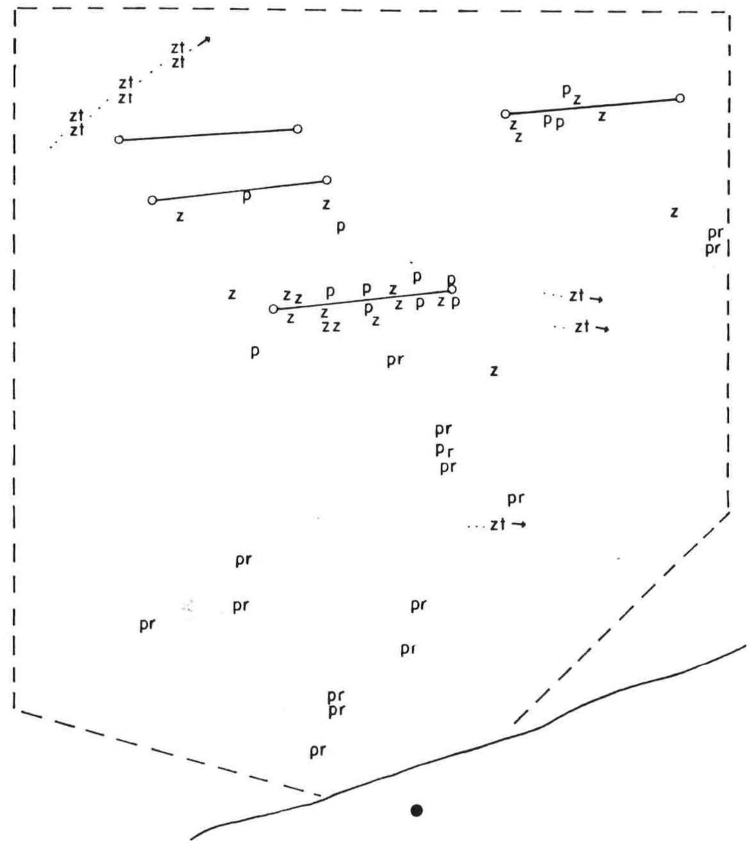

Figure 13. California sea lion (Z) and harbor seal (P) surfacings at and near Pacific herring gill nets at Tomales Bay, 1400-1600, 21 Jan 80.

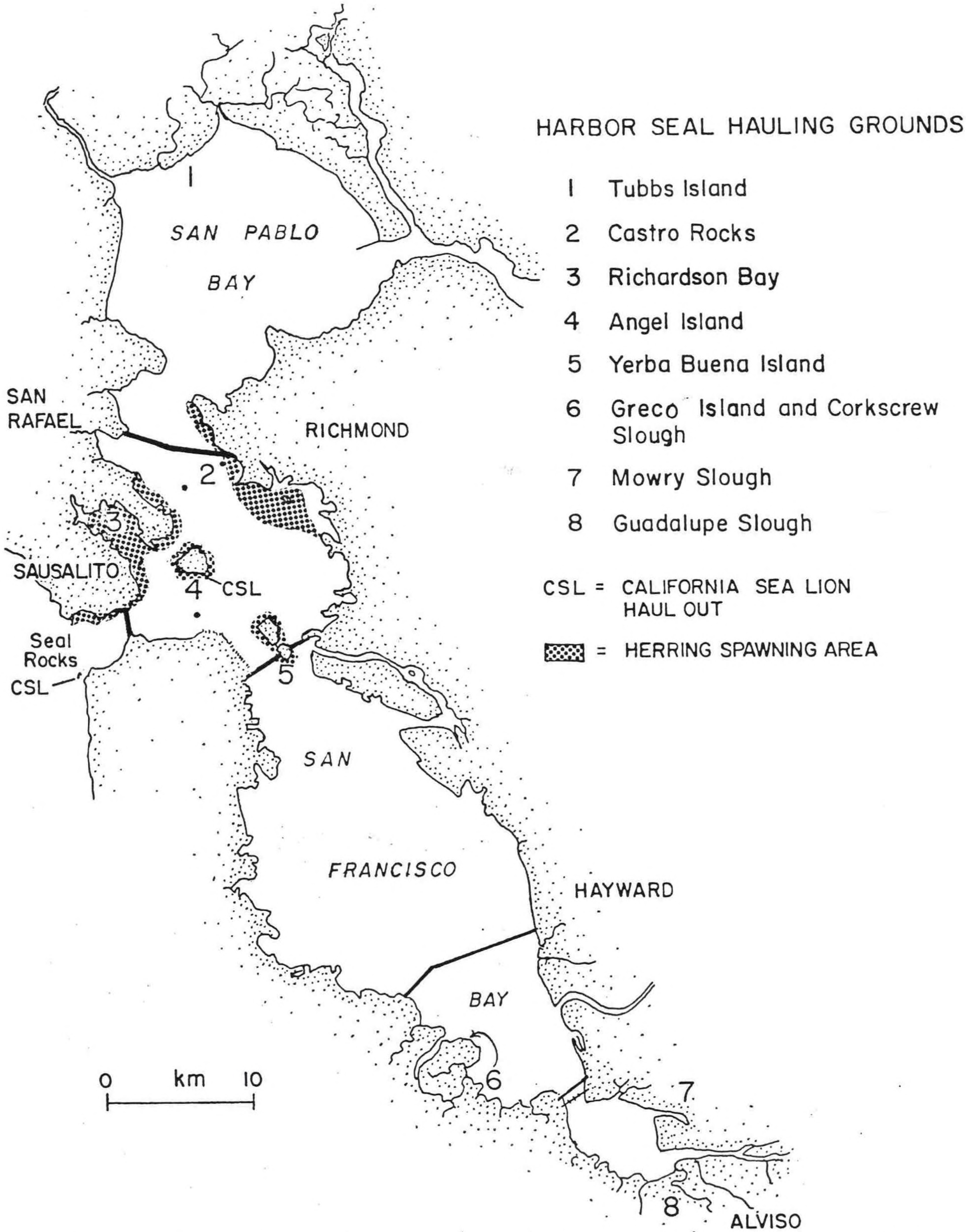

Figure 14. Location of Pacific herring spawning areas and pinniped hauling grounds in San Pablo and San Francisco bays.

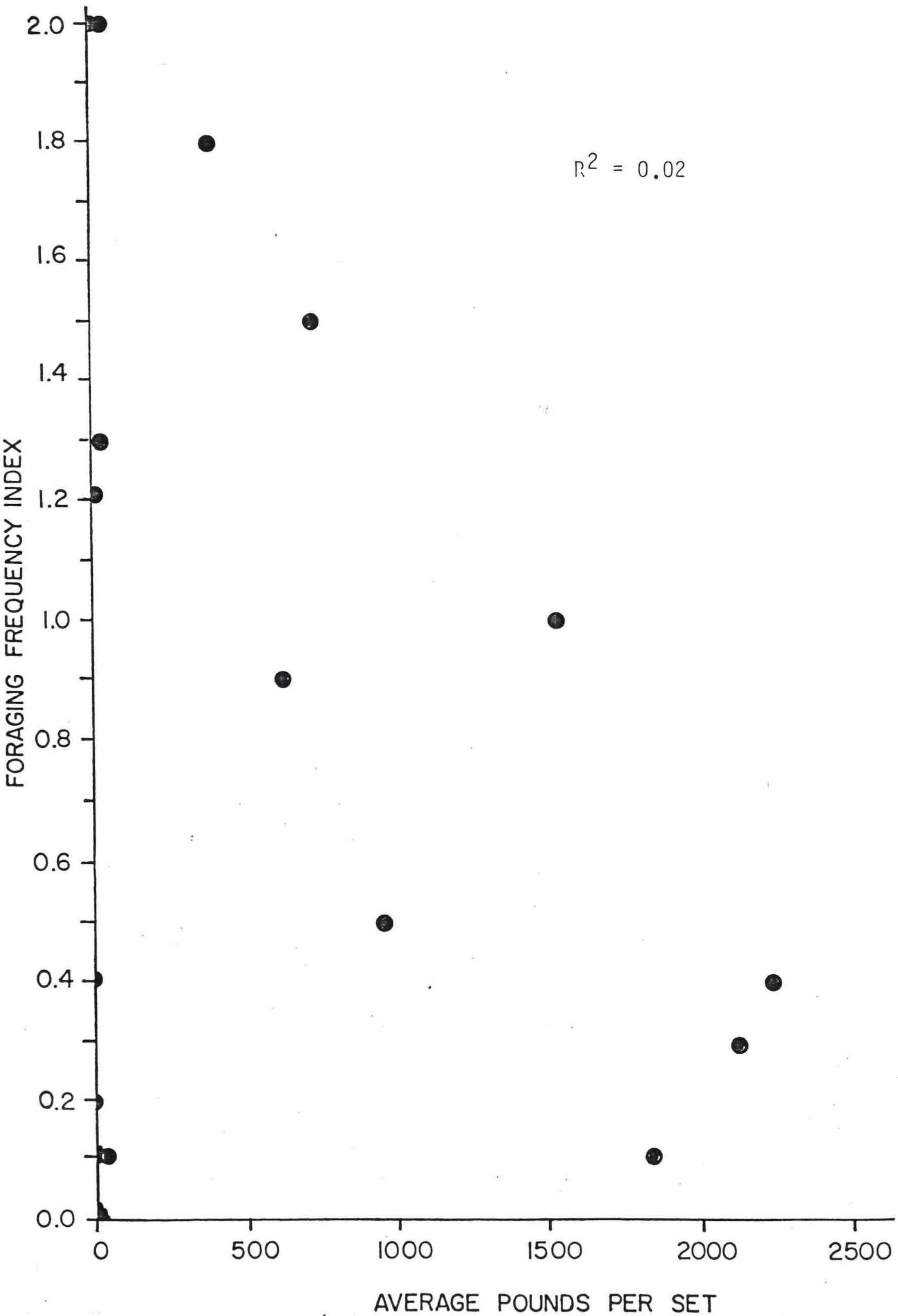

Figure 15. Comparison of foraging frequency index and average pounds per set in Pacific herring gill nets, San Francisco Bay, 1980-81.

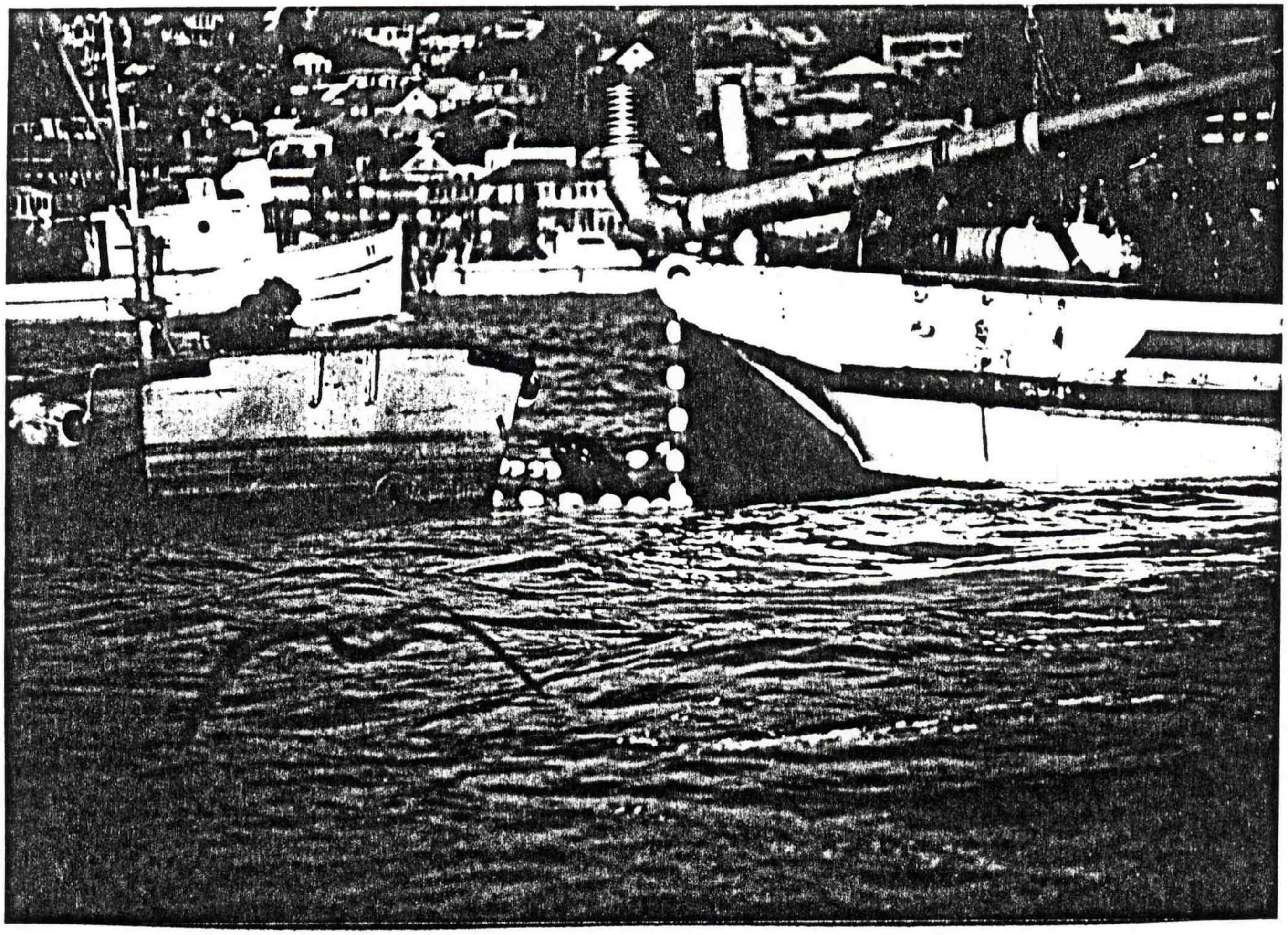

Figure 16. Adult California sea lion foraging on Pacific herring as the fish are about to be brailed out of a lampara net bag.

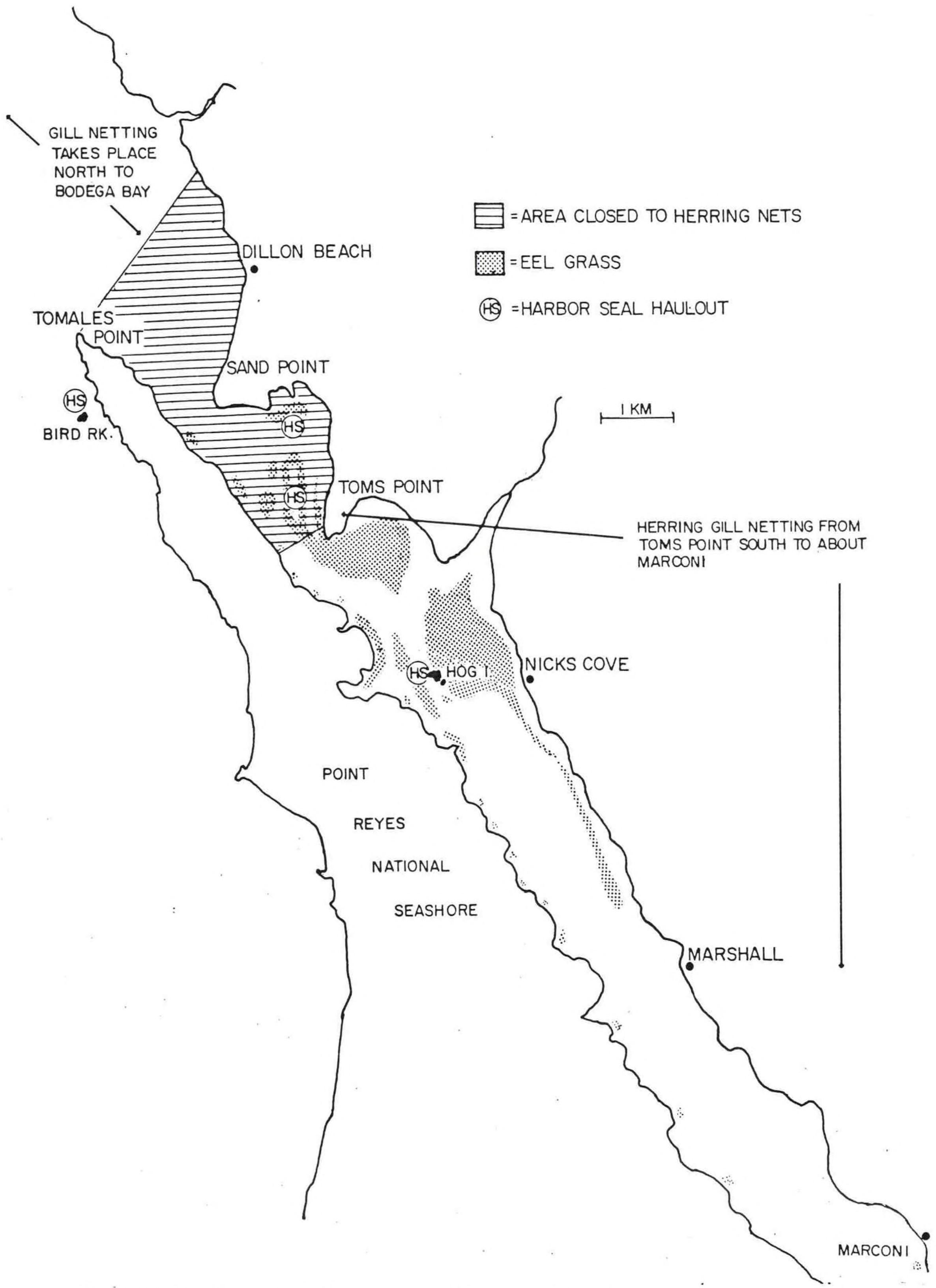

Figure 17. Pacific herring fishing areas and harbor seal hauling grounds in and near Tomales Bay.

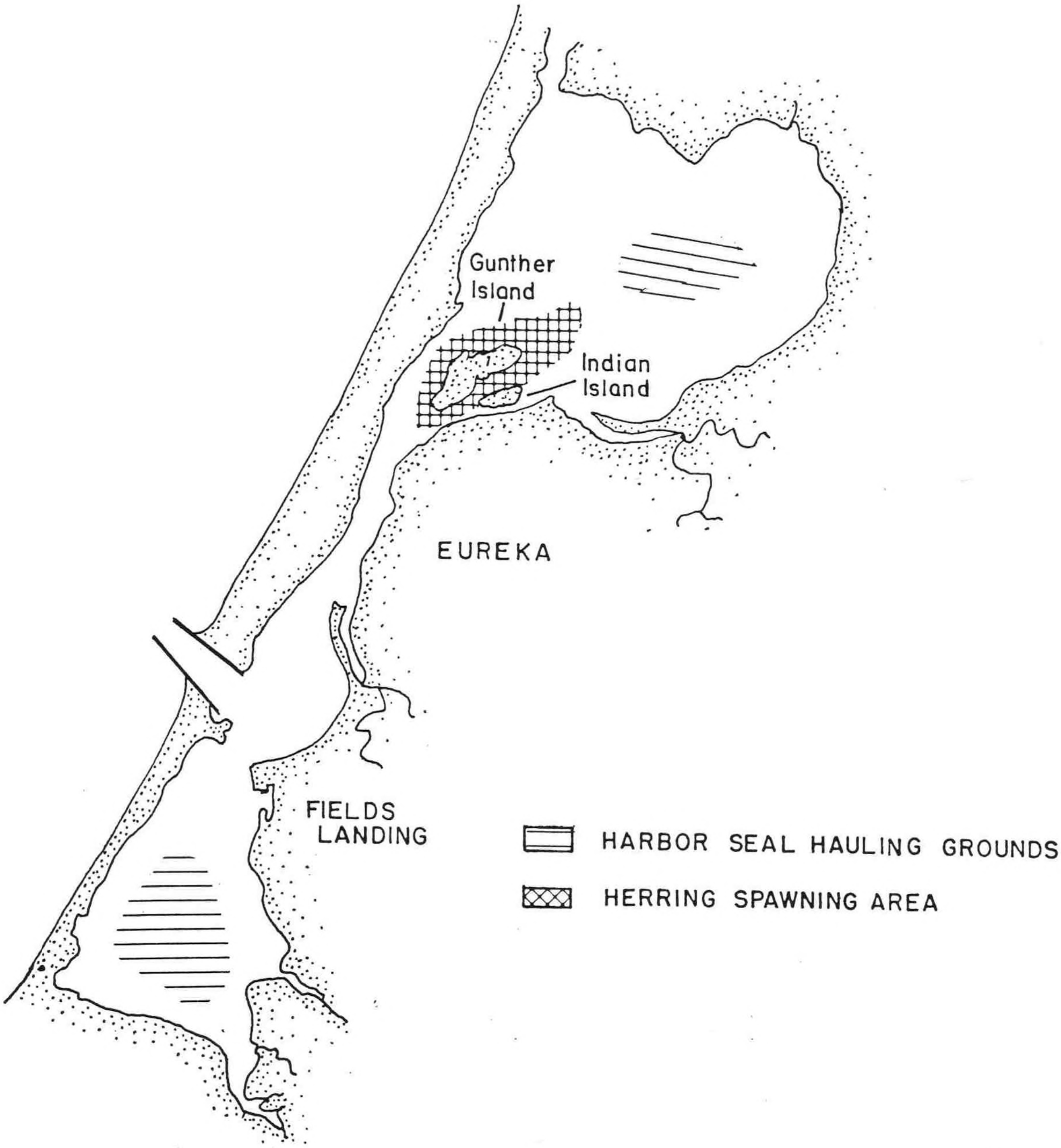

Figure 18. Pacific herring spawning areas and harbor seal hauling grounds in Humboldt Bay.

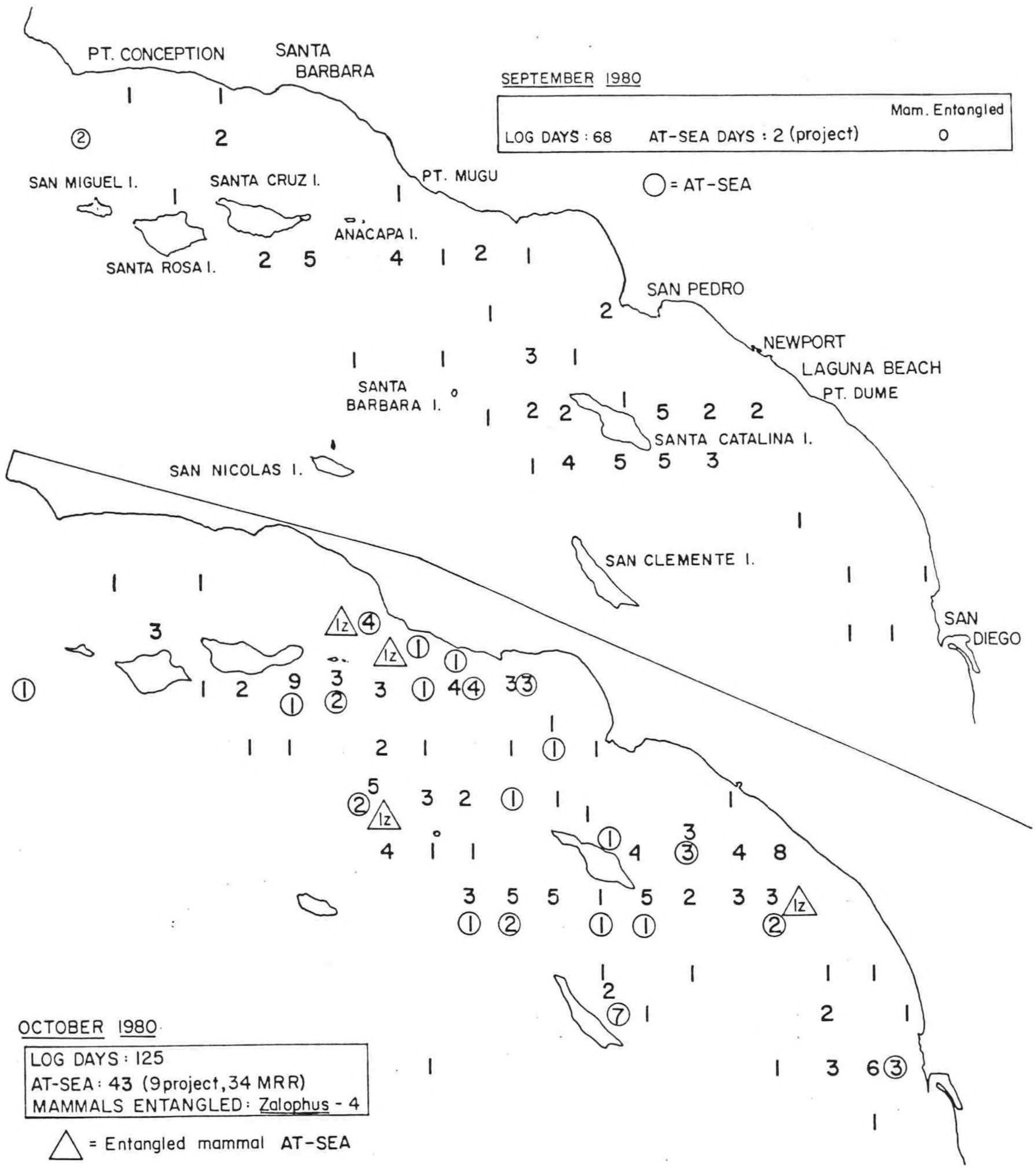

Figure 19. Number of shark drift gill net sets, number of at-sea samples, and number of marine mammals drowned in nets by catch block areas, September and October, 1980.

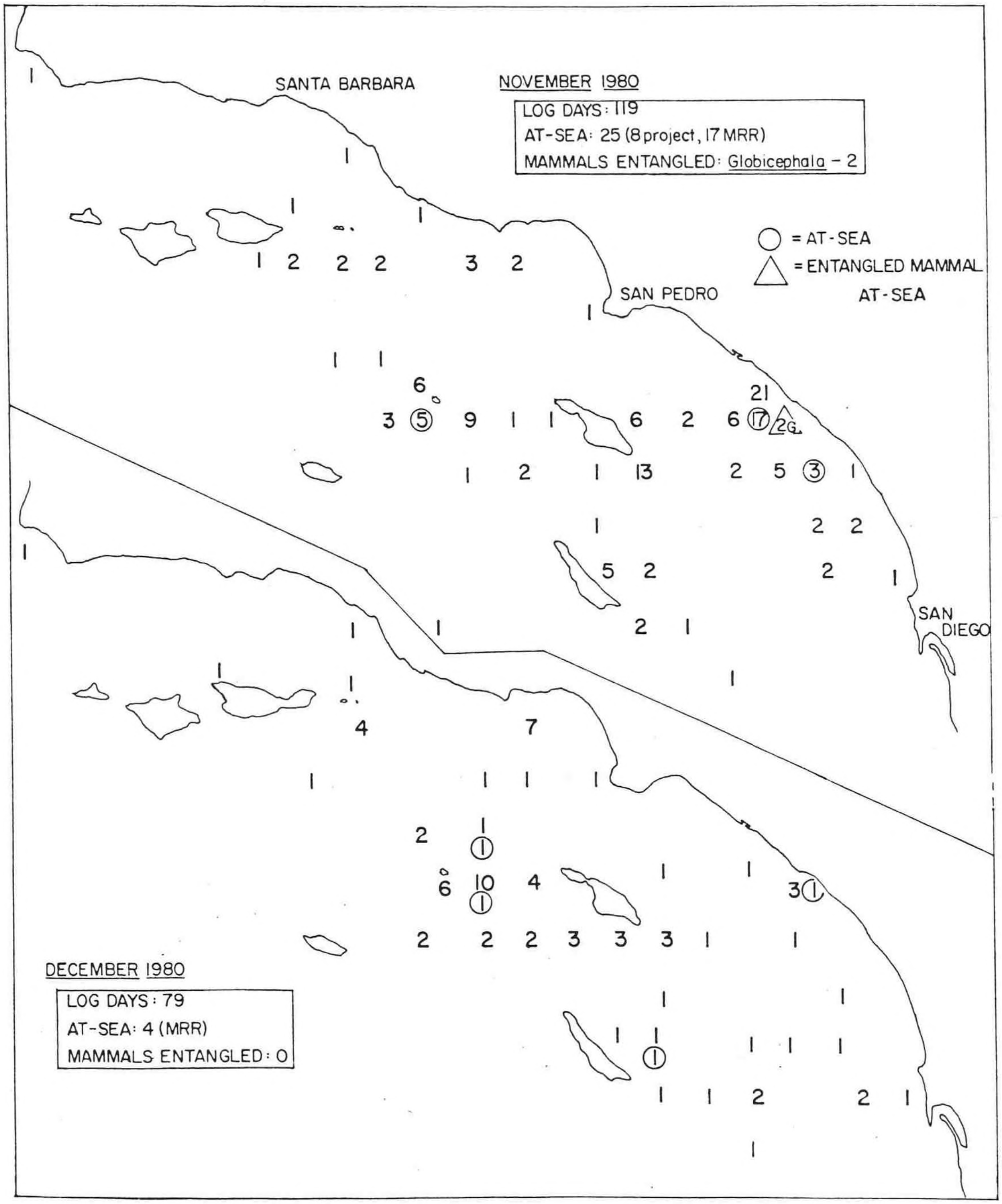

Figure 20. Number of shark drift gill net sets, number of at-sea samples, and number of marine mammals drowned in nets by catch block areas, November and December, 1980.

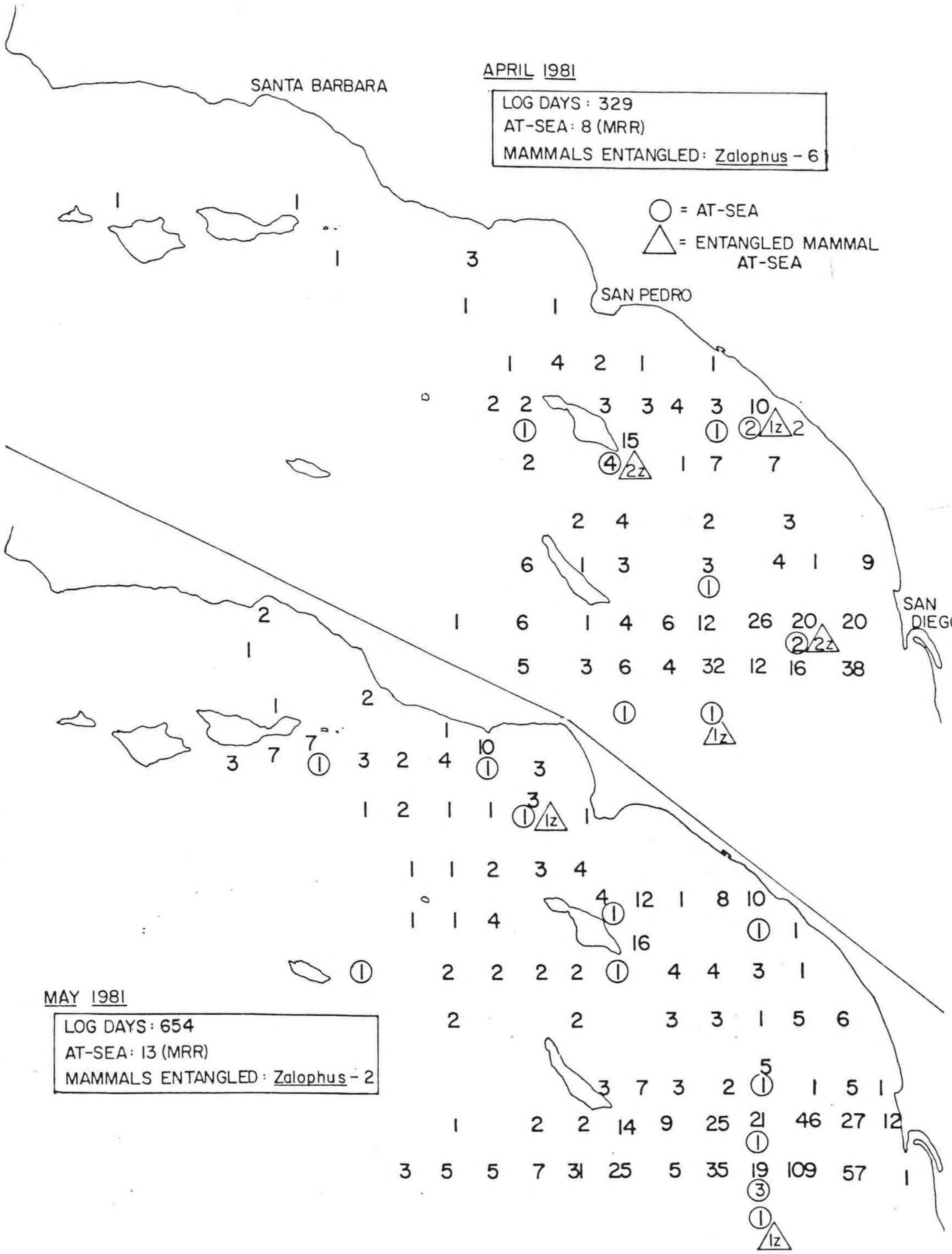

Figure 21. Number of shark drift gill net sets, number of at-sea samples, and number of marine mammals drowned in nets by catch block areas, April and May, 1981.

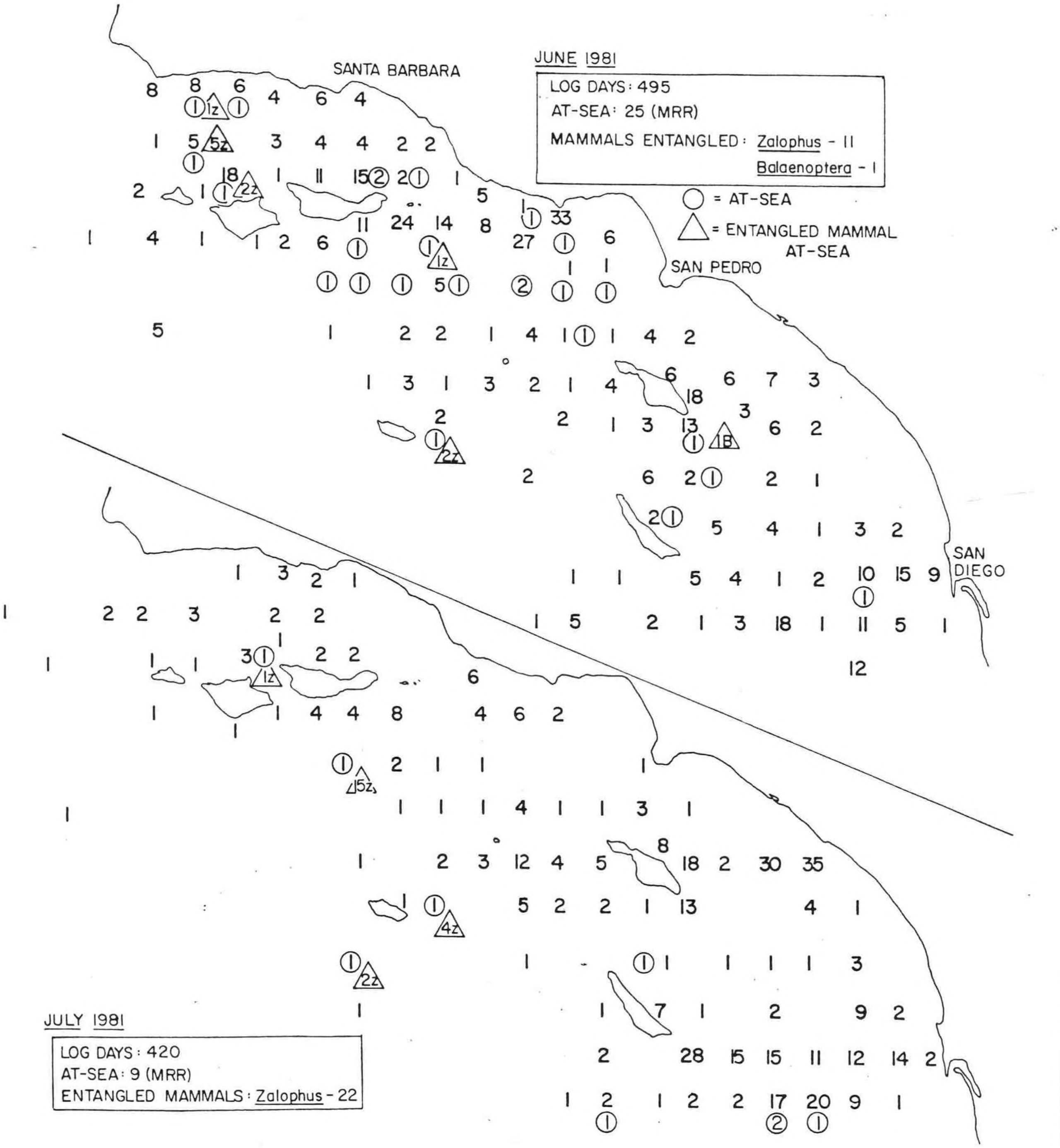

Figure 22. Number of shark drift gill net sets, number of at-sea samples, and number of marine mammals drowned in nets by catch block areas, June and July, 1981.

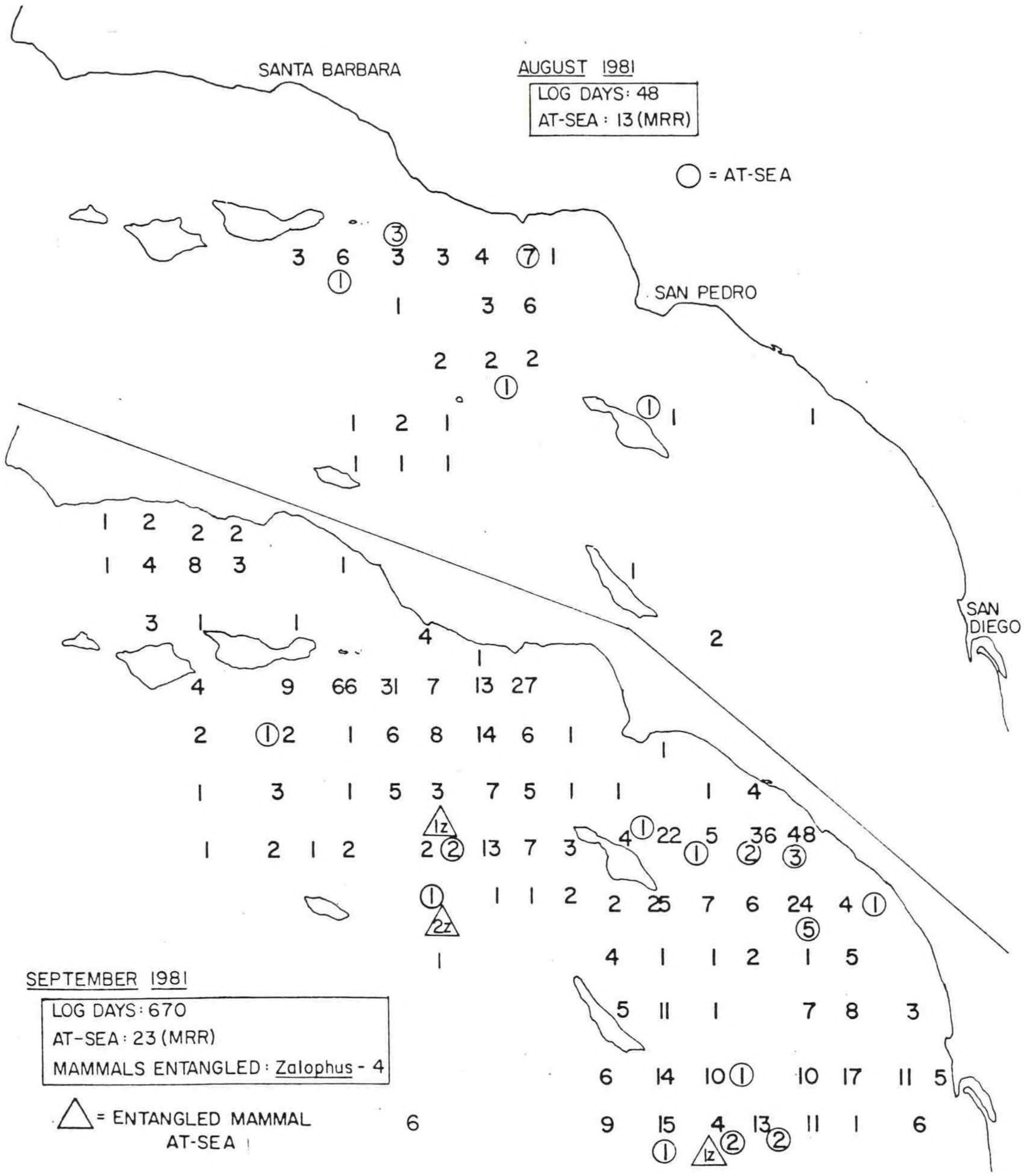

Figure 23. Number of shark drift gill net sets and number of at-sea samples by catch block areas, August and September, 1981.

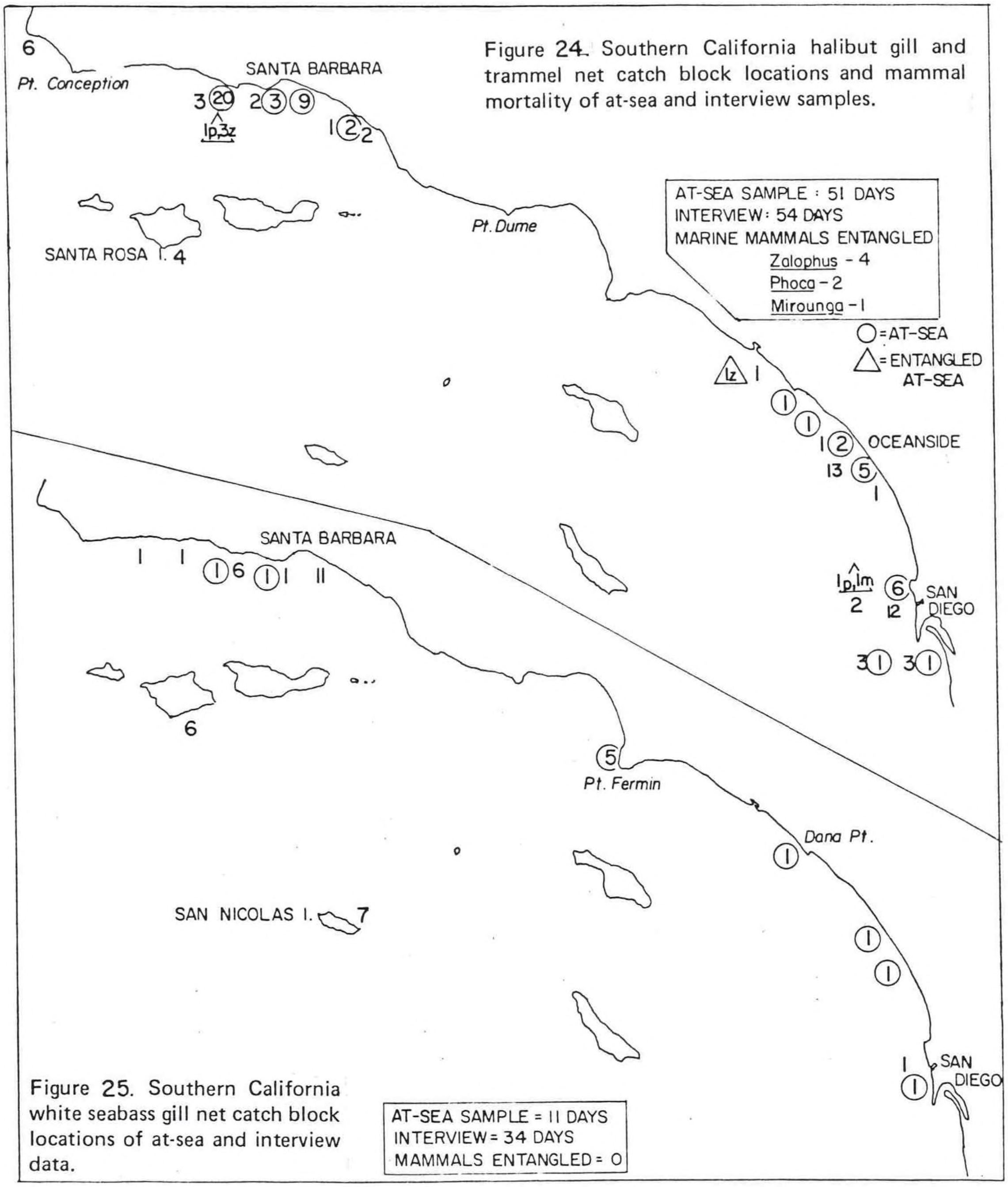

Figure 24. Southern California halibut gill and trammel net catch block locations and mammal mortality of at-sea and interview samples.

Figure 25. Southern California white seabass gill net catch block locations of at-sea and interview data.

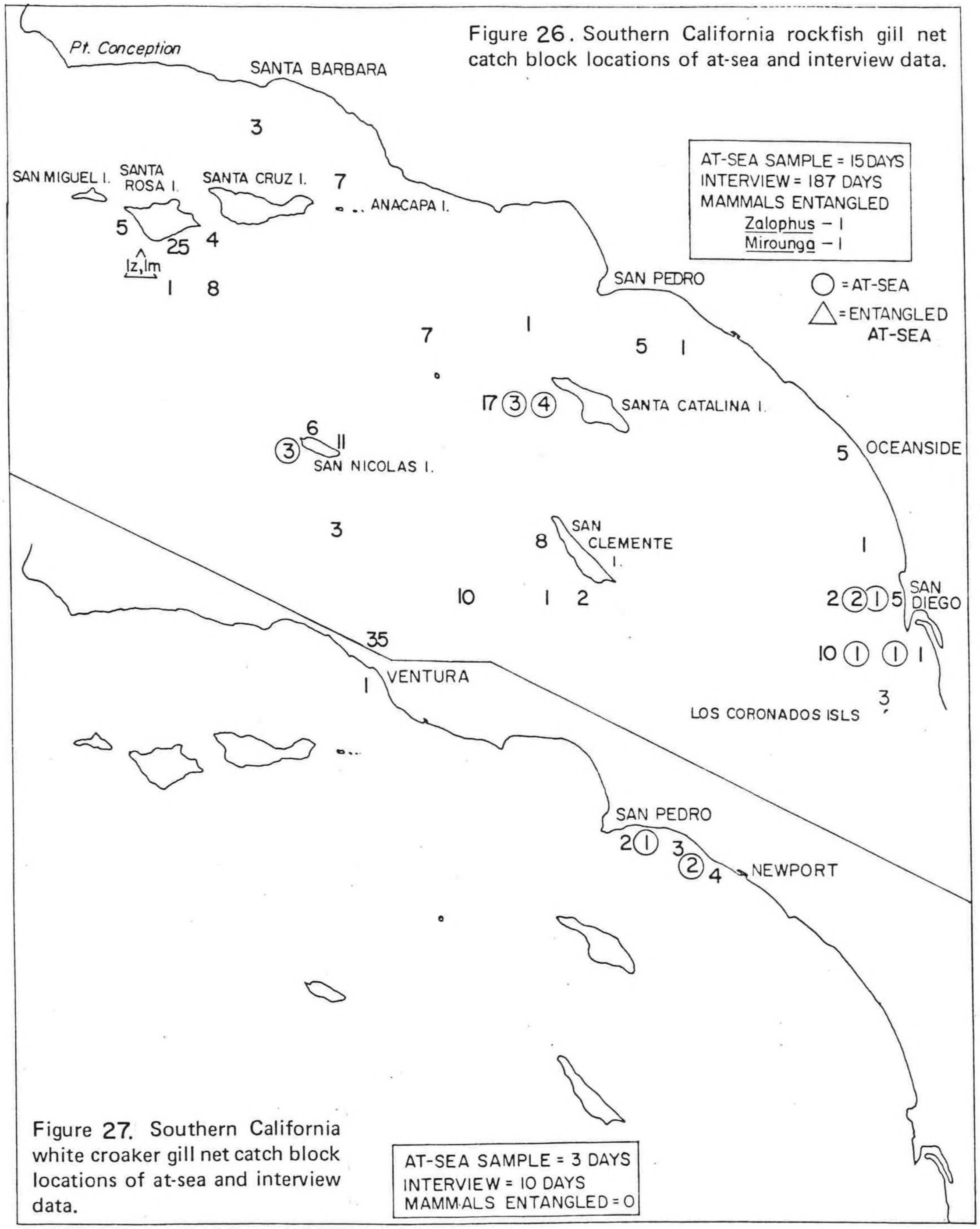

Figure 26. Southern California rockfish gill net catch block locations of at-sea and interview data.

Figure 27. Southern California white croaker gill net catch block locations of at-sea and interview data.

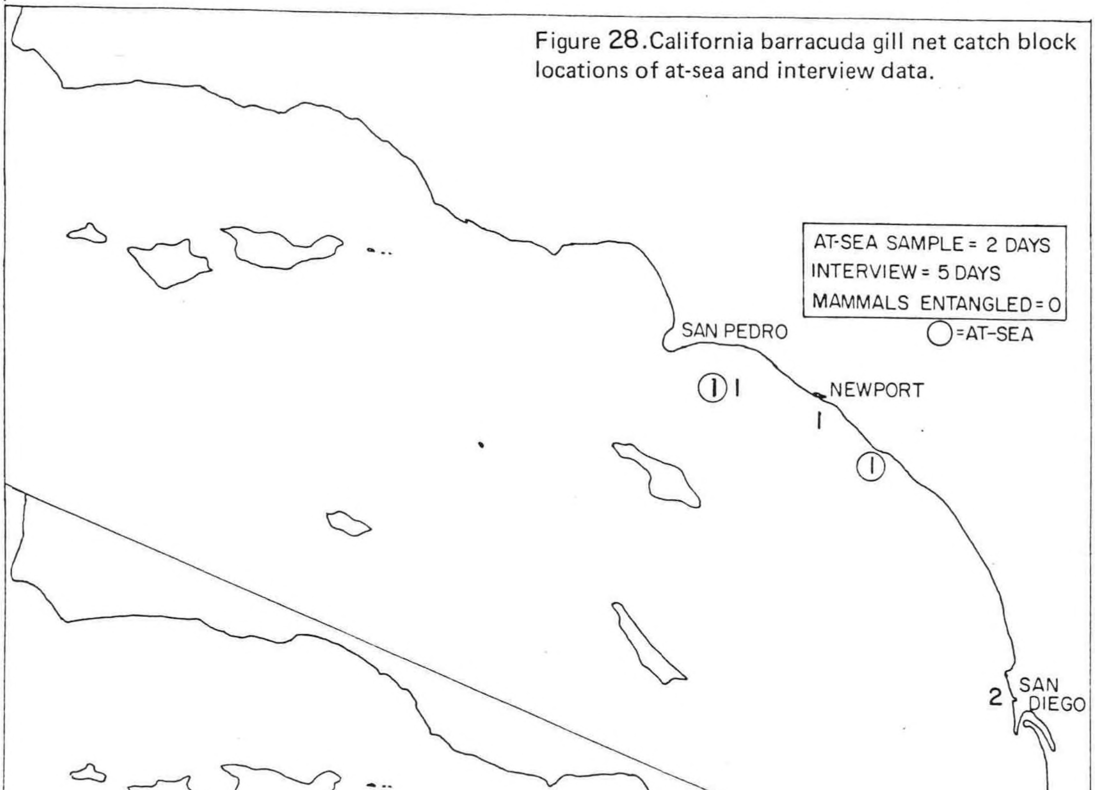

Figure 28. California barracuda gill net catch block locations of at-sea and interview data.

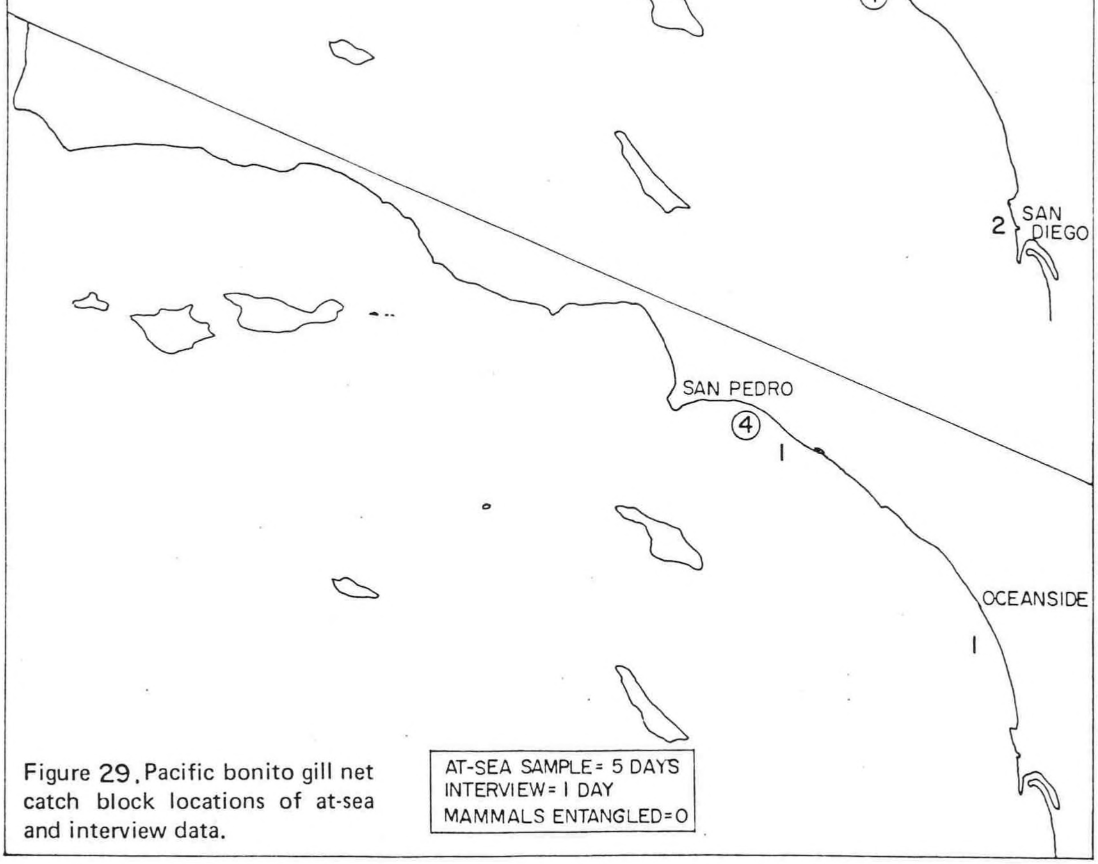

Figure 29. Pacific bonito gill net catch block locations of at-sea and interview data.

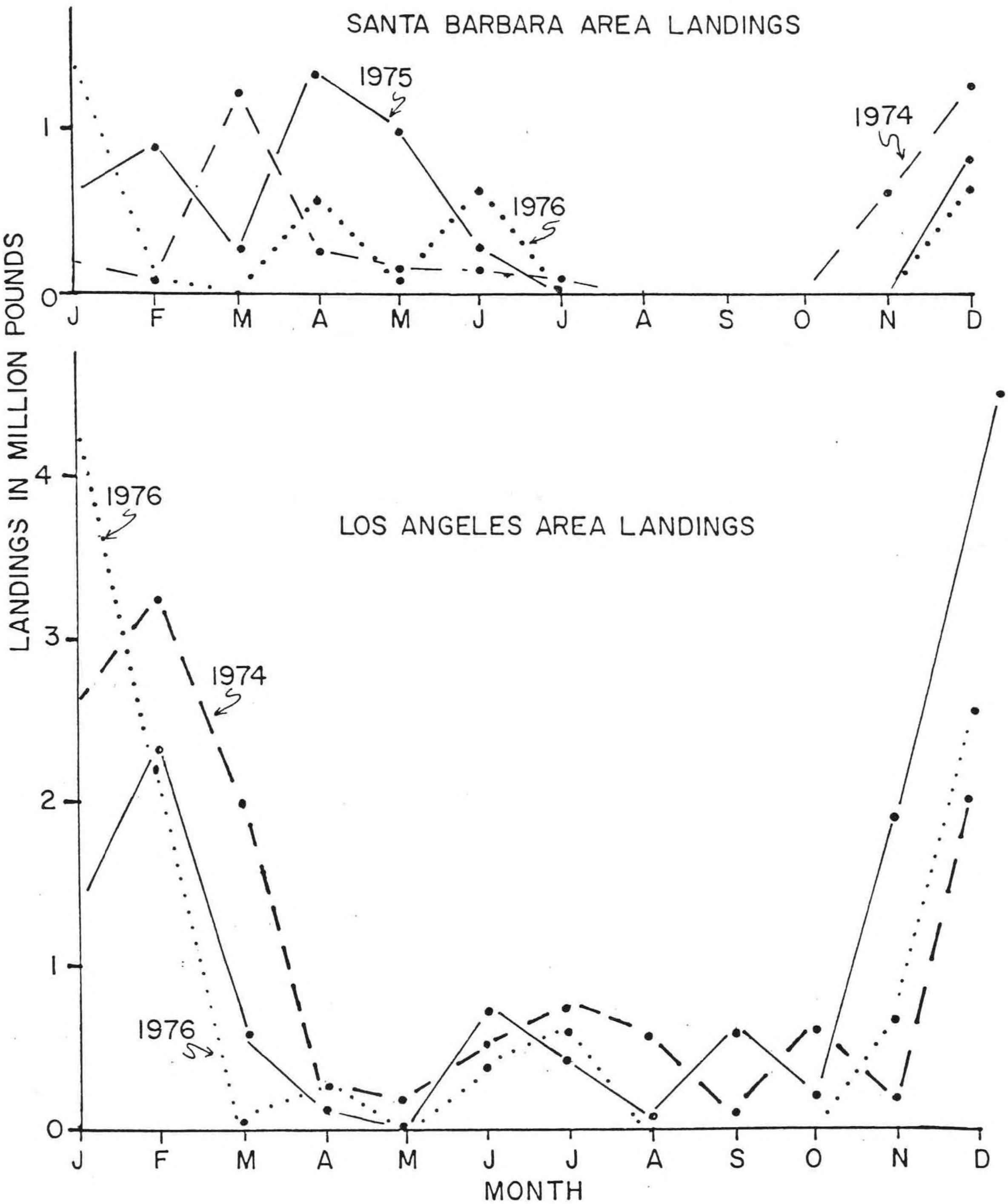

Figure 30. Market squid landings for the Santa Barbara and Los Angeles areas by month, 1974-1976.

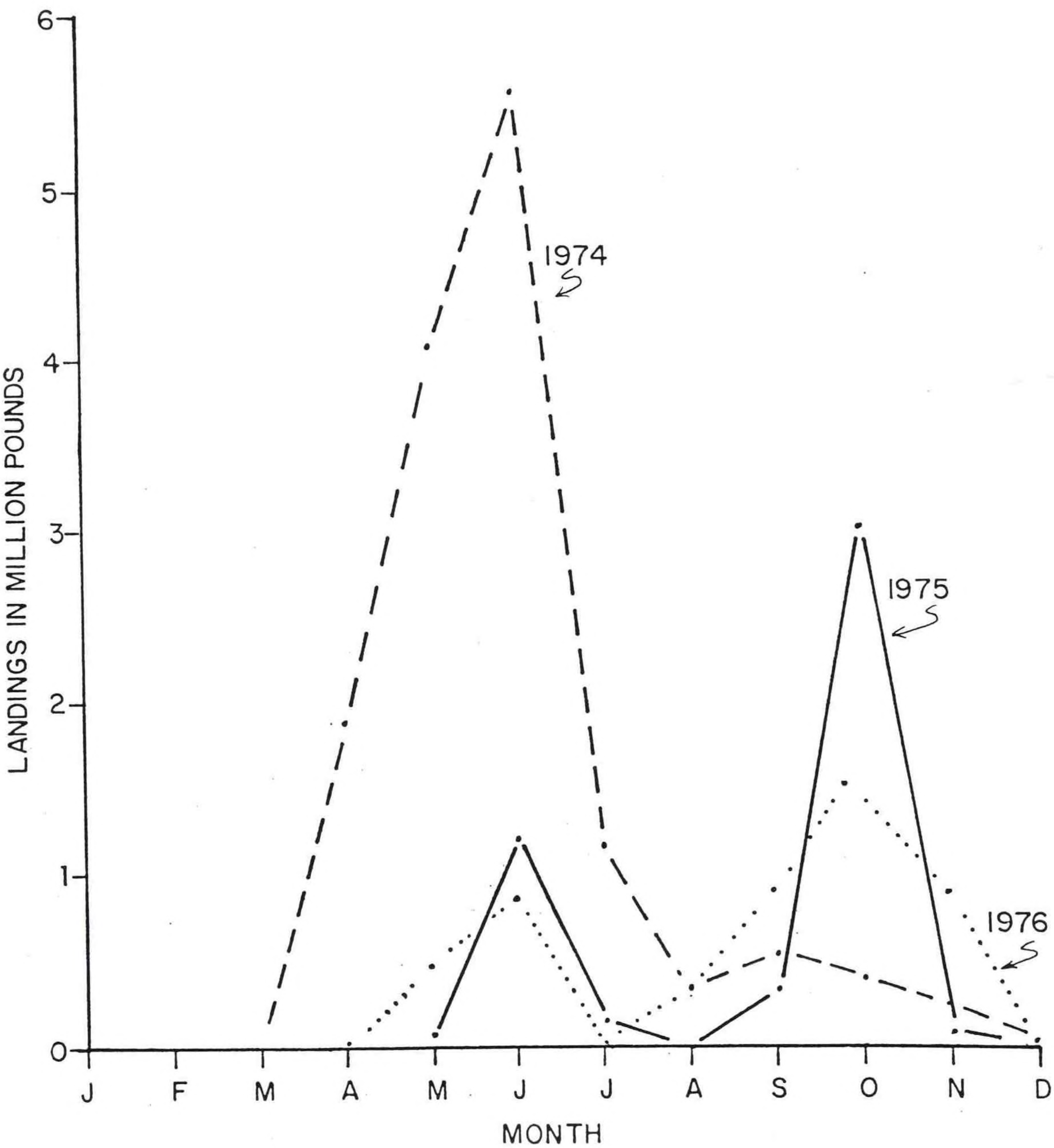

Figure 31. Market squid landings for the Monterey Bay area by month, 1974-1976.

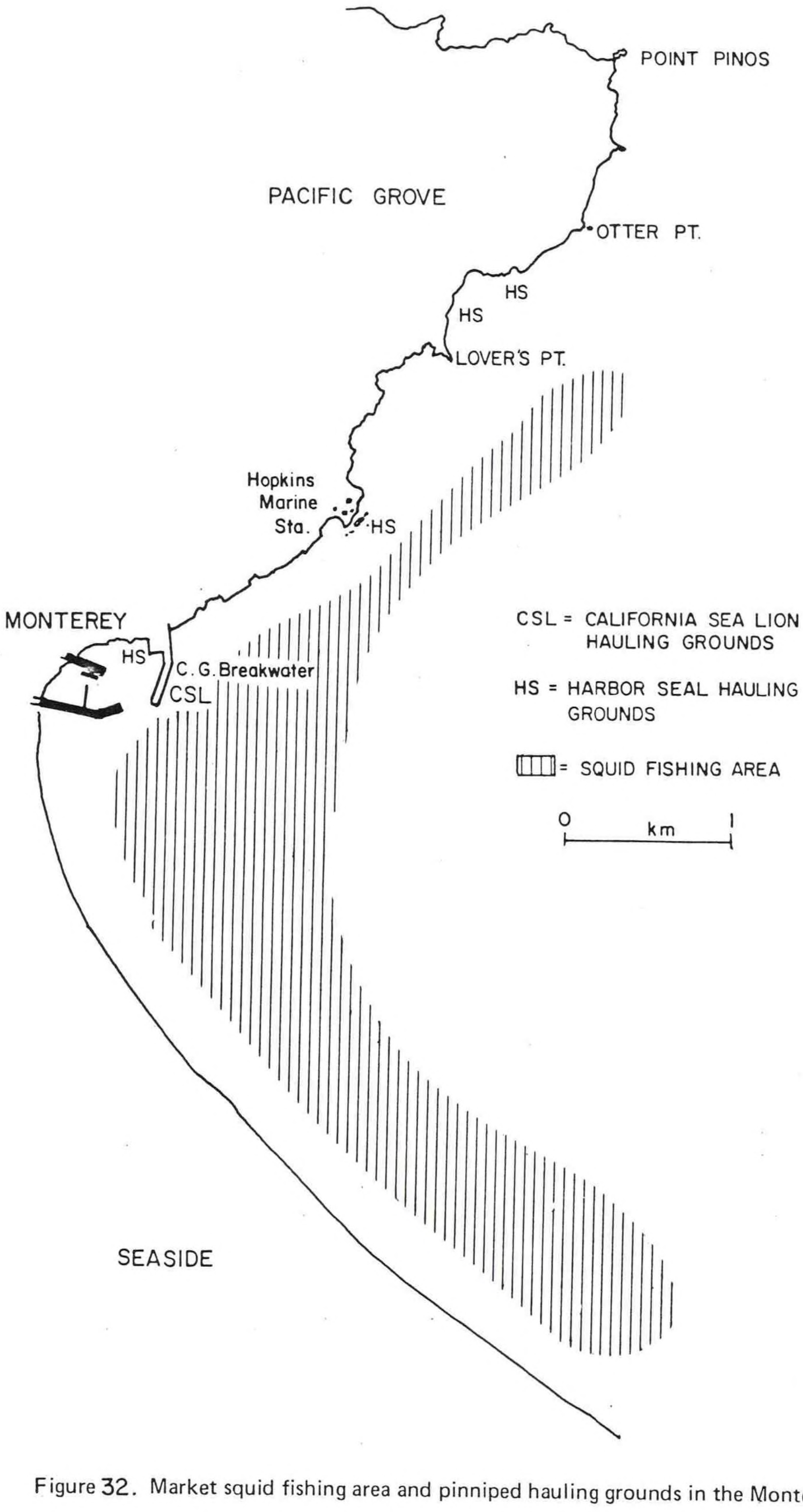

Figure 32. Market squid fishing area and pinniped hauling grounds in the Monterey area.

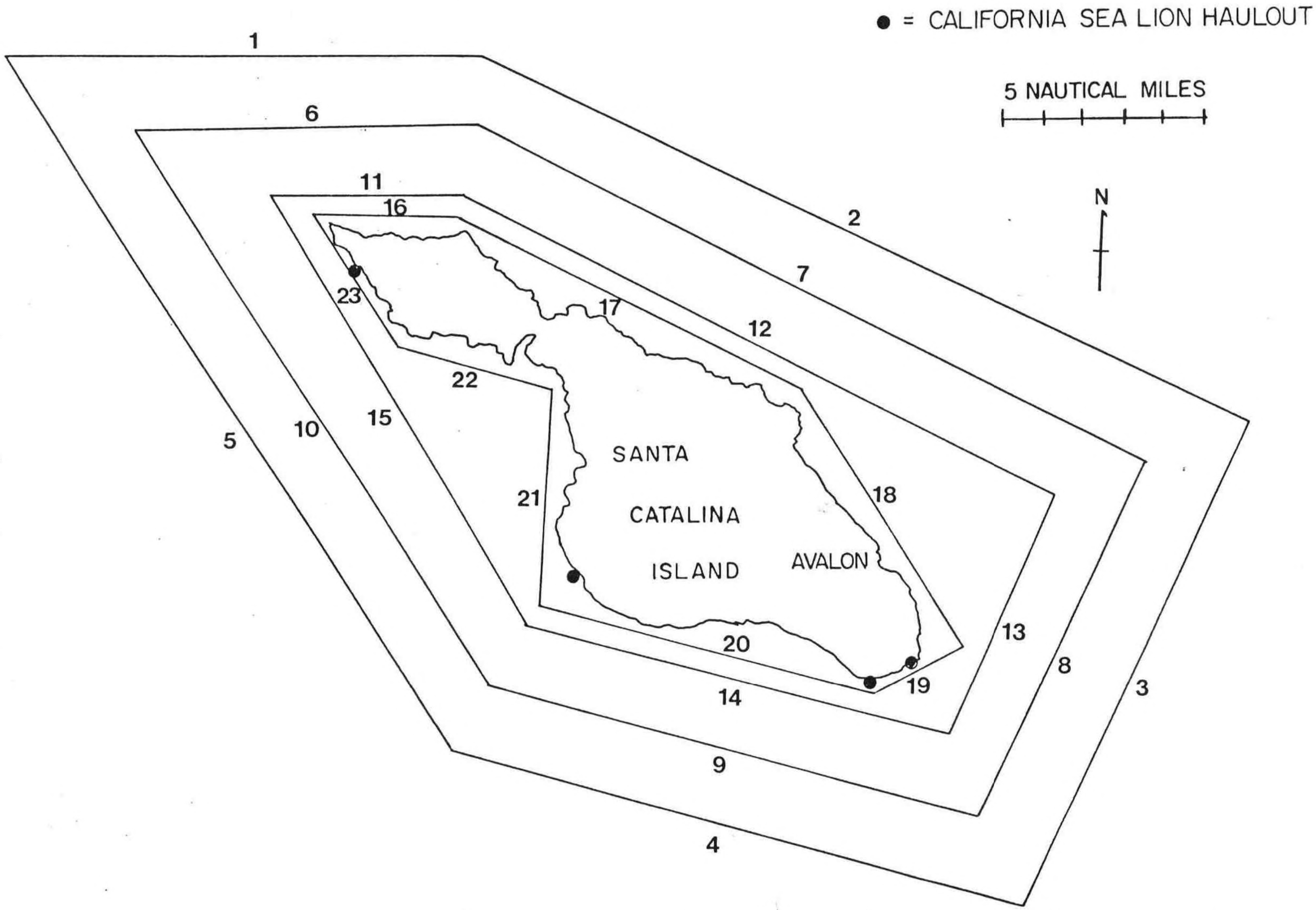

Figure 33. California sea lion hauling grounds and transect numbers utilized in the marine mammal census at Santa Catalina Island, December 1980 – March 1981.