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Early Life-History Studies of Nearshore Rockfishes and Lingcod off Central California, 1987-92

by **David A. VenTresca, James L. Houk, Michelle J. Paddack, Marty L. Gingras, Nicole L. Crane,** *and* **Scott D. Short**

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Abstract

This study focused on the physical and biological processes that influence the distribution, abundance, growth, and survival of young-of-the-year (YOY) rockfishes and lingcod along the central California coast. The annual somatic and reproductive condition of adult female blue rockfish corresponded to annual upwelling. Resulting larval production may correspond to the reproductive potential of adults; however, ultimate recruitment success of YOY is also effected by oceanographic conditions during their planktonic stage. Within a year, each species of settled YOY was observed concurrently and in relatively similar abundances at all study dive sites along the central coast. Most species of YOY exhibited similar growth patterns among stations and years. We found a high degree of interannual variability in the condition of adults and relative abundances of YOY. We believe a large part of this variability is due to annual oceanographic conditions, specifically upwelling.

Marine reserves, which would protect populations of reproductively mature rockfishes and lingcod and insure larval production, have been suggested as an alternative to present management strategies for these species. However, a crucial question is whether or not larvae from adult fish in reserves would significantly contribute to replenishing stocks in other areas. This study was undertaken to assist in determining the feasibility of reserves to enhance nearshore rockfish and lingcod populations.

Table of Contents

List of Figures

List of Tables

Preface

Nearshore reefs of central California are composed of a wide variety of habitats ranging from granitic pinnacles and vertical rock walls to horizontal hard-shale base rock and boulder fields interspersed with sand bottoms. Typically, spring upwelling brings to these reefs cold, nutrient-rich water which produces dense phytoplankton blooms and thick growths of macro algae. This lush plant growth provides the first link in the rich and diverse food chains of these reefs. These food chains support numerous fish species, many of which are an important component of sport and commercial fisheries, such as rockfish and lingcod.

Most species of adult rockfish are residential and exhibit limited or no movement between reef systems. Rockfishes are not only long-lived (14-60 years) but also reach sexual maturity at a relatively old age (5-9 years) (Lea et. al. in press). Lingcod migrate from deep water and utilize the nearshore reefs to build egg nests and subsequently guard the eggs until they hatch.

Since the mid-1950s, the quality of sport and commercial fishing has declined on most of the reefs nearest the fishing ports of Monterey and Morro Bay. Despite similarities in bottom topography, oceanographic conditions, flora, and invertebrate fauna, significant differences exist in the number, size, and species of sport fish inhabiting reefs adjacent to ports and reefs distant from ports. We believe that many of these differences are the result of fishing pressure.

Rockfishes are taken by most fishing methods. Set lines, gill and trammel nets, trawls, hook and line, and commercial gear-types are employed in their capture. Management of the commercial take of rockfishes is under the auspices of the Pacific Fishery Management Council. Sportfishers, including both anglers and divers, are currently restricted to 15 rockfish in any combination of species per day; there is no size or seasonal limitation.

The limited movement, late maturity, and lengthy juvenile stage of rockfishes, coupled with heavy fishing pressure, has resulted in removal of many mature fish from reefs proximal to fishing ports. Once large, reproductive adults are removed, continued fishing pressure prevents the remaining fish from reaching the size at which sexual maturity occurs. Spawning potential may also decline when natural phenomena, such as an El Niño event, reduce growth rates, survival, and reproductive capacity (Bailey and Incze 1985). In Monterey Bay from 1987 to 1991, the average length of many species sampled in the commercial passenger fishing vessel (CPFV) fishery was below the average size at 50% sexual maturity (Reilly et. al. 1993).

The size, relative abundance, and species composition of sport fish now caught inside Monterey Bay is quite different from that in less utilized areas of Carmel Bay, Point Sur, and the Big Sur coast (VenTresca and Lea 1984). If sport anglers are to have a positive fishing experience in future decades we must now explore alternative management strategies to present bag limit regulations.

Our research, as part of the Central California Marine Sport Fish Project, indicates that a system of unfished areas (marine resource reserves) could protect populations of reproductively mature rockfishes. These populations would be a continual source of larvae which in turn would be carried via nearshore currents to other sections of the coastline (Lea et. al. in press). This management approach will reinforce and enhance the reproductive strategies of rockfishes. After birth young rockfish and lingcod are planktonic and remain in the water column for several months before settlement. During this time wind-driven currents frequently move large volumes of water great distances, and may transport larvae far from where they were spawned.

A crucial question to be addressed in determining the size, placement, and ultimate contribution of marine reserves is whether larvae from adult fish in reserves would significantly contribute to replenishing stocks in other areas. To answer this we must understand how physical and biological processes influence the distribution, abundance, growth, and survival of young-of-the-year (YOY) rockfishes and lingcod. Data from a long time series, such as we are collecting, are required to relate the effects of these variables to recruitment success.

Introduction

The planktonic stage of the eggs and larvae of marine organisms has long been considered a crucial period in determining year-class strength and magnitude of recruitment to fisheries. The relationship of oceanographic processes to ultimate recruitment success has been studied by numerous researchers (Parrish et. al. 1981, McLain and Thomas 1983, Norton 1987). Mason and Bakun (1986) hypothesized that fluctuations in stocks of pelagic fishes may be due to interannual variability in upwelling intensity. Peterson (1973) suggests that annual upwelling fluctuations are related to annual variations in the biomass of the Dungeness crab, *Cancer magister*, due to a dependence on increased food production during summer upwelling for growth and survival of larvae. Kim and Bang (1990) used a model of physical oceanographic processes to examine the dispersal of walleye pollock, *Theragra chalcogramma*, larvae, to explain spatio-temporal distribution of larval abundance, and to estimate population parameters such as larval mortality.

Transport and dispersal of eggs and larvae by oceanographic processes appears to be a key factor in recruitment success. Studying larval fish transport in Hawaiian waters, Lobel and Robinson (1986) found that mesoscale eddies or current systems can entrain and entrap larvae from reefs and that sufficient residence time exists for many reef fish species to complete their pelagic development phase. Iwatsuki et. al. (1989) concluded that thermohaline fronts at the mouth of Tokyo Bay may enhance larval survival because they act as barriers for most larvae advecting from the bay, thus keeping the larvae in an area of high concentration of suitable food organisms. In some cases fronts act as a barrier to fish and invertebrate larvae, which are prevented from reaching shore. Retention of larvae away from shore for many months may result in low recruitment levels in some areas (Graham et. al. 1992).

The timing and location of initial settlement of YOY fish after their planktonic stage may also have a significant effect on the ultimate recruitment success of a cohort into the fishery. Larson et. al. (1994) found the smallest pelagic juvenile rockfishes often appeared offshore, in the region of the upwelling fronts, which suggested that they had been advected offshore at some time during upwelling. Lincoln-Smith et. al. (1991) found high variability in abundance of some species of recently settled fish within reefs and among reefs in southeastern Australia. Microhabitat preference can also have a profound effect on the distribution of settled YOY (Levin 1991).

Numerous studies have established the importance of giant kelp, *Macrocystis pyrifera*, canopy as a refuge for YOY rockfishes. In 1976, Houk and McCleneghan (1993) studied the movement and relative abundance of YOY rockfishes in kelp forests along the central California coast. Nelson (1992) followed the migration of YOY kelp rockfish from initial settlement in the canopy of giant kelp to later association with kelp holdfasts. Anderson (1983) identified and described the developmental stages of 18 species of newly settled rockfishes in giant kelp habitats in Stillwater Cove, Carmel. Carr (1983) monitored the seasonal abundance and spatial distribution of nine *Sebastes* species in the same area. Singer (1982) investigated the food habits of selected YOY rockfishes occurring in the Stillwater Cove kelp forest and assessed whether these co-occurring species exhibited partitioning of food resources either by differences in diet or in time of feeding activity. Danner and Schlotterbeck (1992) felt that the high numbers of YOY rockfishes on the newly constructed San Luis Obispo County Artificial Reef (SLOCAR) were due to greater densities of the canopy-forming bull kelp, *Nereocystis luetkeana*, on SLOCAR compared to surrounding natural reefs.

The Groundfish Communities Investigations Group of the Tiburon Laboratory of the Southwest Fisheries Science Center, National Marine Fisheries Service (NMFS) is presently conducting a long-term study of rockfish recruitment (Lenarz and Moreland 1985). The study is focusing on three major objectives: 1) to develop methods for predicting year-class strength of species of rockfish that are either important to the fisheries or are abundant; 2) to gain insight into factors that affect strength of recruitment; and 3) to develop a better understanding of the niches of juveniles of important species.

The object of our study is to examine interannual variability of: 1) the reproductive condition and onset of spawning of adult blue rockfish as an indicator species; 2) the abundance and transport of rockfish during their planktonic stage; 3) the dispersal and timing of initial nearshore settlement of post-planktonic rockfish and lingcod; and 4) the abundance and growth of these fishes during their first year. Larvae abundances and movement were explored during offshore studies of larval and prerecruit aggregations and related physical processes. Initial nearshore settlement, abundance, and growth of fish during their first year were documented during nearshore scuba surveys.

The purpose of this study is to examine the relationship among the spawning condition of adult rockfish, the timing of spawning events, associated oceanographic events, and initial nearshore settlement of YOY. Knowledge of these relationships will assist explaining the interannual variability of recruitment success. Only then can informed and responsible decisions concerning the number, location, size, and contribution to fisheries of future marine reserves be made.

Methods

All fish referred to in this study are young-of-the-year (YOY) unless stated otherwise. Common names are used in the text and the reader is directed to Table 1 for the scientific names.

Study Areas and Collection Dates

Nearshore aspects of the study were conducted at 20 stations along the central California coast from Santa Cruz to Port San Luis (Figure 1 and Table 2). These stations were in depths of 1 to 40 m and were sampled with either scuba, hook-and-line, or a 16-ft otter trawl. Young-of-the-year fishes were collected from 1987 through 1992 and adult female blue rockfish from 1979 through 1992.

Moss Landing Marine Laboratories (MLML) graduate students conducted offshore icthyoplankton surveys with neuston and bongo nets for larval rockfish off Davenport from December 1991 through April 1992. In a cooperative study with MLML and Pacific Fisheries Environmental Group (PFEG), a division of the National Marine Fisheries Service in Monterey, we sampled an additional 57 offshore stations in May, June, and July 1992 with a neuston net and an 80-ft midwater trawl to collect information on pelagic pre-settled fish (Figures 2,3, and 4). These stations were located 2 to 10 nautical miles from shore off Davenport and in Monterey Bay.

Sea surface temperature was taken daily from 1978 through 1992 at the Department of Fish and Game's Marine Culture Laboratory (MCL) at Granite Canyon (19.2 km south of Monterey).

Initial Nearshore Observations and Relative Abundances

Timed Transects

Timed transects were used to collect information on initial occurrence and relative abundance of rockfishes and lingcod in nearshore habitats. This method was modeled after a technique described by Hobson et. al. (1986). Transect areas were randomly stratified by depth and habitat type (i.e. rocky reef, sand/rock interface, shallow sand, eelgrass (*Zostera* sp.) bed, a brown alga (*Desmerestia* sp.) bed, or giant kelp canopy. Divers standardized their swimming speed to cover 20 m during a 1-min period, during practice swims over known distances, and counted fishes only within an area 2 m × 2 m along the transect (Figure 5). Data for each timed transect consisted of all fish observed during 1 min. for each diver. Divers recorded data on waterproof paper attached to a writing slate equipped with a compass, capillary depth gauge, and a count-down timer set to 1 min. Divers followed a pre-determined compass bearing and swam side by side at least 3 m apart. Hand signals were used to simultaneously start each min. count.

Divers were trained in rockfish and lingcod identification. Underwater, some species of newly settled rockfish look very similar. When rockfish could not be confidently identified to species in situ, they were recorded as complexes of similar-looking fishes (e.g. olive, yellowtail, and black rockfish complex [OYTB]; olive and yellowtail rockfish complex [OYT]; kelp, gopher, and black-and-yellow rockfish complex [KGB]; gopher and black-and-yellow rockfish complex [GBY]). Another grouping used by ourselves and other researchers is the "black dorsal spot group" which is comprised of species (black, blue, canary, olive, widow, and yellowtail rockfishes) which have a characteristic black spot on their spinous dorsal fin. When possible, questionable rockfish were collected in the field and returned to the laboratory for positive identification using morphometric and meristic characters described in Laidig and Adams (1991).

Data are presented as the monthly mean number of each species observed per minute at each station, except for infrequently sampled stations where data are presented as the daily mean number of each species observed per minute. Monthly and daily means for each station were derived by dividing the total number of each species counted by the total number of minutes observed during that month or day. Timed and permanent transect data were combined for this analysis. Minutes during which no fish were observed were recorded as zero and were included in the analysis.

Permanent Transects

Permanent transects were used as a second method of estimating relative abundance. Permanent transect lines were deployed on a rocky reef habitat between 10 and 18 m at Otter Point in Monterey Bay (Figure 6). The first line (Line 10) was deployed in May 1991, Lines 20 and 30 were added in July 1991, and a fourth line (Line 50) was added in April 1992. Each line was a 60-m leadline marked at 20-m intervals with a yellow plastic cattle ear tag and a small float tethered 2 m off the bottom. All lines were oriented parallel to the sand/rock interface of the reef and spaced approximately 4 m apart. Lines were surveyed by two divers simultaneously in a method similar to timed transects. Fish counts were recorded at the end of each 20-m segment. Each diver surveyed an area 2 m wide by 2 m high on their side of the line.

Artificial Habitats (condos)

We deployed two types of artificial habitats (condos) as a third method to estimate relative abundance of more cryptic species because of the difficulty of counting these rockfishes using transect methods. Condos were deployed at Monterey, Big Creek, and Diablo Canyon.

Pipe condos were constructed from 5-cm square vexar mesh (Figure 7). A 1.8 × 1.2-m section of vexar was rolled into a cylinder 1.2 × 0.4-m in diameter to create the condo. Twenty 15 × 5-cm PVC pipes were laced into each condo to maintain space between the layers of vexar mesh. A foam float was fastened to one end of each condo to provide floatation and to orient the PVC pipes parallel with the sea floor. The other end was chained to the reef.

Rock condos were constructed of 1.3-cm rebar bent into a square shape and covered with vexar in the shape of an arch (Figure 8). Strands of 2.5-cm unbraded polypropylene rope were attached to the top of the vexar to resemble algal turf and provided additional shelter for fish. The rock condos were chained to each other and to the reef.

All condos were deployed at depths between 12 and 17 m in similar habitats on reefs with moderate relief. They were marked with bright yellow plastic cattle ear tags for identification. Counts were made of fish inside and within 1 m of the condos.

Young-of-the-Year Collections

A total of 11,012 YOY fish was collected for identification and to obtain growth rate information from 1989 to 1992. Sixty-six percent of the fish were collected by spearing, 21% with a two-diver operated lift net (McCleneghan and Houk 1978), 6% with otter trawls, and the remaining 7% by either a small hand-held, one diver operated net, a diver goody bag, or anesthesia (Houk et. al. 1992). Fish were not collected in the same area in which counts for relative abundance estimates were made.

Divers used 4-ft long fiberglass pole spears with homemade tips (Figure 9). Tips were constructed with a cluster of eight 10-cm long by 1-mm thick finely sharpened stainless steel welding rods epoxied into the 7-mm end of a 6 x 7 mm female/female threaded adaptor. When the rods in a tip became dull or bent they could be removed from the adaptor by heating and eight new sharpened rods could be mounted.

Divers used three different-sized nets to capture fishes using scuba. The largest was a two-diver operated net designed by McCleneghan and Houk (1978). It was constructed of 18-lb test nylon, 6-mm mesh and measured 3.7 m by 3.7 m by 1 m deep. Two 3.8-cm by 1-m wooden dowels were tied along opposite sides of the net to enable divers to open and maneuver the net. Usually, the net was opened beneath a school of fish by divers holding the dowels at opposite ends of the net. The divers began a swimming ascent keeping the net open as far as possible. The net was closed around the school of fish and the sides of the net were brought together and rolled on the dowels to prevent the fish from escaping.

The other two nets were each operated by one diver and had mouth openings of 0.6 m × 0.9 m and 0.3 m × 0.6 m, respectively. They were both bag type nets with the open and closing mouth constructed of 1.2-cm PVC pipe hinged together with Tygon tubing. They were used most often to capture fish associated with macro algae.

A 4.9-m otter trawl was infrequently deployed in Elkhorn Slough and over sandy areas proximal to nearshore reefs in southern Monterey Bay in depths greater than 30 m. Populations of fish in these areas were difficult or impossible to assess using scuba.

Fish captured by net were identified, measured, and released alive except for representative subsamples of each species which were returned to the lab for further analysis. When identifications were in question, samples were sent to the NMFS at Tiburon for confirmation. Standard and total length and body weight were recorded for each fish returned to the laboratory. Unless otherwise noted, all lengths are reported as total length in millimeters. Representative samples were packaged by date and species and frozen. This collection is available to responsible interested parties for further analysis.

In this report comparisons of the change in length of species over time (growth) among stations and years are presented graphically as mean monthly total lengths. Additionally, growth of blue rockfish among years (1987-1992) was compared using regression analysis.

To determine if there were differences in mean length of fish captured by spear and by the two-diver lift net, we collected seven paired samples of speared and liftnet-captured blue rockfish at Otter Point. Each pair was taken within a five-day period. An independent Student's *t*-test and two-way ANOVA were performed on these data.

Adult Female Blue Rockfish Collections

Adult female blue rockfish were collected throughout the year by hook-and-line or spear. A total of 1,576 sexually mature females (> 289 mm) (Wyllie Echeverria 1987) was examined to evaluate temporal variability in somatic and reproductive conditions.

The Fulton-type condition factor equation (K-Factor) was used as an index of somatic condition. This index uses the fish weight/length relation as an indicator of the general well-being or plumpness of the fish (Anderson and Gutreuter 1983) and is derived by the formula:

K-Factor = $[BDWT / TL^3] \times 10^5$
BDWT = *weight of fish in grams*
TL = *total length of fish in millimeters*
10^5 = *value to bring index to unity*

A mean value for each year was calculated for fishes collected from September through November.

The general equation for gonadal index was used as an index of reproductive condition. This index uses the gonad weight/fish length relation as an indicator of the reproductive state of the fish (DeVlaming et. al. 1982) and is derived by the formula:

Gonadal Index = $[GWT / TL^3] \times 10^7$
GWT = *weight of gonad in grams*
TL = *total length of fish in millimeters*
10^7 = *value to bring index to unity*

A mean value for each reproductive season was calculated for fishes collected from November through January.

Offshore Studies

In cooperation with scientists from MLML and PFEG, and with funding from the California Sea Grant College Program (R/F-142) we conducted several cruises to examine the importance of transport processes in recruitment of rockfishes to nearshore areas of Monterey Bay. Icthyoplankton surveys for larval rockfish were conducted by MLML using manta neuston and bongo nets every 2 weeks at a known upwelling area off Davenport. The manta neuston net (Brown and Cheng 1981) was constructed with an aluminum frame with a rectangular mouth 1.0 m × 0.2 m and fitted with a 505 µ black-dyed nitex mesh net, normally used with a bongo net. The frame was supported at the sea surface by paired wooden wings made buoyant with urethane foam panels. The manta net was fished at 2 to 2.5 knots for 6 to 10 minutes. Three replicate manta net tows were completed at each of four stations (bottom depths of 15, 60, 100, and 200 m) during daytime surveys. The bongo net consisted of two circular 0.7-m diameter aluminum frames fitted with 505 µ black-dyed nitex mesh nets. Standard oblique tows followed the protocol outlined by Smith and Richardson (1977). Three replicate bongo net tows were completed at each of five stations (bottom depths of 15, 30, 60, 100, and 200 m) during daytime surveys.

Midwater trawl surveys of pre-recruits were conducted off Davenport and Monterey at night. The mouth opening of the midwater trawl was 26.2 m × 26.2 m, the mesh in the net body decreased from 203 mm near the mouth to 25 mm at the cod end, and the mesh of the cod-end liner was 1.27 mm. We estimated that the actual mouth opening of the net while fishing was 13 m X 13 m. Fishing depth ranged from 26 m at shallow stations (59 m) to 77 m at deeper stations (>1000 m). Upwelling fronts were identified from sea surface temperatures and available satellite images. Transects and stations were determined from identified upwelling fronts. A CTD cast, 10-minute neuston tow, and 15-minute midwater tow were conducted at each station.

Oceanographic Data

Sea surface temperature was taken daily with a hand-held thermometer at the MCL intake and recorded to the nearest 0.1° C. Monthly means are presented in this report.

Temperatures at the surface and at transect depth were recorded by divers during fish transects and collections. Temperatures were recorded to 0.1° C using total immersion, mercury-filled general purpose thermometers with a range of -35 to 50° C (one division/degree). To reduce breakage, thermometers were enclosed in 2.54-cm PVC pipes with spaces filled with injectable foam.

Monthly mean upwelling indices were obtained from PFEG. The upwelling index is a calculated value which estimates the volume of offshore directed surface water due to Ekman transport along the coast (Bakun 1973).

Hydrographic data obtained on each cruise of the offshore studies included continuous sea surface temperature and temperature and salinity profiles of the water column at sampling stations using a Sea-Bird SBE 19 CTD recorder.

Results

Initial Nearshore Occurrence

Micro-habitat Preference and Body Pigmentation

Postpelagic newly settled rockfishes and lingcod exhibited specific microhabitat preferences. Blue, black, olive, widow, and yellowtail rockfishes (members of the black dorsal spot group) have a characteristic black spot on their spinous dorsal fin. These species are frequently first observed at the seaward, sand-rock interface of nearshore reefs in depths of 6- to 20-m. They often occur as individuals or in scattered groups of two to 10 and are associated with crevices, sand channels among the rocks, or depressions in the reef. During this period they have not yet developed strong body pigmentation patterns but are rather silvery in appearance which is characteristic of the pelagic stage.

Newly settled canary (member of black dorsal spot group), stripetail, and halfbanded rockfishes are also first observed at the seaward, sand-rock interface but, unlike the previous mentioned members of the black dorsal spot group, these species are also observed farther seaward in deeper water (18-24 m). This group, rather than being associated with crevices, is more often observed hovering 0.5-1.0 m above sand or small rock piles. Canary and halfbanded rockfishes are observed as individuals or in small groups of two to five, while stripetail rockfish are usually more abundant and are seen in loosely associated schools. The body pigmentation patterns of these species are dark. In addition to the black spot on their spinous dorsal fin canary rockfish have two to three dark vertical bands on their body. Halfbanded rockfish have an obvious black diamond on the caudal peduncle and stripetail rockfish have two to three vertical orange stripes on their caudal fin.

Newly settled vermilion rockfish are also observed at the seaward sand-rock interface, but are more commonly observed in shallow water (2-7 m) over sand and in 7- to 12-m depths over low profile reefs and boulder fields. They are darkly pigmented and the caudal fin is clear.

Newly settled copper, gopher, black-and-yellow, and kelp rockfishes are almost always first observed associated with the giant kelp canopy. Each species in this group exhibits several color morphs and pigmentation patterns and is consequently difficult to identify when less than 25 mm.

Newly-settled bocaccio are similarly first observed associated with the giant kelp canopy but are also seen throughout the water column. Their initial body color is light tan.

Infrequently, fast-swimming schools of chilipepper were observed at the seaward side of nearshore reefs. Chilipepper were commonly taken in otter trawls made on the along nearshore reefs in Monterey Bay.

Lingcod were not seen on reefs nor along the sand-rock interface of reefs. We observed them only at depths of 1-7 m in sandy protected areas (Monterey Wharf II, Morro Bay, and Port San Luis). In this habitat they generally occurred as solitary individuals on or near the bottom. Only once, in 1991, did we observe a school (20-30 individuals) of small lingcod swimming 2 m off the bottom. The smallest lingcod are somewhat silvery-green while the larger ones have darker pigment markings.

1990 Observations

The first YOY observed were blue rockfish at Pup Rock in mid-April (Table 3). In late April blue rockfish were again observed at Pup Rock and also at Otter Point. Concurrently, members of the OYB complex were first observed at South Cove, and copper and vermilion rockfishes were first observed at Monterey Wharf II (Table 4). The first stripetail and canary rockfishes were observed at McAbee Beach in early May. These species were observed at two additional stations in Monterey Bay in early June. By mid-May copper rockfish had been observed at four stations in Monterey Bay and two stations near Diablo Canyon. In mid-May the first bocaccio were seen at Diablo Natural Reef and SLOCAR. By late May blue rockfish, members of the OYB complex, copper rockfish, and bocaccio had been observed at most stations along the coast. However, bocaccio were not observed in Monterey Bay until early June.

Prior to August no vermilion rockfish were observed south of Big Creek, and no stripetail rockfish were seen south of Monterey Bay. Canary rockfish were not observed at southern stations until mid-July (at Diablo Natural Reef), two months later than they were first observed in Monterey Bay (mid-May).

Members of the kelp, gopher, black-and-yellow rockfish complex were observed at Diablo Canyon, South Cove, and Del Monte Beach in mid-June (Table 5). The only observation of chilipepper was made at Del Monte Beach in mid-June. Lingcod were first observed in April at Monterey Wharf II.

1991 Observations

The first YOY observed were members of the OYB rockfish complex at Diablo Canyon in mid-April (Table 6). In mid-May members of the OYB complex were first observed at four additional stations and blue rockfish were initially observed at four stations.

Prior to mid-July vermilion rockfish were observed only at Pup Rock in mid-April (Table 7). The first bocaccio were seen at Monterey Wharf II in mid-May concurrently with the observations of canary and stripetail rockfishes at Otter Point. By mid-June bocaccio and canary and stripetail rockfishes had been observed only in Monterey Bay; however, by late June bocaccio and canary rockfish were observed at stations south of Monterey.

Copper rockfish were first observed at Pup Rock in mid-April (Table 8). Not until almost two months later (early June) were they observed at other stations. Members of the KGB complex were initially observed at three southern stations (Big Creek, Point Buchon, and Pup Rock) in late June. Kelp rockfish were first observed within a 3-week period, beginning in late June, at Pt. Buchon, Pup Rock, and two stations in Monterey Bay.

1992 Observations

The first blue and black rockfishes were observed at Monterey Bay in early April (Table 9). In early May members of the OYB complex were seen in the Monterey Bay and blue rockfish were observed in Carmel Bay. No individuals of these species were observed south of Carmel Bay until mid-June. No blue, black, or olive rockfishes were observed south of Big Creek prior to July. Copper rockfish were only seen at Monterey Wharf II in late April (Table 10). Bocaccio were first observed at Big Creek and Cambria Rock in early June and at Monterey Wharf II 2 weeks later (late June). The first members of the KGB complex were seen at Carmel Bay, Diablo Canyon, and Pup Rock in early June.

Kelp rockfish were observed at Otter Point, Carmel, and Big Creek and members of the GB complex were seen at Carmel Bay in late June.

Interannual Comparisons

During 1990, 1991, and 1992 the first major nearshore observations of blue rockfish and members of the OYB complex were in mid- to late May. Although individual fish were observed as early as mid-April in all three years the greatest numbers of newly settled YOY of these species occurred at most stations in late May. Compared to 1990 and 1991, settlement of the black dorsal spot group was extremely poor in 1992, especially at stations south of Big Creek.

Initial settlement of bocaccio, canary, copper, stripetail, and vermilion rockfishes generally occurred during the same period (May-June) in 1990 and 1991. Recruitment of these species in 1992 was poor, similar to the previously mentioned members of the dorsal black spot group. Vermilion rockfish were observed more frequently in 1990 than in 1991. During 1990 and 1991 canary and stripetail rockfishes were observed earlier and more frequently at stations at Monterey Bay than at stations to the south.

Members of the KGB rockfish complex were first observed mid- to late June during 1990 and 1991. In

1992 members of this group were observed in early June at Diablo Canyon.

Relative Abundances

Timed Transects

Black Rockfish

In 1990, monthly mean numbers of black rockfish observed per minute were greatest at SLOCAR Reef (2) in June (Figure 10). Numbers at Diablo Canyon stations were < 1/min. No black rockfish were observed on timed transects in Monterey Bay or at Big Creek.

From June through August 1991 the greatest numbers of black rockfish were observed at Pup Rock (Figure 11). Numbers of black rockfish peaked in August at Otter Point, Big Creek, SLOCAR, and Cambria and in September at the Diablo Canyon Intake.

Only five black rockfish were observed in 1992. These were seen at Monterey in March and August and at Cambria Rock in July. From 1990 through 1992 the relative abundance of black rockfish was highest in 1991 and lowest in 1992. During 1990 and 1991 the greatest numbers were observed at stations in the southern part of the study area.

Blue Rockfish

In 1990 the greatest monthly mean numbers of blue rockfish were observed at Big Creek in June (28/min) and July (35/min) and at Piedras Blancas in July (26/min; Figure 12). Numbers observed at stations inside Monterey Bay (Del Monte, McAbee, and Otter Point) were consistently lower throughout the year. Relatively few blue rockfish were observed at stations south of Point Buchon (Pup Rock and SLOCAR).

At all stations in 1991, numbers of blue rockfish peaked in June and declined, except Otter Point and SLOCAR, in July (Figure 13). The lowest numbers were observed at SLOCAR throughout the year, except for July.

In 1992, numbers of blue rockfish observed were < 1/min at all stations (Figure 14). At Big Creek in September numbers observed increased to the highest monthly mean for the year.

Numbers of blue rockfish observed at Otter Point in June and July 1991 were higher than those observed during any month in 1990 or 1992 (Figure 15). In 1992 the relative abundance of blue rockfish observed at Otter Point was the lowest since the 1982-83 El Niño event (pers. obser.). June and July were the months of peak abundance in 1991 (20/min), while in 1990 the greatest number was observed in August (14/min). In October 1990-91 numbers of blue rockfish observed were low (3 and 6/min, respectively).

Considerable variability existed among monthly mean numbers of blue rockfish observed per minute at any one station in 1990, 1991, and 1992. This variability was greatest during months of peak abundance (June and July) as new recruits continued to settle into the nearshore kelp forest. Generally, there was more variability in the relative abundance of blue rockfish at any station among years than among stations in any year.

Kelp Rockfish

In 1991 daily mean numbers of kelp rockfish observed per minute in the giant kelp canopy increased significantly in August (Figure 16). The last two canopy observations in September showed a decline in numbers of kelp rockfish. Although no timed transects were made in the canopy after September, diver observations indicated very few kelp rockfish in this habitat later in the year. Numbers of kelp rockfish observed on benthic timed transects increased significantly in September and October. This change in numbers of kelp rockfish observed in the canopy and on the bottom reflects the natural mortality and migration of this species from the canopy where they initially recruit, to near the bottom where they later settle.

Lingcod

During 1990 and 1991 the greatest mean monthly numbers of lingcod observed per minute at most stations were in May or June (Figures 17 and 18). Higher numbers were observed at Monterey Wharf II in 1991 (3.3) than in 1990 (1.0). Numbers observed at Morro Bay in 1990 and 1991 were comparable. Numbers observed after June at all stations were no greater than 1/min.

Unlike other species, lingcod were observed for a shorter period (May through September) and only in the shallow protected waters of bays.

Permanent Transects

The monthly mean number of blue rockfish observed in 1991 on Line 10, located nearest the seaward, sand-rock interface, at Otter Point dramatically increased in June (Figure 19). Most of these newly arrived blue rockfish were small (50-61 mm) and had characteristic silvery, pelagic coloration. Lines 20 and 30, located shoreward of line 10 and thus farther from the seaward, sand-rock interface, were not deployed until July. However, in June mean numbers of blue rockfish derived from timed transects in this area were less than on line 10. In July the mean number of blue rockfish on Line 10 declined and was less than numbers observed on Lines 20 and 30. Numbers of blue rockfish on all lines declined in August and continued throughout the rest of the year. The relationship among numbers observed per line (Line 10< Line 20 < Line 30) was consistent from July through October.

Numbers of blue rockfish observed in 1992 were more than an order of magnitude less than in 1991 on Lines 10, 20, and 30 (Figure 20). There appeared to be little correlation among the numbers of blue rockfish observed on each line throughout the year; however, unlike 1991 the greatest numbers observed in 1992 occurred in November rather than July. Numbers observed generally increased from July through November 1992, contrary to the previous year.

Artificial Habitats (condos)

The percent composition and rank of species occupying the pipe condos differed from those occupying the rock condos (Figure 21 and Table 11). In descending order of abundance, kelp, copper, the KGB complex, blue, the OYT complex, and black rockfishes were observed in pipe condos during 1990-92. In contrast, in descending order of abundance, the KGB complex, kelp, blue, canary, copper, OYT complex, and vermilion rockfishes were observed in rock condos during 1991-92.

For all years the numbers of fish observed per pipe condo at most stations were low during August and September and increased significantly in October (Figure 22). In Monterey greater numbers of fishes per pipe condo were observed during 1989, 1990, and 1991 than in 1992. The fewest numbers of fishes per pipe condo were observed at Diablo Canyon in 1990.

Mean numbers of all species of fish (Table 10) per rock condo were greater in Monterey than at Diablo Canyon in 1991 (Figure 23). Numbers of fish observed in rock condos located in different habitats (rock-sand interface vs. reef) in Monterey in 1991 were very similar, averaging about two fish per condo.

In 1992, an average of two fish per rock condo in Monterey occurred in the rock-sand interface habitat (Figure 24). At Big Creek in 1992, we observed from none to four fish (average of two fish) per rock condo in the rock/sand interface habitat. The only four species of fish inhabiting rock condos at both areas were gopher, black-and-yellow, kelp, and vermilion rockfishes.

Standard Length-Total Length Relationships

Standard length-total length and total length-standard length ratios for seven species of YOY rockfishes are summarized in Table 12. Ratios were fairly similar for blue, kelp, olive, and vermilion rockfishes and for black and yellowtail rockfishes.

Growth

Black Rockfish

Black rockfish at Monterey Bay, Big Creek, and Diablo Canyon exhibited similar seasonal growth patterns in 1991 (Figure 25, Table 13). There is no statistical difference between 1991 monthly mean lengths at Diablo Canyon in July (65.9 mm) and August (64.6 mm), indicating little or no growth during this period. During most of the year black rockfish were smaller at Big Creek than at Monterey Bay and Diablo Canyon.

The smallest (43 mm) black rockfish was collected in June at Diablo Canyon and the three largest (83 mm) were taken in August at Monterey Bay and in August and September at Diablo Canyon (Table 13). Black rockfish were first observed associated with nearshore reefs in June at a size of 43 to 63 mm. Based on our growth data (n=290), a 1-year old black rockfish (assigned birth date of January 1) would be approximately 92 mm ($y=19.49+.20x$, $r^2=.5$; where y=length in mm and x=days from January 1).

Blue Rockfish

Seasonal growth of blue rockfish collected in Monterey Bay during 1987, 1990, 1991, and 1992 was statistically different (Figure 26, Table 14). Comparison of growth among years showed that differences among lines, slopes, and intercepts were all highly significant (each $p < 0.0001$). Regressions of log-transformed lengths on sampling days also showed highly significant differences among years. Greatest differences in growth occurred after July. Comparison of regressions for fish sampled prior to August 1 showed differences among slopes were not significant ($p = 0.038$), but differences among correlation coefficients and intercepts were highly significant ($p < 0.0001$). This analysis indicates that annual growth of blue rockfish in Monterey Bay was similar from April through July and different after August.

Blue rockfish at Big Creek exhibited similar growth patterns in 1990 and 1991 (Figure 27, Table 15). Growth in 1992 was difficult to compare to other years because of poor recruitment and resultant small sample size that year. Blue rockfish at Diablo Canyon exhibited similar seasonal growth in 1990 and 1991 (Figure 28, Table 16). In 1990 growth from May through July was similar at all sampled stations (Figure 29, Table 17). In September mean lengths at Cypress Point, Big Creek, and Cambria were smaller than those at other stations. In 1990 growth at Santa Cruz, Del Monte Beach, McAbee Beach, Lovers Point, and Diablo Canyon was the same. Growth in 1991 was fairly similar at all stations (Figure 30, Table 18).

The smallest (42 mm) blue rockfish was collected at McAbee Beach in April 1988 and the largest (112 mm) was taken at Del Monte Beach in December 1990 (Table 14). Blue rockfish were first observed associated with nearshore reefs in April or May at a size of 42 to 64 mm. Based on our growth data (n=5169), a 1-year old blue rockfish (assigned birth date of January 1) would be approximately 108 mm ($y=23.67+.23x$, $r^2=.7$; where y=length in mm and x=days from January 1).

Kelp Rockfish

Kelp rockfish collected at Monterey Bay from 1989 through 1991 exhibited similar seasonal growth patterns (Figure 31, Table 19). In 1991 and 1992 mean lengths among stations were dissimilar (Figures 32, 33, Tables 20, 21). Kelp rockfish at Big Creek were generally smaller than those at other stations in 1991 and 1992.

The smallest (18 mm) kelp rockfish was collected at Monterey Bay in 1990 and the largest two (78 mm) were taken at Monterey Bay in November 1989 and at Cambria Rock in September 1992 (Tables 19, 21). Kelp rockfish were first observed associated with nearshore reefs in June or July at a size of 21 to 48 mm. Based on our growth data (n=1,001), a kelp rockfish at the end of December (10 months old, arbitrary birth date of March 1) would be approximately 68 mm ($y=-10.38+.29x$, $r^2=.8$; where y=length in mm and x=days from March 1).

Olive Rockfish

Mean lengths of olive rockfish from May through July were similar at Monterey Bay for data collected from 1987 through 1990 (Figure 34, Table 22). After July, growth became more variable and was highest in 1990 and 1991 and lowest in 1987 and 1988.

Growth of olive rockfish collected at all stations in 1990 and 1991 was comparable (Figures 35, 36, Tables 23, 24). The sizes of olive rockfish at Monterey Bay from May through June among years (1987-92) and among stations (Monterey Bay, Big Creek, Cambria Rock, and Diablo Canyon) in 1990 and 1991 were comparable.

The smallest (41 mm) and largest (124 mm) olive rockfish were collected at Monterey Bay during May and December 1990, respectively (Table 21). Olive rockfish were first observed associated with nearshore reefs in April or May at a size of 41 to 66 mm. Based on our growth data (n=647), a 1-year (365 days) old olive rockfish (arbitrary birth date of January 1) would be approximately 124 mm ($y=25.15+.27x$, $r^2=.7$; where y=length in mm and x=days from January 1).

Vermilion Rockfish

Vermilion rockfish collected at Monterey Bay in 1988 exhibited a fairly linear growth from April through July (Figure 37, Table 25 and 26). Observations of small (< 40 mm) vermilion rockfish in August, September, and October indicated adults have prolonged or multiple parturition periods (Tables 25 and 26). These new recruits are probably the result of a second release of larvae and may account for the decrease in growth in August. Growth information after the second cohort appeared (in August) became less meaningful because cohort analysis could not be performed due to small sample size.

Although mean length of 58 vermilion rockfish (63 mm) collected by MLML in an otter trawl at Elkhorn Slough in June 1988 (Figure 37) was larger than the Monterey Bay June collection (53 mm) taken by spears, the two samples were not significantly different.

The smallest (26 mm) vermilion rockfish was collected in October 1992 at Big Creek and the largest was collected in Monterey Bay (93 mm) in November 1988. Because of multiple cohorts, the size of 1-year old vermilion rockfish was not estimated with regression.

Yellowtail Rockfish

Small, post-pelagic, recently settled yellowtail rockfish were observed from May through August but distinct cohorts were difficult to distinguish. This continual influx of small fish affected the size composition and mean length of each sample. Because the timing and intensity of this influx varied each year it is difficult to compare annual growth, as evidenced by high standard deviations and a wide range in sizes of fish taken after July (Table 27, 28, 29).

Growth patterns of yellowtail rockfish at Monterey Bay from 1988 through 1992 varied considerably (Figure 38, Table 27). Growth patterns were similar at all stations in 1990 and 1991, except for larger mean lengths at Monterey Bay in 1990 and smaller mean lengths at Big Creek in August and October of 1991 (Figures 39 and 40, Tables 28 and 29). Mean length of yellowtail rockfish at Monterey Bay in May 1988 was significantly greater than in May of other years and at other stations.

The smallest (37 mm) and largest (103 mm) yellowtail rockfish were taken in 1990 at Monterey Bay in June and October, respectively. Because of multiple cohorts, the size of 1-year old yellowtail rockfish was not estimated with regression.

Lingcod

Monthly mean lengths of lingcod sampled in 1988 and 1990 were greater than those collected in 1991 (Figure 41, Table 30). Mean lengths of fish taken in June and July 1991 were approximately 30 mm less than those taken in other years. Growth among stations in 1991 was comparable except for the Morro Bay August sample which was lower (Figure 42, Table 31).

The smallest lingcod (76 mm) was taken in May 1988 at Waddell Creek, north of Santa Cruz, and the largest (193 mm) was collected at Morro Bay in September 1990. Lingcod were first observed associated with sandy protected areas in April, May, or June at a size of 92 to 139 mm. Based on our growth data (n=126), a 1-year (365 days) old lingcod (arbitrary birth date of January 1) would be approximately 234 mm ($y=18.76+.59x$, $r^2=.6$; where y=length in mm and x=days from January 1).

Comparison of Net and Spear Methods of Capture

Spears were most useful to collect individual fish that were near the bottom where it was difficult and cumbersome to use a net, and they were also effective at midwater and in the canopy. Spears captured a wide size range of fishes (18-193 mm TL). The disadvantage of spearing was that all fish collected were killed, whereas fish collected with nets could be released after identification and measurement. The two-diver lift net was most useful for species that schooled in the midwater column, such as blue, olive, yellowtail, and black rockfishes. The smaller one-diver lift net was used to capture species near the surface associated with giant kelp fronds such as copper, kelp, gopher, and black-and-yellow rockfishes.

Blue rockfish were the most common species taken by both spear and two-diver lift net. Mean length of speared blue rockfish was significantly less ($P < 0.05$) than that of netted blue rockfish in six out of the seven samples (Figure 43, Table 321). Mean lengths of the seventh sample were slightly larger but not significantly different. A two way ANOVA for the equality of mean total lengths among samples and between gear types was performed. Levene's test for equality of variances showed $P < 0.01$ for both factors and the Brown-Forsythe ANOVA table showed both gear and sample interactions to be highly significant ($P < 0.001$).

Although the ANOVA showed mean total lengths of fish captured by net or spear to be significantly different, the overall average difference in lengths for all pairs was 3.4 mm which is only slightly greater than the error in measuring the fish (2-3 mm). We therefore concluded that the differences in lengths of fish caught by net or spear were of little practical significance.

Adult Female Blue Rockfish Somatic and Reproductive Condition

Throughout the study period, the condition factor and gonadal index of adult female blue rockfish was lowest in 1982 during the 1982-83 El Niño event (Figures 44, 45). During the El Niño, sea surface temperatures were warm (Figures 46, 47). In 1984, condition factor increased significantly whereas the gonadal index did not. Condition factor generally remained unchanged in 1984 and 1986. From 1986 through 1988 the gonadal indices rose substantially compared to values in 1982, 1983, and 1984. Condition factor and gonadal indices were highest in 1988 which corresponded to relatively low sea surface temperatures. Both indices declined in 1989 and remained relatively unchanged during the next 3 years. Values in 1992 were the lowest since the 1982-84 period. Generally, increases and decreases in condition factor corresponded to similar changes in gonadal index; however, following the 1982-83 El Niño gonadal indices recovered much more slowly than condition factor.

Offshore Studies

Larval Studies

Ten icthyoplankton surveys were completed by MLML during the 1991-92 sampling period (131 bongo net tows). Preliminary results indicated that larval rockfish abundance was markedly higher than previously reported in the literature for this area. Shoreward stations were dominated by northern anchovy (69.1%), white croaker (20.6%), rockfishes (2.2%), and northern lampfish (1.7%). The seaward station was dominated by rockfishes (53.5%), northern lampfish (12.7%), northern anchovy (12.3%), Pacific hake (8.2%), and California smoothtongues (4.0%)

Presettled Young-of-the-Year Studies

During the 1992 midwater trawl surveys, 21 midwater tows, 13 neuston tows, and 18 CTD casts were made during Sweep I, May 4-9. Data were collected along transects (five stations per transect) off Davenport, in northern, central, and southern Monterey Bay, and off Cypress Point (Figure 2). Fishing depths for the mid-water trawl gear ranged from 30 to 60 m. Sea surface temperatures were uniformly high, ranging from 12.9 to 15.5°C. Only one pelagic YOY rockfish, a stripetail, was taken during Sweep I. It was collected with the midwater trawl at Station 20 near the head of Soquel Canyon in northern Monterey Bay.

Twenty midwater tows, 19 neuston tows, and 20 CTD casts were made during Sweep II, June 2-6. Data were collected along transects (five stations per transect) off Davenport, in northern and southern Monterey Bay, and off Cypress Point (Figure 3). Fishing depths for the midwater trawl ranged from 30 m (at shallow stations) to 75 m; average depth of tow was 53 m. Sea surface temperatures were uniformly high (14.2-15.1°C). There was little correlation between rockfish catch and water temperature.

We collected a total of 176 pelagic YOY rockfish with the midwater trawl during Sweep II. Counts of rockfishes (all species combined) ranged from 0-49 fish per tow. Virtually all rockfishes were collected at the three stations off Cypress Point (ave. 29 fish per tow), the seaward stations in southern Monterey Bay off Point Pinos (ave. 18/tow), and off Davenport (ave. 3/tow); only 1 YOY rockfish was collected within the Bay. Most YOY rockfish were unexpectedly small (11.7-27.0 mm SL). Rockfish from only two tows have been identified to species, and include stripetail, bocaccio, splitnose, yellowtail, brown, and shortbelly rockfishes.

Sixteen midwater tows, 15 neuston tows, and 16 CTD casts were completed during Sweep III, July 7-10. Data were collected along transects at six stations off Davenport, at five stations in southern Monterey Bay, and at five stations off Cypress Point (Figure 4). Fishing depth for the midwater gear ranged from 20-60 m and averaged 48 m (similar to Sweep II). A total of 57 pelagic YOY rockfish was collected during Sweep III. The highest catches of YOY were at the 100-m depth contour off Davenport (12/tow) and in nearshore water (depth = 70m) off Cypress Point (9 fish/tow). These highest catches seemed to be associated with the coldest surface water temperatures (12.3-12.4°C off Davenport and 12.8-13.8°C off Cypress Point).

Generally the greatest catches of pelagic YOY rockfish were taken during Sweep II and III off Cypress Point, Point Pinos, and Davenport. Although thermal fronts created by upwelling were weak at the surface, preliminary review of the CTD profiles suggested doming of isotherms and therefore subsurface upwelling with a warm lens of water at the surface.

It is difficult to assess the effectiveness of the midwater trawl; however, fishes from a wide range of sizes and life stages were taken. Active swimmers such as Pacific mackerel, Pacific sardine, and shortbelly rockfish, as large as 183, 161, and 151 mm SL, respectively, were taken. Numerous YOY rockfishes, target species for this cruise, were also taken. Some of these rockfishes were as small as 15 mm SL.

Oceanographic Data

From 1978 through 1992 monthly mean sea surface temperatures at MCL were coldest during the spring of 1984, 1988, and 1991 (Figures 46 and 47). Nearshore cold sea surface temperature in the spring along the central California coast is an indication of upwelling caused by persistent northwestly winds (Bakun 1973; Johnson et. al. 1992). Monthly mean temperatures were warmest in 1982, 1983, and 1992. These years have been described as years during which El Niño events have occurred.

Upwelling along the central coast was generally highest from April through July (Figure 48). It was strongest in May 1991 and July 1989. Upwelling during the 1992 El Niño was relatively weaker than most other years from May through July.

DISCUSSION

Comparison of Relative Abundance Estimation Methods

Timed and permanent transects were the predominant methods used to estimate the relative abundance of rockfishes and lingcod for spatial and temporal comparisons. Permanent transect lines were deployed at Otter Point as a more standard method of measuring temporal variability. However, timed transects did not require the effort needed to deploy and maintain permanent transect lines. Using the timed transect method, more samples could be collected in more areas within a limited time, more than two divers could conduct counts simultaneously in the same area, and counts could be done in habitats where it would be extremely difficult to deploy permanent transect lines (kelp canopy and midwater). On the negative side, each minute of the timed transects could not truly be considered random and independent, (i.e., each new minute count was dependent on where the last minute count ended), and therefore the power of statistical analysis was limited.

Logistical problems in assessing YOY fish abundance with transect methods included the variability in their numbers during the settlement process and changing microhabitat associations during their development. Nearshore settlement for some species occurred in large pulses at the same time (black, blue, and olive rockfishes). However, others had more protracted settlement periods (kelp and yellowtail rockfishes and lingcod) and still others had two distinct settlement periods (vermilion rockfish). The first members of each species were often observed associated with specific nearshore microhabitats (sand/rock interface, crevices, and the giant kelp canopy). Later they were observed in different microhabitats (upcurrent side of reefs, near pinnacles, and giant kelp holdfasts). Toward the end of their first year their distribution became similar to juvenile and adult congeners (midwater column, deeper waters, and crevices).

As much as possible, timed transects were stratified by habitat type and depth for each species and developmental stage; however, we were unable to sample all species during each stage. Benthic timed transects on reefs in 10 to 18 m depths were adequate to assess numbers of black, blue, olive, and yellowtail rockfishes from time of settlement through August. After August, black, blue and olive rockfishes moved higher in the water column and yellowtail rockfish appeared to move out of the kelp forest. Canopy timed transects in June and July were effective for counting black-and-yellow, gopher, and kelp rockfishes when they settled in the giant kelp canopy. However, during this period these species have a similar pigmentation pattern and specimens must be collected to confirm identification.

In August and September, as these species migrated to the bottom and became more cryptic, they were more difficult to find. Gopher and black-and-yellow rockfishes were predominantly observed in crevices between and under rocks, and kelp rockfish were often found among fronds at the base of the giant kelp. At this time timed transects became a less effective method of assessing abundance of these species.

Artificial habitats (condos) reduced the variability and time required searching for cryptic species using the transect methods. Cryptic species were attracted to the condos because they served as refuges. Kelp rockfish was the major species attracted to the pipe condos while a larger complex of rockfishes were attracted to the rock condos. We are continuing to develop a condo that will attract species that are targeted in sport fisheries, such as copper and vermilion rockfishes.

In this study timed transect and permanent transect counts were conducted from April through December and condos were deployed from July through December. We feel future sampling to estimate the yearly relative abundance need not include the months when YOY initially settle in the nearshore environment. We suggest that July *through September would be the optimal time to* estimate yearly relative abundance of black, blue, copper, olive, vermilion, and yellowtail rockfishes and lingcod. Relative abundance of black-and-yellow, gopher, and kelp rockfishes, while they are in the giant kelp canopy, would most effectively be estimated in August and September. After September these species migrate from the canopy to the bottom. Condos deployed from September through December would be a good method of estimating yearly relative abundance of these species.

Despite the limitations we feel that data derived from stratified timed transects were adequate to estimate the relative abundance of many species of YOY. In future work we plan to test the variability among data collected using timed transects, permanent transects, and condos.

Adult Condition, Offshore Studies, Relative Abundances, and Oceanographic Data

Adult female blue rockfish exhibited considerable variability in their somatic and reproductive condition from 1978 through 1992. Food availability, resulting from fluctuation in primary productivity during upwelling, is a probable cause for this variability. Miller and Geibel (1973) noted that during this period of upwelling, blue rockfish fed predominantly on plankton and achieved their highest growth rates. VenTresca et. al. (in press) found that adult blue rockfish annual condition factors are positively correlated with spring and fall upwelling. Recruitment the following year may be effected by the somatic and reproductive condition of females the previous year.

Monthly mean sea surface temperatures at MCL in 1988 were low and persistent upwelling resulted in extremely high somatic and reproductive condition in female blue rockfish. During spring 1989 MCL sea surface temperatures did not drop below 10° C and upwelling fluctuated. Corresponding to warm sea surface temperatures and sporadic upwelling, somatic and reproductive condition of female blue rockfish in 1989 declined sharply to their lowest levels since the 1982-83 El Niño. However, subsequent recruitment of YOY blue rockfish in 1990 was not obviously different than recruitment in 1989.

Sea surface temperatures in spring 1990 were again high, upwelling was weak, and adult somatic and reproductive condition were not significantly different from 1989. Resulting recruitment in 1991 at most station was similar to recruitment in 1990. Sea surface temperatures during spring 1991 were colder and upwelling was more pronounced than in 1989 and 1990. Somatic condition and reproductive condition in 1991 was not markedly different from 1989 and 1990.

Larval surveys using bongo nets, conducted by MLML personnel during and after the period of larval release of the majority of central coast rockfishes, indicated large concentrations of larval rockfish along the coast in January 1992. Three to four months later, at the time these YOYs normally begin to settle in the nearshore environment, very few were caught in midwater trawl surveys and numbers in subtidal surveys were extremely low. It is likely that during spring 1992, El Niño conditions of elevated water temperatures and reduced upwelling along the entire west coast resulted in poor survival of the cohort which had been so strong 3 to 4 months earlier. Numbers of blue rockfish and most other species observed during scuba surveys in 1992 were the lowest of this study. Above normal water temperatures associated with the 1992 El Niño event probably led to poor somatic condition and gonadal development of female blue rockfish from August to December. These indices were the lowest since the 1982-83 El Niño.

In summary, the fall somatic and reproductive condition of adult female blue rockfish appears to be related to the strength of upwelling during the spring and fall. Strong upwelling increases primary productivity which results in elevated somatic and reproductive condition of adults. Although high numbers of larvae may then be released by adults the following winter, settlement success 3 months later may be influenced by other conditions. Therefore there does not appear to be a strong correlation between the somatic and reproductive condition of adult female blue rockfish and the strength of the subsequent year class when it recruits to the nearshore environment as YOY fish. However, we suspect that continued years of poor somatic and reproductive condition will ultimately have an affect on recruitment.

Initial Nearshore Observations, Relative Abundances, and Oceanographic Data

Within a year, each species was observed concurrently and in relatively similar abundances at all study sites along the central coast. For the blackspot group (black, blue, olive, widow, and yellowtail), first nearshore appearance also occurred at the same time (mid-May) among years. This settlement occurred 3 to 4 months after parturition when YOY have achieved a maturation stage and size no longer suitable for a planktonic existence. Numerous studies have presented evidence that the nearshore settlement of larval fishes and invertebrates is associated with hydrographic events, such as upwelling and downwelling (Castillo et. al. 1991; Larson et. al. 1994; Wing et. al. 1994). Because YOY settled along an extensive section of the coast simultaneously it is a fair supposition that they are associated with shoreward-transported water masses or ocean features. Onshore transport of central California coast water may occur in May at depth during upwelling periods and at the surface during downwelling events. Both these events are possible mechanisms for the onshore transport of rockfishes and lingcod.

Considerable variability exists between the numbers of YOY observed at time of initial settlement and the number observed later in the year. Initially high "pulses" were observed for black rockfish at SLOCAR in 1990 and at Pup Rock in 1991, and for blue rockfish at Big Creek and Piedras Blancas in 1990 and at Otter Point and Big Creek in 1991. These pulses contained up to three times the numbers observed at other stations during the same month. If YOY rockfish which are about to settle become associated with and are concentrated by thermal fronts created by upwelling, it is possible these hydrographic features may facilitate the transport of some species to specific sections of the coastline.

The reduction in numbers of YOY observed in October is probably due to a combination of factors, such as natural mortality from predation, a shift to more cryptic habitat for some species, or movement to different depths. We have observed YOY rockfishes in the stomachs of most adult reef fishes.

There was considerable variability, within and among locations and years, in numbers during the first months of settlement (May and June) for the blackspot group and during June and July for the KGB complex. Because of this variability, relative abundance estimates to assess yearly cohort strength should not be made for these species during these months of initial settlement.

Growth and Oceanographic Data

For each species, black, blue, kelp, and olive rockfishes and lingcod exhibited similar growth patterns among stations and years. Growth was most similar during the 2-3 months following settlement but became slightly more varied later. Protracted settlement of yellowtail and vermilion rockfish made it difficult to evaluate their growth. These difficulties may be resolved with daily growth ageing studies to distinguish cohorts.

During all years and at all stations lingcod grew faster than the rockfishes. From July through September, the growth rate of kelp rockfish exceeded that of black, blue, and olive rockfishes. Growth of black, blue, and olive rockfishes was generally similar. Anomalous monthly means may have been due to bias of sampling methods, inadequate sample size, pulses of newly settled fish, or slow growth due to limited food or high densities of YOY.

Conclusions

Determining the feasibility of marine reserves as an effective management strategy for nearshore rockfishes is a complex multi-disciplinary task. A crucial factor in determining the size, placement, and ultimate effectiveness of reserves for enhancing sport fisheries is whether or not larvae from adult fishes within reserves would significantly contribute to replenishing fish stocks in other areas.

Data collected in this study include the somatic and reproductive condition of adults; relative abundance of the pelagic stages of larval and presettled YOY; distribution, relative abundance, and growth of YOY after settlement on nearshore reefs; and associated oceanographic conditions. Results portray a system with a high degree of temporal variability. We feel that this interannual variability is in large part due to the natural variability in upwelling. In spring, the neritic region of the central California coast is characterized by vigorous coastal upwelling resulting in increased onshore/offshore transport of water and high rates of primary production (Mason and Bakun, 1986). The planktonic stages of rockfish and lingcod coincide with this period of onshore/offshore water transport and high productivity. It is a fair supposition that this phenomenon plays an important role in the recruitment success of rockfish and lingcod. This study has attempted to illuminate the relationship between environmental and biological factors in hopes that this information will lead to intelligent management decisions concerning marine reserves.

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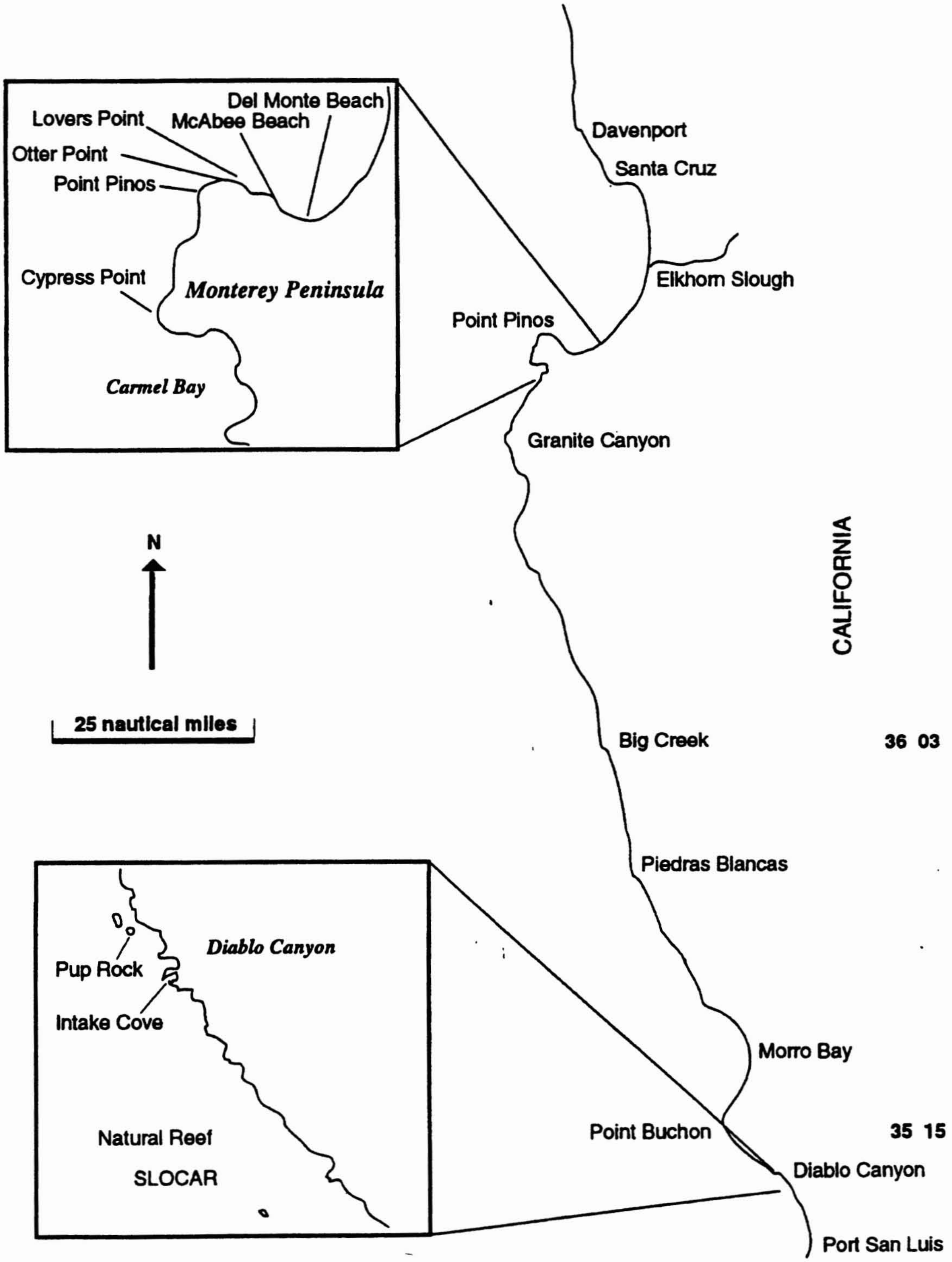

FIGURE 1. Nearshore sampling area in central California.

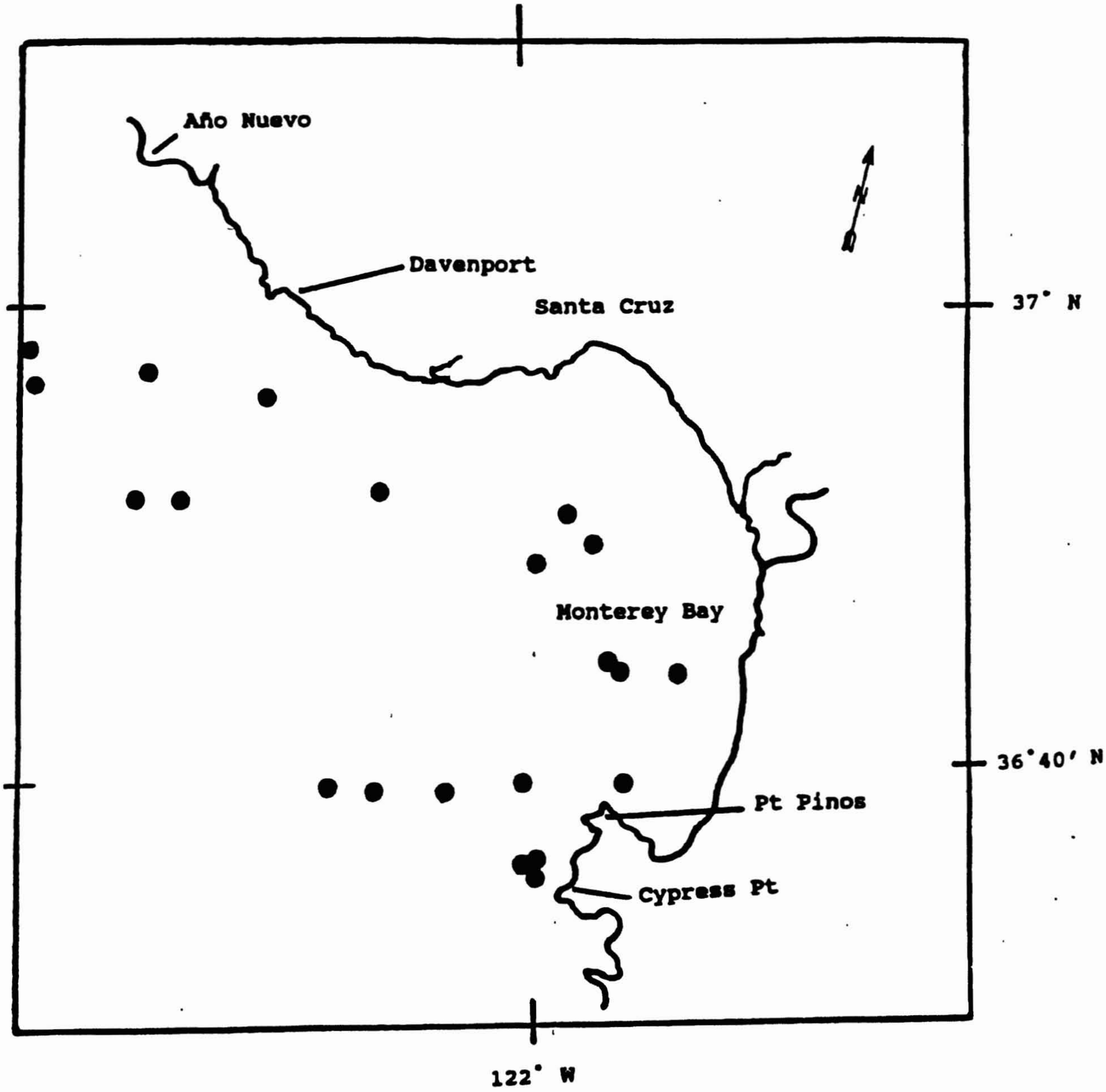

FIGURE 2. Midwater sampling area in central California, May 4-9, 1992 (Sweep I).

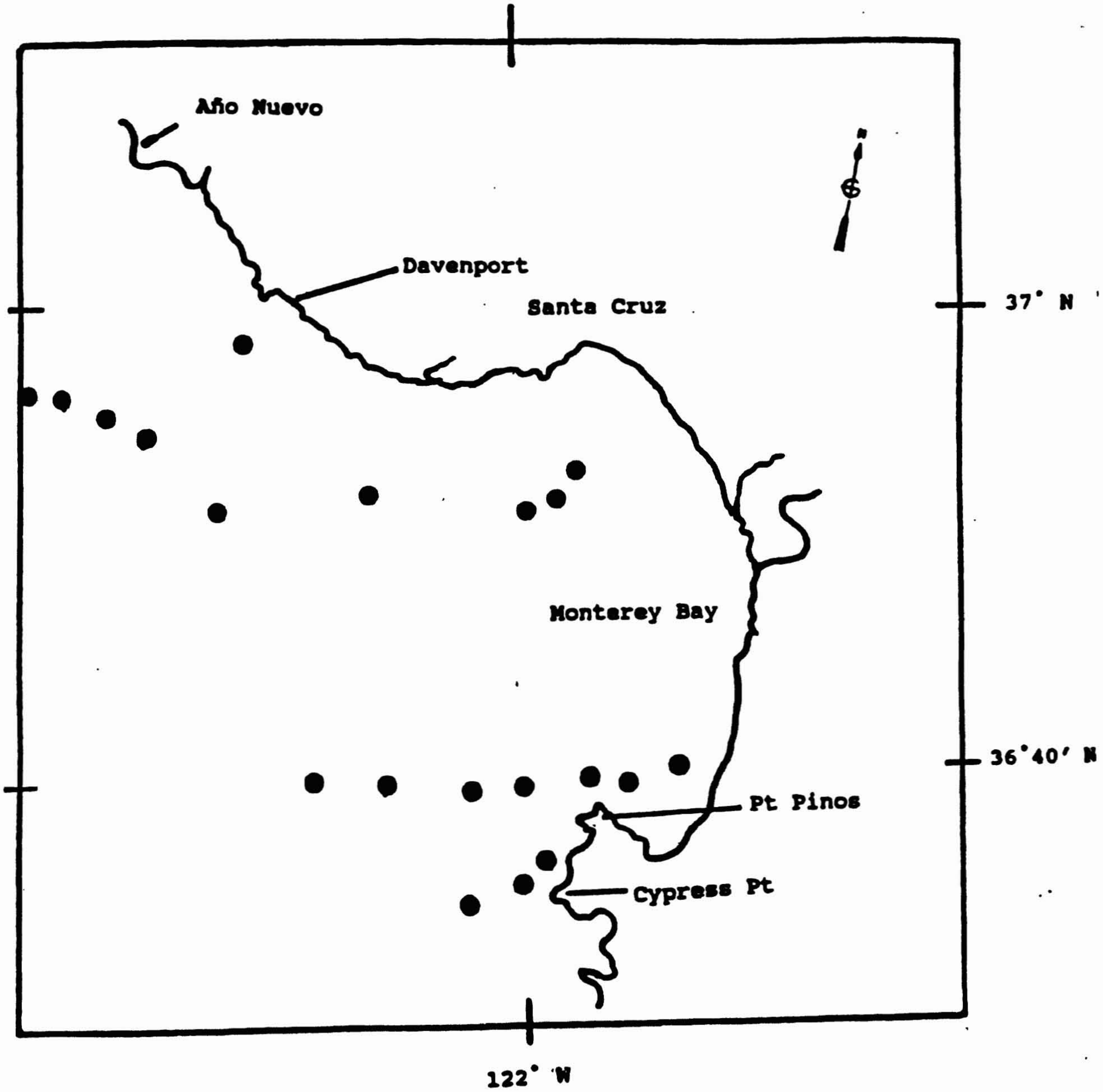

FIGURE 3. Midwater sampling area in central California, June 2-6, 1992 (Sweep II).

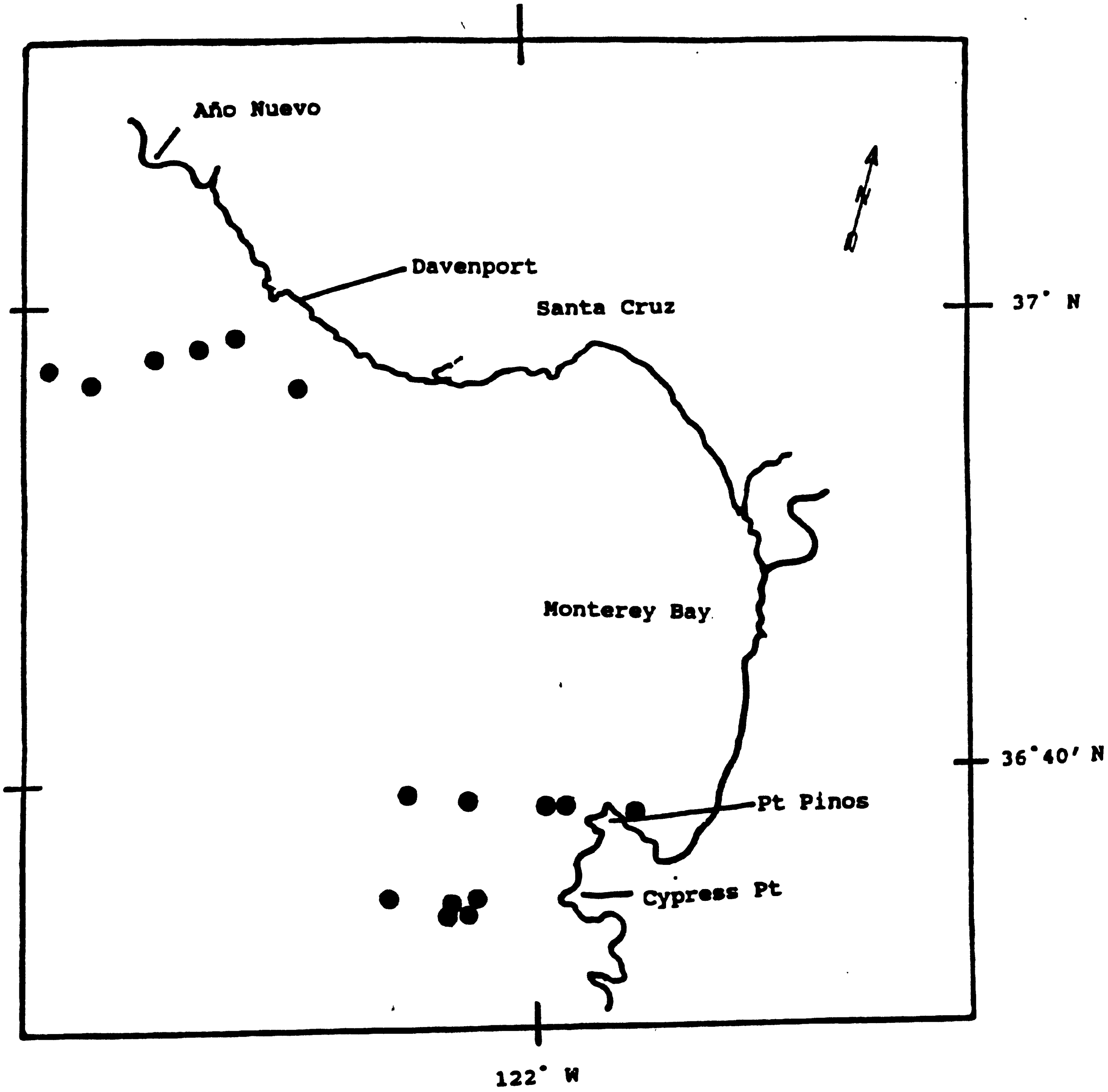

FIGURE 4. Midwater sampling area in central California, July 7-10, 1992 (Sweep III).

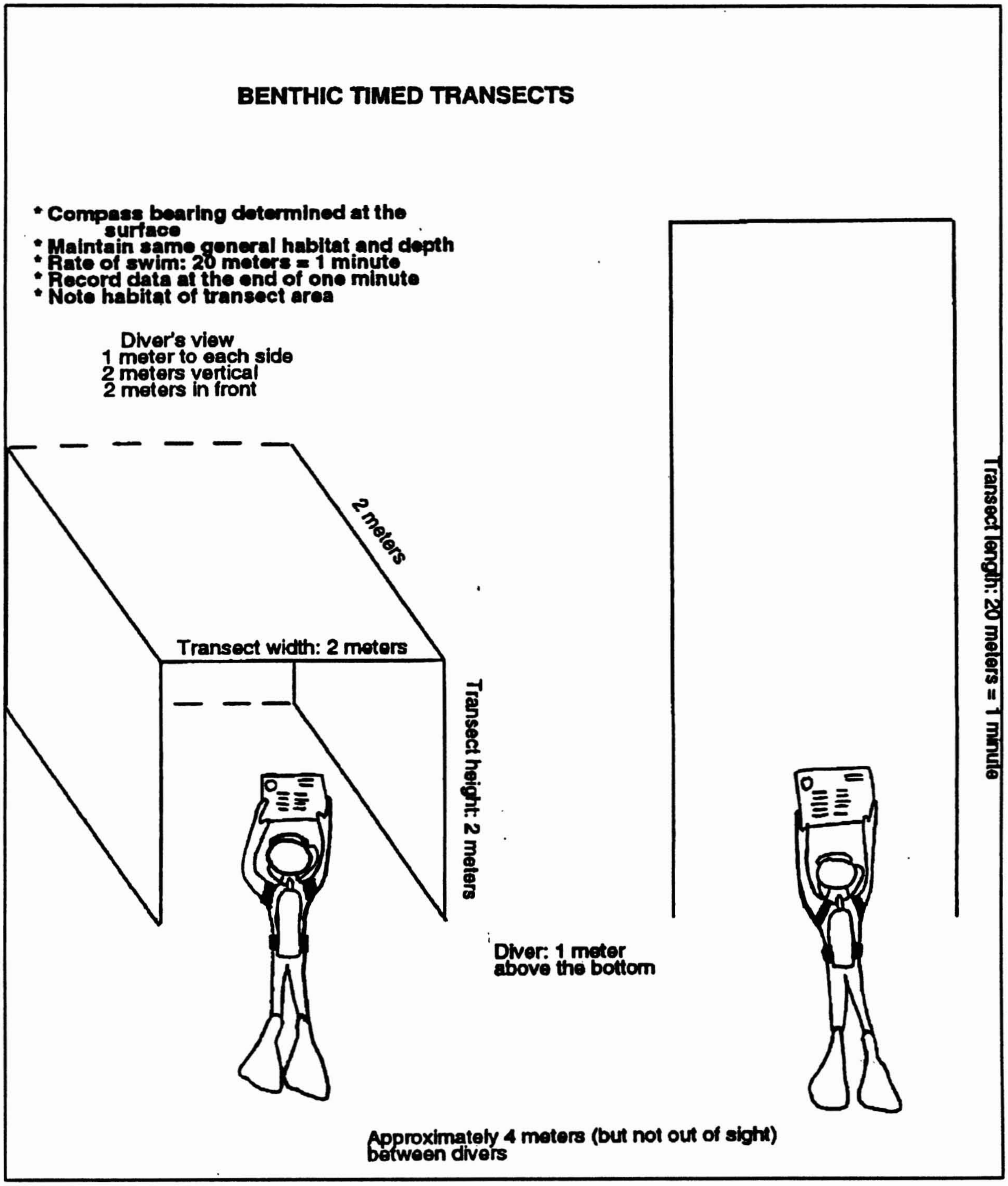

FIGURE 5. Method for benthic-timed transects.

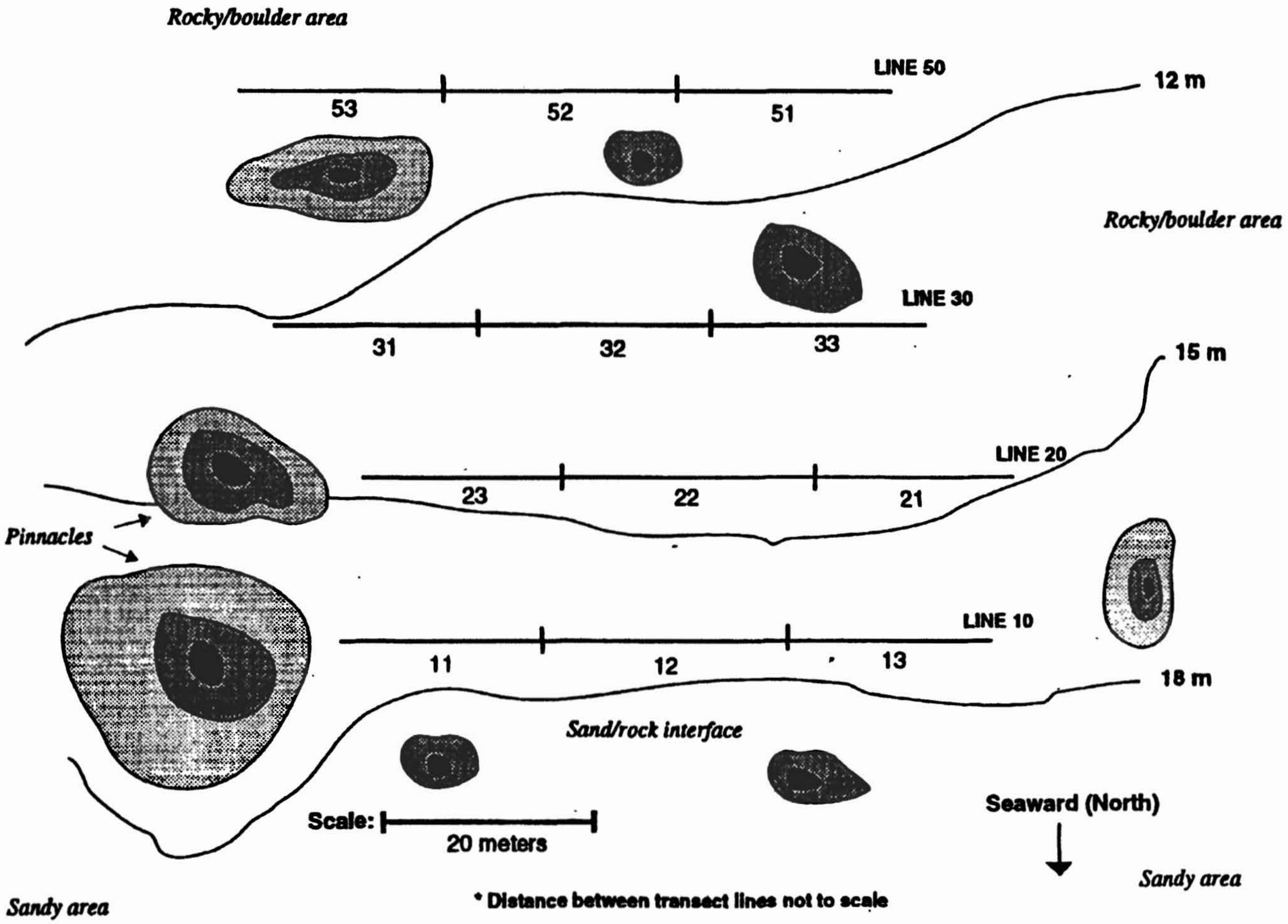

FIGURE 6. Permanent transect lines at Otter Point.

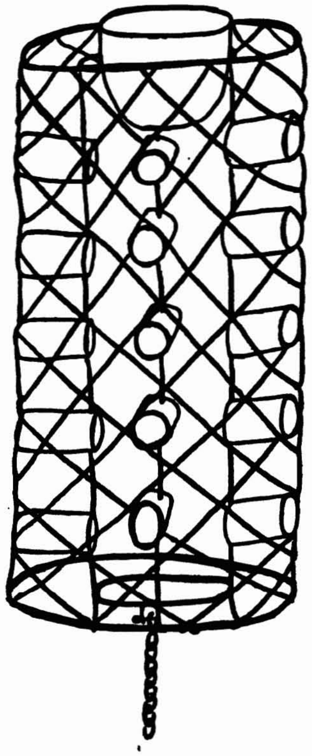

FIGURE 7. Artificial habitat - pipe condo.

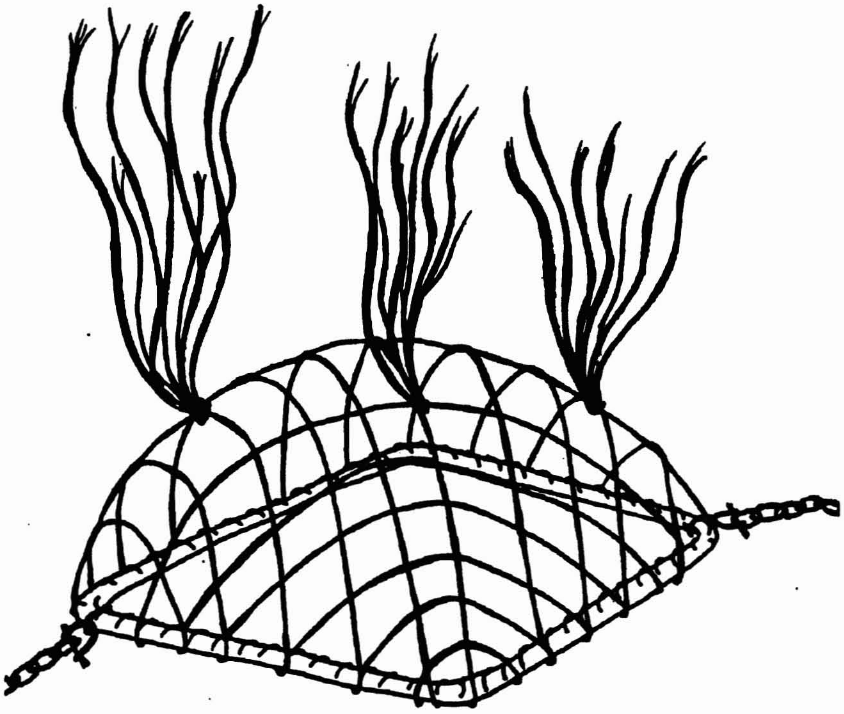

FIGURE 8. Artificial habitat - rock condo.

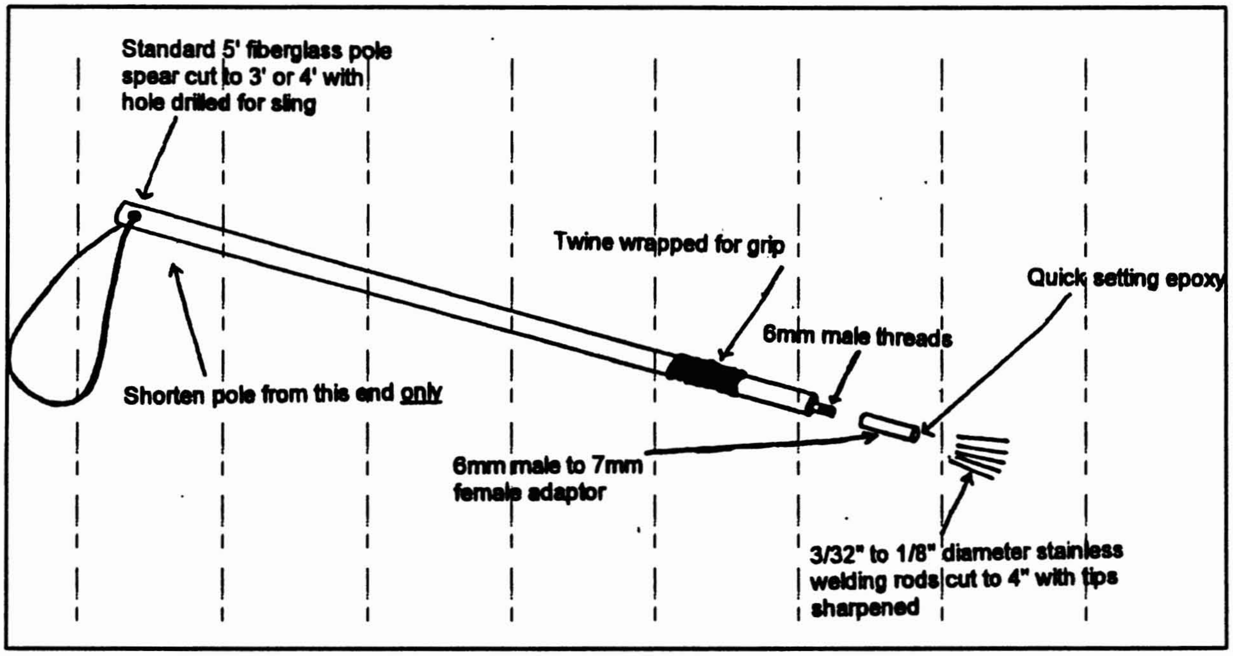

FIGURE 9. Spear used to collect young-of-the-year fish.

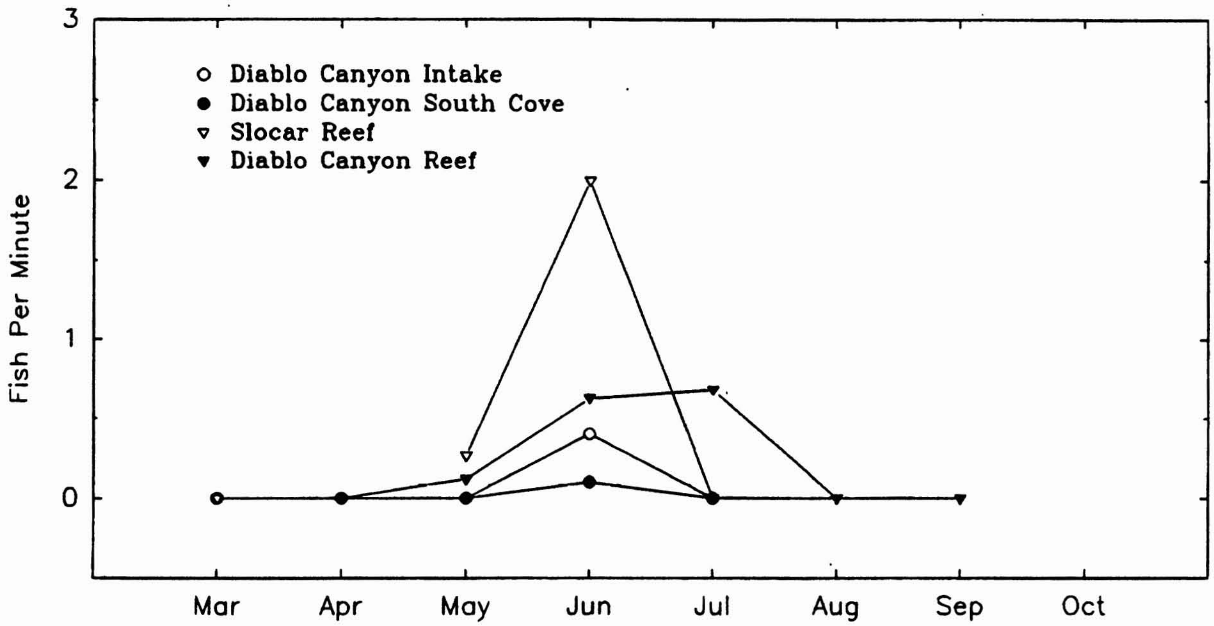

FIGURE 10. Monthly mean number of young-of-the-year black rockfish observed per nute during timed transects, central California coast, 1990.

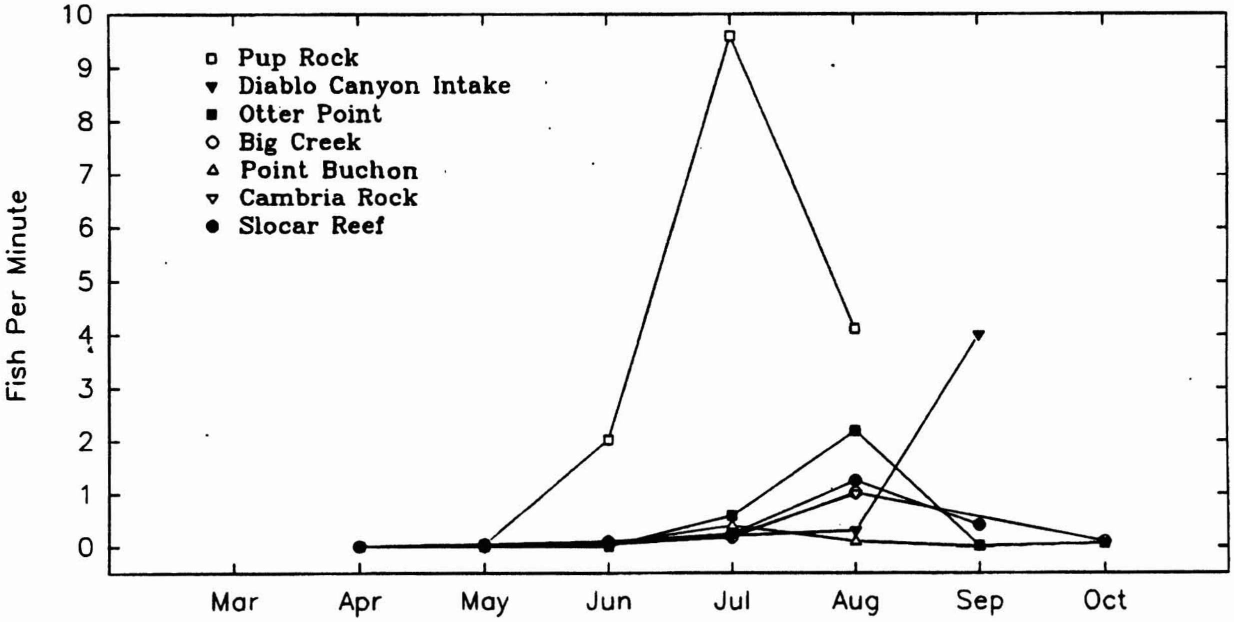

FIGURE 11. Monthly mean number of young-of-the-year black rockfish observed per minute during timed transects, central California coast, 1991.

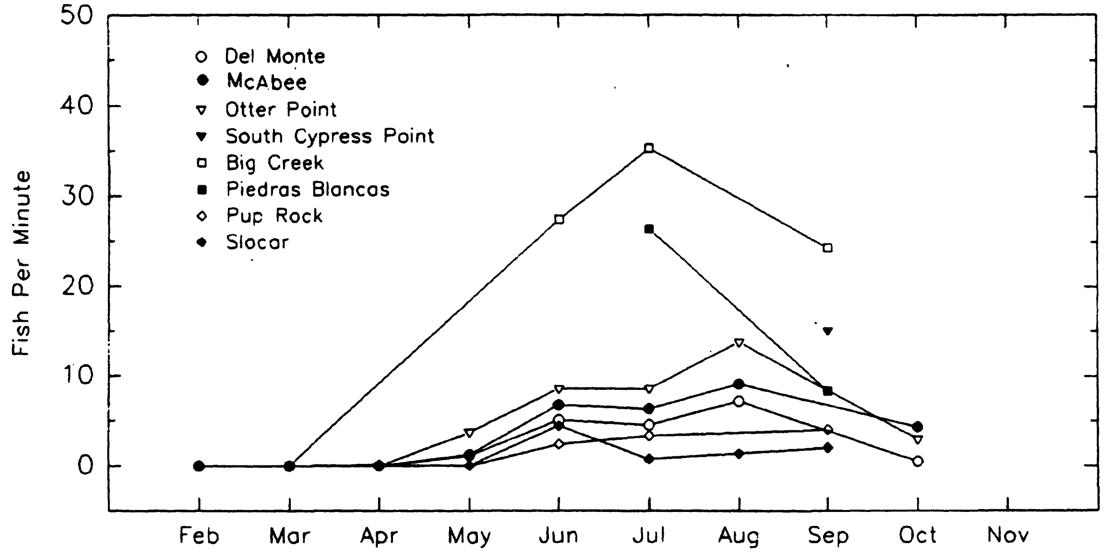

FIGURE 12. Monthly mean number of young-of-the-year blue rockfish observed per minute during timed transects, central California coast, 1990.

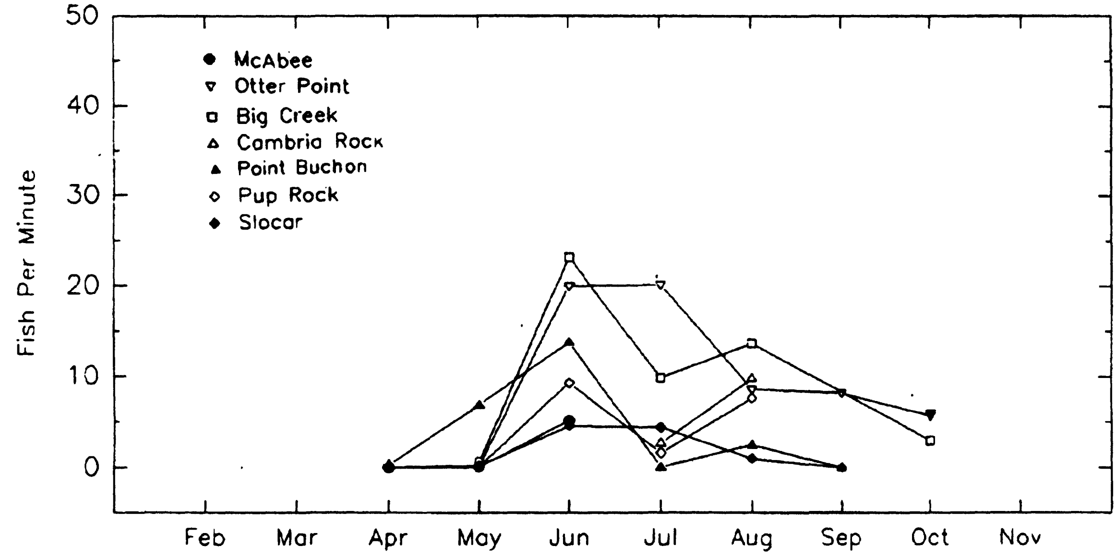

FIGURE 13. Monthly mean number of young-of-the-year blue rockfish observed per minute during timed transects, central California coast, 1991.

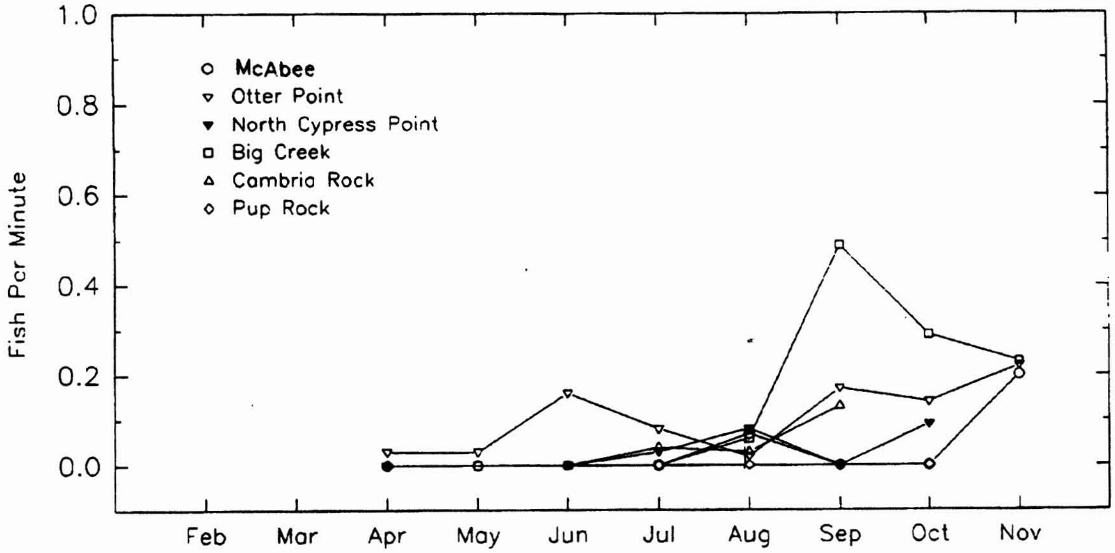

FIGURE 14. Monthly mean number of young-of-the-year blue rockfish observed per minute during timed transects, central California coast, 1992.

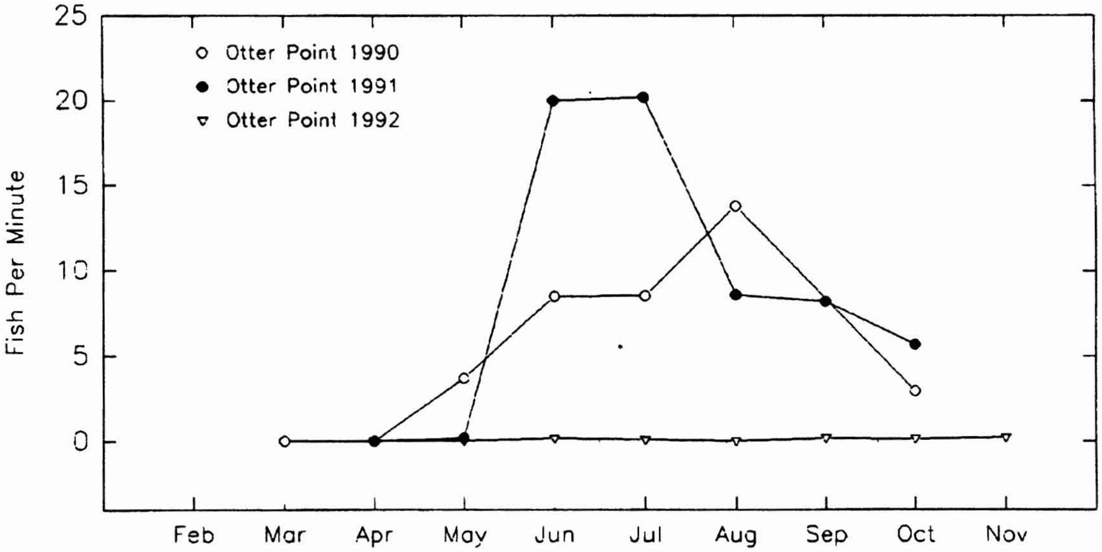

FIGURE 15. Monthly mean number of young-of-the-year blue rockfish observed per minute during timed transects, Otter Point, 1990-92.

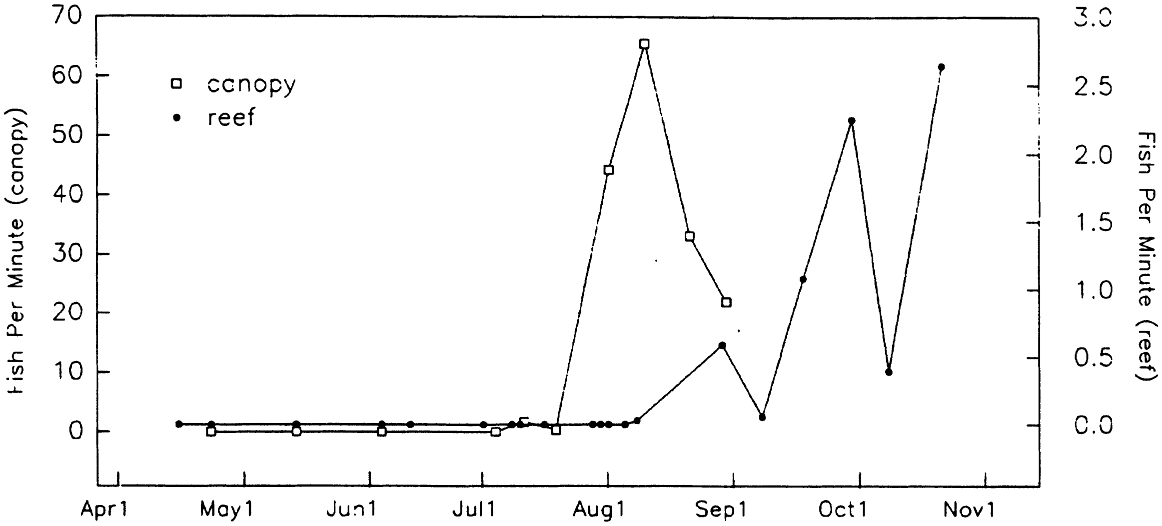

FIGURE 16. Daily mean number of young-of-the-year kelp rockfish observed per minute during timed transects in giant kelp canopy and reef habitat, central California coast,

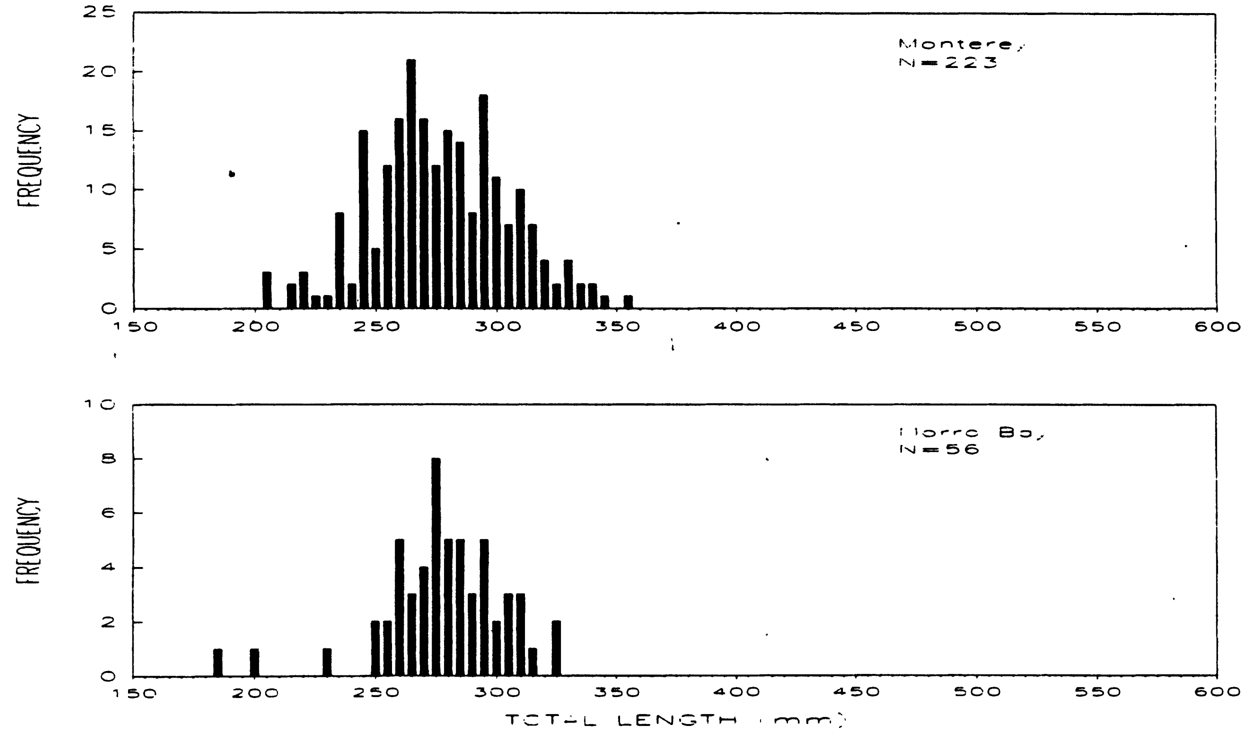

FIGURE 17. Monthly mean number of young-of-the-year lingcod observed per minute during timed transects, Monterey and Morro Bay, 1990.

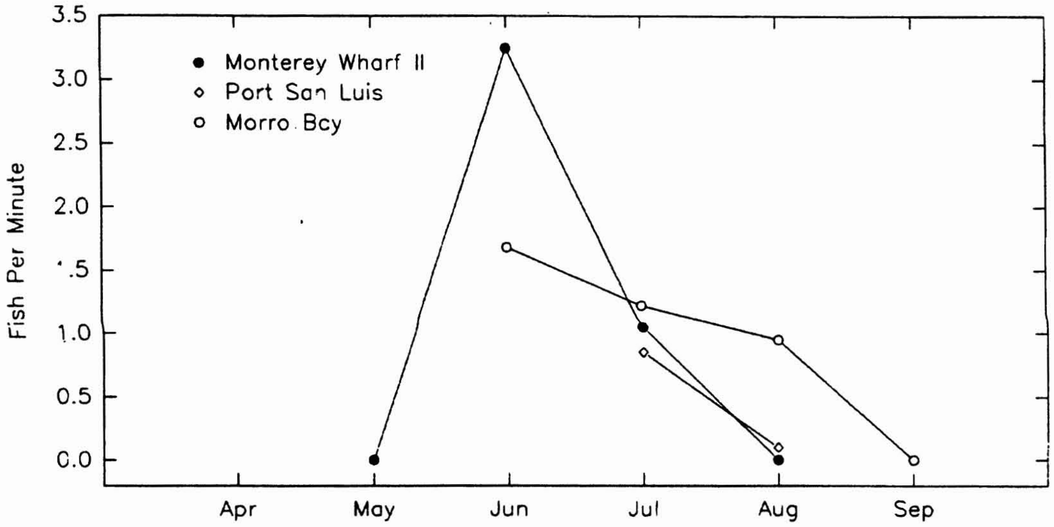

FIGURE 18. Monthly mean number of young-of-the-year lingcod observed per minute during timed transects, Monterey, Morro Bay, and Port San Luis, 1991.

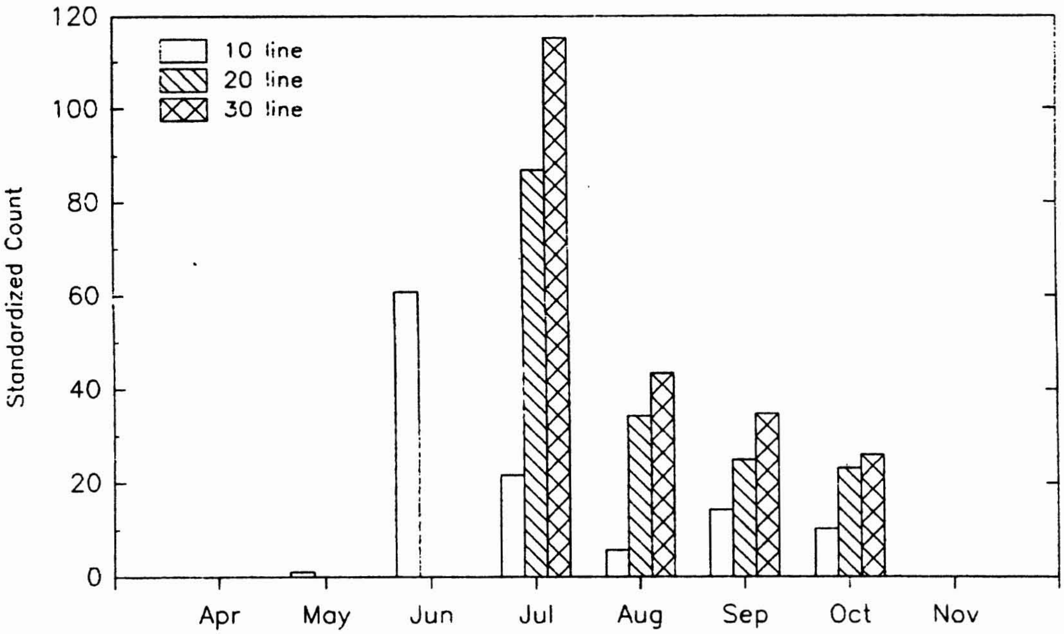

FIGURE 19. Standardized counts of young-of-the-year blue rockfish observed on permanent lines, Otter Point, 1991.

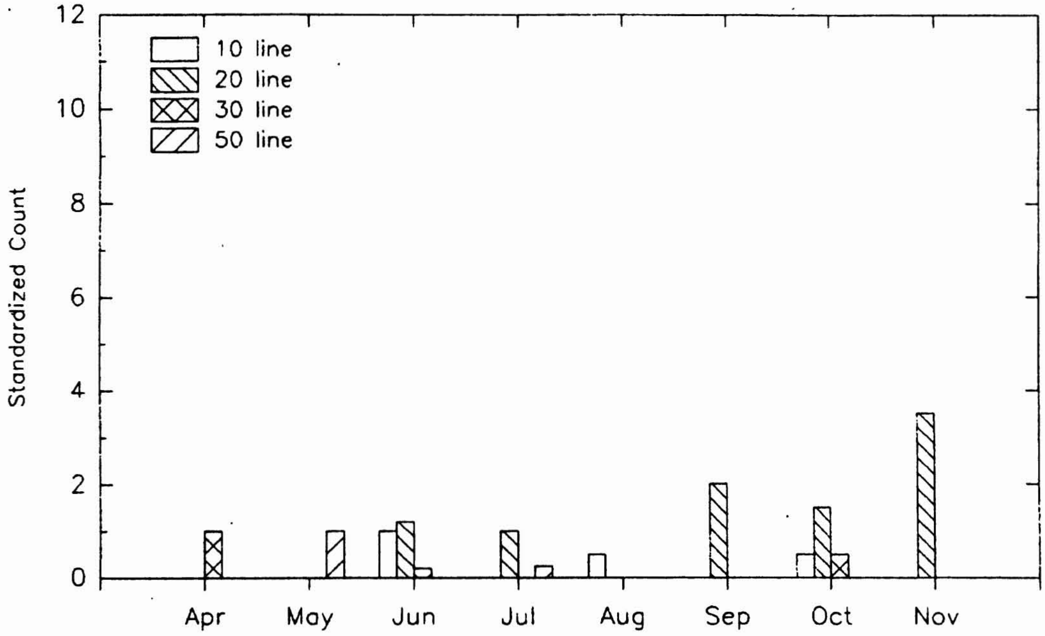

FIGURE 20. Standardized counts of young-of-the-year blue rockfish observed on permanent lines, Otter Point, 1992.

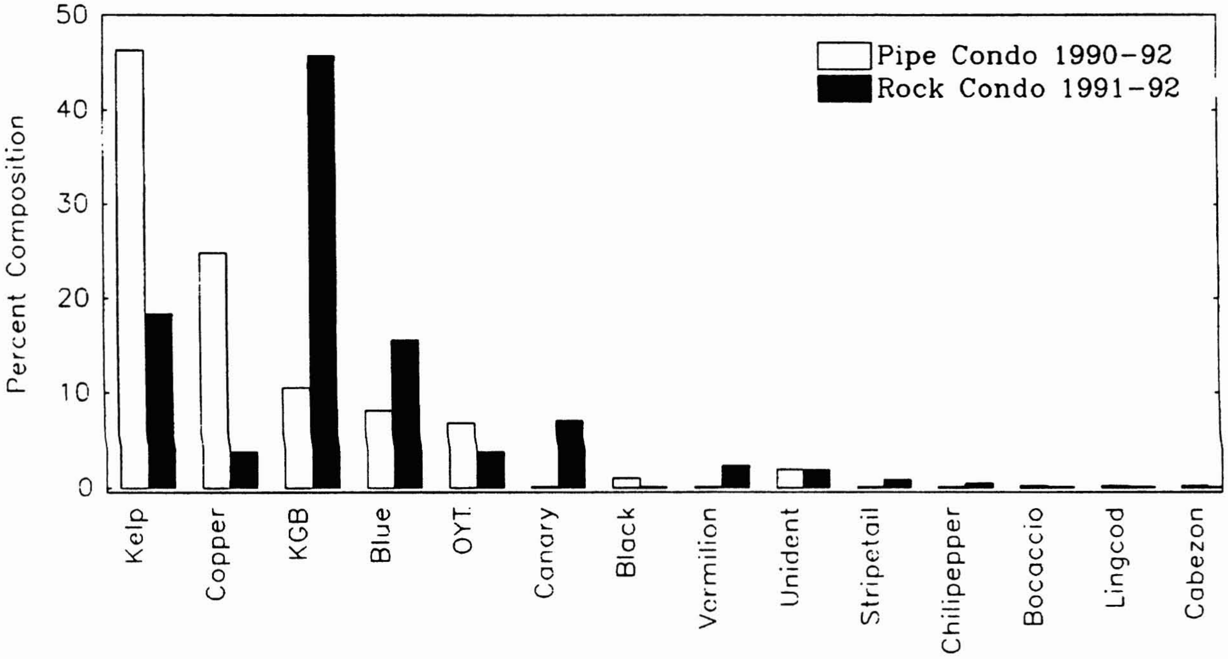

FIGURE 21. Percent composition of young-of-the-year rockfishes in pipe condo, 1990-92 and rock condo, 1991-92.

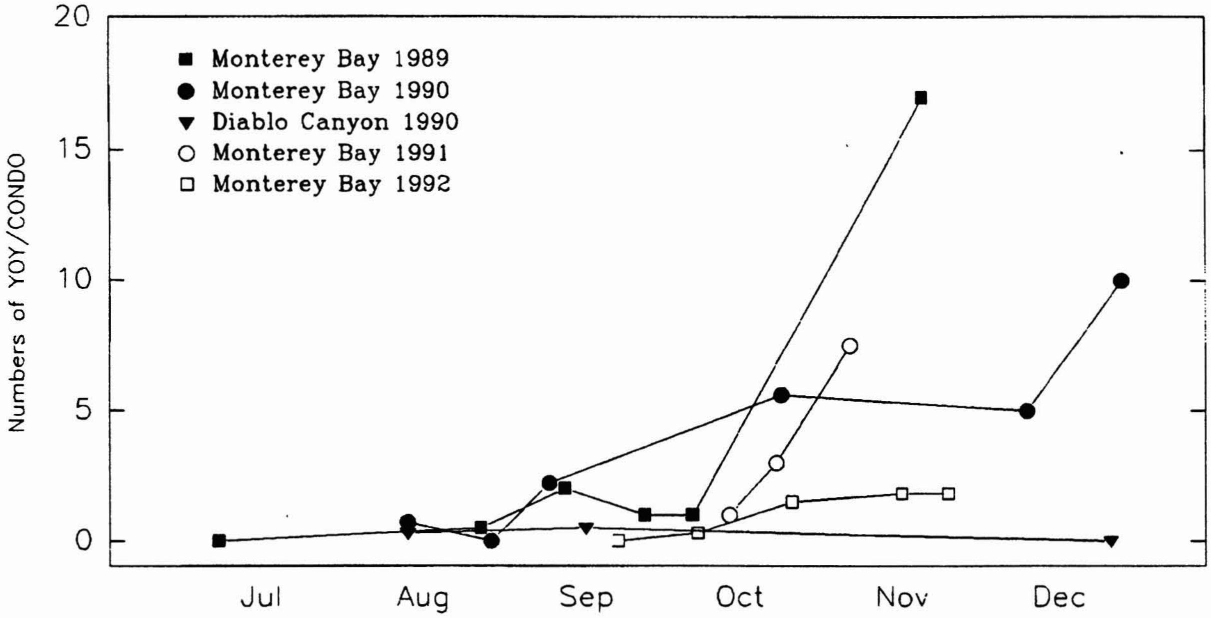

FIGURE 22. Sample mean number of young-of-the-year rockfish observed per pipe condo, Monterey Bay, 1989-92 and Diablo Canyon, 1990.

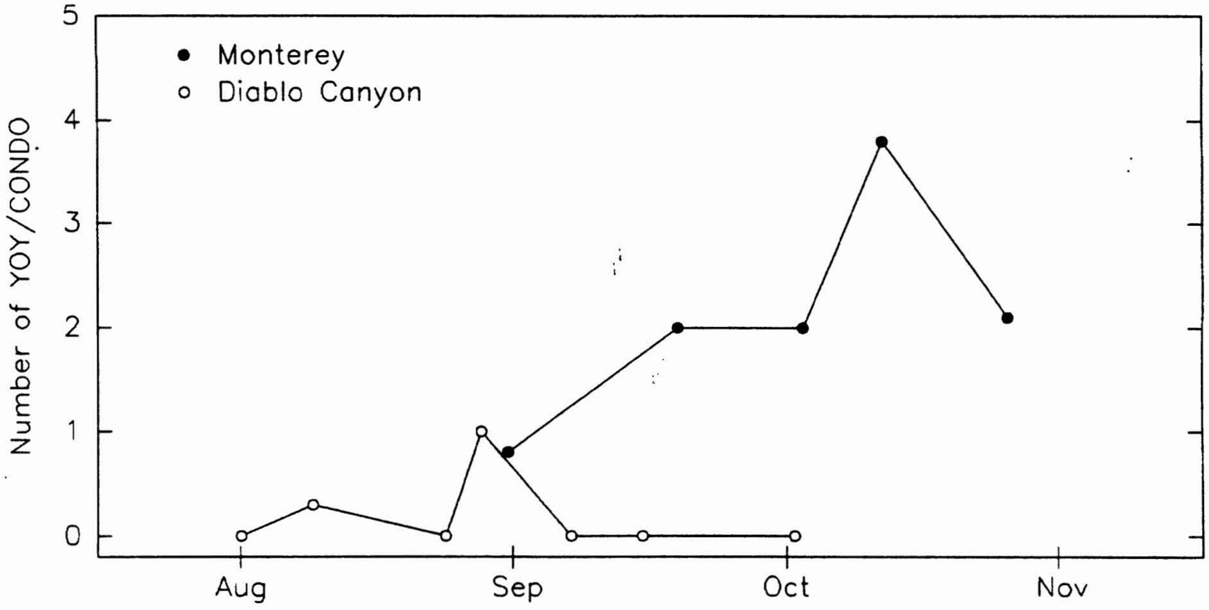

FIGURE 23. Sample mean number of young-of-the-year rockfish observed per rock condo on reef habitat, Monterey Bay and Diablo Canyon, 1991.

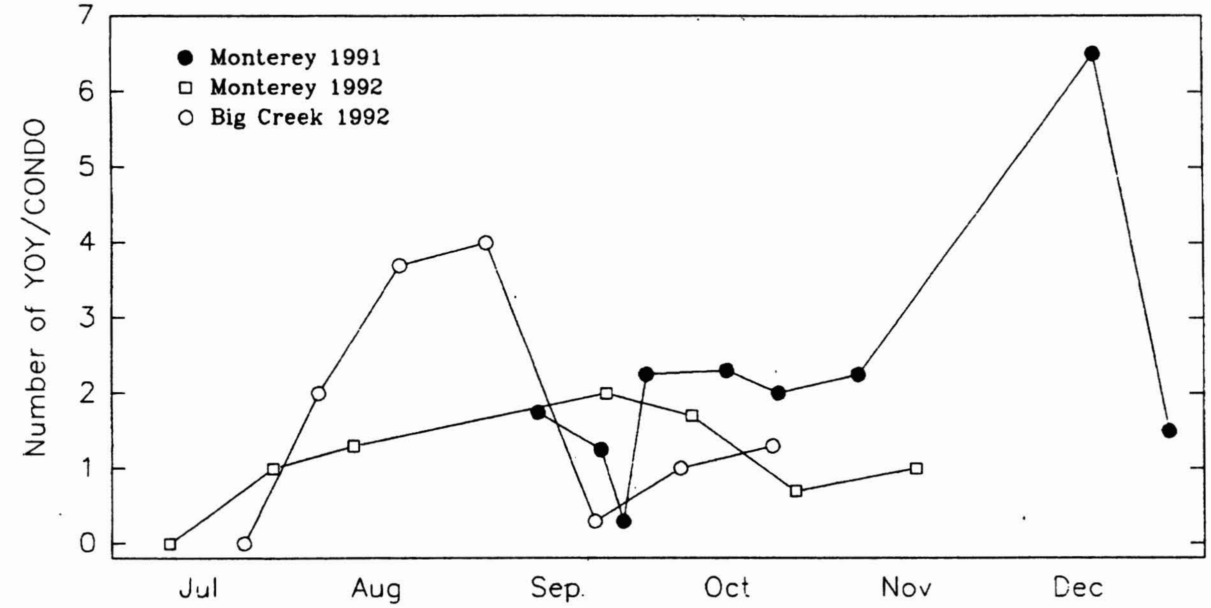

FIGURE 24. Sample mean number of young-of-the-year rockfish observed per rock condo on rock-sand interface, Monterey Bay, 1991-92 and Big Creek,

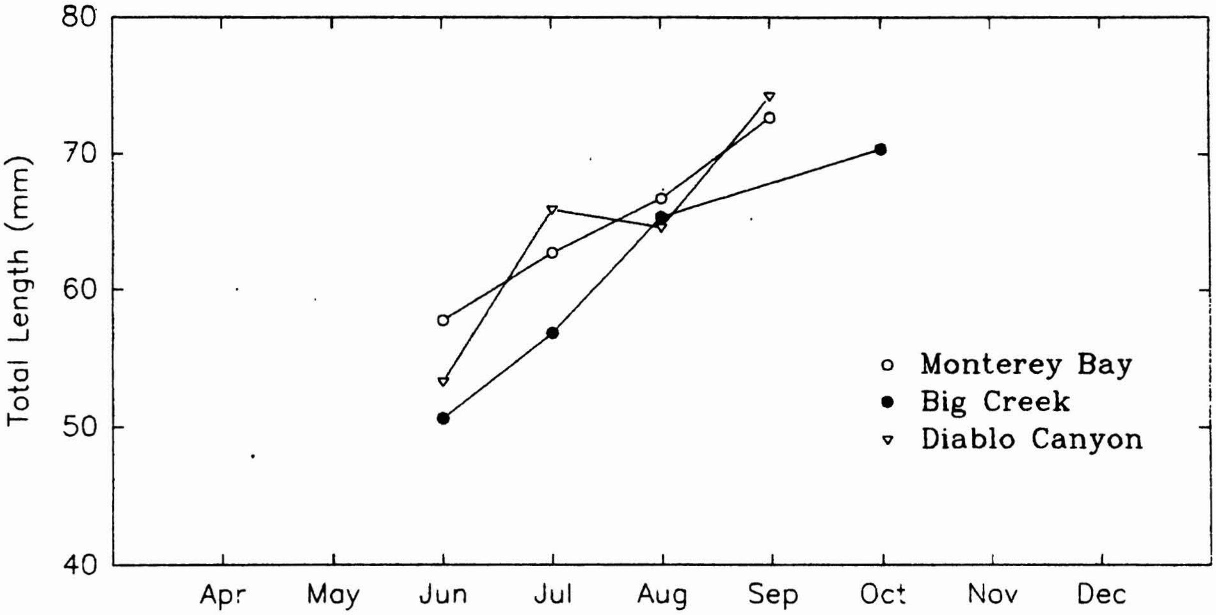

FIGURE 25. Monthly mean length of young-of-the-year black rockfish, central California coast, 1991.

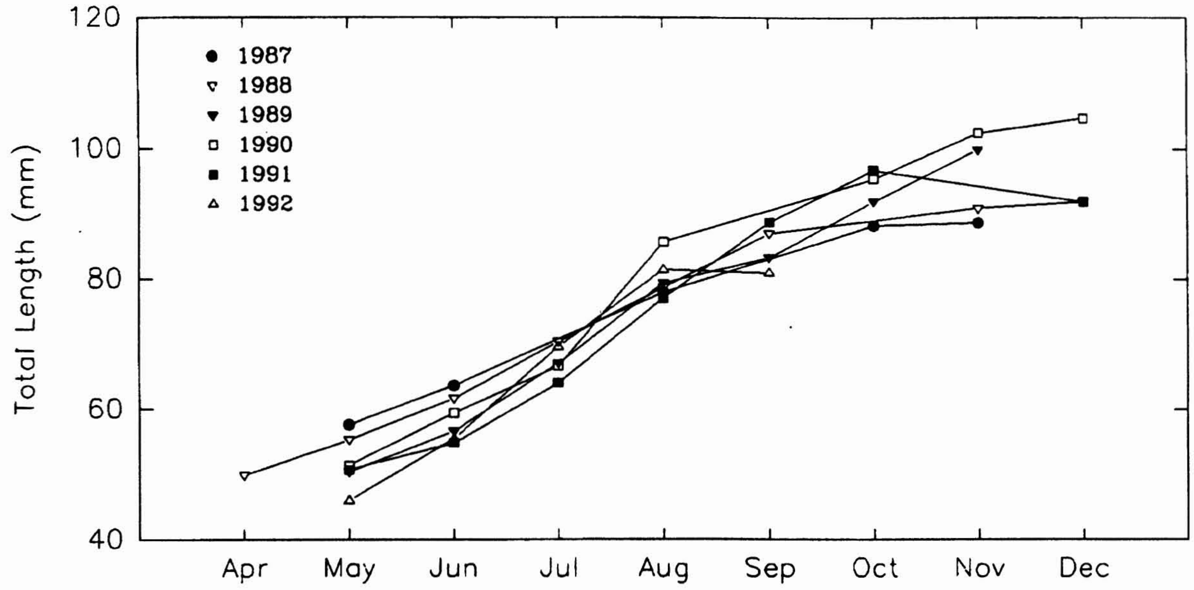

FIGURE 26. Monthly mean length of young-of-the-year blue rockfish, Monterey Bay, 1987-92.

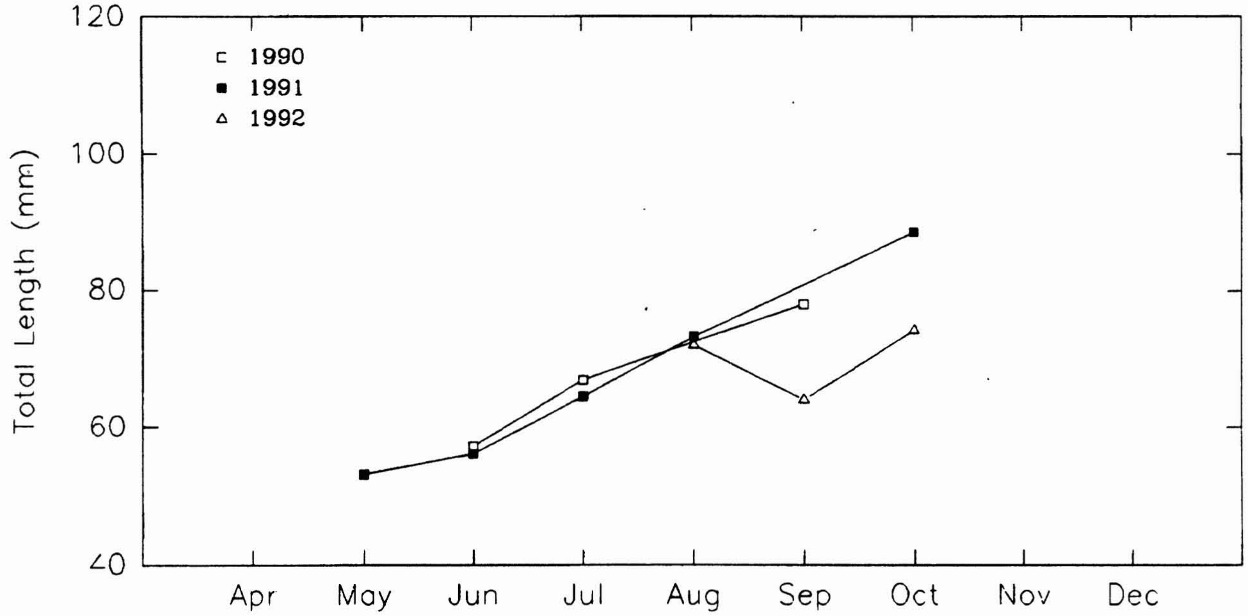

FIGURE 27. Monthly mean length of young-of-the-year blue rockfish, Big Creek, 1990-92.

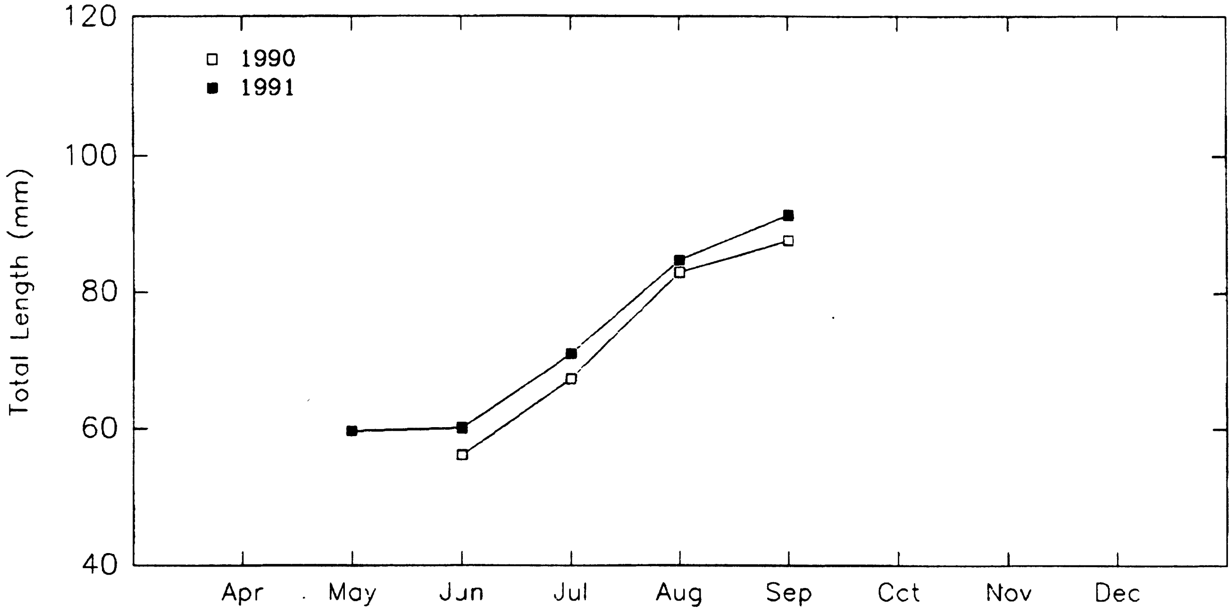

FIGURE 28. Monthly mean length of young-of-the-year blue rockfish, Diablo Canyon, 1990-91.

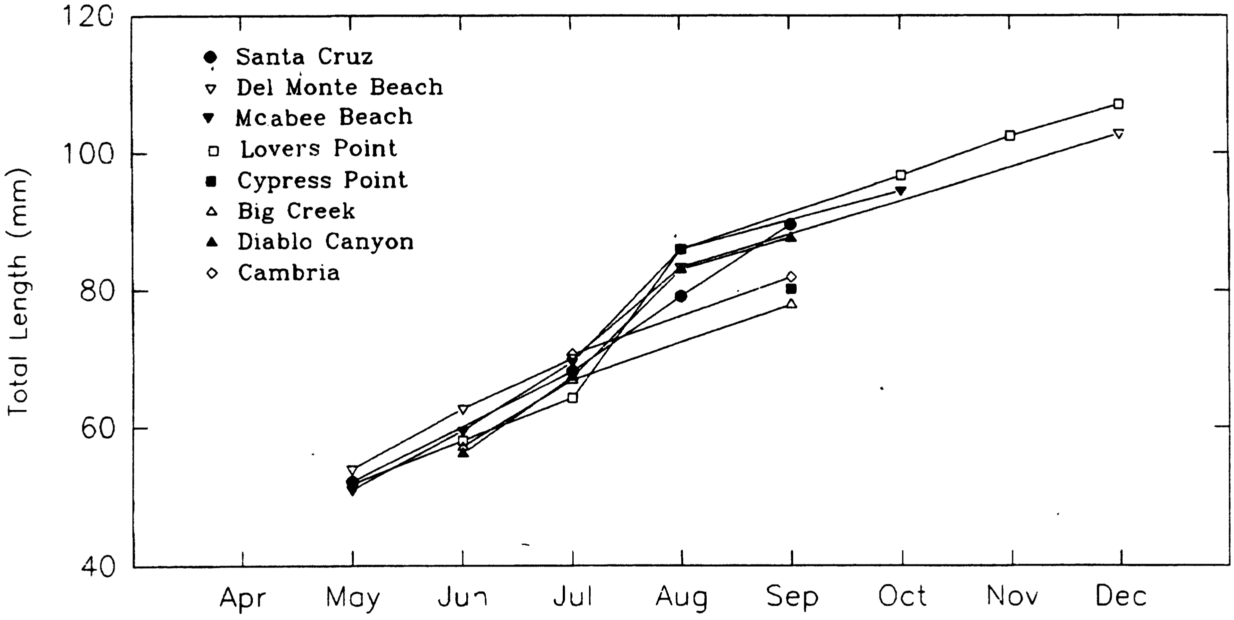

FIGURE 29. Monthly mean length of young-of-the-year blue rockfish, central California coast, 1990.

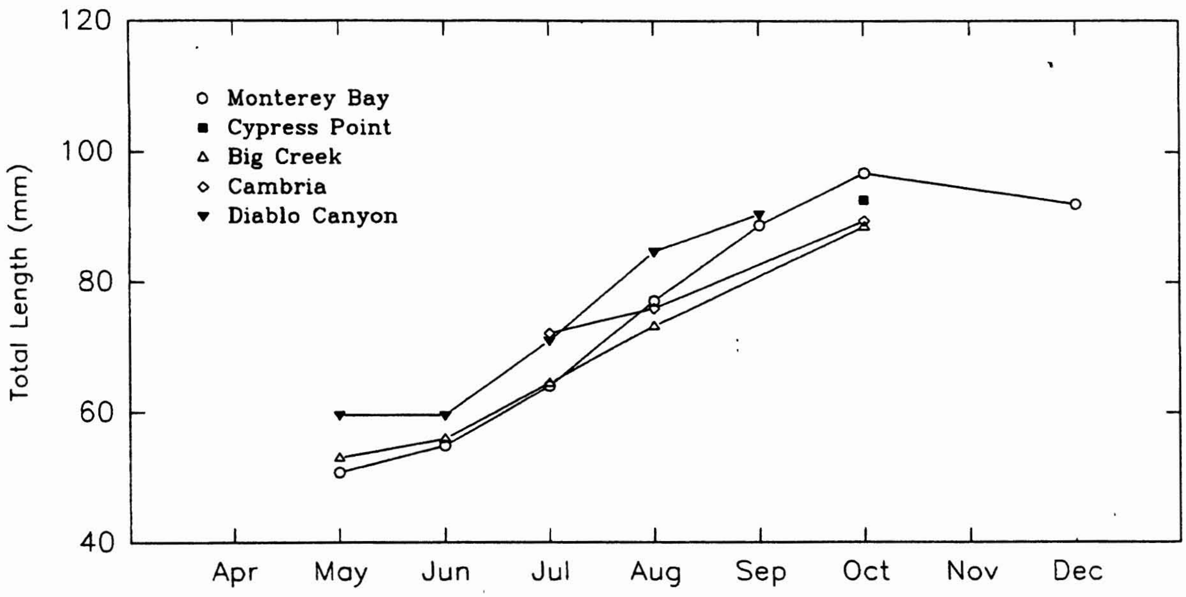

FIGURE 30. Monthly mean length of young-of-the-year blue rockfish, central California coast, 1991.

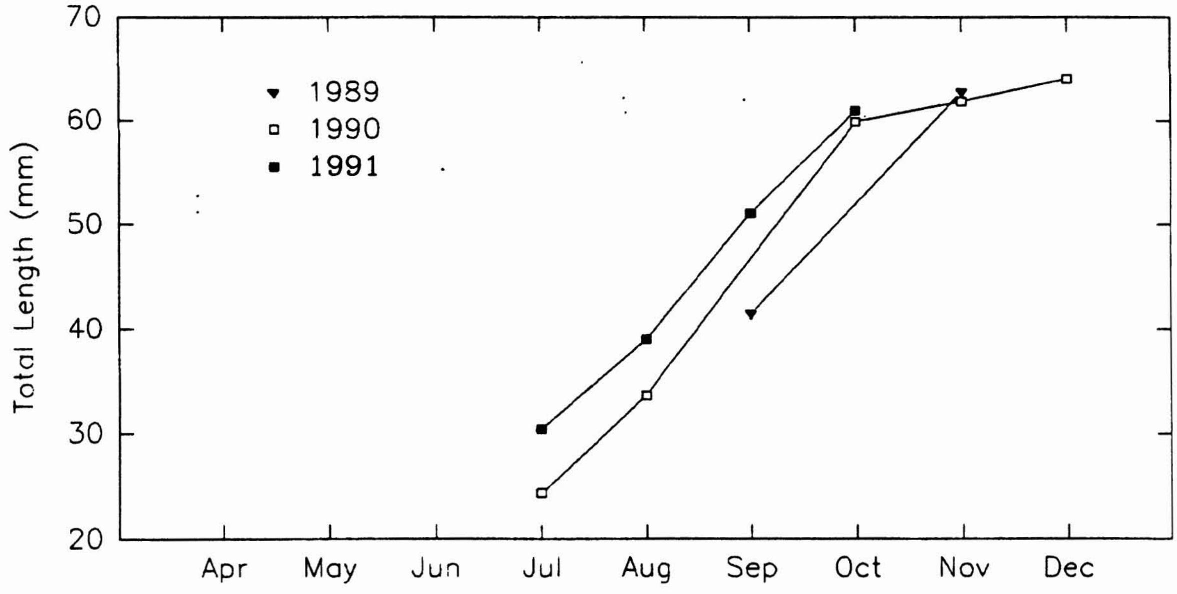

FIGURE 31. Monthly mean length of young-of-the-year kelp rockfish, Monterey Bay, 1989-91.

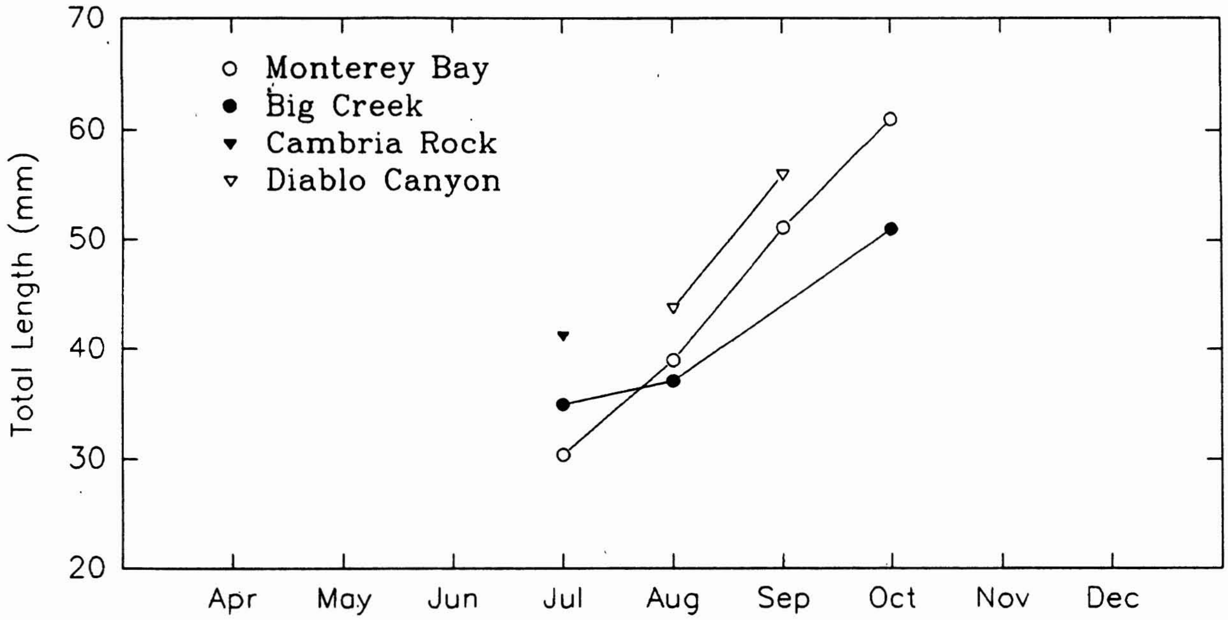

FIGURE 32. Monthly mean length of young-of-the-year kelp rockfish, central California coast, 1991.

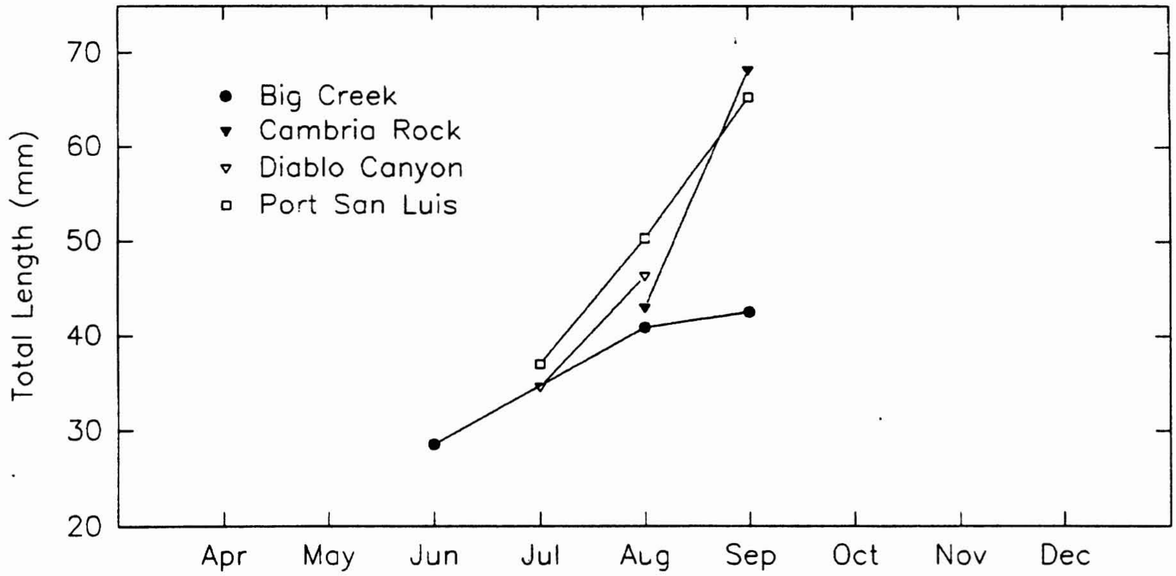

FIGURE 33. Monthly mean length of young-of-the-year kelp rockfish, central California coast, 1992.

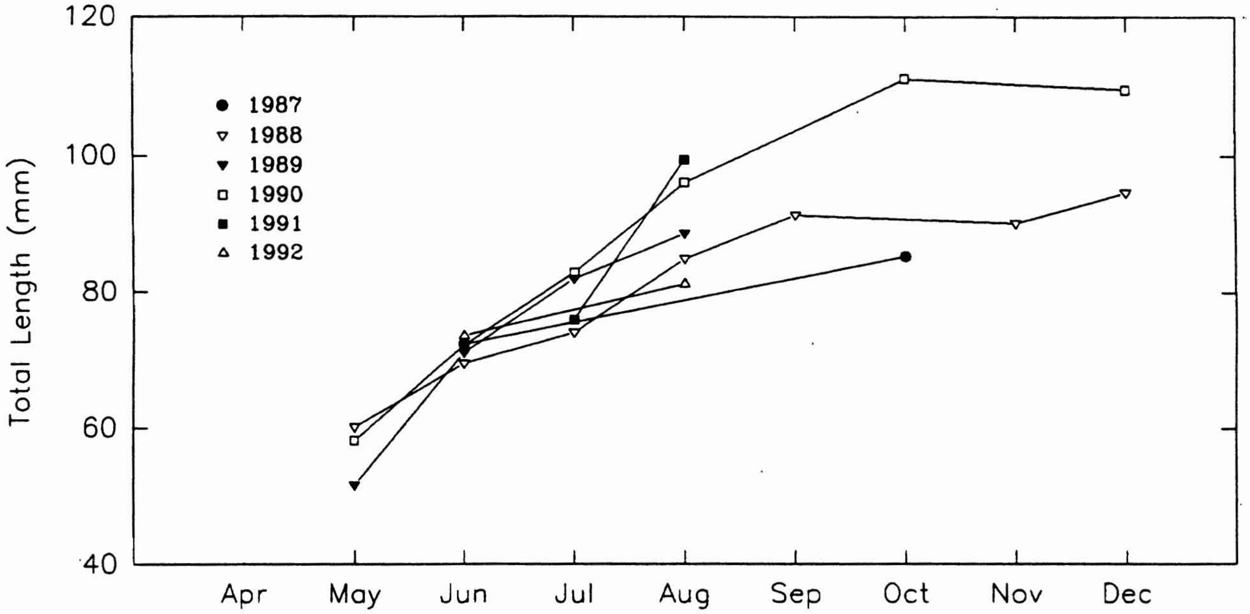

FIGURE 34. Monthly mean length of young-of-the-year olive rockfish, Monterey Bay, 1987-92.

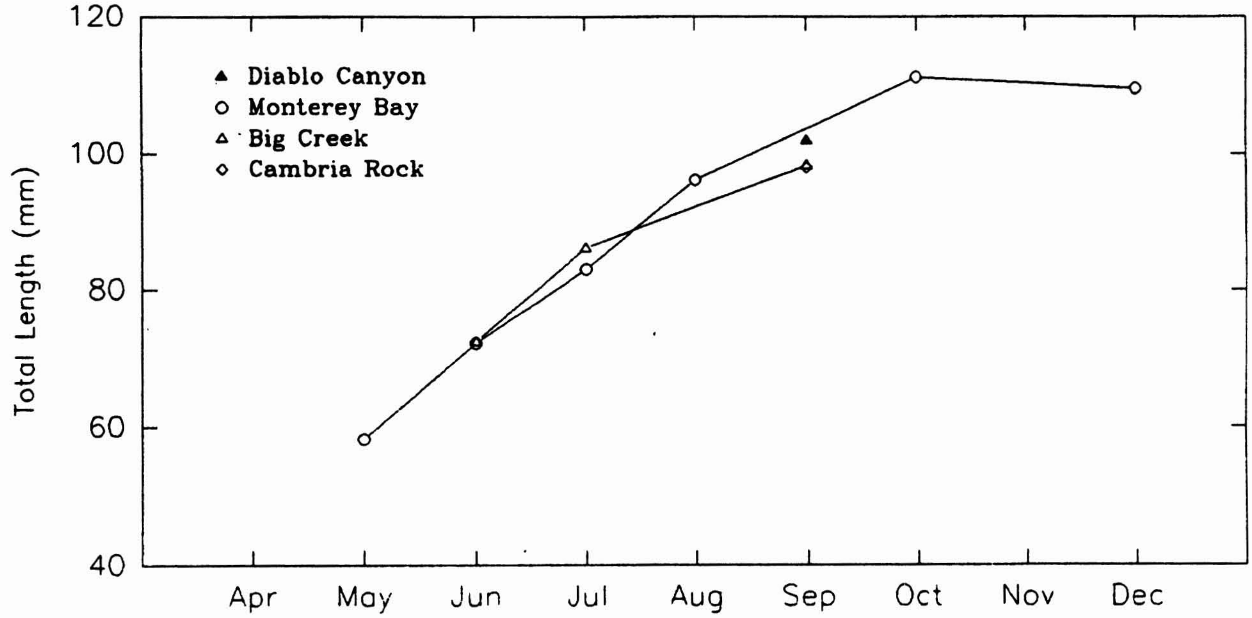

FIGURE 35. Monthly mean length of young-of-the-year olive rockfish, central California coast, 1990.

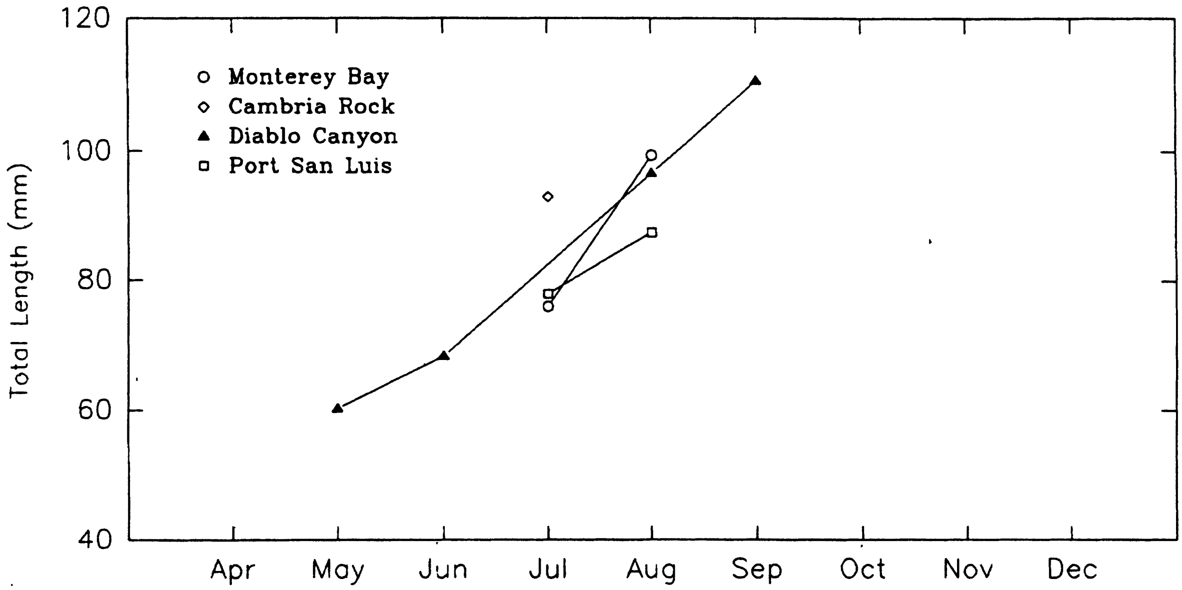

FIGURE 36. Monthly mean length of young-of-the-year olive rockfish, central California coast,

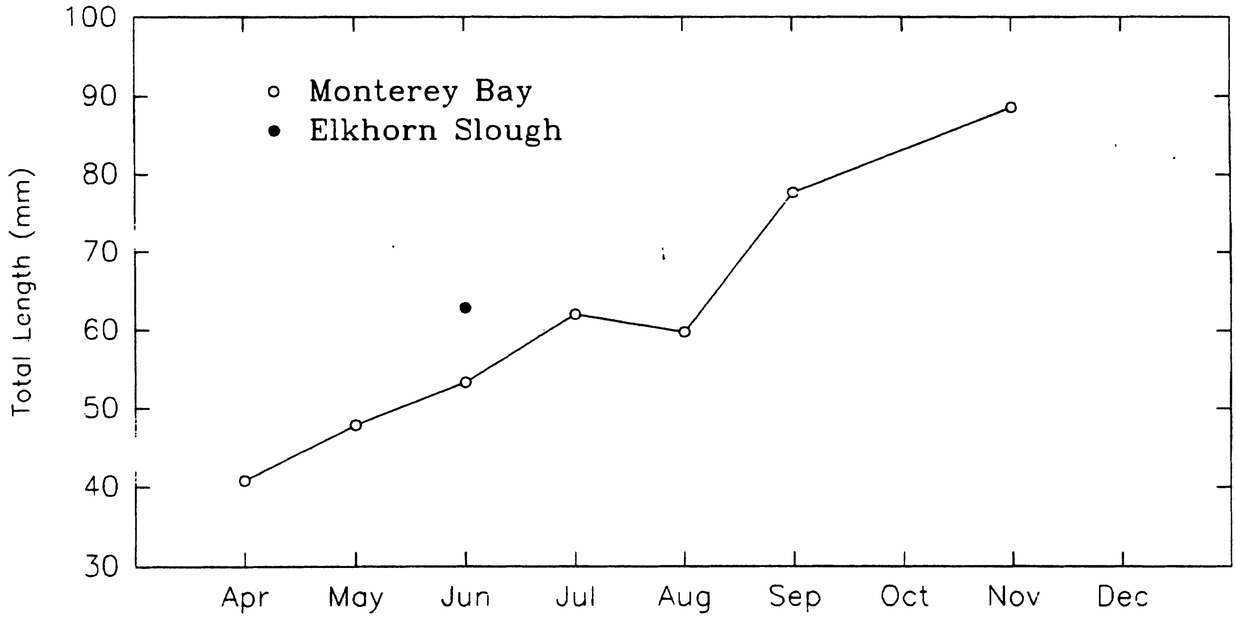

FIGURE 37. Monthly mean length of young-of-the-year vermilion rockfish, Monterey Bay and Elkhorn Slough, 1988.

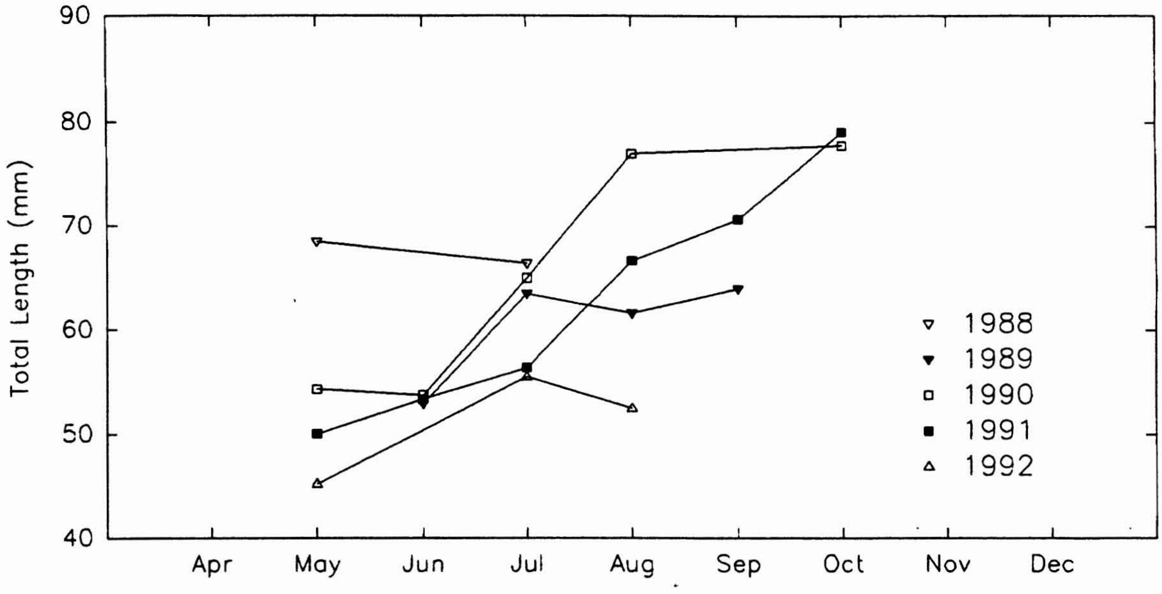

FIGURE 38. Monthly mean length of young-of-the-year yellowtail rockfish, Monterey Bay, 1988-92.

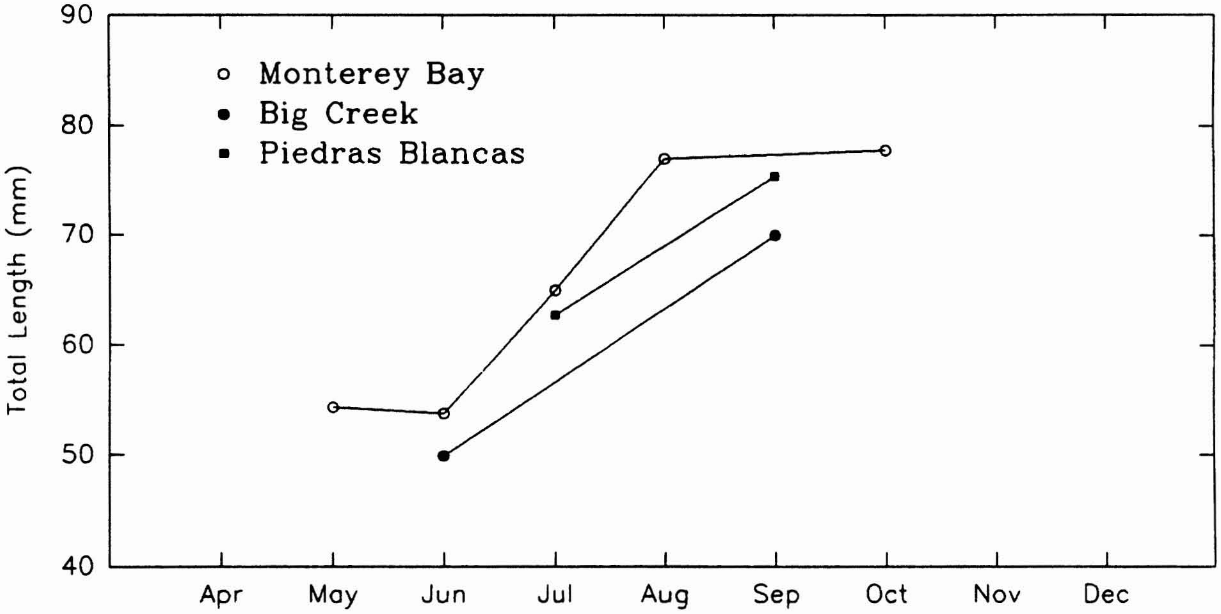

FIGURE 39. Monthly mean length of young-of-the-year yellowtail rockfish, central California coast, 1990.

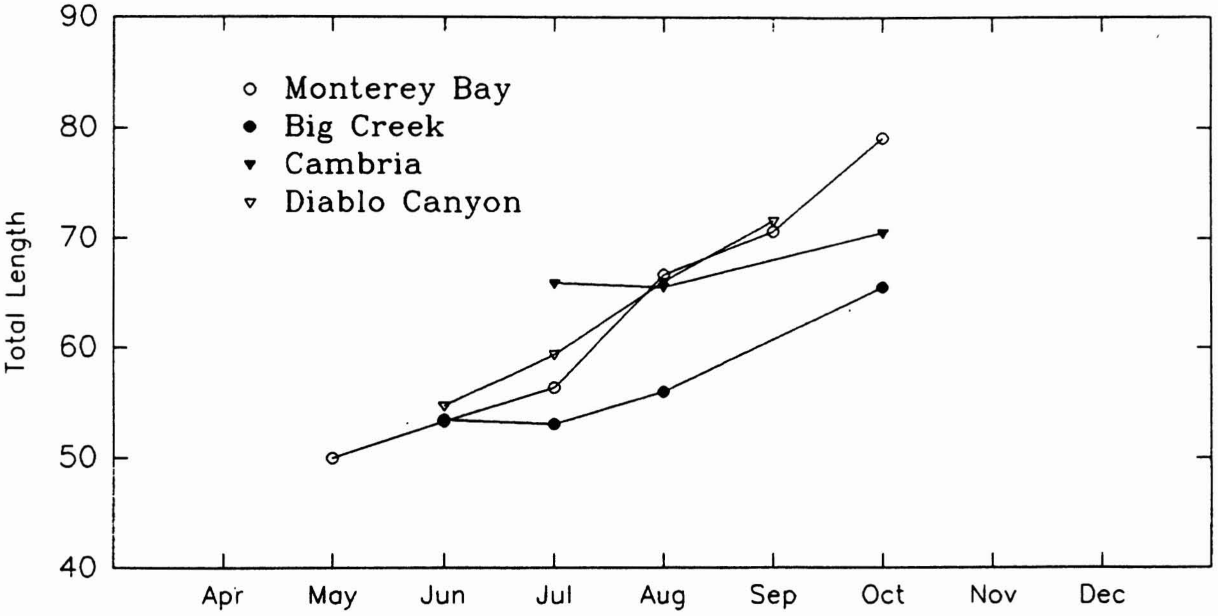

FIGURE 40. Monthly mean length of young-of-the-year yellowtail rockfish, central California coast,

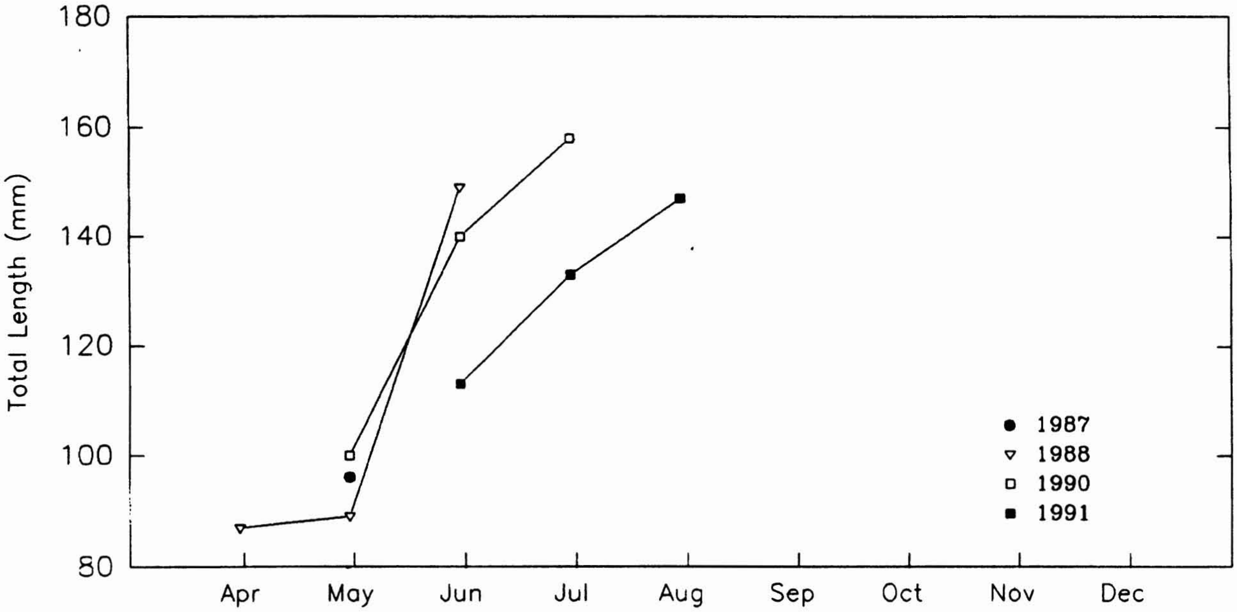

FIGURE 41. Monthly mean length of young-of-the-year lingcod, central California coast (all stations combined), 1987-91.

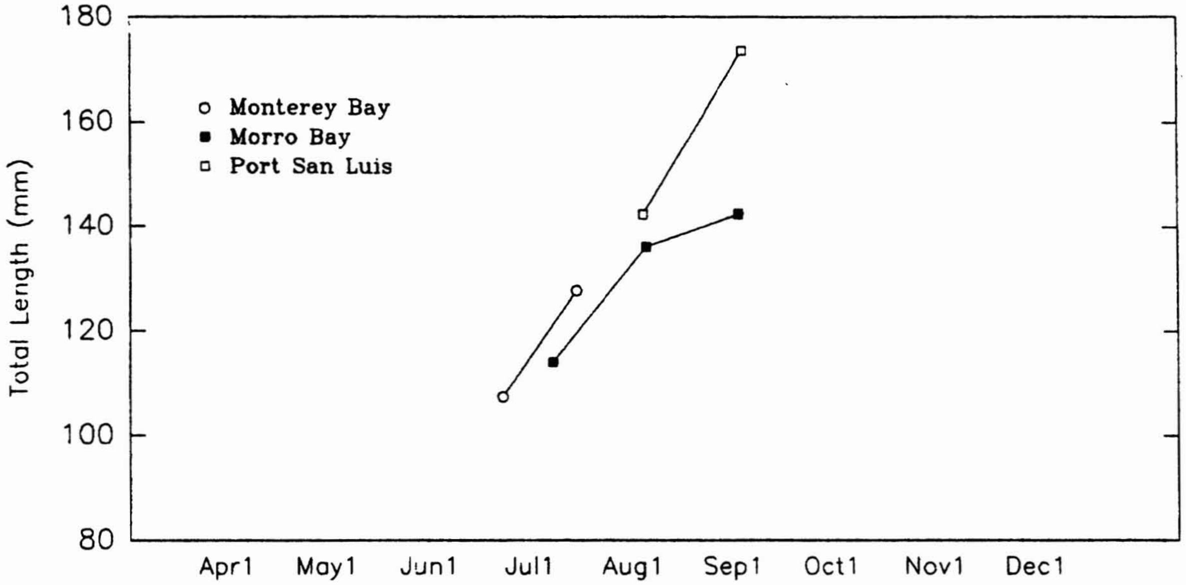

FIGURE 42. Daily mean length of young-of-the-year lingcod, central California coast, 1991.

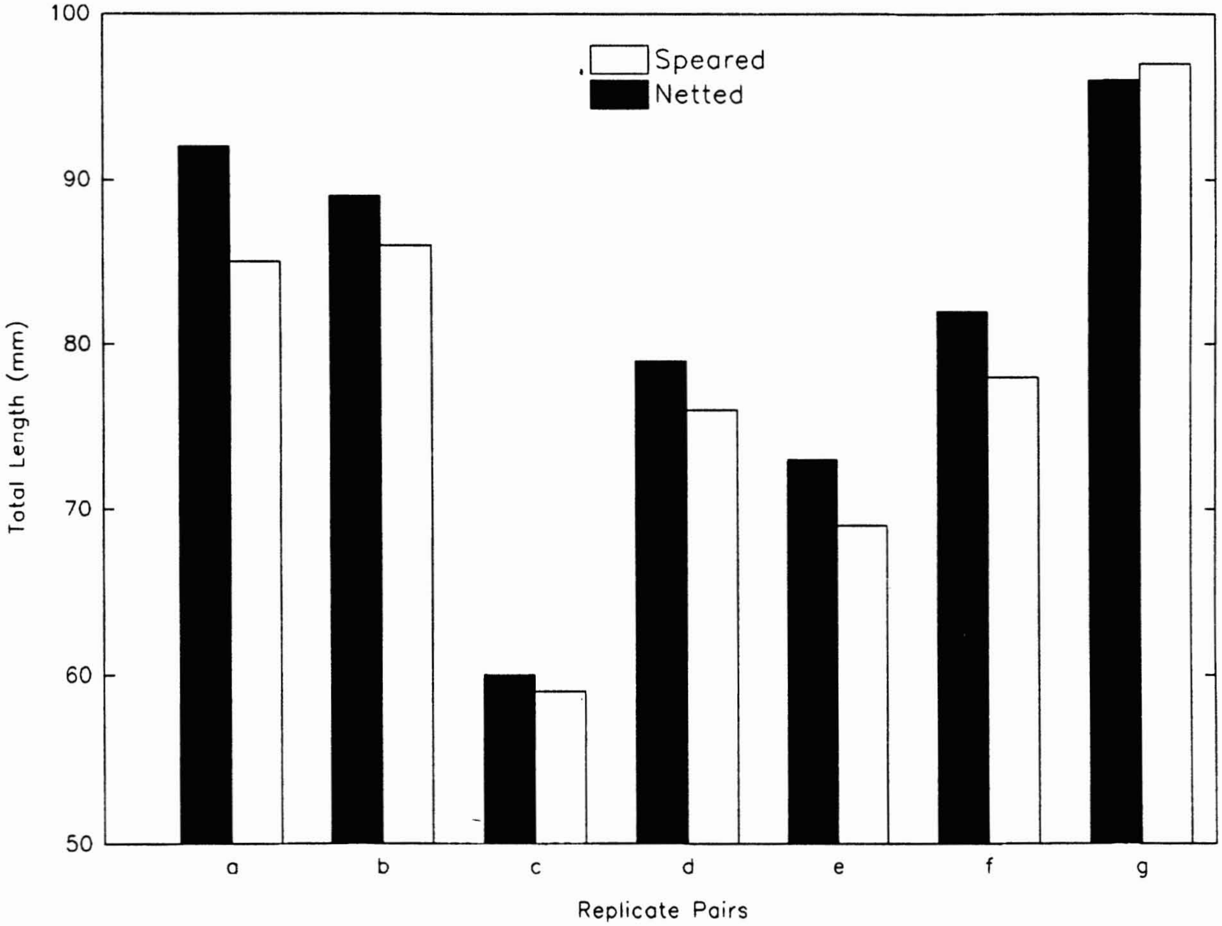

FIGURE 43. Mean length of young-of-the-year blue rockfish captured by net and spear.

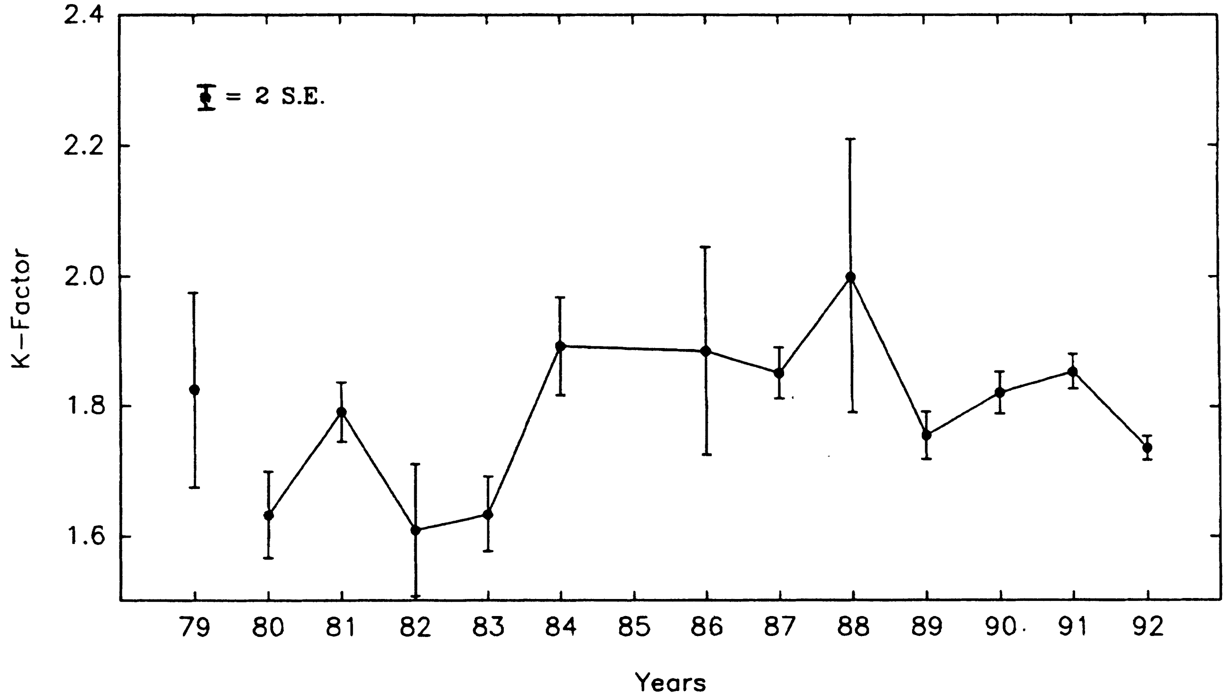

FIGURE 44. Mean condition factor (K-factor) during September-November of adult female blue rockfish, 1979-92.

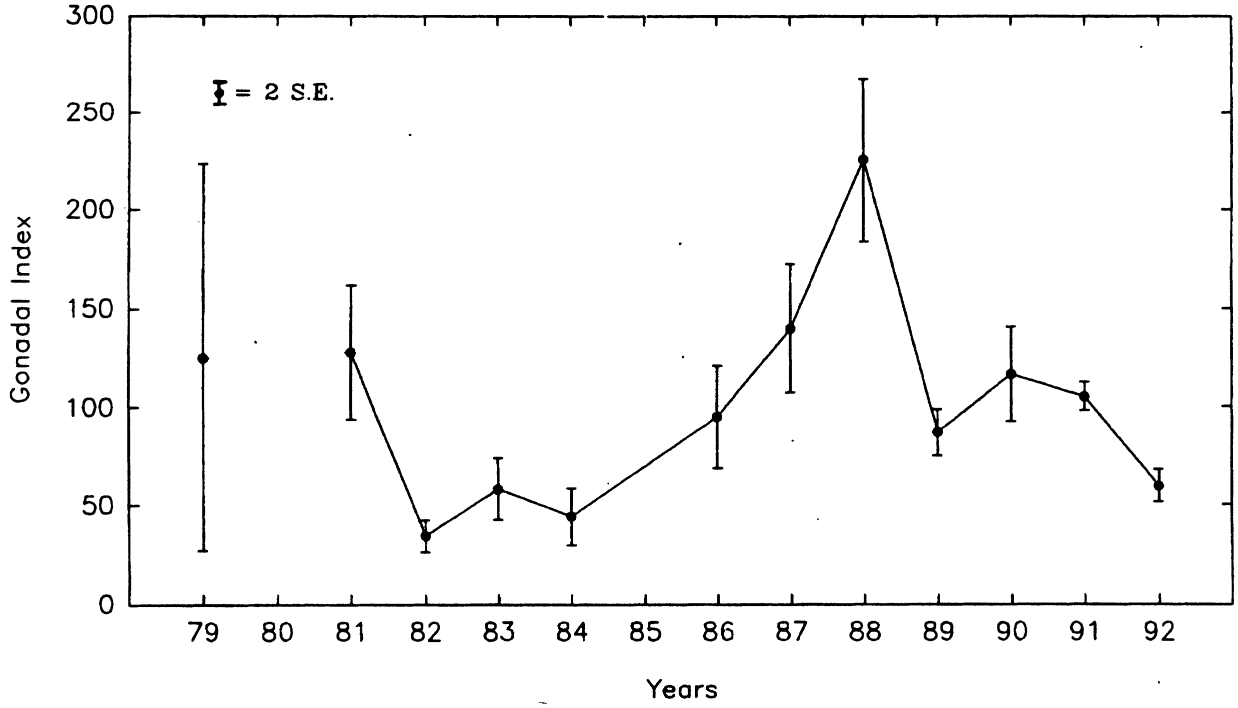

FIGURE 45. Mean gonadal index during November-January of adult female blue rockfish, 1979-92.

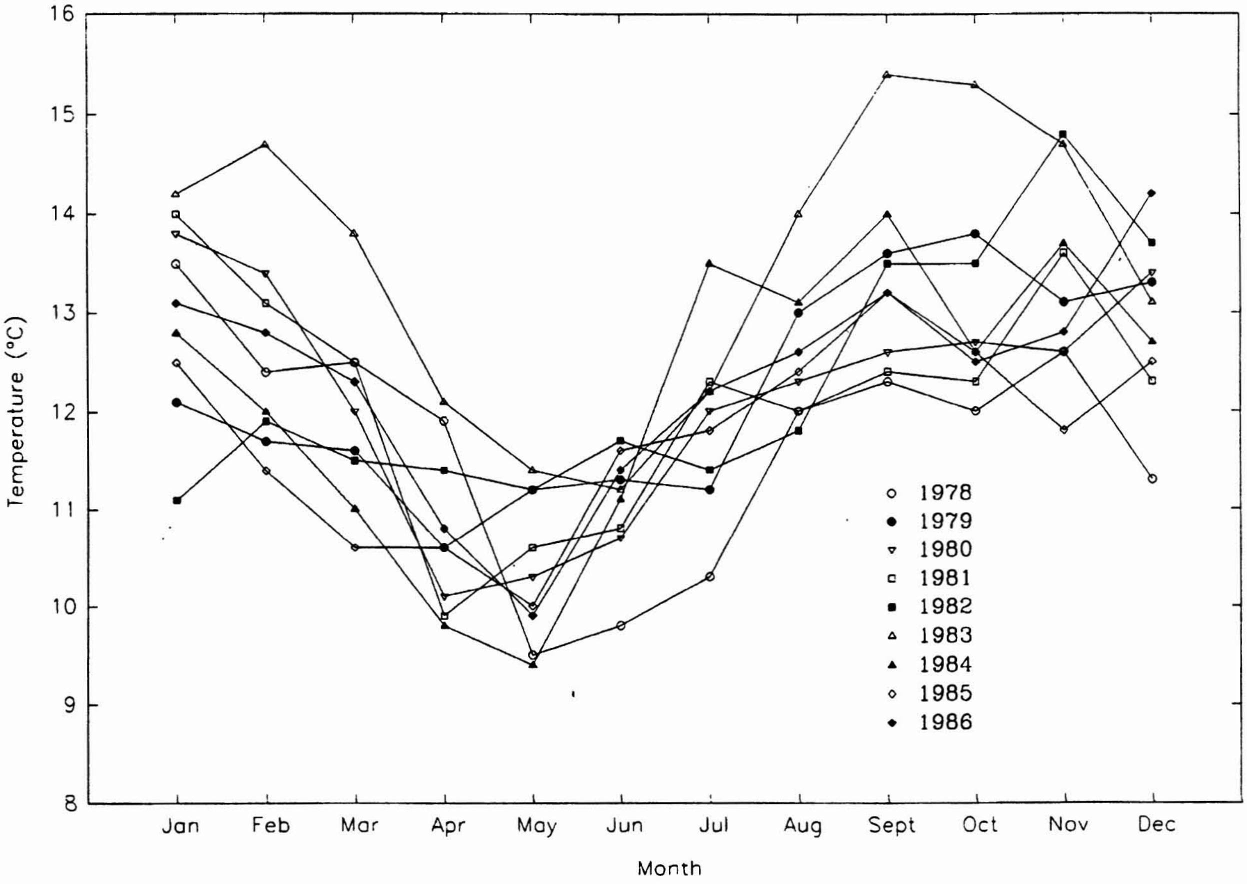

FIGURE 46. Monthly mean sea surface temperature, Granite Canyon Marine Pollution Laboratory, 1978-86.

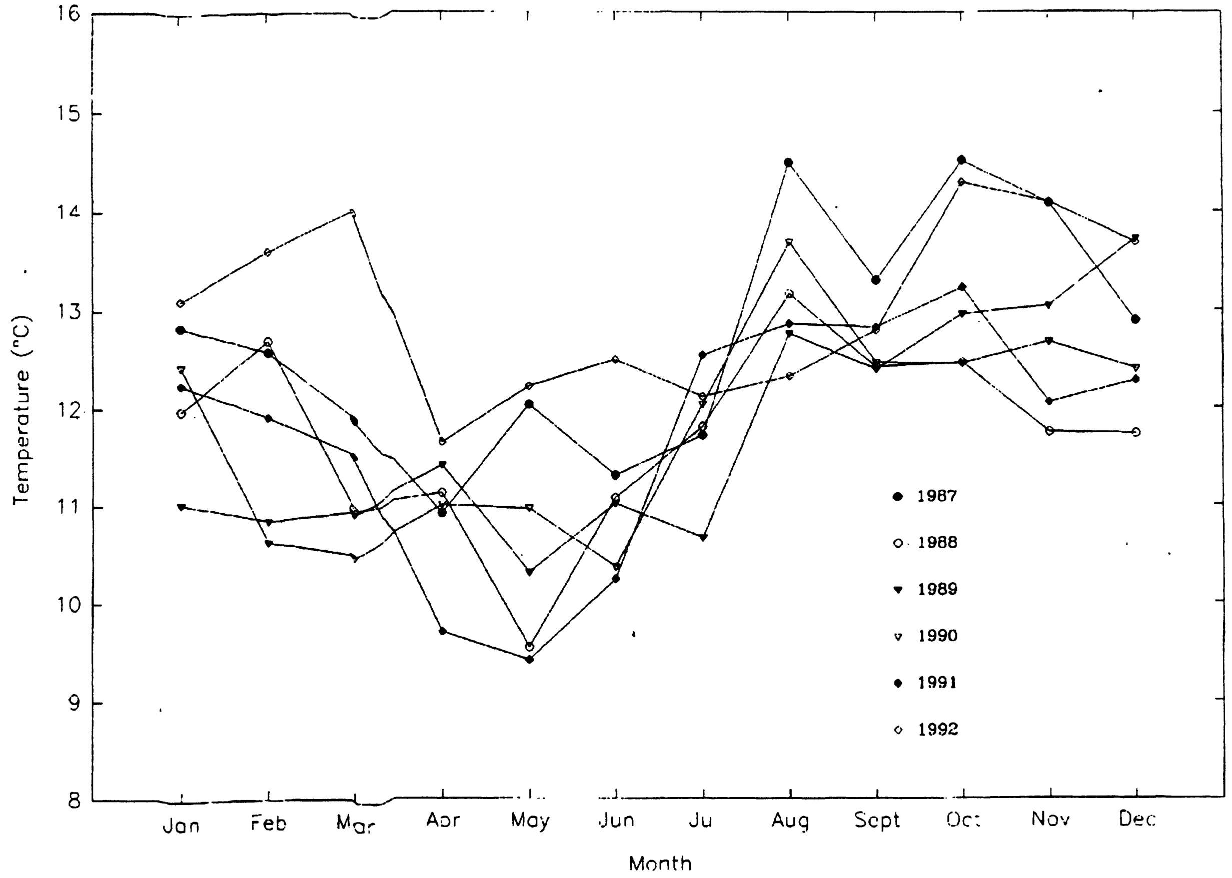

FIGURE 47. Monthly mean sea surface temperature, Granite Canyon Marine Pollution Laboratory, 1987-92.

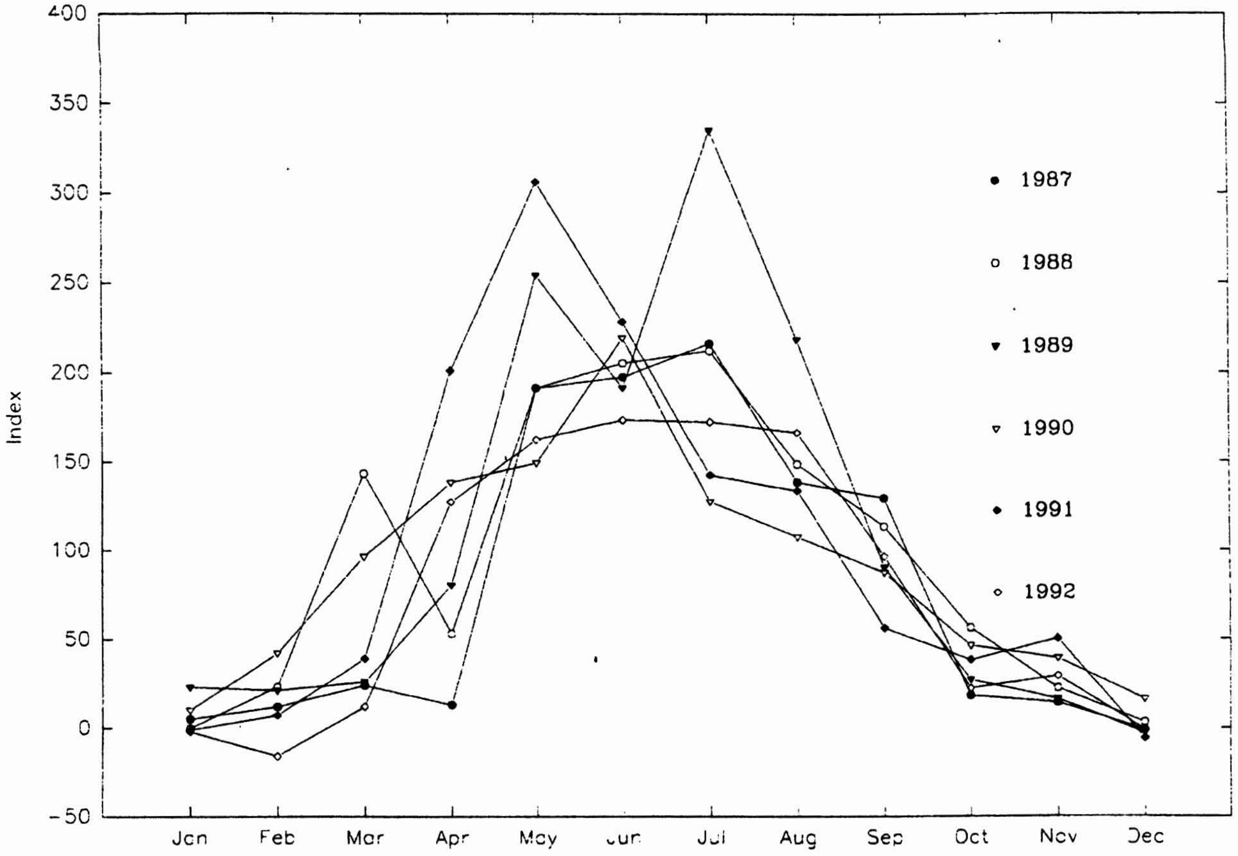

FIGURE 48. Monthly mean coastal upwelling index, 36°N, 122°W, 1987-92.

TABLE 1. List of common and scientific names of fishes referred to in this study.

Common Name	Scientific Name
Black rockfish	*Sebastes melanops*
Black-and-yellow rockfish	*Sebastes chrysomelas*
Blue rockfish	*Sebastes mystinus*
Bocaccio	*Sebastes paucispinis*
Brown rockfish	*Sebastes auriculatus*
Canary rockfish	*Sebastes pinniger*
Chilipepper	*Sebastes goodei*
Copper rockfish	*Sebastes caurinus*
Gopher rockfish	*Sebastes carnatus*
Halfbanded rockfish	*Sebastes semicinctus*
Kelp rockfish	*Sebastes atrovirens*
Olive rockfish	*Sebastes serranoides*
Shortbelly rockfish	*Sebastes jordani*
Splitnose rockfish	*Sebastes diploproa*
Stripetail rockfish	*Sebastes saxicola*
Vermilion rockfish	*Sebastes miniatus*
Widow rockfish	*Sebastes entomelas*
Yellowtail rockfish	*Sebastes flavidus*
Cabezon	*Scorpaenichthys marmoratus*
California smoothtongue	*Leuroglossus stilbius*
Lingcod	*Ophiodon elongatus*
Northern anchovy	*Engraulis mordax*
Northern lampfish	*Stenobrachius leucopsarus*
Pacific hake	*Merluccius stilbius*
Pacific mackeral	*Scomber japonicus*
Pacific sardine	*Sardinops sagax*
Plainfin midshipman	*Porichthys notatus*
White croaker	*Genyonemus lineatus*

TABLE 2. Dive stations, latitude, longitude, and depth (m).

Station Name	Latitude	Longitude	Depth(m)
Santa Cruz	36° 57.08N	121° 58.00W	10-12
Elkhorn Slough	36° 48.20N	121° 47.60W	4-8
Del Monte Beach	36° 36.08N	121° 52.80W	10-24
Monterey Wharf II	36° 36.05N	121° 53.30W	4-8
McAbee Beach	36° 37.06N	121° 54.10W	12-14
Lovers Point	36° 38.18N	121° 54.80W	4-13
Otter Point	36° 37.07N	121° 55.10W	4-13
North Cypress Point	36° 35.02N	121° 58.45W	16-24
South Cypress Point	36° 34.40N	121° 58.55W	20-24
Carmel Bay	36° 33.30N	121° 56.80W	14-20
Big Creek	36° 04.10N	121° 37.10W	4-24
Piedras Blancas	35° 39.30N	121° 15.70W	10-22
Cambria Rock	35° 35.00N	121° 07.50W	10-22
Morro Bay	35° 22.15N	120° 51.35W	4-6
Point Buchon	35° 16.50N	120° 53.60W	10-20
Diablo Canyon - Pub Rock	35° 13.10N	120° 52.07W	10-14
Diablo Canyon - Intake	35° 12.43N	120° 51.25W	10-14
Diablo Canyon - Reef	35° 11.50N	120° 49.62W	16-20
SLOCAR	35° 11.30N	120° 49.50W	16-20
Port San Luis	35° 10.40N	120° 44.50W	4-16

TABLE 3. Initial nearshore observations and relative abundance of young-of-the-year black, blue, olive and yellowtail rockfishes, and the olive/yellowtail/black rockfish complex, central California coast, 1990.

	Apr 8-14	15-21	22-28	Apr 29 May 5	6-12	13-19	20-26	May 27 June 2	3-9	10-16	17-23	24-30
Del Monte Tankers	/	/	/	/	/	BL•	BL•• OL• YT•• OYB••	BL•• OYB••	BL• OYB••	BL•• OYB••	BL•••• OYB•••	
Monterey Wharf 2	/		/	/	/		OYB•••				BL•	
McAbee Aquarium		/	/	/	/	BL•	BL• OL• YT•	BL•• OYB••	OYB•••	OYB••	BL•• OL••• OYB••	
Otter Pt. Blue Mt.	/	/	/	BL•	BL•	BL•	BL•• OYB•	BL•• OYB••	BL•• OYB••	BL•• OYB•	BL••• YT••• OYB••	
Big Creek												BL•••• OYB•••
Diablo Canyon Intake		/	/	/	/	OYB••				BK• BL• OYB••		BL•••• OYB••
Pup Rock	/	BL•		BL•	/	OYB••						BL•• OYB••••
South Cove	/	/	/	OYB•	/	OYB•				BK• BL• OYB•		/
Diablo Reef		/	/	/	/	BK• BL• OYB•	/	OYB•		BK•• BL• OYB••		BL••• OYB•••
SLOCAR		/	/	/	/	BK• BL• OYB•				BK• BL• OYB••		BK•• BL••• OYB•

Species of rockfish:

Black = Bk
Blue = BL
Olive = OL
Yellowtail = YT
Olive/Yellowtail/Black complex = OYB

Observed relative abundance:

None observed = /
< 1 per minute = •
1–5 per minute = ••
6-10 per minute = •••
> 10 per minute = ••••

TABLE 4. Initial nearshore observations and relative abundance of young-of-the-year bocaccio, canary, copper, stripetail, and vermilion rockfishes, central California coast, 1990.

	Apr 8-14	15-21	22-28	Apr 29 May 5	6-12	13-19	20-26	May 27 June 2	3-9	10-16	17-23	24-30	July 1-7	8-14	15-21	22-28	Jul 29 Aug 4
Del Monte Tankers	/	/	/	/	/	CP•	CA•• ST•	CA• ST• VE•	/	BO• CA•	BO• VE•		/	CP• VE•	BO• CP•		CO•
Monterey Wharf 2	/		/	CP• VE•	CP••		CP••	/			BO•• CP•				/		/
McAbee Aquarium		/	/	/	CA• CP• ST•	CP• ST•	VE•	CA• CP•	BO•• VE•	BO•	BO• CP•		BO• CP•	BO•• CP•	BO•• CP•	/	BO••
Otter Pt. Blue Mt.	/	/	/	/	/	CP•	/	CP• ST•	/	/	BO• CA• ST•		/	/	/	/	CA•
Big Creek												BO•				BO• VE•	
Diablo Canyon Intake		/	/	/	/	/				/		/		CP•		/	
Pup Rock	/	/		/	/	/						/		/		BO•	
South Cove	/	/	/	/	/	/				/		/		CP•			
Diablo Reef		/	/	/	CP•	/	BO••••	BO•		/		/	/	CA••	/	/	
SLOCAR		/	/	/	CP•	BO• CP•				/		BO•		/	/	BO• CP•	CA•

Species of rockfish:
Bocaccio = BO
Canary = CA
Copper = CP
Stripetail = ST
Vermilion = VE

Observed relative abundance:
None observed = /
< 1 per minute = •
1–5 per minute = ••
6–10 per minute = •••
> 10 per minute = ••••

TABLE 5. Initial nearshore observations and relative abundance of young-of-the-year chilipepper and kelp rockfishes, and the kelp/gopher/black-and-yellow complex, central California coast, 1990.

	Apr 8-14	15-21	22-28	Apr 29 May 5	6-12	13-19	20-26	May 27 June 2	3-9	10-16	17-23	24-30	July 1-7	8-14	15-21	22-28	Jul 29 Aug 4
Del Monte Tankers	/	/	/	/	/	/	/	/	/	/	CH• KGB•		/	/	/		KP••
Monterey Wharf 2	/		/	/	/		/	/			/				/		/
McAbee Aquarium		/	/	/	/	/	/	/	/	/	/		KP•	/	/	/	KP••
Otter Pt. Blue Mt.	/	/	/	/	/	/	/	/	/	/	/		/	/	KP•	/	KP••
Big Creek												/				KP•	
Diablo Canyon Intake		/	/	/	/	/				KGB•		KGB•		KGB• KP•		KP••	
Pup Rock	/	/		/	/	/						KGB•		/		KP•	
South Cove	/	/	/	/	/	/				KGB••		/		KGB• KP•			
Diablo Reef		/	/	/	/	/	/	/		/		/	/	KP•	/	KP•	
SLOCAR		/	/	/	/	/				/		KP•		KP•	/	KP•	KP•

Species of rockfish:
Chilipepper = CH
Kelp = KP
Kelp/Gopher/Black-and-yellow complex = KGB

Observed Relative Abundance:
None observed = /
< 1 per minute = •
1–5 per minute = ••
6–10 per minute = •••
> 10 per minute = ••••

TABLE 6. Initial nearshore observations and relative abundance of young-of-the-year black, blue, olive, and yellowtail rockfishes, and the olive/yellowtail/black rockfish complex, central California coast, 1991.

	Apr 14-20	21-27	Apr 28 May 4	5-11	12-18	19-25	May 26 June 1	2-8	9-15	16-22	23-29
Monterey Wharf 2					/				BL••••		
McAbee Aquarium	/	/			BL• YT• OYB•			BL•• YT• OYB•			
Otter Pt. Blue Mt.	/	/			BL• OYB•	YT•		BL••• OYB•	BL••••	/	
Big Creek					BL••	BL•					BL•••• YT• OYB•
Pt. Buchon		/	/	/	BK•	BL•		BK• BL• OYB••		BK• BL••	BK• BL•••• OYB•
Diablo Canyon Intake	OYB•	/				BL• OL•					
Pup Rock	/	/	/	BK•		OYB•		BL• OYB••		BK•• BL•••	BK•• BL••• OYB••
SLOCAR	/	/	/	/	BL•			BL• OYB••		BK• BL•	BK• BL•••• YT• OYB•••

Species of rockfish:
Black = BK
Blue = BL
Olive = OL
Yellowtail = YT
Olive/Yellowtail/Black complex = OYB

Observed relative abundance:
None observed = /
< 1 per minute = •
1-5 per minute = ••
6-10 per minute = •••
> 10 per minute = ••••

TABLE 7. Initial nearshore observations and relative abundance of young-of-the-year bocaccio, canary, stripetail, and vermilion rockfishes, central California coast, 1991.

	Apr 14-20	21-27	Apr 28 May 4	5-11	12-18	19-25	May 26 June 1	2-8	9-15	16-22	23-29	June 30 July 6	7-13
Monterey Wharf 2					BO•				BO•• CA•			BO•••	
McAbee Aquarium	/	/			/			CA• ST•					BO• CA• ST•••
Otter Pt./ Blue Mt.	/	/			CA• ST•	/		BO• CA• ST•	CA•	/		BO• CA•	BO• CA• ST•
Big Creek					/	/					BO•		
Pt. Buchon		/	/	/	/	/		/		/	/	BO•	
Diablo Canyon Intake	/	/				/							
Pup Rock	/	VE•	/	/		/		/		BO••	BO•	BO• CA•	
SLOCAR	/	/	/	/	/			/		/	BO• CA•	CA•	

Species of rockfish:

Bocaccio = BO
Canary = CA
Stripetail = ST
Vermilion = VE

Observed relative abundance:

None observed = /
< 1 per minute = •
1-5 per minute = ••
6-10 per minute = •••
> 10 per minute = ••••

TABLE 8. Initial nearshore observations and relative abundance of young-of-the-year, chilipepper, copper, and kelp rockfishes, and the kelp/gopher/black-and-yellow rockfish complex, central California coast, 1991.

	Apr 14-20	21-27	Apr 28 May 4	5-11	12-18	19-25	May 26 June 1	2-8	9-15	16-22	23-29	June 30 July 6	7-13
Monterey Wharf 2					/				CP•			CP•	
McAbee Aquarium	/	/			/			/					KP•
Otter Pt. Blue Mt.	/	/			/	/		/	/	/		/	KP•
Big Creek					/	/					KGB•		
Pt. Buchon		/	/	/	/	/		CP•		CP••	CP•• KP• KGB•	CP•	
Diablo Canyon Intake	/	/				/							
Pup Rock	CP•	/	/	CP•		/		CP•		CP•••	CP•••• KGB••	CP•• KP• KGB•	
SLOCAR	/	/	/	/	/			/		/	CP•	/	

Species of rockfish:
Chilipepper = CH
Copper = CO
Kelp = KP
Kelp/Gopher/Black-and-yellow complex = KGB

Observed relative abundance:
None observed = /
< 1 per minute = •
1-5 per minute = ••
6-10 per minute = •••
> 10 per minute = ••••

TABLE 9. Initial nearshore observations and relative abundance of young-of-the-year black, blue, olive, and yellowtail rockfishes, and the olive/yellowtail/black rockfish complex, central California coast, 1992.

	Mar 22-28	Mar 29 Apr 4	5-11	12-18	19-25	Apr 26 May 2	3-9	10-16	17-23	24-30	May 31 Jun 6	7-13	14-20	21-27	Jun 28 Jul 14
Monterey Wharf 2		BK•			/			OYB•						OL•	
McAbee	/				/			YT•		YT•				OL•	
Otter Pt.			BL•	/	/	/	OYB•	YT•		BL• YT• OYB•	/	BL• YT•	BL•	BL•	/
Cypress Pt.				/								/			
Carmel Bay								BL•				YT•			OL• OYB•
Big Creek									/			BL• YT•		/	
Cambria Rock												/			
Morro Bay												/			
Diablo Canyon Intake			/				/		/	/	/	/			
Pup Rock			/				/		/	/	/	YT•			

Species of rockfish:

Black = BK
Blue = BL
Olive = OL
Yellowtail = YT
Olive/Yellowtail/Black complex = OYB

Observed relative abundance:

None observed = /
< 1 per minute = •
1-5 per minute = ••
6-10 per minute = •••
> 10 per minute = ••••

TABLE 10. Initial nearshore observations and relative abundance of young-of-the-year bocaccio, copper, and kelp rockfishes, the gopher/black-and-yellow rockfish complex, and the kelp/gopher/black-and-yellow rockfish complex, central California coast, 1992.

	Mar 22-28	Mar 29 Apr 4	5-11	12-18	19-25	Apr 26 May 2	3-9	10-16	17-23	24-30	May 31 Jun 6	7-13	14-20	21-27	Jun 28 Jul 14
Monterey Wharf 2		/			CP•			/						BO•	
McAbee	/				/			/		/				/	
Otter Pt.			/	/	/	/	/	/		/	/	/	/	KP••	KP• KGB•
Cypress Pt.				/								/			
Carmel Bay								/				KGB•			KP•• KGB• GB•
Big Creek									/			BO•		KP••	
Cambria Rock												BO•			
Morro Bay												/			
Diablo Canyon Intake			/				/		/	/	KGB•	/			
Pup Rock			/				/		/	/	KGB•	/			

Species of rockfish:

Bocaccio = BO
Copper = CP
Gopher/Black-and-Yellow = GB
Kelp = KP
Kelp/Gopher/Black-and-Yellow = KGB

Observed relative abundance:

None observed = /
< 1 per minute = •
1-5 per minute = ••
6-10 per minute = •••
> 10 per minute = ••••

TABLE 11. Percent composition of rockfishes observed in pipe condos, 1990-92, and rock condos, 1991-92.

Species	Pipe condos 1990-92			Rock condos 1991-92		
	Total fish	% composition	Rank	Total fish	% composition	Rank
KGB	51	10.5	3	97	45.8	1
Copper	120	24.8	2	8	3.8	5
Vermilion	0	0.0	0	5	2.4	7
Kelp	224	46.3	1	39	18.4	2
Blue	39	8.1	4	33	15.6	3
Canary	0	0.0	0	15	7.1	4
OYT	33	6.8	5	8	3.8	6
Unid.	9	1.9	6	4	1.9	8
Stripetail	0	0.0	0	2	0.9	9
Chilipepper	0	0.0	0	1	0.5	10
Black	5	1.0	7	0	0.0	0
Bocaccio	1	0.2	8	0	0.0	0
Lingcod	1	0.2	9	0	0.0	0
Cabezon	1	0.2	10	0	0.0	0

TABLE 12. Standard length-total length relationships for seven species of young-of-the-year fish.

Species	n	Range (TL mm)	SL/TL	TL/SL
Black rockfish	269	43-83	.86	1.14
Blue rockfish	2125	42-112	.82	1.20
Kelp rockfish	659	18-78	.82	1.21
Olive rockfish	647	50-120	.83	1.20
Vermilion rockfish	187	26-93	.83	1.18
Yellowtail rockfish	685	76-103	.85	1.15
Lingcod	126	76-193	.89	1.12

TABLE 13. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year black rockfish, central California coast, 1991.

Location	Month	n	Mean (mm)	Std. Dev.	Minimum (mm)	Maximum (mm)
Monterey Bay	June	13	57.8	3.4	53	63
	July	17	62.7	6.1	50	75
	August	35	66.7	9.3	47	83
	September	18	72.7	4.6	66	81
	October	1	87.0	N/A	N/A	N/A
	December	1	85.0	N/A	N/A	N/A
Big Creek	June	26	50.6	2.7	46	57
	July	33	56.9	4.5	50	65
	August	3	65.3	4.1	61	69
	October	13	70.4	3.7	64	77
Diablo Canyon	June	16	53.3	5.2	43	61
	July	18	65.9	5.1	55	73
	August	33	64.6	6.2	52	83
	September	9	74.2	7.3	62	83

TABLE 14. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year blue rockfish, Monterey Bay, 1987-92.

Year	Month	n	Mean (mm)	Std. Dev.	Minimum (mm)	Maximum (mm)
1987	May	5	57.6	4.7	51	62
	June	16	64.3	3.2	59	70
	August	10	78.0	4.3	73	85
	October	214	88.3	5.4	73	103
	November	231	88.8	6.5	72	106
1988	April	12	49.8	4.0	42	55
	May	149	55.4	4.5	45	69
	June	425	61.6	4.7	48	80
	July	213	70.4	5.5	54	86
	August	144	79.6	6.1	61	98
	September	26	87.1	7.3	73	96
	November	7	91.0	7.3	76	100
	December	15	92.0	9.0	78	103
1989	May	36	50.6	3.1	43	58
	June	155	56.7	4.5	47	75
	July	78	67.1	4.5	56	76
	August	74	79.4	4.6	67	90
	September	57	83.3	3.9	76	93
	November	18	99.1	3.5	90	106
1990	May	42	52.3	4.1	47	64
	June	132	59.7	5.7	43	74
	July	124	67.6	5.9	52	81
	August	162	85.0	5.8	69	98
	October	58	95.5	5.9	75	104
	November	8	102.5	3.3	97	107
	December	11	104.7	4.8	96	112
1991	May	4	50.8	1.3	49	52
	June	57	54.9	3.1	47	63
	July	127	64.0	5.9	47	79
	August	211	77.1	6.8	58	101
	September	48	88.8	6.2	72	104
	October	92	96.8	5.7	78	108
	December	4	92.0	2.9	88	95
1992	May	1	46.0	N/A	N/A	N/A
	June	4	55.5	5.1	51	62
	July	5	69.6	8.0	60	79
	August	6	81.5	4.1	77	89
	September	5	81.0	6.4	70	85
	October	1	75.0	N/A	N/A	N/A

TABLE 15. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year blue rockfish, Big Creek, 1990-92.

Year	Month	n	Mean (mm)	Std. Dev.	Minimum (mm)	Maximum (mm)
1990	June	54	57.1	3.5	49	67
	July	44	66.9	4.3	50	77
	September	33	77.9	5.2	65	88
1991	May	2	53.0	0.0	53	53
	June	37	56.0	3.3	45	65
	July	40	64.5	5.1	50	77
	August	10	73.2	2.9	69	78
	October	47	88.5	4.7	79	97
1992	August	2	72.0	4.2	69	75
	September	6	64.0	3.7	60	70
	October	5	74.2	9.6	64	85

TABLE 16. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year blue rockfish, Diablo Canyon, 1990-91.

Year	Month	n	Mean (mm)	Std. Dev.	Minimum (mm)	Maximum (mm)
1990	June	50	56.1	3.2	49	63
	July	321	67.3	4.4	56	78
	August	270	82.9	5.0	64	95
	September	67	87.6	5.7	72	97
1991	May	3	59.7	8.3	53	69
	June	29	59.7	3.9	50	67
	July	379	71.0	6.3	52	87
	August	40	84.7	4.0	73	91
	September	124	90.4	4.2	76	99

TABLE 17. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year blue rockfish, central California coast, 1990.

Location	Month	n	Mean (mm)	Std. Dev.	Minimum (mm)	Maximum (mm)
Santa Cruz	May	2	52.0	1.4	51	53
	July	52	68.1	5.7	53	80
	August	22	79.0	5.0	67	87
	September	30	89.6	5.7	78	100
Del Monte	May	16	53.8	5.7	47	64
	June	34	62.6	6.6	51	74
	July	38	69.9	6.0	53	81
	August	55	83.3	6.3	69	98
	October	1	96.0	N/A	N/A	N/A
	December	6	102.8	5.8	96	112
McAbee	May	8	50.9	2.9	48	56
	June	48	59.5	4.9	47	71
	July	39	69.5	4.5	56	76
	August	56	85.9	5.6	71	96
	October	34	94.6	6.6	75	104
Lovers Pt.	May	18	51.7	2.2	48	56
	June	50	58.0	5.1	43	68
	July	47	64.2	5.4	52	75
	August	51	85.9	5.3	74	96
	October	23	96.7	4.7	87	104
	November	8	102.5	3.3	97	107
	December	5	107.0	1.6	105	109
Cypress Pt.	September	25	80.1	3.8	74	88
Big Creek	June	54	57.1	3.5	49	67
	July	44	66.9	4.3	50	77
	September	33	77.9	5.2	65	88
Cambria	July	55	70.5	4.1	59	77
	September	46	81.9	5.7	69	97
Diablo	June	50	56.1	3.2	49	63
	July	321	67.3	4.4	56	78
	August	270	82.9	5.0	64	95
	September	67	87.6	5.7	72	97

TABLE 18. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year blue rockfish, central California coast, 1991.

Location	Month	n	Mean (mm)	Std. Dev.	Minimum (mm)	Maximum (mm)
Monterey Bay	May	4	50.8	1.3	49	52
	June	57	54.9	3.1	47	63
	July	127	64.0	5.9	47	79
	August	211	77.1	6.8	58	101
	September	48	88.8	6.2	72	104
	October	92	98.8	5.7	78	108
	December	4	92.0	2.9	88	95
Cypress Pt.	October	23	92.7	3.3	85	98
Big Creek	May	2	53.0	0.0	53	53
	June	37	56.0	3.3	45	65
	July	40	64.5	5.1	50	77
	August	10	73.2	2.9	69	78
	October	47	88.5	4.7	79	97
Cambria	July	25	72.1	5.3	64	82
	August	19	75.9	6.8	61	84
	October	18	89.4	4.8	81	100
Diablo Canyon	May	3	59.7	8.3	53	69
	June	29	59.7	3.9	50	67
	July	379	71.0	6.3	52	87
	August	40	84.7	4.0	73	91
	September	124	90.0	4.2	76	99

TABLE 19. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year kelp rockfish, Monterey Bay, 1989-92.

Year	Month	n	Mean (mm)	Std. Dev.	Minimum (mm)	Maximum (mm)
1989	September	57	41.4	6.4	20	66
	November	60	62.8	5.65	50	78
1990	July	4	24.3	1.7	22	26
	August	81	33.6	9.4	18	55
	October	8	59.9	8.6	42	71
	November	15	61.9	7.2	44	73
	December	7	64.1	7.2	53	74
1991	July	71	30.4	4.7	21	43
	August	83	39.0	6.2	22	50
	September	19	51.1	5.5	41	60
	October	21	61.0	5.5	52	74
	December	1	61.0	N/A	N/A	N/A
1992	June	2	33.0	1.4	32	34
	July	71	32.2	4.3	24	42
	September	1	55.0	N/A	N/A	N/A

TABLE 20. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year kelp rockfish, central California coast, 1991.

Location	Month	n	Mean (mm)	Std. Dev.	Minimum (mm)	Maximum (mm)
Monterey Bay	July	71	30.4	4.7	21	43
	August	83	39.0	6.2	22	50
	September	19	51.1	5.5	41	60
	October	21	61.0	5.5	52	74
	December	1	61.0	N/A	N/A	N/A
Big Creek	July	40	35.0	5.7	27	48
	August	23	37.1	4.5	31	47
	October	67	51.0	5.9	38	64
Diablo Canyon	August	32	43.8	6.2	30	54
	September	2	56.0	4.2	53	59
Cambria Rock	July	3	41.3	5.1	37	47
	August	1	46.0	N/A	N/A	N/A

TABLE 21. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year kelp rockfish, central California coast, 1992.

Location	Month	n	Mean (mm)	Std. Dev.	Minimum (mm)	Maximum (mm)
Monterey Bay	June	2	33.0	1.4	32	34
	July	71	32.2	4.3	24	42
	September	1	55.0	N/A	N/A	N/A
Big Creek	June	7	28.6	1.8	25	31
	August	27	40.9	5.3	30	53
	September	2	42.5	10.6	35	50
Diablo Canyon	July	20	34.6	3.9	29	40
	August	27	46.3	5.3	37	60
Cambria Rock	August	2	43.0	2.8	41	45
	September	6	68.2	10.5	53	78
Port San Luis	July	21	37.0	2.7	33	43
	August	3	50.3	5.5	44	54
	September	3	65.3	2.3	64	68

TABLE 22. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year olive rockfish, Monterey Bay, 1987-92.

Year	Month	n	Mean (mm)	Std. Dev.	Minimum (mm)	Maximum (mm)
1987	June	5	72.4	6.2	67	82
	October	17	83.5	5.1	80	103
1988	April	1	55.0	N/A	N/A	N/A
	May	84	60.2	5.2	48	75
	June	18	69.5	6.9	55	80
	July	47	74.1	6.0	61	86
	August	4	85.0	4.8	81	92
	September	16	91.5	4.1	86	98
	November	8	90.2	5.8	84	99
	December	4	94.8	5.7	88	102
1989	May	8	51.6	10.6	41	66
	June	17	71.1	7.5	55	80
	July	14	82.0	5.6	73	92
	August	5	88.8	6.3	83	96
	September	1	115.0	N/A	N/A	N/A
	November	1	109.0	N/A	N/A	N/A
1990	May	10	58.2	4.2	50	63
	June	43	72.2	8.4	53	93
	July	18	82.9	4.5	74	91
	August	43	96.2	7.3	80	117
	October	10	111.1	4.9	105	121
	November	1	124.0	N/A	N/A	N/A
	December	4	109.5	10.4	101	124
1991	July	3	76.0	10.2	67	87
	August	4	99.5	8.2	89	109
	September	2	77.5	0.7	77	78
1992	May	1	47.0	N/A	N/A	N/A
	June	6	73.7	14.8	61	97
	August	3	81.3	27.0	52	105

TABLE 23. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year olive rockfish, central California coast, 1990.

Location	Month	n	Mean (mm)	Std. Dev.	Minimum (mm)	Maximum (mm)
Monterey Bay	May	10	58.2	4.2	50	63
	June	43	72.2	8.4	53	93
	July	18	82.9	4.5	74	91
	August	43	96.2	7.3	80	117
	October	10	111.1	4.9	105	121
	November	1	124.0	N/A	N/A	N/A
	December	4	109.5	10.4	101	124
Big Creek	June	13	72.4	4.6	65	79
	July	9	86.1	6.1	73	92
	September	3	98.3	1.5	97	100
Cambria Rock	September	9	98.0	10.7	84	119
Diablo Canyon	June	1	61.0	N/A	N/A	N/A
	September	27	101.9	7.29	90	113

TABLE 24. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year olive rockfish, central California coast, 1991.

Location	Month	n	Mean (mm)	S.D.	Minimum (mm)	Maximum (mm)
Monterey Bay	July	3	76.0	10.2	67	87
	August	4	99.5	8.2	89	109
	September	2	77.5	0.7	77	78
Cambria Rock	July	2	93.0	N/A	N/A	N/A
Diablo Canyon	May	3	60.3	6.0	55	66
	June	8	68.4	2.7	57	84
	July	1	77.0	N/A	N/A	N/A
	August	3	96.7	1.5	95	98
	September	18	110.7	5.2	100	119
Port San Luis	July	7	78.0	9.4	60	89
	Aug	9	87.4	7.8	72	96

TABLE 25. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year vermilion rockfish, Monterey Bay, 1987-92.

Year	Month	n	Mean (mm)	S.D.	Minimum (mm)	Maximum (mm)
1987	November	1	75.0	N/A	N/A	N/A
1988	April	4	40.8	9.7	31	51
	May	38	47.8	5.7	36	66
	June	13	53.3	5.5	45	64
	July	7	62.0	6.5	53	72
	August	4	59.8	1.9	57	61
	September	3	77.7	3.5	74	81
	November	2	88.5	6.4	84	93
1989	April	1	55.0	N/A	N/A	N/A
	May	7	58.1	8.2	44	69
	June	1	70.0	N/A	N/A	N/A
1990	April	1	54.0	N/A	N/A	N/A
	May	1	62.0	N/A	N/A	N/A
	August	2	35.0	2.8	33	37
	November	1	50.0	N/A	N/A	N/A
1991	April	2	54.0	4.2	51	57
1992	May	3	60.3	8.1	51	65
	September	1	33.0	N/A	N/A	N/A

TABLE 26. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year vermilion rockfish, central California coast, 1988-92.

Location	Year	Month	n	Mean (mm)	S.D.	Minimum (mm)	Maximum (mm)
Elkhorn Slough	1988	June	58	62.8	5.5	53	77
Big Creek	1990	September	7	40.4	4.9	36	51
	1991	October	3	42.0	1.7	41	44
	1992	August	2	36.5	0.7	36	37
		September	1	36.0	N/A	N/A	N/A
		October	5	40.6	11.9	26	55
Piedras Blancas	1988	August	1	39.0	N/A	N/A	N/A
	1990	September	1	38.0	N/A	N/A	N/A
Morro Bay	1990	June	6	54.3	5.5	50	65
		July	2	57.0	0	57	57
		September	2	65.5	0.7	65	66
Diablo Canyon	1990	June	1	59.0	N/A	N/A	N/A
Port San Luis	1992	August	1	52.0	N/A	N/A	N/A

TABLE 27. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year yellowtail rockfish, Monterey Bay, 1988-92.

Year	Month	n	Mean (mm)	S.D.	Minimum (mm)	Maximum (mm)
1988	May	21	68.5	6.7	59	84
	July	5	66.4	2.8	63	69
1989	June	29	52.9	3.3	44	58
	July	20	63.5	8.2	42	77
	August	11	61.6	14.0	41	81
	September	5	64.0	11.4	53	80
	November	1	71.0	N/A	N/A	N/A
1990	May	19	54.3	6.1	38	64
	June	95	53.7	7.7	37	68
	July	40	65.0	10.7	39	86
	August	15	77.0	12.8	54	102
	October	9	77.8	13.6	61	103
1991	May	3	50.0	1.0	49	51
	June	14	53.4	2.0	51	57
	July	109	56.4	8.7	41	85
	August	49	66.7	9.5	49	79
	September	23	70.7	8.9	59	88
	October	20	79.1	11.0	62	94
1992	March	1	48.0	N/A	N/A	N/A
	May	4	45.3	5.0	41	52
	June	1	49.0	N/A	N/A	N/A
	July	2	55.5	12.0	47	64
	August	2	52.5	3.5	50	55

TABLE 28. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year yellowtail rockfish, central California coast, 1990.

Location	Month	n	Mean (mm)	S.D.	Minimum (mm)	Maximum (mm)
Monterey Bay	May	19	54.3	6.1	38	64
	June	95	53.7	7.7	37	68
	July	40	65.0	10.7	39	86
	August	15	77.0	12.8	54	102
	October	9	77.8	13.6	61	103
Big Creek	June	8	49.9	2.9	42	56
	September	2	70.0	2.8	68	72
Piedras Blancas	June	24	62.7	6.1	52	77
	September	10	75.4	8.6	60	87

TABLE 29. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year yellowtail rockfish, central California coast, 1991.

Location	Month	n	Mean (mm)	S.D.	Minimum (mm)	Maximum (mm)
Monterey Bay	May	3	50.0	1.0	49	51
	June	14	53.4	2.0	51	57
	July	109	56.4	8.7	41	85
	August	49	66.7	9.5	49	79
	September	23	70.7	8.9	59	88
	October	20	79.1	11.0	62	94
Big Creek	June	10	53.5	3.3	48	57
	July	9	53.1	7.5	46	66
	August	7	56.0	8.1	46	69
	October	4	65.5	2.9	62	69
Cambria	July	23	65.9	9.1	53	85
	August	17	65.5	7.2	50	74
	October	2	70.5	0.7	70	71
Diablo Canyon	June	17	54.8	3.1	50	60
	July	12	59.4	8.2	45	72
	August	4	66.0	5.7	61	74
	September	7	71.6	2.1	70	75

TABLE 30. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year lingcod, central California coast (all stations combined), 1987-91.

Year	Month	n	Mean (mm)	S.D.	Minimum Length	Maximum Length
1987	May	6	96	3.6	93	99
1988	April	2	87	4.2	84	90
	May	16	89	9.1	76	105
	June	4	149	18.2	129	173
1989	May	1	95	N/A	N/A	N/A
	June	1	119	N/A	N/A	N/A
1990	May	5	100	6.4	92	108
	June	17	137	22.8	99	175
	July	3	158	8.4	153	168
	Sept	1	193	N/A	N/A	N/A
1991	June	27	113	11.7	92	139
	July	25	133	14.8	111	167
	Aug	15	147	14.9	127	175

TABLE 31. Monthly mean length, standard deviation, minimum length, and maximum length for young-of-the-year lingcod, central California coast, 1991.

Location	Month	n	Mean (mm)	S.D.	Minimum (mm)	Maximum (mm)
Monterey Bay	June	5	107.4	5.5	99	114
	July	9	127.7	11.2	111	150
Morro Bay	June	22	114.0	12.7	92	139
	July	8	136.1	18.3	111	167
	August	13	142.5	10.9	127	169
Port San Luis	July	6	142.3	10.7	131	161
	August	2	173.5	2.1	172	175

TABLE 32. T-test statistics of net and speared samples of blue rockfish.

Sample#	Sample Method	Sample Date	n	Mean Length (mm)	t-test Statistic
1	Speared	8 Oct 87	23	84.61	$t_{calc}= -4.852$ $t_{.05(2),51}=2.008$ $t_{.20(2),51}=1.299$
	Netted	12 Oct 87	30	91.93	
2	Speared	25 Oct 87	30	85.63	$t_{calc}= -3,154$ $t_{.05(2),159}=1.975$ $t_{.20(2),159}=1.287$
	Netted	25 Oct 87	131	88.70	
3	Speared	26 May 88	54	58.59	$t_{calc}= -2.837$ $t_{.05(2),207}=1.972$ $t_{.20(2),207}=1.286$
	Netted	1 June 88	155	60.19	
5	Speared	5 Aug 88	33	75.91	$t_{calc}= -2.474$ $t_{.05(2),100}=1.984$ $t_{.20(2),100}=1.290$
	Netted	5 Aug 88	69	78.52	
6	Speared	29 July 91	36	69.47	$t_{calc}= -4.304$ $t_{.05(2),134}=1.984$ $t_{.20(2),134}=1.290$
	Netted	1 Aug 91	100	73.39	
8	Speared	1-2 Oct 91	58	97.03	$t_{calc}= 0.7865$ $t_{.05(2),89}=1.987$ $t_{.20(2),89}=1.291$
	Netted	1-2 Oct 91	33	96.06	