Title

Fish Bulletin 176. The Marine Recreational Fishery In Northern and Central California : A Historical Comparison (1958–86), Status of Stocks (1980–86), and Effects of Changes In The California Current

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Publication Date

1995-12-01

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF FISH AND GAME
FISH BULLETIN 176
The Marine Recreational Fishery In Northern and Central California A Historical Comparison (1958–86), Status of Stocks (1980–86), and Effects of Changes In The California Current

by
Konstantin A. Karpov
Douglas P. Albin
Wade H. Van Buskirk
1995

ABSTRACT

Our study focused on the status of the marine recreational fishery along the northern and central California coast, where surveys of recreational fishing effort and catch were conducted from 1958–61 and from 1981–86. Between the two surveys, annual recreational fishing effort rose from 1.6 million fishing days to 2.7 million fishing days. Nearly all the increase was due to increases in fishing from boats (commercial passenger fishing vessels and private/rental boats). Annual recreational catch rose from 3.9 million fish weighing 2700 metric tons to 6.5 million fish weighing 5400 metric tons. The average number of fish caught per day decreased for fishing from piers (1.9 to 1.6), other shore areas (1.7 to 1.1), and private/rental boats (2.8 to 2.4), and increased from commercial passenger fishing vessels (5.4 to 6.0). The variety of different fish species caught in a typical day of fishing from boats decreased, but variety from shore increased. Direct expenditures in the fishery from 1981–86 were about $160 million per year (1992 dollars).

Rockfish (Sebastes spp.) dominated the catch from boats in both surveys. Between the two surveys, recreational catch of rockfish rose from 1.3 million fish to 3.4 million fish, while average weight per rockfish decreased from 0.82 kg to 0.71 kg. Average weight decreased in 12 of 16 major rockfish species. The 12 species were mainly shallow-water (<73 m) species or species with wide depth ranges. The catch from boats shifted towards a higher proportion of deep-water (>73 m) species. Signs of population stress were found in blue rockfish S. mystinus (decrease in catch), canary rockfish S. pinniger and yellowtail rockfish S. flavidus (decrease in mean length in recreational and trawl catches and high incidence of sexually immature fish in recreational catch), and brown rockfish S. auriculatus (decrease in mean length and high incidence of sexually immature fish in recreational catch). Abrupt declines in lengths of blue rockfish and yellowtail rockfish occurred in central California between 1983 and 1984. Declines reflect mortalities that may in part be attributed to effects of the 1982–83 El Niño event. Mean weight per rockfish decreased in a north-to-south cline from Del Norte/Humboldt (1.13 kg) to San Luis Obispo (0.48 kg) in 1980–86. The major species generally had smaller fish and fewer successful year-classes in central California than northern California.

Catches of lingcod Ophiodon elongatus, a trophy species of importance to both boat and shore fishing, have been in slow oscillating decline since the early 1970s. It is unclear whether the decline is due to overharvest and is a long-term trend that will continue, or if it is due to natural population fluctuations.

Fishes of the surfperch family (Embiotocidae) dominated catch from shore in both surveys. of the fish groups we examined, the surfperch showed the greatest evidence of decline. Between the surveys, the weight of sport catch of surfperches declined by 54% and the weight of commercial catch declined by 26%. Barred surfperch Amphistichus argenteus and redtail surfperch A. rhodoterus (the two most important surfperches by number and weight landed), and also striped seaperch Embiotoca lateralis showed substantial decreases in recreational catch and average weight per fish. Commercial landings of redtail surfperch in the Eureka area declined by 54% from 1953 through 1992, despite a rise in price per pound. Commercial landings of barred surfperch in the Santa Barbara area rose by 118% from 1953 through 1992, perhaps due to a rise in price per pound. White seaperch Phanerodon furcatus stocks may have collapsed prior to the 1958–61 survey. Like rockfish, mean weight per surfperch decreased in a north-to-south cline from Del Norte/Humboldt (0.33 kg) to San Luis Obispo (0.22 kg) in 1980–86.

Populations of lingcod and five of six rockfishes examined for interannual length-frequency trends were found to be subject to wide variation in recruitment from year to year. Strong year-classes often dominated a species' catch for several consecutive years. Strong year-classes were not found to be established in the 1957–58 and 1982–83 El Niño periods.

Ten pelagic fish species (albacore Thunnus alalunga, bigeye tuna T. obesus, bluefin tuna T. thynnus, bullet mackerel Auxis rochei, Pacific mackerel Scomber japonicus, Pacific bonito Sarda chiliensis, skipjack Katsuwonus pelamis, yellowfin tuna T. albacares, dolphinfish Coryphaena hippurus, and California barracuda Sphyraena argentea) showed obvious northward shifts in the sampled recreational catch during the 1982–83 El Niño event. Eighteen other species showed less pronounced changes that may have been related to El Niño.

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ACKNOWLEDGMENTS

The preparation of this paper represents the cooperative efforts of researchers from the California Department of Fish and Game (CDFG), National Marine Fisheries Service (NMFS), and others. Within CDFG we thank John Geibel, Chuck Haugen, Frank Henry, Chuck Knutson, Phillip Law, John Mello, and Paul Reilly. From NMFS thanks are due Pete Adams, Jim Bence, Anne Hollowed, with special thanks to Janet Mason for her exceptional effort in reviewing the document. We also thank Karl Brookins, Alfred Ebling, Dan Gotshall, Gerry Kwiecien, Milton Love, Mary Patyten, Mia Tegner, and Elaine Stewart for their assistance.

The data utilized in this report also represent cooperative efforts of numerous organizations and individuals. Contributions were made by NMFS in designing and supporting the Marine Recreational Fisheries Stastical Survey (MRFSS) and by Russell Porter of Pacific States Marine Fisheries Commission (PSMFC) and Bob Bell and Steve Crooke from CDFG for coordinating the MRFSS sampling effort. Thanks to the numerous field samplers from CDFG, Oregon Department of Fish and Wildlife, and PSMFC who collected the data. Dan Miller, John Geibel, and Dan Gotshall collected and compiled the historical data we utilized. Jim Hardwick of CDFG, and Dick Parrish, Linda Garrett, and Janet Mason of NMFS made the historical data accessible in computer format. Gordon Kubota and Larry Ponseggi of CIC Research helped restructure and recalculate the MRFSS effort and catch estimates. Thanks are also due to the thousands of anglers and commercial passenger fishing vessel operators whose cooperation with samplers made data collection possible.

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1. INTRODUCTION

The nearshore Pacific coast from the Oregon border to Point Conception is an area of high productivity for numerous species of fish taken by both sport and commercial fisheries (Miller and Gotshall 1965; Oliphant et al. 1990). The coastal area, spanning approximately 800 kilometers, has a variety of habitats including nearshore kelp forests, rocky reefs, sandy bottoms and beaches, bays and estuaries, submarine canyons, and open ocean areas. Southward advection by the California Current and northerly winds with upwelling of nutrients cause high levels of primary and secondary productivity and fish biomass (Parrish et al. 1981; Chelton et al. 1982; Roesler and Chelton 1987). Fish and invertebrates in this area have feeding and reproductive strategies to deal with resulting offshore transport (Parrish et al. 1981; Hobson and Chess 1988; Roughgarden et al. 1988). The diversity of species and habitats is reflected in the 169 species of fish recorded in the sport catch (Appendix A). Recreational fishing occurs from a variety of *modes* (defined by the structure or platform from which fishing occurs and the gear used) including hook-and-line fishing from piers and docks, jetties and breakwaters, beaches and banks, private or rental boats (PRBs), and commercial passenger fishing vessels (CPFVs), and also spear and net fishing (Albin et al. 1993).

Interannual variability in the California Current influences distribution and abundance of plankton, invertebrates, and fish (Chelton et al. 1982; Roesler and Chelton 1987; Roughgarden et al. 1988; Dayton and Tegner 1989). Periodic disruptions of the California Current, often associated with El Niño-Southern Oscillation (ENSO) events, affect available nutrients and zooplankton in central and southern California (Chelton et al. 1982; Dayton and Tegner 1989) and may influence recruitment success among invertebrates and fish (Parrish et al. 1981; Roughgarden et al. 1988; Hollowed and Wooster 1992). Range extensions and northward population shifts of sport and commercial fish have been reported for the 1941, 1957–59, and 1982–83 ENSO events (Hubbs 1948; Radovich 1961; Dayton and Tegner 1989).

Seasonal differences in geostrophic flow patterns between northern and southern California affect both productivity and reproductive strategies of fish. Northern and central California waters exhibit offshore transport throughout the year that increases during spring and summer months with resulting seasonal periods of increased upwelling and high productivity. Such offshore transport supports reproductive success of fish with spawning strategies that minimize pelagic exposure (e.g. demersal spawning, livebearing). The Southern California Bight, with a gyre that minimizes offshore transport, has lower productivity but allows successful reproduction of species with pelagic early life stages (Parrish et al. 1981).

Long-term studies of fish stocks of importance to both sport and commercial fisheries in central and northern California are limited to select species groups such as salmonids, several rockfishes (bocaccio[1] , canary rockfish, chilipepper, and yellowtail rockfish), and lingcod. Commercial landing weights and value have been recorded by port area continuously since 1916 (Oliphant et al. 1990). Joint federal and state stock assessments for ground-fish have been conducted since 1978 (Pearson and Ralston 1990; Pacific Fishery Management Council (PFMC) 1992; Rogers and Bence 1992; Bence and Rogers 1993), and for salmon since 1976 (PFMC 1992). Groundfish monitoring, primarily directed at rockfish, has included fishery-independent trawl surveys since 1977 (Fraidenburg 1980; Gunderson and Sample 1980; Dark et al. 1983), dockside sampling (PFMC 1992), and rockfish recruitment surveys (Adams 1992a).

Past monitoring of the northern and central California marine recreational fishery was minimal. CPFV effort and catch data have been tabulated by port area from operator logs since 1947 and published by port area only for the 1947–67 period (Young 1969). The California Department of Fish and Game (CDFG) conducted an overview survey of all species from 1958 through 1961 (Miller and Gotshall 1965) and a more detailed assessment of blue rockfish and lingcod from 1959 through 1972 (Miller and Geibel 1973).

In 1980–89 a new national marine sport fishery survey, the Marine Recreational Fisheries Statistics Survey (MRFSS), was conducted on the west coast from Washington through California. MRFSS was a cooperative effort among the National Marine Fisheries Service (NMFS), the Pacific States Marine Fisheries Commission (PSMFC), and Washington, Oregon, and California state fishery resource agencies. The goal of the survey was to obtain effort and catch statistics and biological data for all marine recreational fish except salmon, which are subject to independent surveys by the states. During 1987 to 1989 reduced MRFSS funding halved the sampling effort, which reduced survey comparability to previous years. The MRFSS was suspended on the Pacific coast from 1990 through 1992.

MRFSS effort and catch statistics from 1980 through 1986 have been published as data tables separating California into two broad regions (U.S. Department of Commerce 1987). More recently, 1980–86 MRFSS statistics were restructured to allow historical comparisons by smaller county areas (Karpov 1987; Karpov and Kwiecien 1988; Albin et al. 1993).

The purpose of our study is to use the restructured 1980–86 MRFSS statistics and other available data to:

- characterize the 1980–86 northern and central California sport fishery in relation to concurrent commercial fisheries and historic sport fisheries of 1958–61, with more detailed analyses of sport fisheries for lingcod, rockfish, and surfperch;
- quantify geographic distributions of lingcod, rockfish, and surfperch in the sport catch;
- evaluate trends in length and recruitment for lingcod and the more frequently sampled rockfishes;
- make management and research recommendations based on our findings; and
- evaluate distribution in sport catch of species that may have shifted north or south during the 1982–83 ENSO.

2. METHODS

MRFSS data for 1980–86 were the main source of recent recreational fishery data examined in this report. Recreational salmon fishery statistics and commercial fish catch statistics were also incorporated from other sources (Pearson and Ralston 1990; CDFG unpublished data). Recreational effort and catch estimates for 1958–61 were from Miller and Gotshall (1965). Length-frequency data for years prior to 1980 were from the CDFG field surveys conducted pursuant to the studies of Miller and Gotshall (1965) and Miller and Geibel (1973).

2.1. Restructuring MRFSS

The MRFSS had two major components: a telephone survey which estimated total effort and a field-based creel survey which determined catch per unit of effort (CPUE), species composition, and length frequency (U.S. Department of Commerce 1987). The telephone survey was random and restricted to coastal counties (counties within 40 kilometers of the coast, including San Francisco Bay), where most people who engage in marine sport fishing live. The creel survey was randomly stratified by mode, gear, and relative fishing effort at each fishing site. Sampling effort remained relatively constant throughout the 1980–86 period. Due to telephone survey quality problems in 1980, we used the creel survey data for that year, but did not produce total effort and catch estimates.

For 1981–86, effort and catch estimates were recalculated based on the MRFSS methods (U.S. Department of Commerce 1987) to allow comparison to historical data and provide a more useful baseline for future work. The recalculations produced smaller study areas, corrected oversights in the federal expansion methods, and defined catch in a format comparable to Miller and Gotshall (1965).

2.1.1. Coastal County Districts

Federal MRFSS data reports divided California into northern and southern subregions along the boundary between Monterey and San Luis Obispo counties (U.S. Department of Commerce 1987). The federal reports calculated total effort and catch for each subregion by pairing the creel survey data for each subregion with the telephone survey effort estimates from the coastal counties in the subregion. Calculation of effort and catch by smaller geographic units would allow greater flexibility in examining latitudinal differences in total catch, species composition, length frequency, and CPUE. We therefore modified the effort and catch calculation methods to divide the northern California subregion into four coastal county districts, each consisting of one or more counties; San Luis Obispo County was included as a fifth district (Albin et al. 1993) (Figure 1). To further refine our analysis of boat mode fisheries, boat mode estimates for district 2 were separated into Mendocino County (mainly Noyo Harbor) and Sonoma County (mainly Bodega Bay). Our methods paired creel survey data for each district with telephone survey estimates of effort in the district originating from the northern California subregion. Trip estimates for the San Luis Obispo district did not include trips originating from the southern California subregion and are therefore probably underestimated. Another drawback of our method was the frequent lack of telephone survey effort data for a district, although it was known from the creel survey data that fishing effort did occur there. In those instances the six-year average effort for the district was applied.

The methods used and the results published in federal MRFSS data reports had several deficiencies. To ensure that large population counties would not monopolize the finite number of telephone survey assignments available, the MRFSS telephone survey assignments were intentionally biased towards small population counties by assigning the number of telephone contacts to a coastal county during each two-month period using the square root of the number of censused households (U.S. Department of Commerce 1987). The flaw in the federal MRFSS data reports was the subsequent failure to down-weight the number of trips reported by residents of small counties to reflect their true proportion of the county population. In a 1988–89 MRFSS-based study of red abalone Haliotis rufescens, Karpov (1991, 1992) found that small coastal counties had disproportionately high participation in abalone fishing. He down-weighted trip estimates to adjust for the square root assignment of telephone

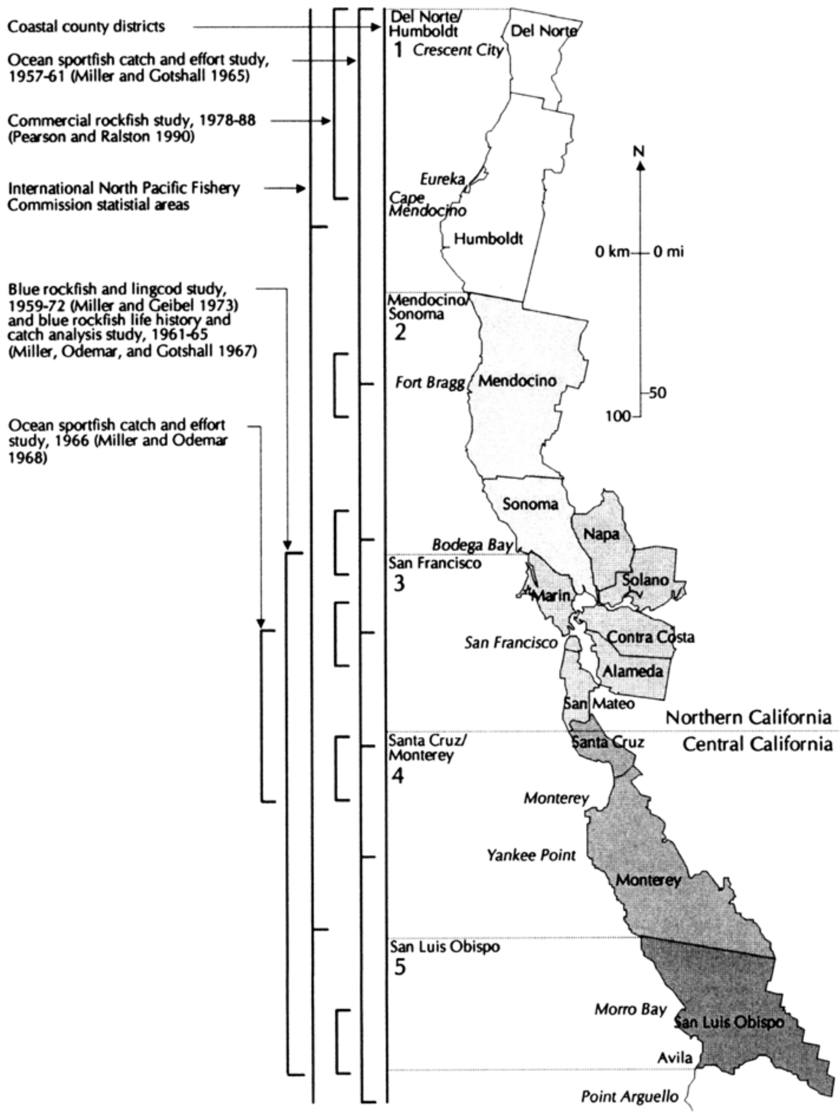

FIGURE 1. Coastal county districts and locations of other marine fishery study areas in northern and central California.

FIGURE 1. Coastal county districts and locations of other marine fishery study areas in northern and central California

intercepts and found effort had been exaggerated by 28% and 32% in the two years examined. We used similar methods to downweight MRFSS trip estimates for 1981 to 1986.

In California the MRFSS excluded fishing for salmon aboard PRBs and CPFVs. Those fisheries were subject to a separate survey conducted by CDFG. However the MRFSS creel survey did collect salmon angler county-of-origin data without catch information (in intercepts described as "salmon short-forms"). In the federal data reports, salmon angler county- or state-of-origin data were combined with nonsalmon creel survey data to determine relative fishing effort from people living outside the coastal county telephone census population (L. Ponseggi, CIC Research, pers. comm.). We excluded all salmon short-form data to avoid a potential bias of salmon anglers having a county- or state-of-origin composition different from others interviewed in the creel survey.

Fishing trips on CPFVs targeting striped bass in San Francisco Bay were excluded in the MRFSS telephone survey, but were not excluded from the creel survey. Our estimates of striped bass catch should therefore not be used to analyze the striped bass fishery. We used the striped bass estimates mainly as a component of total catch.

Our editing of creel survey data found coding errors that had not been corrected in the federal data reports. Surf smelt, a species caught in large numbers by net, was frequently erroneously assigned to hook-and-line gear, causing overestimation of catch by number in the federal reports.

Fishing with nets for surf smelt and night smelt from northern California beaches occurs when the fish are running, but fishing activity is especially patchy in occurrence and was poorly sampled due to the MRFSS's stratified random design. We therefore excluded the net fishery from our analysis.

2.1.2. *Catch Definition*

Unless otherwise specified, the catch type used in this report is the landed catch (the catch that is utilized in some fashion). Landed catch is essentially the same as used by Miller and Gotshall (1965). It includes fish landed whole and available for identification by the surveyor, and also fish caught and filleted, given away, or used for bait or other purposes. Landed catch excludes fish that were caught and subsequently released alive or discarded.

2.1.3. *Weight Computation*

Fish were not weighed directly. The weights of measured fish were computed from known length-weight relationships. A portion of the landed catch was unavailable to the sampler for measurement (e.g. fish filleted at sea or used for bait). The sampler identified those fish based on information from the person being interviewed, and identification to a general taxon (e.g. rockfish) was frequently the case. The weights of fish unavailable for measurement were assumed to be equal to the average weight of fish of the same taxon, or of a more specific taxon from the same mode, gear, district, area, year, and quarter (quarters were January–March, April–June, July–September, or October–December). When substitute weight data from the same quarter were unavailable, average weight data from other quarters of the same year were used.

After the weights of landed but unavailable fish were estimated, the average weight per fish for each combination of taxonomic group, year, mode-gear combination and district-area combination was calculated by dividing the total weight of all fish by the total number of fish. Then, estimates of catch by weight for each combination were calculated by multiplying the catch-by-number estimate by the average weight per fish.

2.2. General Description of Fishery and Historical Comparison

An important precursor to examining changes in the sport and commercial fisheries from 1958–61 to 1980–86 was to recognize, and when possible adjust for, differences in survey methods used. Substantial differences exist between methods used by Miller and Gotshall (1965), methods used in our restructured MRFSS estimates, and methods used for commercial landing statistics. The two recreational fishing surveys differed in fishing mode definitions, scope, methods for estimating effort and take, targeted species groups, and study-area boundaries. While both recreational fishery surveys are based on subsampling, commercial landing statistics are not (Oliphant et al. 1990).

To compare survey results by fishing mode, two of the modes used in the restructured MRFSS (jetty and breakwater, beach and bank) were combined to approximate the shore mode designation used by Miller and Gotshall (1965). The pier, skiff, party boat, and diver modes used by Miller and Gotshall (1965) are directly comparable to our pier and dock, PRB, CPFV, and spear modes, respectively.

2.2.1. *Historical Adjustments*

Although Miller and Gotshall's (1965) sport survey began in June 1957, most of the summaries used for comparison to MRFSS spanned 1958 through 1961. Their survey was accomplished with considerably fewer resources than the MRFSS and as a result was much smaller and more field directed in design. Their survey was not intended to provide yearly estimates but instead provided 1958–61 average estimates. Miller and Gotshall (1965) described their effort and catch estimates as minimum values and did not provide statistical confidence limits.

It is likely that the 1958–61 survey underestimated fishing effort because it relied heavily on logbook data for estimation of CPFV effort, did not survey the substantial PRB fishery in San Francisco Bay, and did not survey several of the small piers. To compare total effort and catch between the two survey periods, we developed adjustments for the 1958–61 CPFV and PRB estimates as follows:

Logbook data provided by CPFV operators are mandated by state law but compliance is poor (P. Gregory, CDFG, pers. comm.). The compliance rate for submission of logs, for central California CPFV trips with an onboard CDFG sampler, ranged from 61% to 92% depending on the port and year (Reilly et al. 1993). Compliance without onboard samplers may be lower. Assuming our restructured MRFSS values are the best available estimates of actual effort and catch, CPFV logs reported averages of 51% of the actual CPFV effort and 65% of the actual CPFV catch in 1981–86 (Appendix C). Assuming CPFV log compliance has not changed between the two survey periods, we adjusted the 1958–61 CPFV effort and catch estimates accordingly. Future logbook compliance studies may provide a basis for the reader to make adjustments to increase the accuracy of the catch and effort estimates provided herein.

The other major adjustment was to correct for the omission of San Francisco Bay in the 1958–61 PRB estimates. In 1981–86, PRB fishing in the bay produced an annual average of 389,000 fish weighing 863,000 kg, or 81% by number and 90% by weight of the district PRB catch. Averaging the difference in the percentages, we assumed that San Francisco Bay fishing constituted 85% of the PRB effort in the district, or 47% of the total PRB effort in our northern and central California study area. Assuming the percentage had not changed over time, we adjusted the 1958–61 PRB effort and catch estimates accordingly. Since species composition of the PRB catch in San Francisco Bay differs greatly from species composition coastwide, we used the adjusted 1958–61 PRB data only for gross comparisons of total effort and catch. For purposes of historically comparing catches of individual taxa, we omitted the San Francisco Bay PRB catch from the 1981–86 estimates.

Several piers were not surveyed in 1958–61, but we did not have a rational basis to estimate effort at the unsurveyed piers. Miller and Gotshall (1965) stated that, had those piers been surveyed, pier fishing effort (estimated at 530,702 fishing days) might have exceeded shore fishing effort (estimated at 603,097 fishing days), a relatively minor difference. A fishing day is defined as one person fishing for all or part of one day.

We estimated direct expenditures on fishing activities from cost-per-trip data gathered in the 1981 northern California MRFSS survey. We assumed the cost of transportation in 1981 was $0.20 per mile, and we adjusted costs from 1981 dollars to 1992 dollars using consumer price index data supplied by the California Department of Finance.

Comparisons of sport and commercial catches of major taxa were based on commercial landings data for 1958–61 and 1981–86 (Marine Resources Operations 1960a, 1960b, 1961, 1963; Oliphant et al. 1990; CDFG unpublished data), our adjusted 1958–61 recreational catch estimates, and our 1981–86 recreational catch estimates.

It is important to recognize that the MRFSS used a telephone survey to estimate effort for all modes, but the effort estimation methods of Miller and Gotshall (1965) were field directed and differed among modes. They applied aerial surveys and field angler counts in skiff and shore modes, while dive clubs were directly censused in the spear mode. Estimates derived through telephone survey in the MRFSS showed greatest variance between years for the spear mode (Albin et al. 1993) and comparisons to historic spear data should be interpreted cautiously. Single-year estimates derived from the restructured MRFSS data for rare and patchy fisheries, such as spear and shore-based surfperch fishing, are probably of poor quality.

The 1958–61 survey of Miller and Gotshall (1965) included salmon fishing from boats, but the MRFSS did not. To allow a complete comparison to historical sport and commercial fisheries, we provided salmon estimates (CDFG unpublished data) with the 1981–86 restructured MRFSS data. We estimated salmon catch by weight using calculated average weights of salmon incidentally caught by anglers interviewed in the MRFSS creel survey who were targeting other species. Commercial landing weights for salmon are reported for dressed (gutted, head-on) fish. We converted dressed weights to whole fish weights by multiplying by a factor of 1.15 (A. Baracco, CDFG, pers. comm.). We used the salmon catch-by-weight estimates mainly as a component of total catch by weight, and not to analyze trends in salmon fisheries.

Our restructured MRFSS districts and also the commercial port areas were very different from the subareas delineated by Miller and Gotshall (1965) (Figure 1). We did not attempt to assess historical changes by district or commercial port area. Instead we compared the entire northern and central California study area. Our northern and central California study area differed slightly from the Miller and Gotshall (1965) study area at the southern boundary; the former ended at the southern boundary of San Luis Obispo County but the latter extended 40 km south to Point Arguello (Figure 1).

2.3. Distribution Maps

The percentage of a given species in the total catch of all species along the coastline may reflect its latitudinal distribution and abundance over time. We therefore used 1980–86 MRFSS creel survey data (percent of the total sampled catch by number, by district and year) to construct distribution maps for selected species. To provide a larger frame of reference, we also included 1980–86 MRFSS creel survey data from Oregon and southern California; however, Oregon data were not available for 1980. Each map was based on catch data from over 230,000 angler bags from 12 defined districts from northern Oregon to southern California (Figure 2).

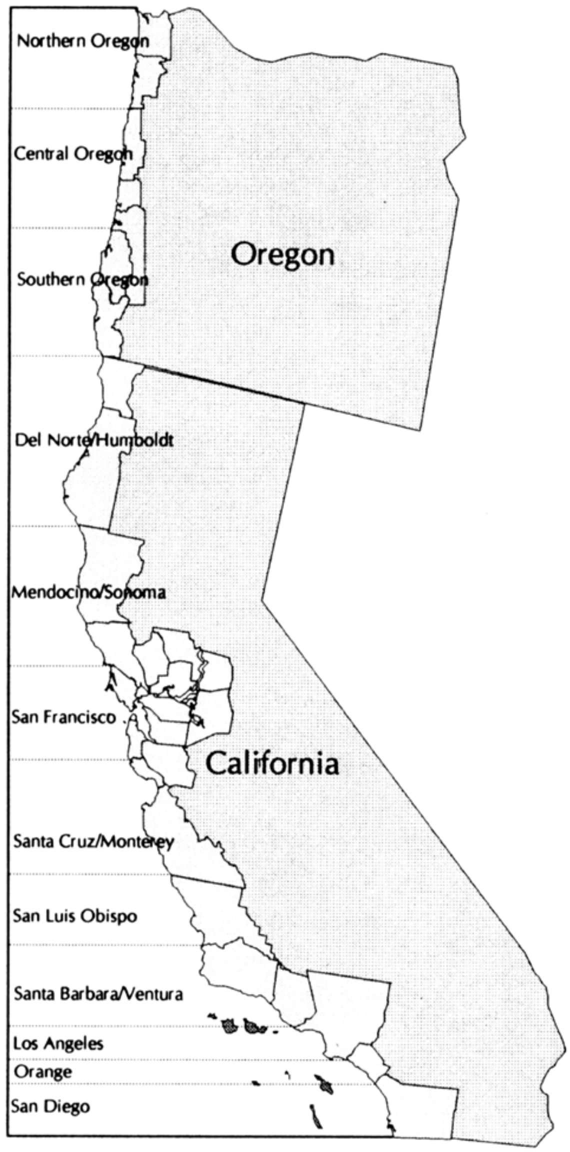

FIGURE 2. Coastal county districts for Oregon and California

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2.4. Index of Relative Importance

To rank the relative importance of species taken by districts and mode, we developed an index of relative importance (IRI), similar to indices used in food habit studies (Pinkas et al. 1971). Our IRI incorporated three factors: percent frequency of occurrence in angler bags (i.e. the percentage of bags that contained one or more fish of a particular species), percent by number, and percent by weight. Our IRI does not necessarily indicate the desirability of the species. Unlike the Pinkas et al. (1971) IRI, which gave different weighting to occurrence, our index gave equal weight to all three components. The IRI was calculated as IRI = $F_i + N_i + W_i$ where

$$\text{IRI} = F_i + N_i + W_i$$

where

$$F_i = 100\left(\frac{\Sigma B_{in}}{\Sigma B_n}\right) = \text{Percent frequency of occurrence in bags}$$

$$B_{in} = \text{Bag with species } i \text{ in bags } 1, 2, \ldots n$$

$$B_n = \text{Bags } 1, 2, \ldots n$$

$$N_i = 100\left(\frac{\Sigma N_{in}}{\Sigma N_n}\right) = \text{Percent by number}$$

$$N_{in} = \text{Number of fish of species } i \text{ } 1, 2, \ldots n$$

$$N_n = \text{Number of all fish } 1, 2, \ldots n$$

$$W_i = 100\left(\frac{\Sigma W_{in}}{\Sigma W_n}\right) = \text{Percent by weight}$$

$$W_{in} = \text{Weight of fish of species } i \text{ } 1, 2, \ldots n$$

$$W_n = \text{Weight of all fish } 1, 2, \ldots n$$

EQUATION

In the creel survey, bags may or may not have contained fish and often contained the catch of more than one person.

2.5. Selection of Major Species to Assess

Available data and time limited our detailed analysis to rockfish, lingcod, and surfperch. Our selection of those taxa was based on their importance to recreational fisheries and evidence of historic decline among surfperch. The selection of species within each taxa and the extent of analysis depended on importance in the catch and extent of available data. Sixteen rockfish species were analyzed for catch and distribution; the selection criterion used was an annual average landing minimum of 10,000 fish in 1981–86. Seven of those rockfish species were also selected for length-frequency analysis based on availability of 1980–86 MRFSS length data. Ten of the more common surfperches were analyzed for catch. Eight species were analyzed for distribution; the selection criterion used was a cumulative sample size minimum of 1000 fish in 1980–86. Barred surfperch and redtail surfperch, the two main surfperch species taken by sport and commercial fisheries in 1980–86, were analyzed in greater detail.

2.6. Length-frequency and Modal-progression Analysis

We analyzed length-frequency data to discern differences in stocks within the major species, either geographically or among different fisheries. Length-frequency data sources included the MRFSS, historic CDFG recreational fishery studies, and commercial fishery studies. Length frequencies were compared graphically using standardized histograms and statistical tests. Species whose length frequencies showed evidence of cohort dominance were subject to modal-progression analysis to identify differences in growth, survival, and patterns of recruitment by geographic area and fishery.

For most species, the length data collected were total lengths, measured from the tip of the lower jaw or end of the snout, whichever was terminal, to the tip of the longest caudal lobe with the caudal lobes pinched together (Miller and Lea 1972). For tuna-like fish with rigid concave caudal fins, fork lengths, measured from the tip of the snout to the middle of the fork in the tail, were taken.

Small sample sizes in the MRFSS length data compelled us to combine length-frequency data from adjacent districts to form two larger areas, northern California (districts 1, 2, and 3) and central California (districts 4 and 5; Figure 1). Inclusion of the San Francisco district in northern California was logical because Cordell Bank, the major offshore reef fished by boats from Sonoma County, is also fished from San Francisco. Length-frequency counts for adjacent districts were not weighted by landings; instead the sample size by district was assumed to represent size of the landings. That assumption is valid for MRFSS data since MRFSS sampling effort was generally allocated in proportion to an area's fishing effort (Karpov 1987; U.S. Department of Commerce 1987).

When necessary, length-frequency data for PRBs and CPFVs were combined to provide a sample size sufficient for resolution of annual recruitment patterns. Although sizes of fish taken by PRBs were usually smaller than those taken by CPFVs, frequency-distribution patterns were similar.

Commercial trawl length-frequency data were assigned to the same approximate northern and central California areas by combining samples from coincident port areas (Figure 1). Again, port-area data were not weighted by size of landings. Commercial length-frequency data were utilized for bocaccio, chilipepper, canary rockfish, and yellowtail rockfish (CDFG unpublished data).

Lengths were grouped into 10-mm or 20-mm intervals depending on the species maximum length reported in Miller and Lea (1972), as used by Karpov (1987). Thus 10-mm intervals were applied to blue rockfish, chilipepper, brown rockfish, black rockfish, barred surfperch, and redtail surfperch, and 20-mm intervals were applied to canary rockfish, bocaccio, yellowtail rockfish, lingcod, and Pacific mackerel.

Length-frequency distributional differences were tested using the Kolmogorov-Smirnov (KS) test. Differences in lengths between areas and years were compared using analysis of variance (ANOVA). For lingcod, ANOVA was followed by a Scheffe multiple-comparison test for paired comparisons. Regression analysis and analysis of covariance (ANCOVA) were used to compare decreases in length of yellowtail rockfish and canary rockfish for commercial trawl catches from 1978 to 1989 and MRFSS from 1980 to 1986. Significance for all tests was accepted at [a] = 0.05.

Modal-progression analysis of dominant cohorts was possible for four species: blue rockfish, yellowtail rockfish, bocaccio, and lingcod. The analysis was used to compare growth rates and mortality rates, and to interpret recruitment patterns in northern versus central California. Age-at-length data were available and were based on otoliths for bocaccio, chilipepper, and lingcod, and on scales or tag-and-recapture studies for blue rockfish (Miller and Geibel 1973; Rogers and Bence 1992; Bence and Rogers 1993). For bocaccio and chilipepper, age-at-size data were used to assign a cohort birth year to dominant length-frequency modes for the 1980–86 period.

A longer time series of length-frequency data was available for lingcod and blue rockfish (1959–86). Ford-Walford analysis was applied to the modal growth increments for both species to determine growth rates and age at size. For both species modal-progression analysis was possible only in central California.

In northern California, blue rockfish did not show dominant cohorts and there were too few lingcod samples. As with bocaccio and chilipepper, age-at-size data were used to identify birth year for the dominant cohorts, assess year-class strength, and estimate age and size at recruitment to the fishery.

The Ford-Walford analysis involved applying Ford's equation,

$$l_{t+1} = L_\infty(1 - e^{-K}) + e^{-K} l_t$$

where

l_{t+1} = length the following year

L_∞ = asymptotic length (intersection of the regression and a 45° line)

e^{-K} = Ford's growth coefficient and slope of the regression line,

EQUATION

to modal progressions in yearly pairs to generate parameters of a Von Bertalanffy growth model (Ricker 1975). Using these parameters, age at size was approximated using the relation

$$t = \frac{1}{K} \log_e \left(\frac{L_\infty}{L_\infty - l_t} \right) + t_0$$

EQUATION

described by Gulland (1969). In our analysis, t_0 is assumed to equal zero. Age-at-length approximations were then used to estimate an approximate birth year for each dominant mode from the 1959–86 sample data.

2.7. Reduced Bag Limits

We used 1980–86 MRFSS creel survey data for single-angler bags to examine the potential effects of lowering recreational bag limits of rockfish, lingcod, redtail surfperch, and barred surfperch. Potential effects on the number of fish harvested were estimated by plotting the frequency of number of fish per bag, and determining percent of total catch at hypothetical new bag limits. At each hypothetical limit, we assumed bags containing numbers of fish greater than the hypothetical limit would contain the hypothetical limit.

2.8. The 1982–83 El Niño Distributional Shifts

All species sampled by the MRFSS, excluding salmon, were examined graphically for annual changes in percent of catch (both released and kept) by coastal county district in Oregon and California for 1980 through 1986. The data were plotted on the same type of maps used in the section on rockfish, lingcod, and surfperch to describe distribution through availability to sport fisheries. We looked for shifts in availability during the 1982–83 ENSO years to the north or south of the 1980–81 and 1984–86 distribution.

3. HISTORICAL COMPARISON AND OVERVIEW

3.1. Effort

We estimated 1981–86 average annual fishing effort for all modes and gears in northern and central California at 2,685,000 fishing days, a 65% increase over our adjusted 1958–61 estimate of 1,628,000 days (Table 1); the increase over the unadjusted 1958–61 estimate was 90%. Most of the difference between the two periods occurred in boat-mode fishing.

TABLE 1. Annual fishing effort (thousands of fishing days) in the marine recreational fishery in northern and central California, 1958–61 and 1981–86, and annual direct expenditures in 1981–86 (millions of 1992 dollars).

1958-61	**Pier**	**Shore***	**Skiff**	**Party Boat**	**Skin-diving**	**Total**
CDFG Survey	531	603	121	116	40	1410
Adjusted	531	603	227	227	40	1628

1981-86	**Pier & Dock**	**Jetty & Break-water**	**Beach & Bank**	**PRB**	**CPFV**	**Spear**	**Total**
MRFSS Estimates							
Del Norte/Humboldt	12	14	55	88	1	1	170
Mendocino (Boat)	-	-	-	29	17	-	46
Sonoma (Boat)	-	-	-	35	13	-	47
Mendo./Sonoma (Non-Boat)	15	26	91	-	-	11	143
San Francisco	376	45	351	514	172	1	1459
Santa Cruz/Monterey	91	17	75	95	79	9	366
San Luis Obispo	93	2	61	91	52	-	299
Subtotal	587	103	632	853	334	21	2530
CDFG Salmon Survey	-	-	-	83	72	-	155
Total	587	103	632	936	406	21	2685
Direct Expenditures	$26.2	$4.6	$25.3	$69.5	$36.2	$1.2	$163.0

***** *Miller and Gotshall (1965) shore mode includes jetty, breakwater, beach, and bank.*

TABLE 1. Annual fishing effort (thousands of fishing days) in the marine recreational fishery in northern and central California, 1958–61 and 1981–86, and annual direct expenditures in 1981–86 (millions of 1992 dollars)

Percentage increases in population and fishing license sales support our adjustments to the 1958–61 estimates. Between the two survey periods, population in the 20 telephone-survey "coastal" counties increased 57% (4,968,375 to 7,783,267), and population statewide increased 64% (15,576,000 to 25,614,933) (California Department of Finance data). Resident one-year fishing license sales statewide increased 58% (1,320,000 to 2,087,000) (CDFG data). The 65% effort increase obtained by adjusting the 1958–61 estimates is more comparable to those increases than the 90% increase that would be obtained with the unadjusted 1958–61 estimate.

The PRB and CPFV modes showed the greatest increases in effort between the 1958–61 and 1981–86 surveys. PRB effort increased from 227,000 (adjusted) to 936,000 fishing days (312% increase) (Table 1). CPFV effort increased from 227,000 to 406,000 fishing days (79% increase). While boat fishing increased substantially between the two surveys, shore fishing did not; it actually decreased relative to population growth. Miller and Odemar (1968) found a similar pattern in marine recreational fishing effort from San Francisco to Yankee Point; PRB fishing effort there between 1959 and 1966 increased by 59%, while shore fishing effort decreased by 29%.

Shore fishing is much less expensive than boat fishing (which requires boat ownership, rental, or payment of a passenger fee). The relative decrease in shore fishing effort may be a reflection of changing lifestyles of low-income people. A 1989 survey of southern California found that a significantly larger percentage of "recent" anglers (people who had gone fishing at some time in the last three years) had annual incomes in excess of $50,000 than people who had not (Fletcher and King 1989). Loss of interest, insufficient time, pollution of oceans, bays, and estuaries, and high costs were the main reasons given by past anglers for not fishing.

We estimated that in 1981–86 direct expenditures for fishing activities, in 1992 dollars, averaged $163 million per year (Table 1).

3.2. Catch

The estimated average annual catch for all modes and gears for 1981–86 was 6,491,000 fish weighing 5382 metric tons (MT) (Table 2). The increase from our adjusted 1958–61 estimate of 3,944,000 fish weighing 2716 MT was substantial (65% by number, 98% by weight). Catch estimates for pier and shore modes decreased somewhat, while catch estimates for boat modes increased greatly.

Our 1981–86 estimate of average catch per day for all modes and gears is 2.4 fish weighing 2.0 kg (Table 3); our adjusted 1958–61 estimate is 2.4 fish weighing 1.7 kg. The number caught per day decreased from piers (1.9 to 1.6),

TABLE 2. Average annual fish catch by number (thousands) and weight (thousands of kilograms) in the marine recreational fishery in northern and central California, 1958–61 and 1981–86.

1958-61	Pier No.	Pier Wt.	Shore No.	Shore Wt.	Skiff No.	Skiff Wt.	Party Boat No.	Party Boat Wt.	Skindiving No.	Skindiving Wt.	Total No.	Total Wt.
CDFG Survey	1034	-	1025	-	337	-	800	844	22	-	3218	1986
Adjusted	1034	-	1025	-	632	590	1231	1299	22	-	3944	2716

1981-86	Pier & Dock No.	Pier & Dock Wt.	Jetty & Breakwater No.	Jetty & Breakwater Wt.	Beach & Bank No.	Beach & Bank Wt.	PRB No.	PRB Wt.	CPFV No.	CPFV Wt.	Spear No.	Spear Wt.	Total No.	Total Wt.
MRFSS	966	230	84	41	750	253	2165	2282	2352	2179	40	41	6357	5026
CDFG Salmon	-	-	-	-	-	-	53	140	81	215	-	-	134	356
Total	966	230	84	41	750	253	2218	2422	2433	2394	40	41	6491	5382

TABLE 2. Average annual fish catch by number (thousands) and weight (thousands of kilograms) in the marine recreational fishery in northern and central California, 1958–61 and 1981–86

other shore areas (1.7 to 1.1), and PRBs (2.8 to 2.4), and increased from CPFVs (5.4 to 6.0) and for spear fishing (0.5 to 1.9). The number caught per day for all modes combined did not decrease between the two surveys mainly due to the large increases in effort for the boat modes and inherently larger catch-per-day rates for those modes, relative to the shore modes.

No distinct trends in overall fishing effort or catch were evident within the 1981–86 survey period (Figure 3). Our annual estimates of effort ranged from 2,398,000 to 3,400,000 fishing days, and the annual effort and catch estimates were generally within the 95% confidence intervals of the other years' estimates. CPUE data from the 1980–86 MRFSS creel survey were plotted by mode and year (Appendix B). No trends were observed and no further interannual analysis was performed.

In 1958–61 the northern and central California adjusted recreational catch by weight was 6.6% of the total recreational and commercial catch of 41,000 MT, and in 1981–86 it was 8.0% of the total recreational and commercial catch of 67,000 MT (Figure 4). Since the 1958–61 average percentage was

TABLE 3. Average annual catch per day by number and weight (kg) in the marine recreational fishery in northern and central California, 1958–61 and 1981–86.

1958-61	Pier No.	Pier Wt.	Shore No.	Shore Wt.	Skiff No.	Skiff Wt.	Party Boat No.	Party Boat Wt.	Skindiving No.	Skindiving Wt.	Total No.	Total Wt.
CDFG Survey	1.9	-	1.7	-	2.8	-	6.9	7.3	0.5	-	2.3	1.4
Adjusted	1.9	-	1.7	-	2.8	-	5.4	5.7	0.5	-	2.4	1.7

1981-86	Pier & Dock No.	Pier & Dock Wt.	Jetty & Breakwater No.	Jetty & Breakwater Wt.	Beach & Bank No.	Beach & Bank Wt.	PRB No.	PRB Wt.	CPFV No.	CPFV Wt.	Spear No.	Spear Wt.	Total No.	Total Wt.
MRFSS	1.6	0.4	0.8	0.4	1.2	0.4	2.5	2.7	7	6.5	1.9	1.9	2.5	2
CDFG Salmon	-	-	-	-	-	-	0.6	1.7	1.1	3	-	-	0.9	2.3
Total	1.6	0.4	0.8	0.4	1.2	0.4	2.4	2.6	6	5.9	1.9	1.9	2.4	2

TABLE 3. Average annual catch per day by number and weight (kg) in the marine recreational fishery in northern and central California, 1958–61 and 1981–86

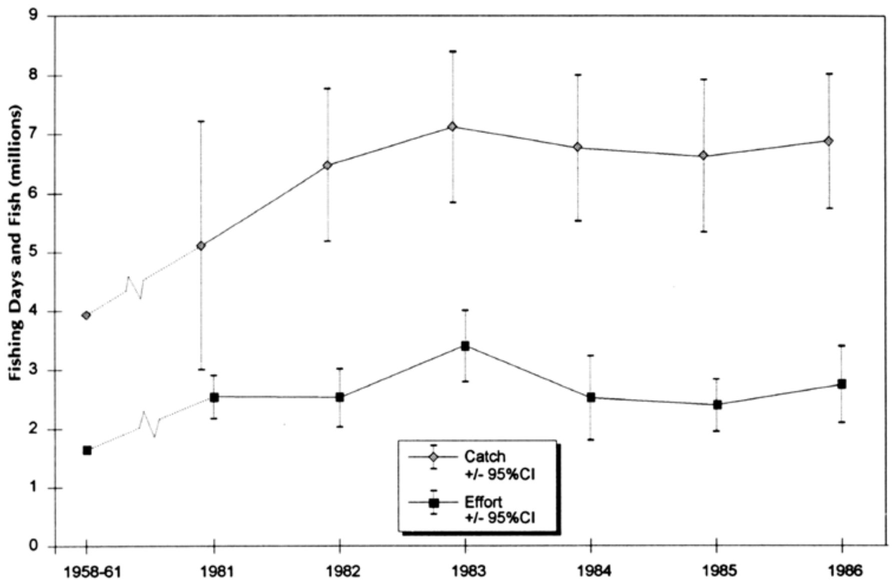


FIGURE 3. Average annual effort (millions of fishing days) and catch (millions of fish), with 95% confidence intervals in the marine recreational fishery in northern and central California.

FIGURE 3. Average annual effort (millions of fishing days) and catch (millions of fish), with 95% confidence intervals in the marine recreational fishery in northern and central California

less than each of the annual 1981–86 percentages, which ranged from 6.7% to 9.3%, the data indicate a trend towards a higher portion of recreational catch between the two surveys.

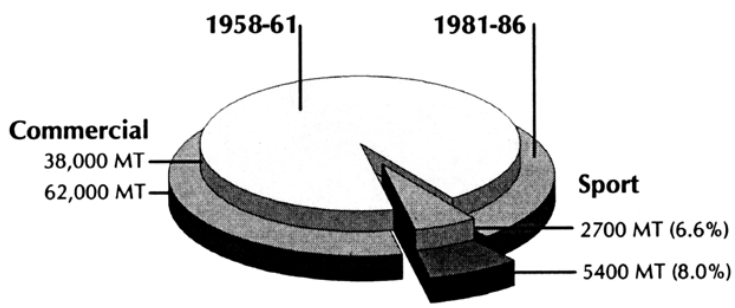


FIGURE 4. Commercial and recreational landings of marine finfish in northern and central California, 1958–61 and 1981–86.

FIGURE 4. Commercial and recreational landings of marine finfish in northern and central California, 1958–61 and 1981–86

Most major fish taxonomic categories showed large increases in both recreational and commercial catch between the two survey periods (Figure 5). Exceptions are salmon, where recreational landings increased by 151 MT but commercial landings decreased by 565 MT, and surfperch, where recreational and commercial landings declined by 54% and 27% respectively. Surfperch were also the only major category with greater recreational catch than commercial catch.

3.3. Species Composition

Recreational catch by number and weight for most major species increased greatly between the two surveys (Figure 6). Exceptions were vermilion rockfish, barred surfperch, redtail surfperch, shiner perch, silver surfperch, striped seaperch, walleye surfperch, jacksmelt, kelp greenling, and white croaker. The major decreases in number and weight caught were confined to the surfperch.

Average weight per fish decreased in about as many species as it increased. Relatively large decreases in weight per fish occurred in black rockfish, brown rockfish, bocaccio, chilipepper, gopher rockfish, olive rockfish, vermilion rockfish, widow rockfish, barred surfperch, redtail surfperch, and striped seaperch (Figure 6). The changes in catch and mean weight of rockfish and surfperch are discussed in the Status of Important Stocks section (page 41).

For CPFVs, the main changes in species composition, expressed as percent of catch by number, were decreases in olive rockfish, lingcod, striped bass, and vermilion rockfish, and increases in chilipepper and Pacific mackerel (Figure 7). The most pronounced changes were the decreases in striped bass and vermilion rockfish and the increases in chilipepper and Pacific mackerel.

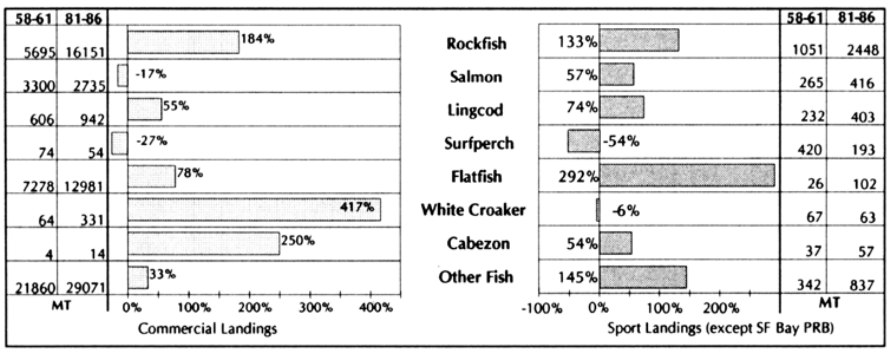


FIGURE 5. Commercial and recreational landings of marine fish groups in northern and central California, 1958–61 and 1981–86.

FIGURE 5. Commercial and recreational landings of marine fish groups in northern and central California, 1958–61 and 1981–86

	kg/fish 1958-61	kg/fish 1981-86
BLUE ROCKFISH	0.56	0.51
YELLOWTAIL ROCKFISH	0.79	0.81
BLACK ROCKFISH	1.26	0.97
OLIVE ROCKFISH	0.88	0.71
BOCACCIO	1.55	0.97
CANARY ROCKFISH	0.75	0.71
COPPER ROCKFISH	1.16	1.37
VERMILION ROCKFISH	1.78	1.51
ROSY ROCKFISH	0.21	0.25
GOPHER ROCKFISH	0.53	0.39
WIDOW ROCKFISH	0.77	0.59
BROWN ROCKFISH	1.14	0.58
GREENSPOTTED ROCKFISH	0.62	0.72
CHILIPEPPER	1.19	0.78
BARRED SURFPERCH	0.45	0.30
SHINER PERCH	0.03	0.04
REDTAIL SURFPERCH	0.82	0.33
WALLEYE SURFPERCH	0.14	0.15
SILVER SURFPERCH	0.05	0.15
STRIPED SEAPERCH	0.55	0.42
PILE PERCH	0.55	0.55
WHITE CROAKER	0.23	0.20
JACKSMELT	0.18	0.23
LINGCOD	3.56	3.59
KELP GREENLING	0.38	0.51
CABEZON	0.94	1.34
PACIFIC SANDDAB	0.11	0.13
PACIFIC MACKEREL	0.26	0.43

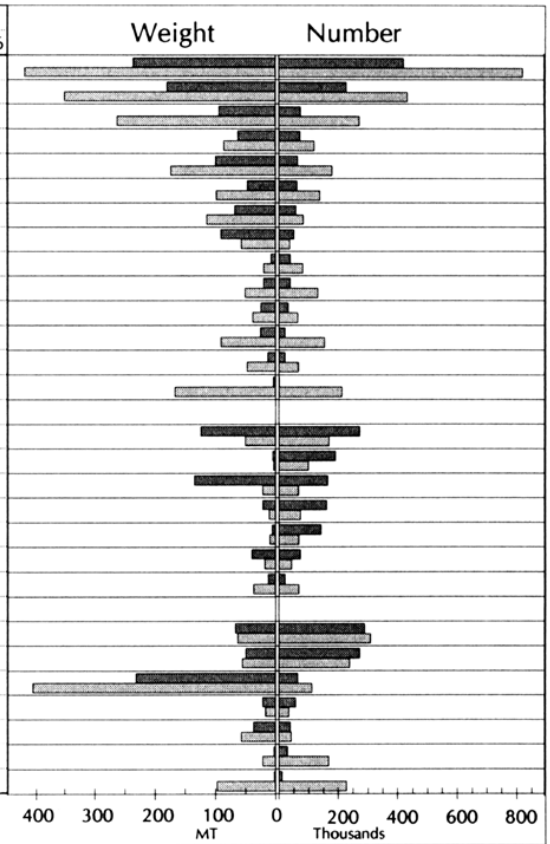


FIGURE 6. Number, weight, and average weight of fish caught in the marine recreational fishery in northern and central California, 1958–61 and 1981–86 (except San Francisco Bay PRB).

FIGURE 6. Number, weight, and average weight of fish caught in the marine recreational fishery in northern and central California, 1958–61 and 1981–86 (except San Francisco Bay PRB)

Between the two surveys, annual average percent of catch by number of 13 of the top 20 species decreased, while only seven increased. Because fewer species dominate the total CPFV catch, the variety of different species in a day's catch of fish was likely to be lower in 1981–86 than in 1958–61.

The main species composition changes for PRBs were decreases in copper rockfish and jacksmelt and increases in gopher rockfish, brown rockfish, yellowtail rockfish, and Pacific mackerel (Figure 7). The decreases in copper rockfish and jacksmelt were the most pronounced. Annual average percent of catch by number of 12 species decreased, while eight increased. Thus, like the CPFV catch, the variety of different species in a day's catch appears to have decreased.

The main differences in relative species composition for shore fishing were decreases in redtail surfperch, silver surfperch, walleye surfperch, kelp greenling, and striped bass, and increases in Pacific staghorn sculpin, pile perch, black perch, starry flounder, Pacific mackerel, and brown rockfish (Figure 7). The changes in walleye surfperch, kelp greenling, and Pacific staghorn sculpin were the most pronounced. Annual average percent of catch by number of nine species decreased, while 11 increased.

For pier fishing, the main species composition changes were decreases in white croaker, shiner perch, walleye surfperch, barred surfperch, and silversides (mainly topsmelt), and increases in Pacific herring, Pacific staghorn sculpin, bocaccio, Pacific sanddab, Pacific mackerel, and brown rockfish (Figure 7). The most pronounced changes were the decreases in white croaker, barred surfperch, and silversides. Annual average percent of catch by number decreased for seven taxa and increased for 13.

The main species composition changes for spear fishing were decreases in striped seaperch and kelp greenling and increases in cabezon and olive rockfish (Figure 7).

For boat modes, more species decreased than increased, while the converse was true for shore modes. Much of the change in shore species composition appears to be related to replacement of a few dominant surfperch species by a larger number of other species. The pattern in the boat catch is less clear. Species that changed similarly in multiple modes include Pacific mackerel (increases in CPFV, PRB, shore, and pier), Pacific staghorn sculpin (increases in pier and shore), walleye surfperch (decreases in pier and shore), and brown rockfish (increases in PRB and shore). Catch trends in rockfish, lingcod, surfperch, and Pacific mackerel are further discussed in the sections on Status of Important Stocks and Distributional Shifts Related to the 1982–83 ENSO (page 41 and page 139).

4. DESCRIPTION OF THE FISHERY, 1980–86

The following sections provide a general discussion of the northern and central California marine recreational fishery by fishing mode, based on 1980–86 MRFSS data. Boat fishing trips targeting salmon are excluded.

4.1. Commercial Passenger Fishing Vessel (CPFV)

A CPFV is a boat which is operated by a hired skipper, and on which anglers pay a fee to board and fish. The term CPFV encompasses the terms *charter boat* (which usually refers to a boat carrying a prearranged, or closed, group of anglers) and *party boat* (which usually refers to a boat carrying a

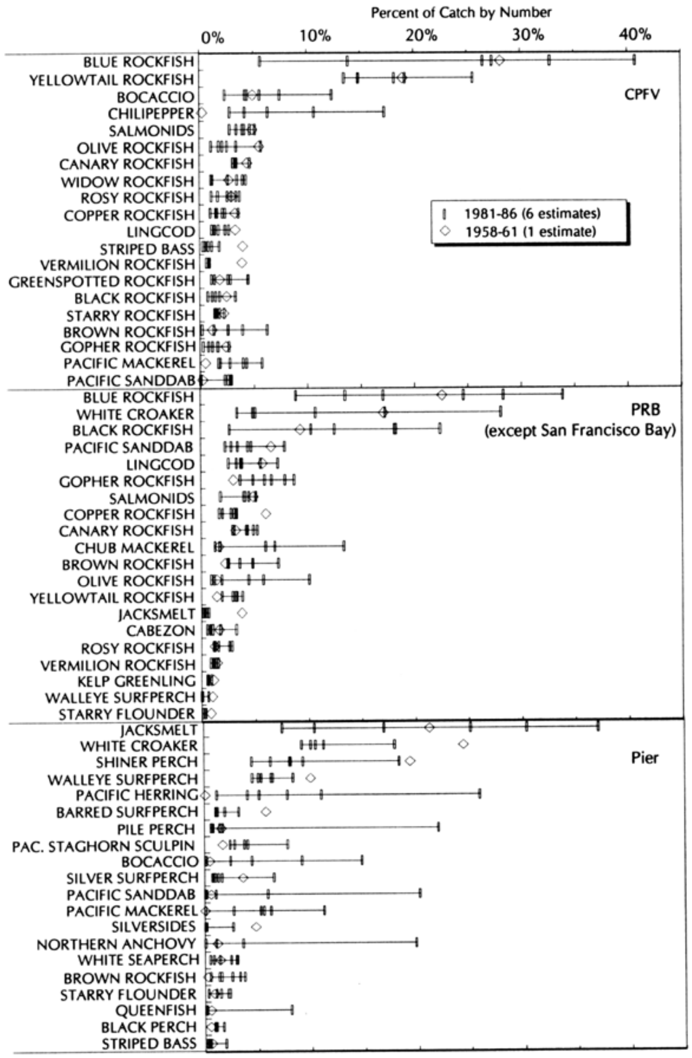


FIGURE 7. Percent of catch by number for major species in the northern and central California marine recreational fishery, 1958–61 and for each year from 1981 through 1986

FIGURE 7. Percent of catch by number for major species in the northern and central California marine recreational fishery, 1958–61 and for each year from 1981 through 1986

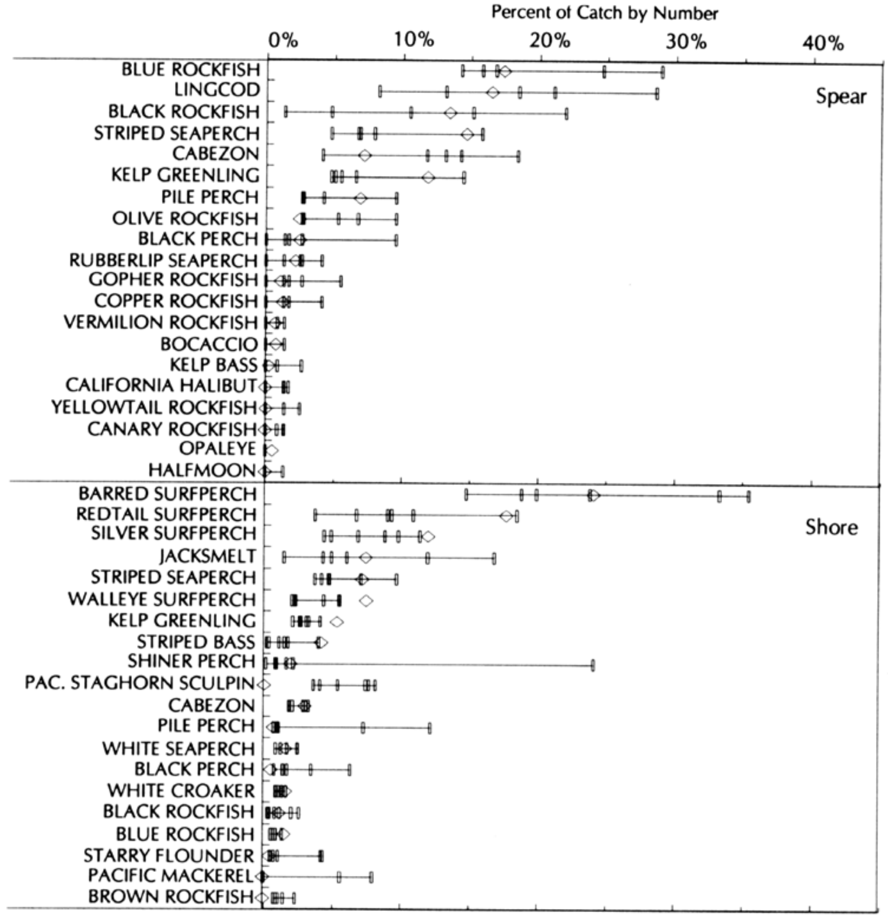


FIGURE 7. (Continued)

FIGURE 7. Percent of catch by number for major species in the northern and central California marine recreational fishery, 1958–61 and for each year from 1981 through 1986

nonprearranged group). CPFVs in northern and central California typically have capacities of six to 50 anglers. Fishing trips normally are for one-half day or a full day; overnight trips are unusual. Our CPFV-mode definition includes hook-and-line gear only.

During 1981–86, CPFV fishing accounted for about 334,000 fishing days annually, or about 13% of total nonsalmon effort (Table 1). It was the most productive mode, with an average catch per day of 7.0 fish weighing 6.5 kg (Table 3). CPFV fishing was most active in the San Francisco district (172,000 fishing days); little CPFV effort occurred in Del Norte/Humboldt (Figure 8).

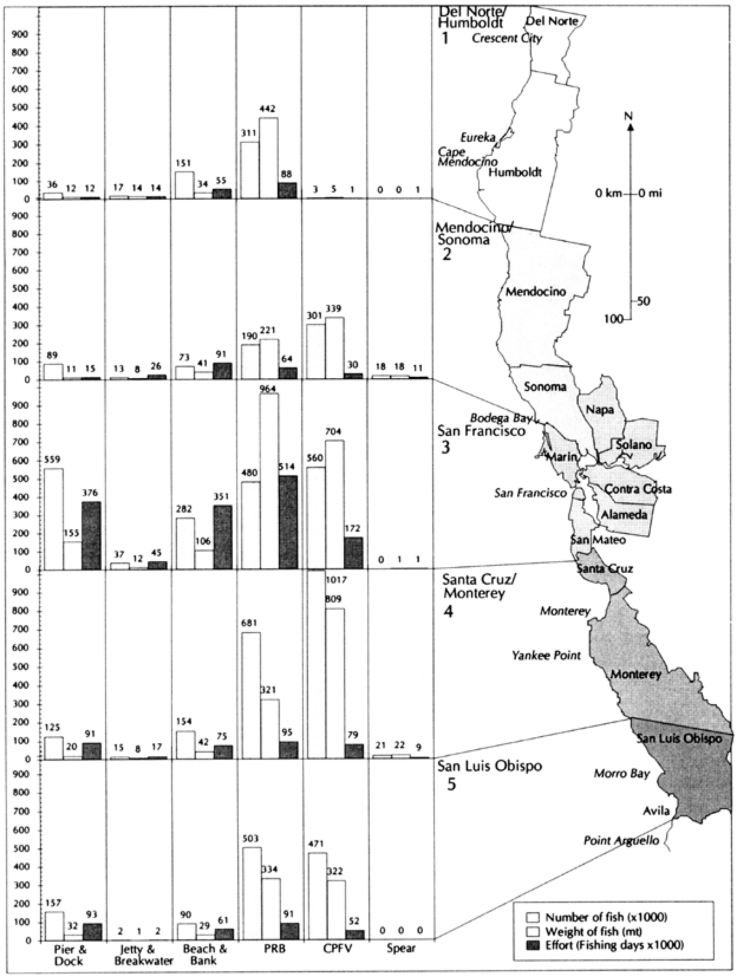


FIGURE 8. Number and weight of fish caught and effort by fishing mode in the northern and central California marine recreational fishery, 1981–86.

FIGURE 8. Number and weight of fish caught and effort by fishing mode in the northern and central California marine recreational fishery, 1981–86

CPFV fishing was most successful in Mendocino/Sonoma and in Santa Cruz/Monterey, where catch per day averaged 10.9 fish weighing 11.8 kg and 12.6 fish weighing 9.9 kg, respectively (Figure 9). The lowest catch per day (0.5 fish weighing 3.4 kg) was in San Francisco Bay, where anglers target white sturgeon and striped bass.

The species of greatest importance (as defined by our IRI) in the CPFV fishery were yellowtail rockfish, blue rockfish, chilipepper, bocaccio, lingcod, and canary rockfish (Figure 10). Yellowtail rockfish was the most important species in the Mendocino/Sonoma and San Francisco districts, while blue rockfish was the most important species in the Santa Cruz/Monterey and San Luis Obispo districts.

4.1.1. *CPFV Log Data*

The owner of a CPFV is required by state law to procure a commercial passenger fishing boat license, maintain a daily log of persons fishing and fish taken, and report the log data to CDFG. The number of reporting CPFVs in northern and central California has not changed greatly since the early 1960s, fluctuating between about 180 and 210 boats (CDFG unpublished data). The total effort and total catch estimates of the 1958–61 survey were from CPFV log data, supplemented by creel sampling to determine species composition of the catch. However, subsequent information indicates that log data and the level of compliance by CPFV skippers are inadequate for fishery management purposes (Ally et al. 1991). From 1981 through 1986, CPFV log data account for 38% to 62% of our best estimate of total effort, and 49% to 84% of our best estimate of total catch (Appendix C). Thus our estimates indicate that 1) CPFV log data underreport both effort and catch, 2) percentages of effort and catch reported by CPFV logs can vary from year to year, and 3) like true fishermen, CPFV skippers overreport catch relative to effort.

Despite shortcomings, CPFV log data are of potential value for indicating long-term trends. CPFV log data indicate total effort. Rockfish catch rose substantially between the late 1950s and the early 1970s, and has remained fairly constant since then (Figure 11). Years of relatively high salmon catch per day show relatively low rockfish catch per day, and vice versa, a reflection of increased effort for rockfish in years when salmon fishing is poor (Figure 12). The highest salmon catch per day and the lowest rockfish catch per day occurred in 1964. The lowest salmon catch per day, corresponding to the second highest rockfish catch per day, occurred in 1992. Thus catch-per-day estimates from CPFV log data are poor indices of rockfish abundance in areas where salmon fishing also occurs.

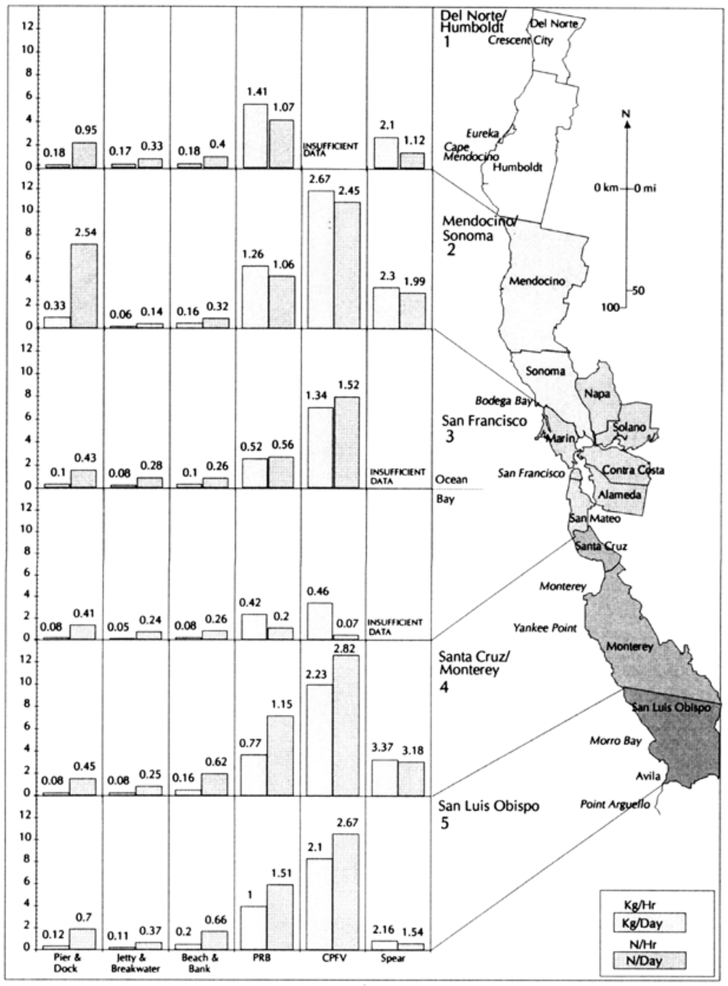


FIGURE 9. Catch per unit effort in kg/day, number/day, kg/hour, and number/hour in the marine recreational fishery in northern and central California, 1980–86.

FIGURE 9. Catch per unit effort in kg/day, number/day, kg/hour, and number/hour in the marine recreational fishery in northern and central California, 1980–86

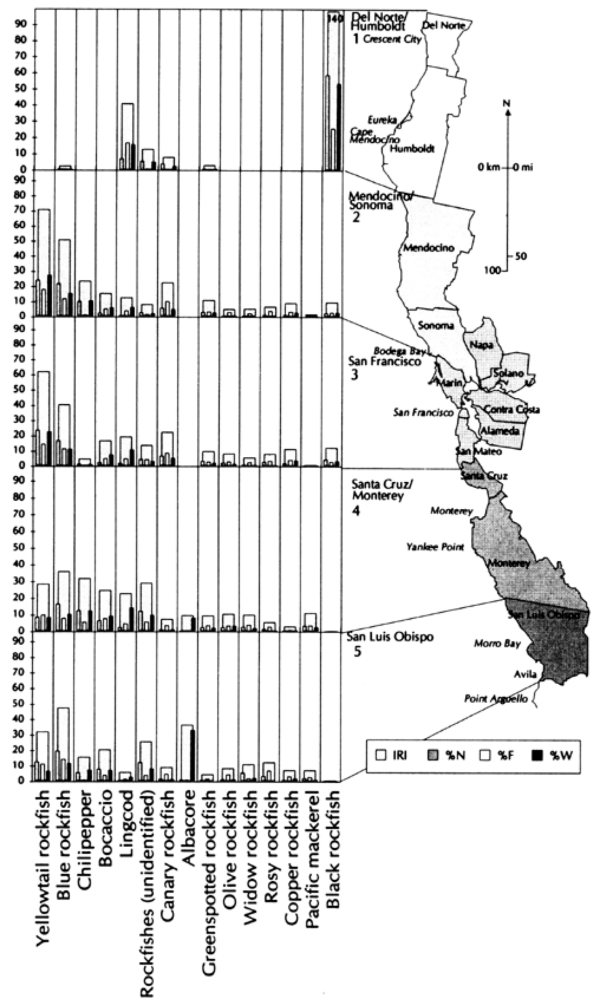


FIGURE 10. The most important 15 species as ranked by IRI (sum of percent by number, percent by weight, and frequency of occurrence in creels) in the CPFV marine recreational fishery in northern and central California, 1980–86.

FIGURE 10. The most important 15 species as ranked by IRI (sum of percent by number, percent by weight, and frequency of occurrence in creels) in the CPFV marine recreational fishery in northern and central California, 1980–86

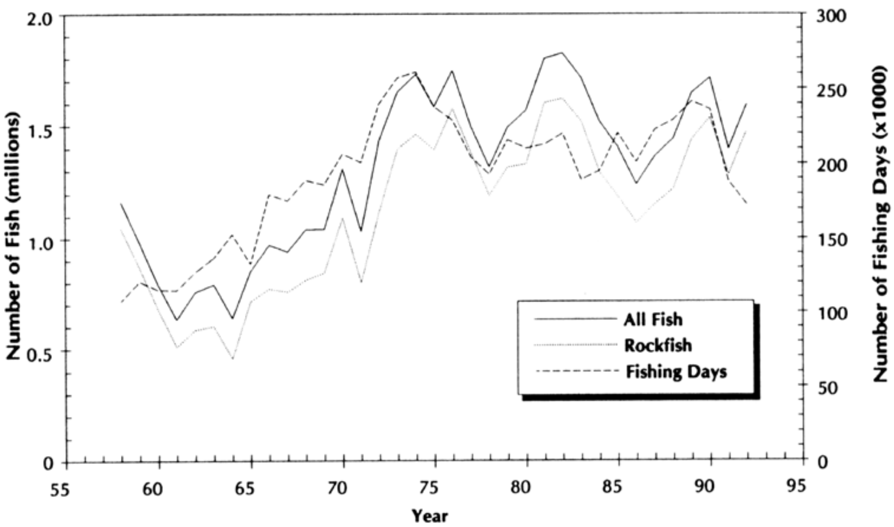


FIGURE 11. Total fish catch, rockfish catch, and effort from northern and central California CPFV log data, 1958–92.

FIGURE 11. Total fish catch, rockfish catch, and effort from northern and central California CPFV log data, 1958–92

4.2. Private/Rental Boat (PRB)

The PRB mode encompasses all hook-and-line sport fishing activity from boats other than CPFVs. In northern and central California PRBs (commonly called "skiffs") are typically 5–8 m long, privately owned, trailered, and launched from ramps for single-day trips.

In 1981–86, PRB fishing was the most popular fishing mode, accounting for about 853,000 fishing days annually, or about 34% of nonsalmon effort (Table 1). It was the second most productive mode, with an average catch per day of 2.5 fish weighing 2.7 kg (Table 3). Over half the PRB fishing effort occurred in the San Francisco district (514,000 days) (Figure 8).

PRB anglers took the greatest weight of fish per day in Del Norte/Humboldt (5.6 kg) and Mendocino/Sonoma (5.3 kg). PRBs took the highest number of fish per day in Santa Cruz/Monterey (7.2) and San Luis Obispo (5.9). The least successful PRB fishing was in San Francisco Bay (1.1 fish weighing 2.4 kg) (Figure 9).

The catch of the PRB fishery, like that of the CPFV fishery, was dominated by rockfish and lingcod (Figure 13). The species with the largest IRIs were blue rockfish, black rockfish, lingcod, canary rockfish, copper rockfish, and white croaker. Black rockfish was most important in Del Norte/Humboldt. Blue rockfish was most important in Mendocino/Sonoma and San Luis Obispo. White croaker had the highest IRI in Santa Cruz/Monterey.

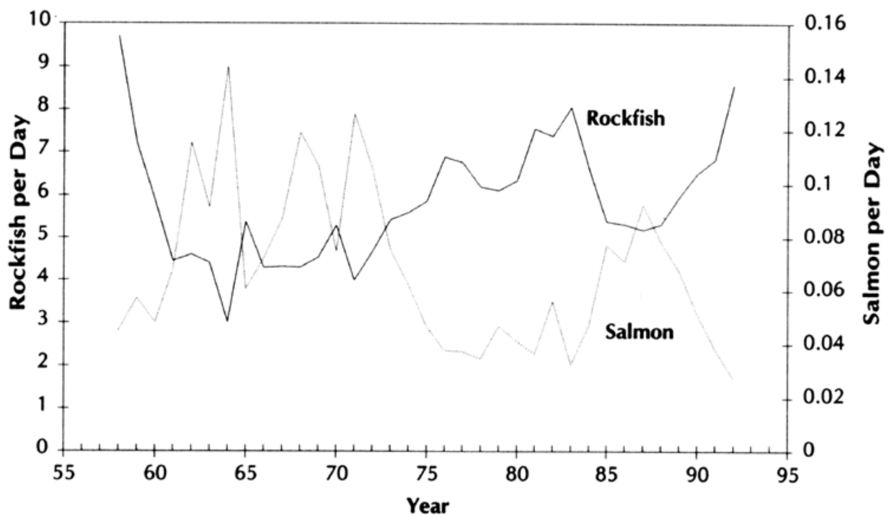


FIGURE 12. Catch per unit effort (number of fish per day) for rockfish and salmon from northern and central California commercial passenger fishing vessel log data, 1958–92.

FIGURE 12. Catch per unit effort (number of fish per day) for rockfish and salmon from northern and central California commercial passenger fishing vessel log data, 1958–92

4.3. Beach and Bank

The beach and bank mode encompasses hook-and-line fishing from all naturally-formed shoreline areas, including sandy beaches, rocky headlands, and the muddy banks of estuaries.

During 1981–86, beach and bank fishing accounted for about 632,000 fishing days annually, or about 25% of total nonsalmon effort (Table 1). Catch per day averaged 1.2 fish weighing 0.4 kg (Table 3). Over half the beach and bank fishing effort (351,000 days) occurred in the San Francisco district (Figure 8).

The weight of fish caught per day by beach and bank anglers varied little among districts, ranging from 0.3 to 0.5 kg (Figure 9). Smaller fish were taken in the south where anglers in Santa Cruz/Monterey and San Luis Obispo took 2.0 and 1.7 fish per day respectively. In the other districts catch per day ranged from 0.9 to 1.1 fish.

The catch of the beach and bank fishery was dominated by the surfperch (Figure 14). Species with the largest IRIs were barred surfperch, redtail surfperch, silver surfperch, striped seaperch, cabezon, and kelp greenling. Redtail surfperch and striped seaperch were generally more important in the northern districts, while barred surfperch and silver surfperch were generally more important in the southern districts.

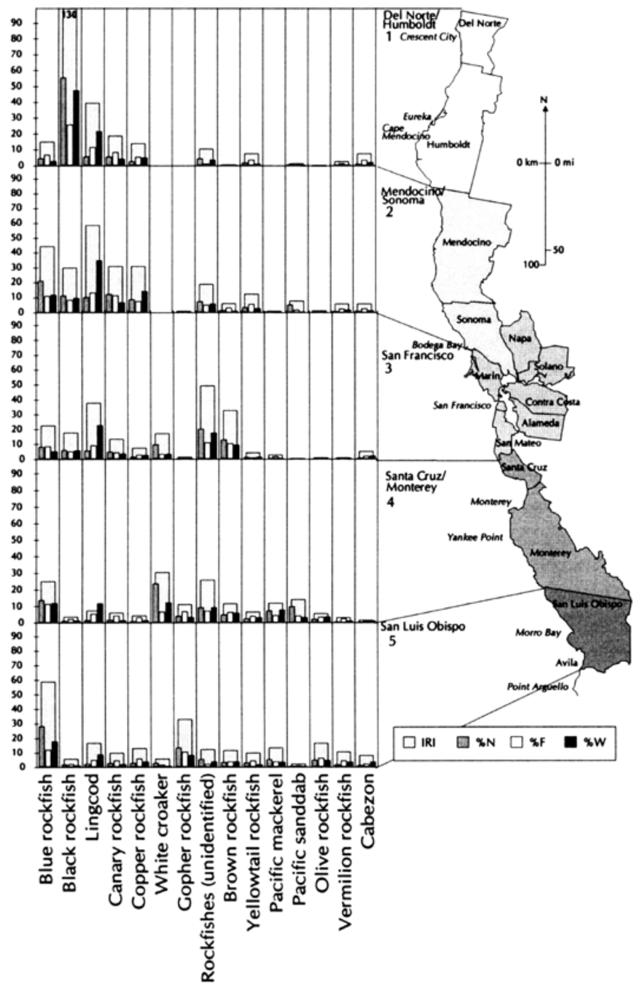


FIGURE 13. The most important 15 species as ranked by IRI (sum of percent by number, percent by weight, and frequency of occurrence in creels) in the PRB marine recreational fishery in northern and central California, 1980–86.

FIGURE 13. The most important 15 species as ranked by IRI (sum of percent by number, percent by weight, and frequency of occurrence in creels) in the PRB marine recreational fishery in northern and central California, 1980–86

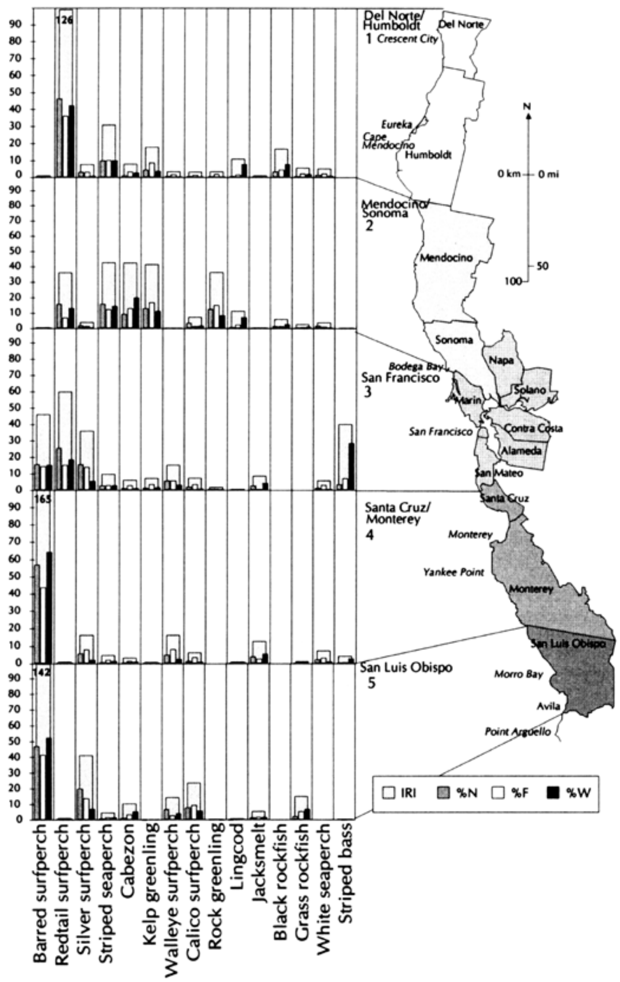


FIGURE 14. The most important 15 species as ranked by IRI (sum of percent by number, percent by weight, and frequency of occurrence in creels) in the beach/bank marine recreational fishery in northern and central California, 1980–86.

FIGURE 14. The most important 15 species as ranked by IRI (sum of percent by number, percent by weight, and frequency of occurrence in creels) in the beach/bank marine recreational fishery in northern and central California, 1980–86

4.4. Jetty and Breakwater

The jetty and breakwater mode encompasses hook-and-line fishing activity from artificial walls, usually made from boulders, built either on the shore or offshore. Their purpose is usually to restrain currents or to protect anchorages from waves.

During 1981–86, jetty and breakwater fishing accounted for about 103,000 fishing days annually (Table 1). The catch-per-day was the lowest of any mode, averaging 0.8 fish weighing 0.4 kg (Table 3). The greatest effort was in the San Francisco district (45,000 days) (Figure 8). Jetty and breakwater fishing showed little variation in catch-per-day among districts (Figure 9).

The catch of the jetty and breakwater fishery was not dominated by any particular taxonomic group and varied greatly among districts (Figure 15). Kelp greenling and striped seaperch were of high importance in Del Norte through Sonoma counties. Jacksmelt was of high importance south of San Mateo County. Barred surfperch was important primarily in San Luis Obispo County.

4.5. Pier and Dock

The pier and dock mode encompasses hook-and-line fishing from structures built over the water that are supported by pilings or floats. Piers may be constructed for mooring boats or specifically for fishing. Piers are popular shore fishing sites since they are frequently near urban areas, access is usually easy, and no license is required for sport fishing on public piers in the ocean waters of California, including San Francisco Bay.

During 1981–86, pier and dock fishing accounted for about 587,000 fishing days annually, or about 23% of total nonsalmon effort (Table 1). Catch per day averaged 1.6 fish weighing 0.4 kg (Table 3). Most fishing effort occurred in the San Francisco district (376,000 days) and in the Santa Cruz/Monterey and San Luis Obispo districts (184,000 days combined) (Figure 8). Generally, catch per day by weight was low and similar to the jetty and breakwater and beach and bank modes in all districts, with little variation among districts. Catch per day by number was higher than in the other shore modes, again with little variation among districts. Success in the Mendocino/Sonoma district was relatively high, where catch per day averaged 7.0 fish weighing 0.8 kg (Figure 9).

The species composition of the pier and dock catch, like that of the jetty and breakwater catch, was not dominated by any particular taxonomic group and varied greatly among districts (Figure 16). Pacific herring was highly important in Mendocino/Sonoma. The high importance of Pacific mackerel

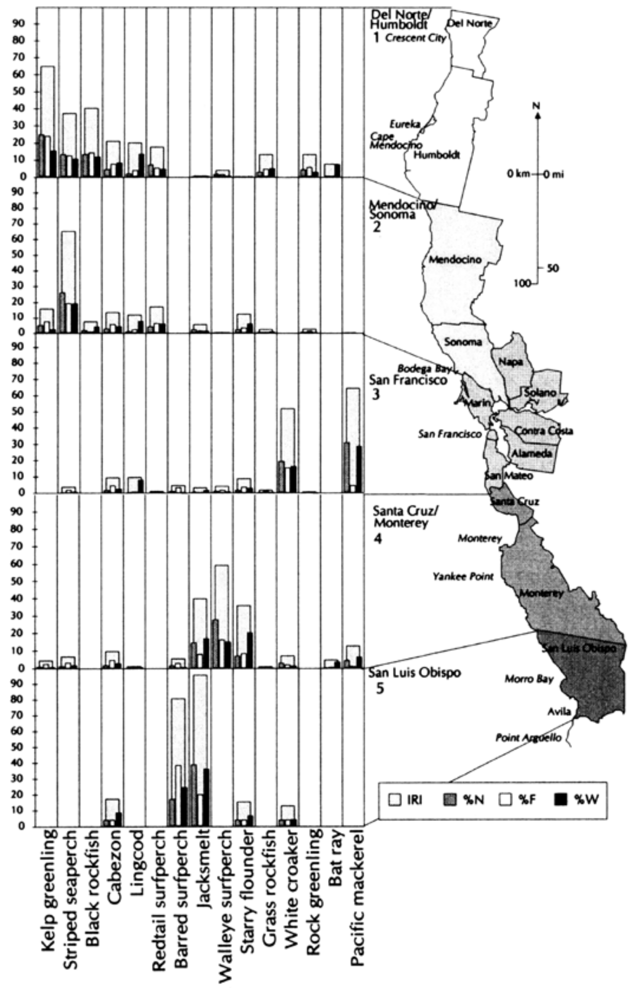


FIGURE 15. The most important 15 species as ranked by IRI (sum of percent by number, percent by weight, and frequency of occurrence in creels) in the jetty and breakwater marine recreational fishery in northern and central California, 1980–86.

FIGURE 15. The most important 15 species as ranked by IRI (sum of percent by number, percent by weight, and frequency of occurrence in creels) in the jetty and breakwater marine recreational fishery in northern and central California, 1980–86

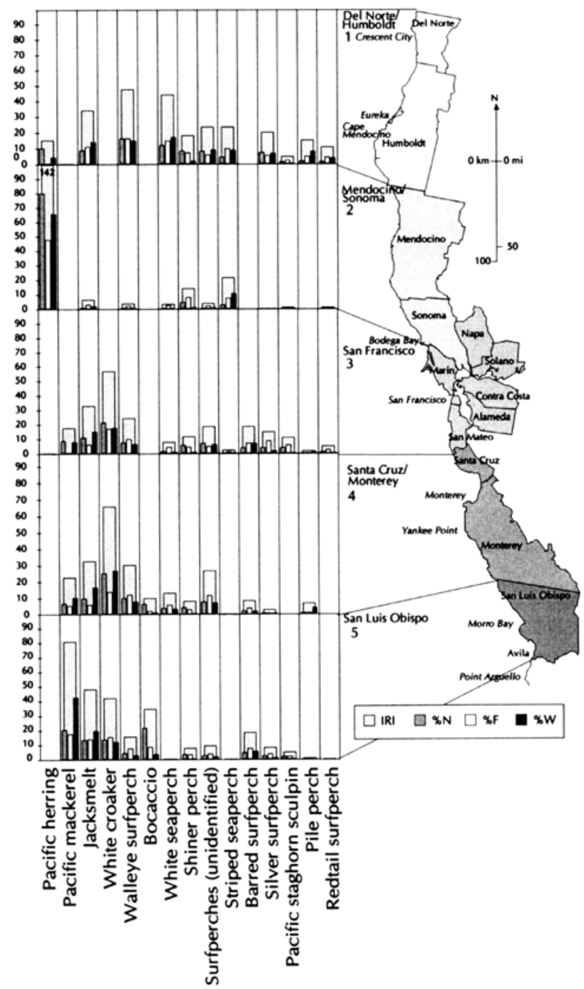


FIGURE 16. The most important 15 species as ranked by IRI (sum of percent by number, percent by weight, and frequency of occurrence in creels) in the pier and dock marine recreational fishery in northern and central California, 1980–86.

FIGURE 16. The most important 15 species as ranked by IRI (sum of percent by number, percent by weight, and frequency of occurrence in creels) in the pier and dock marine recreational fishery in northern and central California, 1980–86

in the central districts was probably due to the 1982–83 ENSO event (see page 141). White croaker had the highest IRI in the San Francisco and Santa Cruz/Monterey districts.

4.6. Spear

The spear mode encompasses all fishing activity, whether from a boat or from shore, where spear gear is used. Spear fishing in northern and central California is pursued by divers using scuba and by free (breathhold) divers.

During 1981–86, spear fishing was the least active mode, accounting for about 21,000 fishing days annually, or about 0.8% of total nonsalmon effort (Table 1). Catch per day averaged 1.9 fish weighing 1.9 kg (Table 3). Nearly all spearfishing activity occurred in the Mendocino/Sonoma and Santa Cruz/Monterey districts (Figure 8). Those districts have relatively good conditions for spear fishing due to lack of large river discharges of suspended sediment. Catch per day was similar in those districts (3.1 fish weighing 3.5 kg in Mendocino/Sonoma and 3.0 fish weighing 3.2 kg in Santa Cruz/Monterey) (Figure 9).

The catch of the spear fishery was dominated by lingcod, which had the largest IRI in all districts where spear fishing occurred (Figure 17). Other important species in the Mendocino/Sonoma and Santa Cruz/Monterey districts were blue rockfish and cabezon. Black rockfish and striped seaperch were also important north of the San Francisco district.

5. STATUS OF IMPORTANT STOCKS

5.1. Rockfish

Rockfish dominate the marine recreational fishery catch in northern and central California, comprising about half the catch. of the 62 rockfish species reported from the Pacific coast of North America (Robins et al. 1991), 57 are found off California (Miller and Lea 1972; Chen 1975, 1986).[1] of the 57 California species, 29 (51%) were encountered in the 1958–61 survey (Miller and Gotshall 1965); 43 (75%) were encountered in the 1980–86 MRFSS creel survey (36 in northern California and 39 in central California) (Appendix A).

All rockfish are viviparous and fertilization is internal (Boehlert and Yoklavich 1984). After egg development and hatching within the ovary, larvae are extruded into the water column. Rockfish fecundity averages about 1.1 million

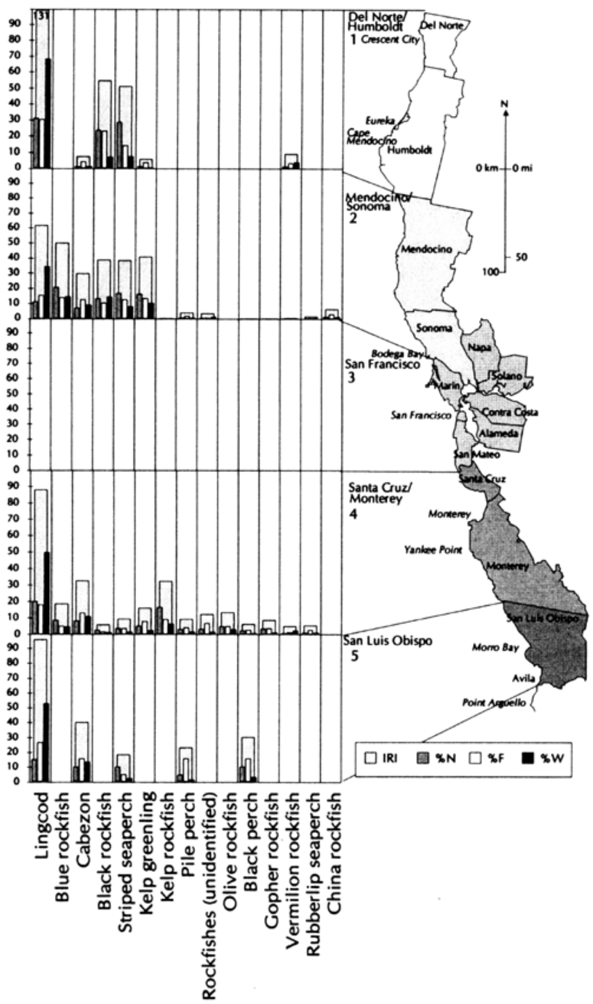


FIGURE 17. The most important 15 species as ranked by IRI (sum of percent by number, percent by weight, and frequency of occurrence in creels) in the marine recreational spear fishery in northern and central California, 1980–86.

FIGURE 17. The most important 15 species as ranked by IRI (sum of percent by number, percent by weight, and frequency of occurrence in creels) in the marine recreational spear fishery in northern and central California, 1980–86

eggs per female (Haldorson and Love 1991). The larval and juvenile stages are pelagic for several months to a year (Alstrom 1961; Miller and Geibel 1973; Boehlert 1977) and are routinely found in samples from the California Current (Ahlstrom et al. 1978; Lenarz et al. 1991; Adams 1992a). After the pelagic phase, many species use nearshore rocky reefs, kelp beds, or bays as juvenile nursery grounds (Miller and Geibel 1973; Feder et al. 1974; Gotshall et al. 1980; Gaines and Roughgarden 1987). True to their name, adult rockfish are typically associated with high-relief rocky substrate; however, some semipelagic schooling species are occasionally found over sand (Miller and Gotshall 1965; Haldorson and Love 1991).

Despite their high fecundity, annual recruitment of many rockfish species fluctuates widely. Strong year-classes dominate southern California sport catches of vermilion rockfish, blue rockfish, chilipepper, and bocaccio (Ally et al. 1991; Rogers and Bence 1992; Bence and Rogers 1993). California commercial catches of bocaccio and chilipepper exhibit dominant cohorts synchronous with other species and related to environmental changes such as ENSO (Hollowed et al. 1987).

5.1.1. Depth Distribution

The depth distributions of rockfish range from surface intertidal and off-shore zones to waters deeper than 1000 m (Miller and Gotshall 1965; Miller and Lea 1972; Hart 1973; Miller and Geibel 1973). Miller and Gotshall (1965) described three main depth distributions and habitats for marine fish based on where they were commonly caught by the northern and central California sport fishery: kelp bed (0–46 m), shallow reef (0–46 m), and deep reef (46–107 m). Blue rockfish and olive rockfish were taken in all three habitats. Yellowtail rockfish, canary rockfish, and vermilion rockfish were found in shallow reef and deep reef habitats. Black rockfish and gopher rockfish were ascribed to kelp bed and shallow reef habitats. Brown rockfish were ascribed only to shallow reef habitat. Bocaccio, chilipepper, greenspotted rockfish, widow rockfish, and greenstriped rockfish were found mostly at deep reef habitat. Bocaccio, chilipepper, yellowtail rockfish, and widow rockfish were also described as found occasionally over deep (< 67 m) sandy habitats.

Miller and Geibel (1973) described 73 m as a transitional depth for northern and central California species composition. Blue rockfish, olive rockfish, kelp rockfish, black rockfish, and brown rockfish were described as principally taken in depths less than 73 m. Yellowtail rockfish, widow rockfish, bocaccio, chilipepper, greenspotted rockfish, rosy rockfish, and starry rockfish were ascribed to depths greater than 73 m.

To focus our analysis of the fishery, we categorized our top 16 rockfish species by the depth range where the fish are usually caught. Our categories are *shallow* (< 73 m), *deep* (> 73 m), and *all depths*. The depth groupings were adapted from the 73-m zonation of Miller and Geibel (1973); however, we added greenstriped rockfish to the deep-water species, gopher rockfish to the shallow-water species, and removed bocaccio from the deep-water species. Greenstriped rockfish and gopher rockfish were not included in the Miller and Geibel (1973) zonation. Greenstriped rockfish are found in depths of 61–402 m while gopher rockfish are found in depths less than 55 m (Miller and Lea 1972; Eschmeyer et al. 1983). We categorized bocaccio as an all-depths species because they were frequently caught from piers in 1980–86. We categorized canary rockfish, copper rockfish, and vermilion rockfish as all-depths species based on published habitat descriptions and depth ranges (Miller and Gotshall 1965; Miller and Lea 1972; Eschmeyer et al. 1983).

Species composition data from the 1958–61 and 1981–86 surveys support our depth groupings (Table 4). Virtually all the catch of the seven deep-water species was taken by PRBs or CPFVs. Other sources confirm that each of those species is found in waters deeper than 73 m, with reported maximum depths ranging from 128 m (rosy rockfish) to 402 m (greenstriped rockfish) (Miller and Lea 1972; Eschmeyer et al. 1983). The five shallow-water rockfishes were taken more frequently from the nonboat modes (3.5% and 5.8% in 1981–86 and 1958–61 respectively) than were the deep-water rockfishes. Two shallow-water species, brown rockfish and gopher rockfish, are reported only in waters of less than 55 m (Miller and Lea 1972). Blue rockfish and black rockfish range from the surface to 91 m, while olive rockfish range from the surface to 122 m (Miller and Lea 1972).

5.1.2. Distribution Maps

The percent by number of total catch in the 1980–86 MRFSS creel survey provides a quantitative assay of yearly and spatial variation in availability of each of our top 16 rockfish species (Figures 18 19 20 21). The catch data are from over 230,000 angler bags from 12 districts in northern Oregon and California. We classified the 16 rockfish species into three categories of latitudinal distribution: 1) northern, 2) southern, and 3) coastwide. Northern species were those found mainly north of Point Conception (black rockfish, canary rockfish, widow rockfish, and yellowtail rockfish). Southern species were those found mainly south of the Oregon-California border (rosy rockfish and brown rockfish) or those found mainly south of Cape Mendocino (olive rockfish, greenspotted rockfish, starry rockfish, gopher rockfish, and chilipepper). The coastwide species were those that were found throughout our study area (blue rockfish, vermilion rockfish, bocaccio, copper rockfish, and greenstriped rockfish).

5.1.2.1. Northern Species

Black rockfish were most available in Oregon and northern California, with no significant catch south of Point Conception (Figure 18). Black rockfish availability was remarkably high off central Oregon where they comprised up to 41.4% of the catch. The highest consistent availability occurred in Del Norte/Humboldt where contribution to the catch ranged from 14.8% to 31.2%. South of Point Conception the only occurrence of black rockfish was off Los Angeles County in 1981, which approximates the southernmost range of the species (Eschmeyer et al. 1983).

Canary rockfish showed a trend of higher catch to the north from Santa Barbara/Ventura northward through Oregon (Figure 18). From Los Angeles to San Diego, canary rockfish were found only infrequently and in low concentrations. The highest consistent contribution to the catch occurred off Mendocino/Sonoma (3.4% to 11.1%). The contribution to the catch off Oregon ranged from 0.03% to 12.9%. Canary rockfish range from Baja California to Alaska (Miller and Lea 1972; Hart 1973). Dark et al. (1983) estimated biomass of major rockfish species in 1980 by four International North Pacific Fisheries Commission (INPFC) areas: Vancouver, Columbia, Eureka (Cape Blanco to Cape Mendocino), and Monterey (Cape Mendocino to Monterey Bay). Percentages of total canary rockfish stock biomass were greatest in the northern INPFC areas, with the Vancouver area having 38%, Columbia 41%, Eureka 18%, and Monterey 3%.

Widow rockfish catch distribution was patchy both spatially and temporally. Patchiness was most pronounced from Del Norte/Humboldt through Oregon (0% to 2.9%) and south of Santa Barbara/Ventura (0% to 0.75%) (Figure 18). Widow rockfish range from southeastern Alaska to northern Baja California (Eschmeyer et al. 1983).

Yellowtail rockfish were taken mainly north of Los Angeles County (Figure 18). The highest and most consistent percentage of catch was in Mendocino/Sonoma (5.9% to 14%). Catch contributions off northern Oregon were occasionally high, but fluctuated greatly (0% to 11.3%). Such fluctuation may be a reflection of the variable year-class strength for the species reported by Tagart (1991). Yellowtail rockfish range from San Diego to the Gulf of Alaska (Miller and Lea 1972; Hart 1973). As with canary rockfish, estimates of percentage of total stock biomass in 1980 were greatest in the northern INPFC areas, with the Vancouver area contributing 46%, Columbia 47%, Eureka 5%, and Monterey 2% (Dark et al. 1983).

TABLE 4. Average annual number (thousands) and percent of rockfish caught in the marine recreational fishery in northern and central California by depth grouping and mode, 1958-61 and 1981-86.

	Pier & Dock				Jetty & Breakwater + Beach & Bank			
	58-61		*81-86*		*58-61*		*81-86*	
	No.	%	No.	%	No.	%	No.	%
All Depths								
BOCACCIO	4	43.8	44	67.5	0	0.2	0	1.0
CANARY ROCKFISH	-	-	0	0.3	0	0.4	1	2.7
COPPER ROCKFISH	0	0.5	0	0.3	0	1.4	2	7.1
VERMILION ROCKFISH	0	0.4	0	0.1	-	-	0	1.0
Total %		44.8		68.1		1.9		11.9
% of All Modes		1.7		10.0		0.2		0.7
Deep								
YELLOWTAIL ROCKFISH	-	-	0	0.3	-	-	0	1.0
CHILIPEPPER	-	-	0	0.3	-	-	-	-
ROSY ROCKFISH	-	-	0	0.3	-	-	0	0.7
GREENSPOTTED ROCKFISH	-	-	0	0.1	-	-	-	-
WIDOW ROCKFISH	-	-	-	-	-	-	-	-
STARRY ROCKFISH	-	-	-	-	-	-	-	-
GREENSTRIPED ROCKFISH	-	-	-	-	-	-	-	-
Total %		-		0.9		-		1.7
% of All Modes				0.1				0.0
Shallow								
BLUE ROCKFISH	1	6.7	1	0.8	14	55.2	6	22.4
BLACK ROCKFISH	2	23.1	1	1.3	11	42.2	7	29.9
BROWN ROCKFISH	2	19.2	19	28.7	0	0.2	8	33.0
GOPHER ROCKFISH	-	-	0	0.1	0	0.3	0	0.7
OLIVE ROCKFISH	1	6.2	-	-	0	0.2	0	0.3
Total %		55.2		30.9		98.1		86.4
% of All Modes		0.8		1.3		4.0		1.4
TOTAL**	9	100	65	100	26	100	25	100
OTHER ROCKFISHES	3	0	6	0.6	10	1	13	1.5
ALL ROCKFISH	12	1.2	71	7.3	35	3.4	37	4.4
ALL FISH	1034	100	966	100	1025	100	834	100

* Excludes San Francisco Bay
** Excludes other rockfishes

TABLE 4. Average annual number (thousands) and percent of rockfish caught in the marine recreational fishery in northern and central California by depth grouping and mode, 1958–61 and 1981–86

5.1.2.2. Southern Species

Brown rockfish had a catch distribution with a northern limit at the Oregon-California border, availability throughout California, and relatively low fluctuation in availability between years (Figure 19). The greatest availability was in the San Francisco district where catch by number ranged from 1.7% to 6.6%. Catches south of Point Conception were low, ranging from 0.04% to 1.0%. The reported range of brown rockfish extends from southeast Alaska to central Baja California (Miller and Lea 1972; Hart 1973; Eschmeyer et al 1983), which encompasses our observed range of catch.

PRB *				CPFV				Spear			
58-61		*81-86*		*58-61*		*81-86*		*58-61*		*81-86*	
No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	0.8	5	0.5	59	5.8	131	7.3	0	2.0	0	0.6
10	6.1	63	6.4	52	5.2	76	4.2	-	-	0	1.8
19	11.5	40	4.0	39	3.9	42	2.3	0	3.4	1	3.7
5	2.8	20	2.0	46	4.6	18	1.0	0	1.8	0	1.2
	21.2		12.9		19.4		14.9		7.3		7.4
	15.0		28.8		82.9		60.3		0.1		0.2
5	2.7	49	4.9	224	22.1	384	21.4	0	0.1	0	2.5
0	0.0	2	0.2	3	0.3	212	11.8	-	-	-	-
4	2.4	27	2.7	35	3.5	55	3.0	-	-	-	-
0	0.0	6	0.6	22	2.2	61	3.4	-	-	-	-
0	0.0	3	0.3	32	3.2	63	3.5	-	-	-	-
1	0.4	9	0.9	26	2.6	36	2.0	-	-	-	-
-		1	0.1	4	0.4	27	1.5	-	-	-	-
	5.5		9.6		34.2		46.7		0.1		2.5
	2.6		10.2		97.4		89.7		0.0		0.0
72	43.0	303	30.6	331	32.7	506	28.2	3	46.9	6	46.0
30	17.7	224	22.6	29	2.9	37	2.0	2	36.2	4	27.0
7	4.2	71	7.2	14	1.3	58	3.2	0	0.0	-	-
10	5.8	104	10.5	29	2.8	28	1.5	0	2.9	1	5.5
5	2.7	61	6.2	66	6.5	58	3.2	0	6.6	2	11.0
	73.3		77.0		46.3		38.3		92.6		89.6
	19.6		50.8		74.6		45.7		1.0		0.8
168	100	990	99	1008	100	1766	100	7	100	14	99
12	3.4	231	13	39	3	297	12	3	15	6	16
169	50.0	1217	66.5	1050	85.3	2087	85.8	10	45.3	20	50.3
337	100	1830	100	1231	100	2433	100	22	100	40	100

EQUATION

Chilipepper were caught only south of the Del Norte/Humboldt district. Contribution to catch fluctuated widely, but was most consistent in Santa Cruz/Monterey and in Los Angeles through Orange counties (Figure 19). The highest contribution to catch (16.9%) occurred in 1986 in Mendocino/Sonoma, and followed a period of low contribution (0% to 0.02%) from 1980 through 1984. Variable year-class strength may be a factor, as discussed in the rockfish length-frequency analysis section (page 82). Chilipepper range from Baja California to Vancouver Island (Miller and Lea 1972; Hart 1973). Estimates

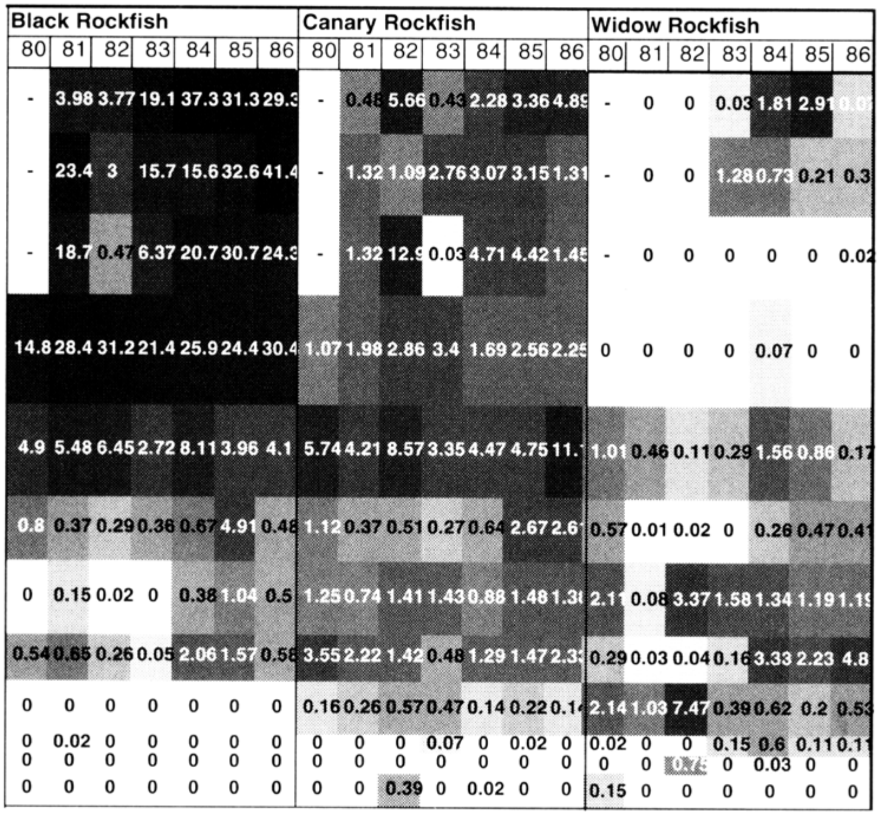
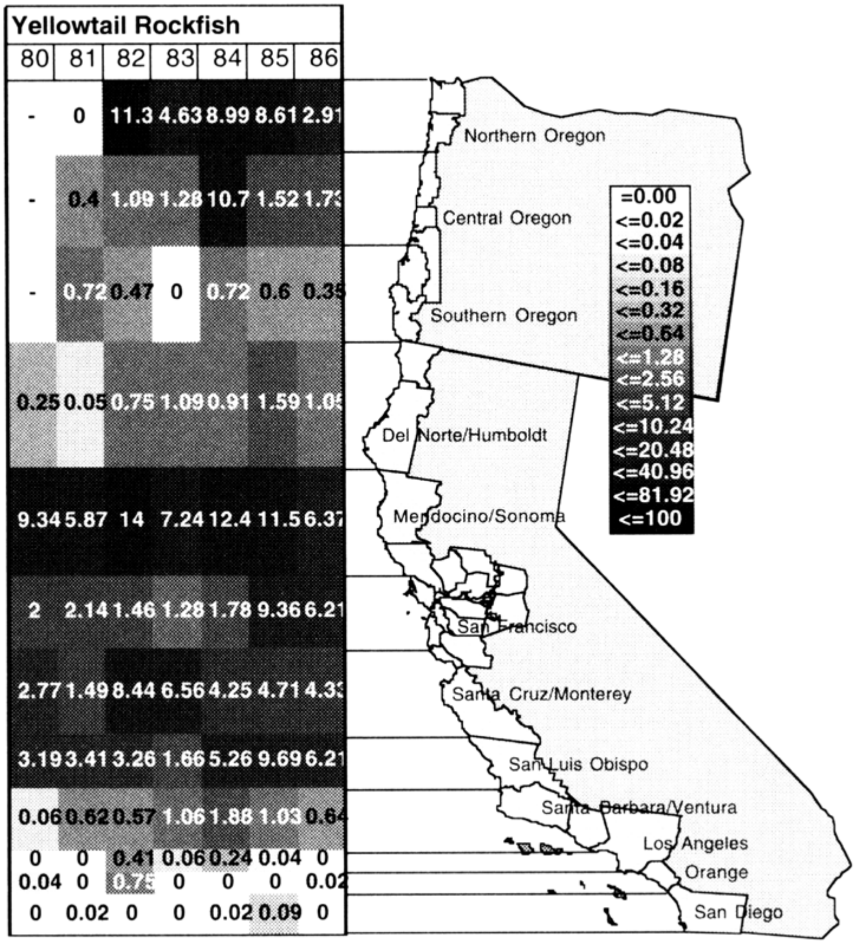


FIGURE 18. Percent by number of total sampled catch of black rockfish, canary rockfish, widow rockfish, and yellowtail rockfish by district and year in Oregon and California marine recreational fisheries, 1980–86.

FIGURE 18. Percent by number of total sampled catch of black rockfish, canary rockfish, widow rockfish, and yellowtail rockfish by district and year in Oregon and California marine recreational fisheries, 1980–86

of percentage of total stock biomass in 1980 were greatest in the southern INPFC areas, with Vancouver having 0%, Columbia 0.1%, Eureka 6%, and Monterey 93.6% (Dark et al. 1983).

Gopher rockfish had a northern boundary of take near Cape Mendocino; the only occurrence north of there was in 1984 (0.05% in southern Oregon) (Figure 19). The distribution of gopher rockfish availability was relatively patchy over time and space. A band of high contribution to the catch (4.0% to 10.7%) occurred off San Luis Obispo. South of Point Conception, contribution to the catch ranged from 0% to 1.6%. Gopher rockfish were rarely caught in northern California, where contribution to the catch ranged from 0% to 0.2%. Eschmeyer et al. (1983) described the range of gopher rockfish as extending from San Roque, Baja California to Eureka. The occurrence in southern



EQUATION

Oregon extends beyond that range, but our data cannot document a range extension since fish were not kept for taxonomic verification.

Greenspotted rockfish had a fairly distinct northern boundary of catch near Cape Mendocino; the only occurrence north of there was in 1985 (0.04% in Del Norte/Humboldt) (Figure 19). Like gopher rockfish and chilipepper, greenspotted rockfish had a patchy temporal and latitudinal distribution; patchy temporal availability suggests variable recruitment. Catches in 1985 and 1986 in Mendocino through Monterey counties increased from previous years. Greenspotted rockfish were most available in Santa Barbara/Ventura where contribution to catch ranged from 2.1% in 1980 to 9.8% in 1984. Greenspotted rockfish range from central Baja California to Washington (Miller and Lea 1972; Hart 1973).

Olive rockfish catch distribution (Figure 20) was similar to that of greenspotted rockfish, starry rockfish, gopher rockfish, and chilipepper (Figures 19 and 20). The northern boundary of catch was near Cape Mendocino. Spatial and temporal distribution of olive rockfish was less patchy than that of

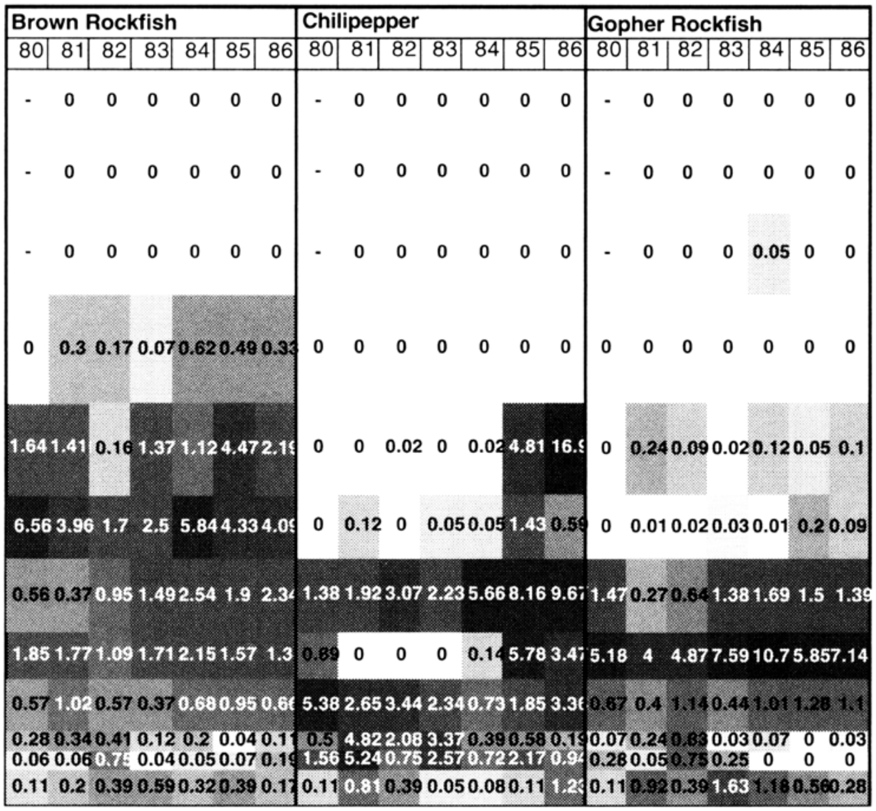
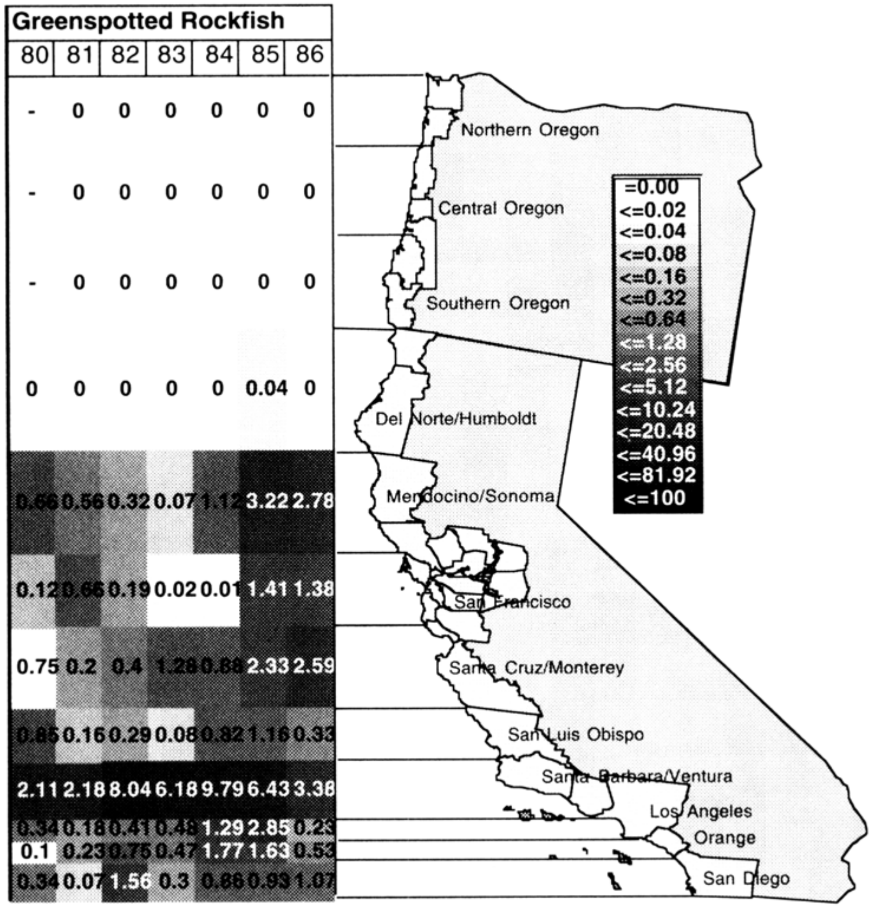


FIGURE 19. Percent by number of total sampled catch of brown rockfish, chilipepper, gopher rockfish, and greenspotted rockfish by district and year in Oregon and California marine recreational fisheries, 1980–86.

FIGURE 19. Percent by number of total sampled catch of brown rockfish, chilipepper, gopher rockfish, and greenspotted rockfish by district and year in Oregon and California marine recreational fisheries, 1980–86

greenspotted rockfish, gopher rockfish, or chilipepper. The highest availability was from Santa Cruz/Monterey through Santa Barbara/Ventura, where contribution to the catch ranged from 0.7% to 5.9%. Olive rockfish range from San Benito Island, Baja California to Redding Rock, Del Norte County (Eschmeyer et al. 1983). The one rare occurrence (0.08%) in Del Norte/Humboldt falls within that range.

Rosy rockfish were caught mainly south of the Oregon-California border (Figure 20). Fluctuation in availability between years was low. Catch distribution was centered in San Luis Obispo, where a fairly constant portion (1.6% to 2.8%) of catch was maintained. Rosy rockfish range from Turtle Bay, Baja California to Puget Sound (Miller and Lea 1972; Hart 1973).



EQUATION

Starry rockfish had a fairly distinct northern boundary of catch near Cape Mendocino; the only occurrence north of there was in 1982 (0.03% in Del Norte/Humboldt) (Figure 20). That boundary is well north of San Francisco, the northern range reported by Miller and Lea (1972). (Our data cannot be used to document a range extension as the fish taken were not preserved for taxonomic verification.) The highest availability was in San Luis Obispo through Santa Barbara/Ventura where contribution to catch ranged from 0.7% to 3.5%.

5.1.2.3. Coastwide Species

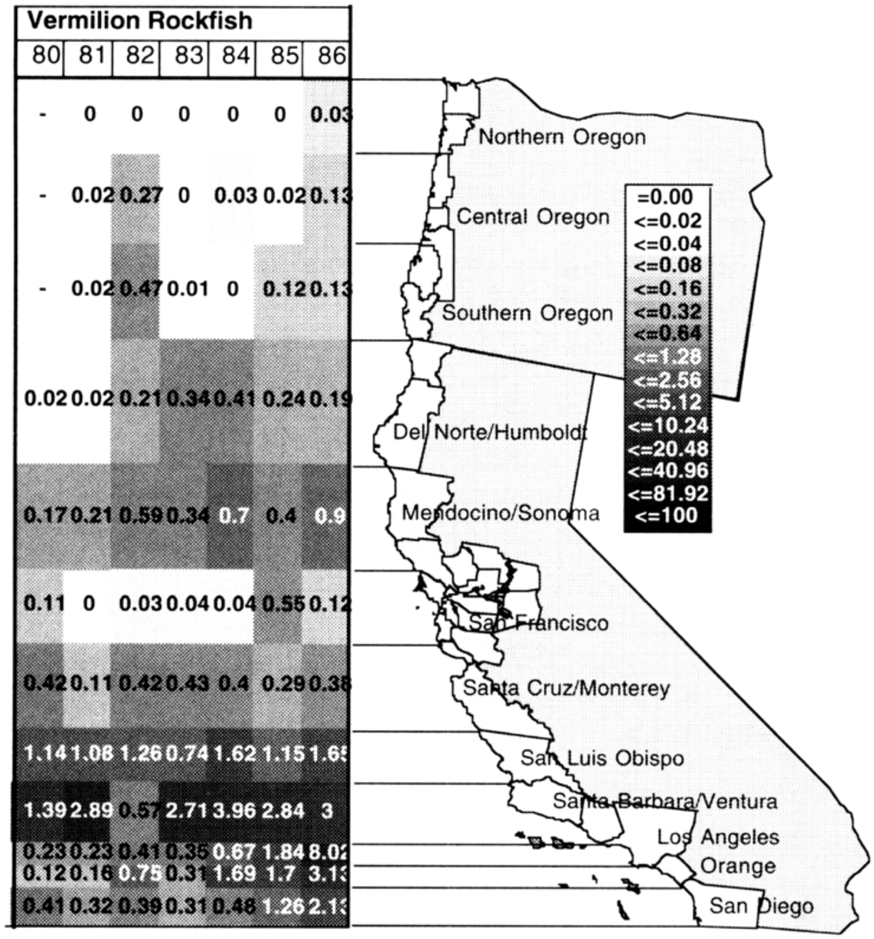
Vermilion rockfish were broadly distributed at low percentages of total catch (0% to 8.0%) increasing southward from central Oregon to Los Angeles County (Figure 20). The highest consistent contribution to catch occurred in Santa Barbara/Ventura (0.6% in 1982 to 4.0% in 1984). The increase in catch observed in 1985 and 1986 from Los Angles through San Diego counties may reflect the strong 1982 year-class reported by Ally et al. (1991). Vermilion rockfish range from Baja California to central Vancouver Island (Hart 1973).

Olive Rockfish							Rosy Rockfish							Starry Rockfish						
80	81	82	83	84	85	86	80	81	82	83	84	85	86	80	81	82	83	84	85	86
-	0	0	0	0	0	0	-	0	0	0	0	0	0	-	0	0	0	0	0	0
-	0	0	0	0	0	0	-	0	0	0	0	0	0	-	0	0	0	0	0	0
-	0	0	0	0	0	0	-	0	0	0	0	0.06	0	-	0	0	0	0	0	0
0.08	0	0	0	0	0	0	0.02	0	1.11	0.22	0.7	0.12	0.17	0	0	0.03	0	0	0	0
0.21	0.41	0.5	1.87	0.36	0.34	0.21	1.62	0.34	1.76	1.53	0.97	1.5	1.94	0.21	0.02	0.02	0.1	0.31	0.38	0.26
0.19	0.51	0.14	0.17	0.1	0.66	1.12	0.15	0.04	0.22	0.29	0.3	0.74	1.91	0	0.05	0.03	0.03	0.05	0.06	0.59
3.95	0.71	1.56	4.1	1.78	0.89	1.57	0.9	0.24	0.05	1.65	1.73	1.73	1.52	0.64	0.24	0.6	0.66	0.77	0.71	0.77
2.1	2.49	4.56	4.04	3.45	1.57	1.2	2	2.17	2.82	1.62	2.57	1.96	2.04	1.23	1.49	1.64	0.67	1.15	1.92	1.64
3.68	2.1	1.14	2.17	2.97	5.86	3.2	1.23	1.16	0.57	0.44	1.2	1.59	1.85	1.32	1.7	2.29	1.65	3.49	2.09	2.13
0.64	0.65	0.41	0.93	0.76	0.07	0.5	0.08	0.31	2.5	0.29	0.93	0.67	0.53	0.34	0.47	0.41	0.79	1.32	1.17	1.32
0.38	2.1	0.75	0.18	0.59	0.1	0.23	0.08	0.27	0.75	0.08	0.51	0.23	0.19	0.2	0.1	1.51	0.21	0.83	0.23	0.1
1.54	1.13	0.39	0.53	0.2	0.3	1.18	0.04	0	0.39	0.19	0.1	0.5	0.36	0.25	0.38	0.39	1.12	0.8	0.82	1.68

FIGURE 20. Percent by number of total sampled catch of olive rockfish, rosy rockfish, starry rockfish, and vermilion rockfish by district and year in Oregon and California marine recreational fisheries, 1980-86.

FIGURE 20. Percent by number of total sampled catch of olive rockfish, rosy rockfish, starry rockfish, and vermilion rockfish by district and year in Oregon and California marine recreational fisheries, 1980–86

Blue rockfish showed the widest spatial distribution of our top 16 rockfish species. Contribution to catch was high in central Oregon, Mendocino/Sonoma, Santa Cruz/Monterey and San Luis Obispo (Figure 21). The highest contribution was in San Luis Obispo in 1982 (31%); contribution there declined to 8.5% in 1985. The lowest contributions (0% to 3.0%) were from Los Angeles through San Diego counties. The large fluctuations in availability are discussed in the rockfish length-frequency analysis section and the management implications section (page 67 and page 102). Blue rockfish range well beyond our study area, from Santo Tomas, Baja California to the Bering Sea (Miller and Lea 1972; Hart 1973; Eschmeyer et al 1983).



EQUATION

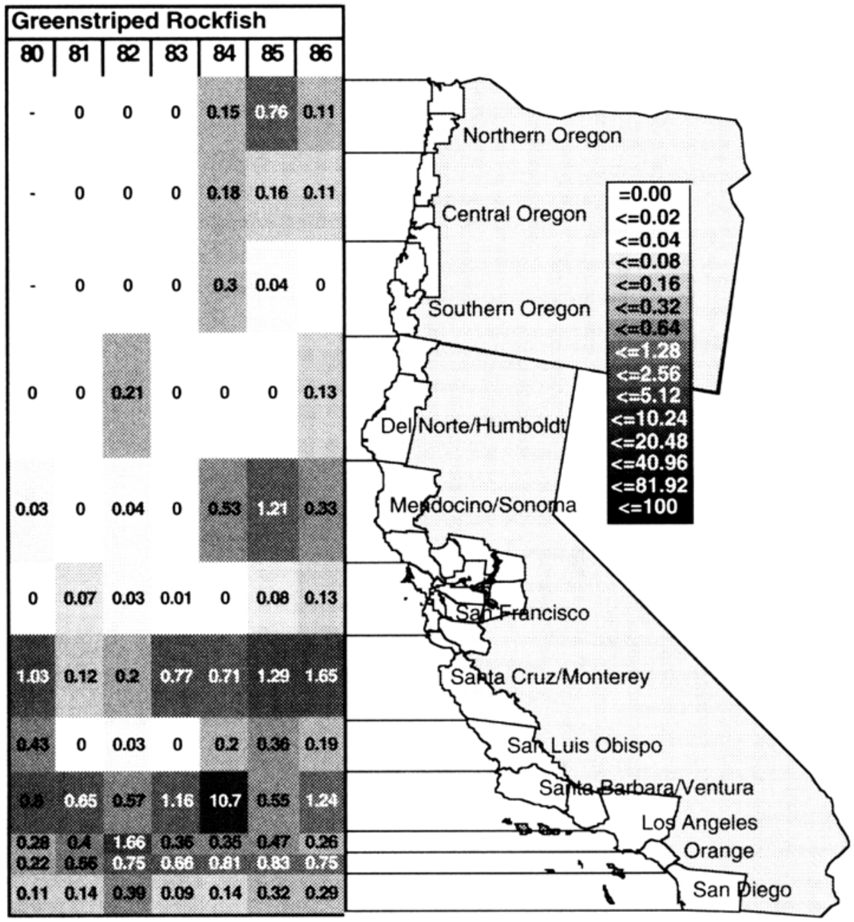
Bocaccio were caught throughout Oregon and California, but were caught most consistently and in higher percentages south of Del Norte/Humboldt (Figure 21). Contributions to the catch were highest from Santa Cruz through Orange counties but fluctuated widely (0.11% to 14.1%). Percentages of catch off San Diego were low (0.12% to 1.4%) (Figure 21). Fluctuations in contribution to catch may reflect fluctuations in cohort strength reported by Bence and Rogers (1993); cohort strength is discussed in greater detail in the length-frequency analysis section (page 79). Bocaccio range from central Baja California to the Gulf of Alaska (Miller and Lea 1972; Hart 1973; Eschmeyer et al. 1983). Estimates of percentage of total 1980 stock biomass were greatest in the southern INFPC areas, with Vancouver having 3%, Columbia 11%, Eureka 15%, and Monterey 71% (Dark et al. 1983). Such a distribution agrees with our findings.

Blue Rockfish							Bocaccio							Copper Rockfish						
80	81	82	83	84	85	86	80	81	82	83	84	85	86	80	81	82	83	84	85	86
-	2.23	1.88	1.8	2.43	0	0.18	-	0	0	0.03	0.12	0.19	0.14	-	0.09	0	0.11	0.02	0.19	0.11
-	7.98	0.54	20.1	20.6	4.39	3.74	-	0.05	0.27	0.03	0.57	0.04	0	-	0.15	0	0.09	0	0.19	0
-	2.54	8.57	0.19	1	2.16	2.16	-	0.02	0.95	0	0.13	0.06	0	-	0.37	0	0	0.8	0.72	0.26
1.48	2.72	4.29	3.28	4.12	1.31	1.85	0	0.08	0.32	0	0	0	0.04	0.83	0.66	2.9	1.58	1.27	1.14	1.03
10.8	23	14.4	19.3	18.2	18.3	3.89	1.55	2.29	1.53	0.39	1.19	0.74	1.04	1.26	15.1	2.56	1.82	1.56	2.03	2.7
2.89	2.24	0.5	1.83	4.15	7.71	2.48	0.25	1.16	0.5	0.11	0.29	0.82	0.58	0.17	0.38	0.27	0.28	0.6	0.68	0.75
8.98	19.2	17.6	15.7	16.7	10.1	4.05	3.38	1.44	3.1	3.28	2.32	2.23	8.45	0.73	0.34	0.8	0.61	0.78	0.56	0.49
21	30.7	31	21.7	12.1	8.47	9.46	11	4.8	0.32	0.11	5.82	6.22	10.5	1.71	2.74	1.93	1.38	1.51	1.15	1.48
7.59	4.39	0.57	0.31	1.5	4.89	1.31	9.16	9.46	2.29	6.43	3.28	12	10.2	4.25	2.23	1.14	3.04	2.23	2.85	2.14
0.62	0.34	0.41	0.5	0.63	0.18	0.73	12.1	13.6	2.91	2.78	2.86	6.14	6	0.1	0.18	1.25	0.07	0.34	0.36	0.21
0.02	0.27	3.03	0.06	0.13	0.13	0	7.74	14.1	3.78	2.03	2.93	2.83	1.09	0.12	0.1	0.75	0.02	0.08	0	0
0.7	0.56	0.78	0.59	1.26	0.11	0.45	1.04	1.4	0.39	0.12	0.24	0.71	1.25	0.1	0.25	0.39	0.19	0.02	0.04	0.05

FIGURE 21. Percent by number of total sampled catch of blue rockfish, bocaccio, copper rockfish, and greenstriped rockfish by district and year in Oregon and California marine recreational fisheries, 1980–86.

FIGURE 21. Percent by number of total sampled catch of blue rockfish, bocaccio, copper rockfish, and greenstriped rockfish by district and year in Oregon and California marine recreational fisheries, 1980–86

Copper rockfish were caught throughout Oregon and California (Figure 21). Percentage of total catch was most consistent from the Oregon-California border through Los Angeles County, where copper rockfish were caught in all districts in 1980–86. High contributions to the catch were off Mendocino/Sonoma (1.3% to 15.1%) and off San Luis Obispo through Santa Barbara counties (1.2% to 4.3%). Concentrations were low (0% to 0.8%) throughout Oregon and in Orange County. Miller and Lea (1972) and Hart (1973) describe the distribution of copper rockfish as ranging from Monterey through the Gulf of Alaska. Eschmeyer et al. (1983) incorporate the range of the synonymized whitebelly rockfish (Chen 1975, 1986) and describe the range as extending from central Baja California to the Gulf of Alaska.



EQUATION

Greenstriped rockfish, although classified as coastwide, had a catch distribution similar to that of widow rockfish, with patchy spatial and yearly availability that was most pronounced in the north (Figure 21). Percent of the total catch ranged from 0% to 1.2% in Oregon through San Francisco, with lowest percentages occurring in 1980–83. In southern California, greenstriped rockfish were caught in all seven years; contribution to the catch ranged from 0.09% to 10.7%. The increase in contribution to the catch in 1984 in Oregon, San Francisco, and Santa Barbara/ Ventura may reflect variation in recruitment. Greenstriped rockfish range from central Baja California to Alaska (Miller and Lea 1972; Hart 1973; Eschmeyer et al. 1983).

5.1.3. *Historical Comparison*

In 1981–86 the average annual recreational catch of rockfish, excluding San Francisco Bay, was 3,431,100 fish weighing 2,447,700 kg, nearly a threefold increase over our adjusted 1958–61 estimate of 1,286,800 fish weighing 1,051,000 kg. Rockfish comprised 35.3% by number and 43.0% by weight of the total 1958–61 sport catch, and 54.7% by number and 54.1% by weight of the total 1981–86 sport catch (Table 5). Thus the percentage (by number) of

TABLE 5. Average annual number (thousands), weight (MT), weight per fish (kg/fish), and percent of total catch by mode in the northern and central California marine recreational fishery, 1981–86, with totals compared to 1958–61.

	Pier & Dock		Jetty & Breakwater		Beach & Bank		PRB**	
All Depths*	*Wt.*	*Kg/f*	*Wt.*	*Kg/f*	*Wt.*	*Kg/f*	*Wt.*	*Kg/f*
BOCACCIO	2.0	0.05	0.0	0.20	0.1	0.50	3.8	0.77
CANARY ROCKFISH	0.1	0.80	0.1	0.80	0.5	0.77	39.3	0.62
COPPER ROCKFISH	0.2	1.40	0.5	0.78	1.2	1.09	51.8	1.30
VERMILION ROCKFISH	0.1	1.20	0.2	2.80	0.3	1.80	26.1	1.34
Totals	2.5	0.06	0.8	0.91	2.0	1.01	121.1	0.95
% of All Rockfish	31.2		18.1		11.9		14.7	
% All Modes	0.6		0.2		0.5		27.2	
Deep*								
YELLOWTAIL ROCKFISH	0.1	0.80	0.0	0.40	0.1	0.60	28.3	0.58
CHILIPEPPER	0.2	0.90	-	-	-	-	0.6	0.40
ROSY ROCKFISH	0.0	0.20	-	-	0.1	0.30	7.2	0.27
GREENSPOTTED ROCKFISH	0.1	1.00	-	-	-	-	3.8	0.68
WIDOW ROCKFISH	-	-	-	-	-	-	1.2	0.46
STARRY ROCKFISH	-	-	-	-	-	-	5.1	0.60
GREENSTRIPED ROCKFISH	-	-	-	-	-	-	0.5	0.34
Totals	0.4	0.69	0.0	0.40	0.2	0.45	46.6	0.49
% of All Rockfish	5.1		0.7		0.9		5.7	
% All Modes	0.1		0.0		0.0		7.1	
Shallow*								
BLUE ROCKFISH	0.2	0.33	0.4	0.23	1.8	0.46	135.3	0.45
BLACK ROCKFISH	0.9	1.02	1.1	0.52	5.1	0.98	220.0	0.98
BROWN ROCKFISH	2.1	0.11	0.4	0.21	1.4	0.22	41.4	0.58
GOPHER ROCKFISH	0.0	0.40	0.1	0.40	-	-	39.5	0.38
OLIVE ROCKFISH	-	-	0.1	0.60	0.0	0.40	38.0	0.62
Totals	3.2	0.16	2.0	0.34	8.3	0.54	474.1	0.62
% of All Rockfish	40.1		43.8		48.8		57.5	
% All Modes	0.3		0.2		0.9		52.2	
OTHER ROCKFISHES	1.9	0.32	1.7	0.45	6.6	0.76	182.4	0.79
% of All Rockfish	23.6		37.3		38.5		22.1	
ALL ROCKFISH TOTAL	7.9	0.11	4.6	0.43	17.0	0.65	824.2	0.68
Total All Fish Species	230		41		253		1559	
% of All Fish	3.4		11.2		6.7		52.9	
% of All Modes	0.3		0.2		0.7		33.7	

** Excludes San Francico Bay

* Depth Categories based on Miller and Gotshall (1965) and Miller and Geibel (1973)

TABLE 5. Average annual number (thousands), weight (MT), weight per fish (kg/fish), and percent of total catch by mode in the northern and central California marine recreational fishery, 1981–86, with totals compared to 1958–61

CPFV		Spear		Total 1981-86			Total 1958-61**		
Wt.	*Kg/f*	*Wt.*	*Kg/f*	*No.*	*Wt.*	*Kg/f*	*No.*	*Wt.*	*Kg/f*
168.4	1.28	0.0	0.40	180.3	174.4	0.97	64.4	99.6	1.55
58.7	0.78	0.1	0.33	139.6	98.8	0.71	62.8	47.4	0.75
60.7	1.45	0.4	0.73	84.0	114.8	1.37	59.0	68.5	1.16
30.3	1.69	0.2	1.10	37.9	57.3	1.51	51.2	91.0	1.78
318.1	1.19	0.7	0.67	441.8	445.2	1.01	237.4	306.5	1.29
20.1		5.2		12.9	18.2		18.4	29.2	
71.5		0.1			100				
321.5	0.84	0.3	0.85	434.0	350.4	0.81	228.4	180.2	0.79
166.7	0.79	-	-	213.3	167.4	0.78	3.3	4.0	1.19
13.2	0.24	-	-	81.8	20.5	0.25	39.0	8.2	0.21
44.0	0.72	-	-	66.9	47.9	0.72	21.9	13.5	0.62
37.2	0.59	-	-	65.1	38.4	0.59	32.5	25.1	0.77
21.3	0.60	-	-	44.3	26.4	0.60	26.8	17.0	0.64
7.9	0.29	-	-	28.3	8.4	0.30	3.7	1.2	0.32
611.8	0.73	0.3	0.85	933.6	659.3	0.71	355.6	249.2	0.70
38.7		2.2		27.2	26.9		27.6	23.7	
92.8		0.0			100				
274.6	0.54	3.9	0.63	821.6	416.1	0.51	421.2	236.1	0.56
32.2	0.88	3.6	0.98	272.3	262.8	0.97	74.5	94.1	1.26
45.7	0.79	-	-	155.8	90.9	0.58	22.4	25.5	1.14
11.5	0.42	0.3	0.38	132.2	51.4	0.39	38.7	20.6	0.53
47.1	0.81	1.0	0.63	120.8	86.2	0.71	71.3	62.4	0.88
411.1	0.60	8.8	0.72	1502.7	907.4	0.60	628.0	438.7	0.70
26.0		68.0		43.8	37.1		48.8	41.7	
45.3		1.0			100				
240.1	0.81	3.2	0.49	547.3	433.9	0.79	65.8	56.6	0.86
15.2		24.6		15.9	17.7				
1581.1	0.76	12.9	0.65	3431.1	2447.7	0.71	1286.8	1051.0	0.82
2395		41		6274	4524		3649	2441	
66.0		31.4		54.7	54.1		35.3	43.0	
64.6		0.5			100				

EQUATION

rockfish in the total catch increased substantially between the two surveys, but average weight decreased from 0.82 kg/fish to 0.71 kg/fish.

The catch of rockfish changed differently among the various fishing modes (Table 4). The CPFV rockfish catch doubled from 1,050,000 fish to 2,087,000 fish. The proportion of total rockfish in the CPFV catch of all species did not change (85.3% in 1958–61 and 85.8% in 1981–86). The dramatic increase in PRB effort between the two surveys (Table 1) resulted in a sevenfold increase in PRB rockfish catch from 169,000 fish to 1,217,000 fish, while the proportion of rockfish in the total PRB catch of all species increased from 50.0% to 66.5%. The catch of rockfish by divers doubled from 10,000 fish to 20,000 fish, while the proportion of rockfish in the total diver catch rose from 45.3%

to 50.3%. The catch of rockfish from shore rose slightly from 35,000 to 37,000 fish; the rockfish portion of total shore catch of all species also rose slightly from 3.4% to 4.4%. Pier and dock rockfish catch increased sixfold from 12,000 (16th rank) to 71,000 (seventh rank); the proportion of rockfish in the total pier catch of all species rose from 1.2% to 7.3%.

Average weight per fish during 1981–86 varied among the fishing modes (Table 5). The CPFV mode took the largest rockfish (0.76 kg/fish), followed by the PRB mode (0.68 kg/fish), and divers (0.65 kg/fish). Among the shore-based modes, beach and bank took the largest rockfish (0.65 kg/fish), followed by jetty and breakwater (0.43 kg/fish), and pier and dock (0.11 kg/fish).

Examination of our top 16 rockfishes reveals several general trends: 1) a decrease in size among the shallow-water species with no consistent decline among the deep-water species; 2) an increase in the PRB take of all-depths rockfishes relative to the CPFV take; and 3) an increase in the proportion of deep-water species to shallow-water species in the PRB and CPFV catches (Tables 4 and 5).

The decline in average weight per rockfish from 1958–61 to 1981–86 resulted primarily from declines among species of the shallow-water rockfish and all-depths group with the deep-water rockfish generally showing no consistent trend (Table 5). The average weight of shallow-water rockfish declined from 0.70 kg/fish to 0.60 kg/fish with all five species declining. That decline did not result from the increased share of rockfish taken by PRBs (19.6% to 50.8%) since the average weights of shallow-water rockfish taken by PRBs (0.62 kg/fish) and CPFVs (0.60 kg/fish) were nearly identical in 1981–86.

Average weight of the all-depths group declined from 1.29 kg/fish to 1.01 kg/fish due mainly to decreases in average weight of bocaccio (1.55 to 0.97 kg/fish), canary rockfish (0.75 to 0.71 kg/fish), and vermilion rockfish (1.78 to 1.51 kg/fish) (Table 5). The decrease in size of bocaccio can be attributed in part to recruitment of young fish, probably the strong 1984 year-class (Bence and Rogers 1993). An annual average of 44,000 juvenile bocaccio, weighing 0.05 kg/fish, were taken from pier and dock mode in 1981–86. Those fish were 24% of the bocaccio taken from all modes in 1981–86, compared to 4000 fish or 6% in 1958–61. Average weight of the deep-water rockfish did not change (0.70 to 0.71 kg/fish).

The increased take of rockfish by PRBs relative to CPFVs (Tables 4 and 5) from 1958 to 1986 resulted from rapid growth in PRB effort (Table 1). PRB catch by number of the deep-water rockfish increased from 2.6% to 10.2% while the share taken by CPFVs declined from 97.4% to 89.7%. PRB catch of the shallow-water rockfish increased from 19.6% to 50.8% while CPFV catch declined from 74.6% to 45.7%. PRB catch of the all-depths group increased from 15.0% to 28.8%, while the CPFV catch declined from 82.9% to 60.3%.

While the proportion of rockfish taken by PRBs has increased relative to CPFVs, the proportion of rockfish taken by PRBs has shown a greater increase for the deep-water rockfish than for the shallow-water rockfish. Among PRBs, catch of all seven species of the deep-water rockfish increased relative to other species taken. Together, they produced an increase from 5.5% of the catch in 1958–61 to 9.6% by 1981–86 (Table 4). Shallow-water species showed mixed results with blue rockfish, the major shallow-water species, declining from 43.0% to 30.6% and the other four species increasing. On average, shallow-water species increased from 73.3% to 77.0%. The all-depths species declined from 21.2% to 12.9%.

The CPFV catch also showed a proportional increase in deep-water rockfish and a decline in shallow-water rockfish between the 1958–61 and 1981–86 surveys. Increased percentages of chilipepper (0.3% to 11.8%), greenspotted rockfish (2.2% to 3.4%), widow rockfish (3.2% to 3.5%), and greenstriped rockfish (0.4% to 1.5%) resulted in an overall increase from 34.2% to 46.7% for the deep-water rockfish (Table 4). Several deep-water species showed minor decreases including yellowtail rockfish (22.1% to 21.4%), rosy rockfish (3.5% to 3.0%), and starry rockfish (2.6% to 2.0%). The CPFV catch of all shallow water species except brown rockfish declined, including blue rockfish (32.7% to 28.2%), black rockfish (2.9% to 2.0%), gopher rockfish (2.8% to 1.5%), and olive rockfish (6.5% to 3.2%). Brown rockfish showed an increase (1.3% to 3.2%) that was mirrored in all other modes except spear, suggesting a general increase in availability or increased targeting of the species. Bocaccio, an all-depths species, increased from 5.8% to 7.3% of the catch (Table 4), averaging 1.28 kg in 1981–86 (Table 5).

5.1.4. *Description of Rockfish Fishery, 1981–86*

5.1.4.1. Coastal County Districts

In 1981–86, rockfish comprised more than half the recreational catch by number and weight throughout northern and central California except in San Francisco Bay (Table 6). Percent by number ranged from 7.5% in San Francisco Bay to 71.9% in San Luis Obispo. Percent by weight ranged from 1.7% in San Francisco Bay to 72.6% in Mendocino/Sonoma.

Santa Cruz/Monterey had the largest share (about one-third) of the total rockfish catch (35.2% by number and 30.6% by weight) (Table 6). San Luis Obispo ranked second by number (25.3%) and was fourth by weight (17.3%). The San Francisco ocean and bay districts ranked third by number (18.4%)

TABLE 6. Average annual number (thousands), weight (MT), and weight per fish (kg/fish) of rockfish landed in the northern and central California marine recreational fishery, 1981–86.

	Del Norte/ Humboldt			Mendocino/ Sonoma			S. Francisco (Ocean)		
	No.	*Wt.*	*Kg/f*	*No.*	*Wt.*	*Kg/f*	*No.*	*Wt.*	*Kg/f*
All Depths*									
BOCACCIO	0	0	1.27	10	22	2.07	23	47	2.03
COPPER ROCKFISH	8	17	2.23	22	36	1.63	19	28	1.45
CANARY ROCKFISH	17	16	0.95	41	29	0.71	33	25	0.76
VERMILION ROCKFISH	2	3	2.17	4	10	2.39	4	7	1.84
Totals	27	37	1.40	78	97	1.25	79	106	1.35
% of All Rockfish	9.6	11.9		16.9	20.9		14.0	21.8	
% of All Districts	6.0	8.4		17.5	21.7		17.7	23.8	
Deep (> 73 meters)*									
YELLOWTAIL ROCKFISH	9	7	0.78	83	100	1.20	119	108	0.90
CHILIPEPPER	-	-		16	18	1.09	9	7	0.73
ROSY ROCKFISH	1	1	0.49	10	4	0.36	14	4	0.28
GREENSPOTTED ROCKFISH	0	0	1.00	12	11	0.96	18	13	0.73
WIDOW ROCKFISH	0	0	0.40	4	4	0.88	5	4	0.73
STARRY ROCKFISH	0	0	1.00	2	2	0.93	4	4	0.86
GREENSTRIPED ROCKFISH	0	0	0.70	4	1	0.37	2	1	0.38
Totals	11	8	0.75	131	139	1.06	171	139	0.81
% of All Rockfish	3.8	2.5		28.6	30.1		30.6	28.7	
% of All Districts	1.1	1.2		14.0	21.1		18.3	21.1	
Shallow (< 73 meters)*									
BLUE ROCKFISH	15	13	0.85	133	99	0.75	112	66	0.59
BLACK ROCKFISH	177	192	1.08	40	41	1.02	23	17	0.72
BROWN ROCKFISH	1	1	0.82	18	15	0.83	49	34	0.70
GOPHER ROCKFISH	-	-		2	1	0.62	2	1	0.54
OLIVE ROCKFISH	-	-		6	5	0.87	11	7	0.64
Totals	194	206	1.06	198	160	0.81	197	125	0.63
% of All Rockfish	69.9	65.7		43.2	34.7		35.3	25.7	
% of All Districts	12.5	22.4		12.8	17.5		12.8	13.6	
OTHER ROCKFISHES	46	62	1.35	52	66	1.27	112	115	1.03
% of All Rockfish	16.6	19.9		11.3	14.2		20.0	23.8	
Total Rockfish	277	314	1.13	458	462	1.01	559	486	0.87
Total All Fish Species	518	507		684	636		799	680	
% of All Fish	53.5	61.9		66.9	72.6		69.9	71.5	
% of All Districts	8.0	12.7		13.1	18.8		16.0	19.7	

* Depth categories based on Miller and Gotrshall (1965) and Miller and Geibel (1973)

TABLE 6. Average annual number (thousands), weight (MT), and weight per fish (kg/fish) of rockfish landed in the northern and central California marine recreational fishery, 1981–86

and second by weight (20.6%). Mendocino/Sonoma ranked fourth by number and third by weight, while Del Norte/ Humboldt ranked fifth by number and weight. San Francisco (bay) produced only 2.4% by number and 0.9% by weight.

Del Norte/Humboldt was distinct among other districts in showing extreme dominance of a single shallow-water species, black rockfish, which had an IRI of 73.8 (Figure 22). Black rockfish occurred in 19.1% of angler bags and comprised 22.9% by number and 31.8% by weight of all fish sampled. Blue rockfish, another shallow-water species, ranked second among rockfishes with an IRI of 7.3 (1/10th that of black rockfish). Two all-depth species, canary rockfish and copper rockfish, ranked third and fourth with IRIs of 7.2 and 6.2 respectively. China rockfish, yelloweye rockfish, and grass rockfish ranked fifth, sixth, and seventh respectively; those species were not

S. Francisco (Bay)			Santa Cruz/ Monterey			San Luis Obispo			Total		
No.	*Wt.*	*Kg/f*	*No.*	*Wt.*	*Kg/f*	*No.*	*Wt.*	*Kg/f*	*No.*	*Wt.*	*Kg/f*
-	-		90	90	1.00	57	16	0.28	180	174	0.97
1	0	0.77	15	16	1.02	20	18	0.92	85	115	1.36
1	0	0.60	30	19	0.65	19	9	0.49	140	99	0.71
-	-	-	9	11	1.16	19	25	1.36	38	57	1.51
1	1	0.69	145	136	0.94	114	69	0.61	443	446	1.01
1.4	3.8		11.8	18.0		12.9	16.2		12.7	18.1	
0.3	0.2		32.7	30.5		25.7	15.5		100	100	
-	-	-	145	104	0.72	79	32	0.41	434	350	0.81
-	-		160	118	0.74	28	25	0.90	213	167	0.78
0	0	0.20	26	5	0.21	31	7	0.23	82	21	0.25
-	-	-	32	20	0.64	6	3	0.55	67	48	0.72
-	-	-	33	23	0.72	24	8	0.33	65	38	0.59
-	-	-	16	8	0.53	22	13	0.57	44	26	0.60
-	-	-	20	6	0.28	2	0	0.24	28	8	0.30
0	0		431	285	0.66	190	88	0.46	934	659	0.71
0.1	0.1		35.1	37.9		21.6	20.6		26.8	26.8	
0.0	0.0		46.1	43.3		20.4	13.3		100	100	
2	1	0.47	297	129	0.43	264	109	0.41	823	417	0.51
5	2	0.43	12	6	0.48	20	8	0.38	277	265	0.96
59	10	0.18	44	22	0.51	23	17	0.75	193	100	0.52
-	-	-	33	11	0.33	96	39	0.40	132	51	0.39
-	-	-	59	47	0.79	45	27	0.61	121	86	0.71
66	14	0.21	444	214	0.48	448	200	0.45	1547	919	0.59
79.1	64.6		36.2	28.4		50.9	46.9		44.4	37.3	
4.3	1.5		28.7	23.3		28.9	21.8		100	100	
16	7	0.41	207	118	0.57	128	70	0.54	561	438	0.78
19.4	31.6		16.9	15.7		14.6	16.4		16.1	17.8	
84	21	0.25	1227	753	0.61	880	426	0.48	3484	2462	0.71
1120	1262		2013	1223		1223	718		6357	5026	
7.5	1.7		60.9	61.5		71.9	59.4		54.8	49.0	
2.4	0.9		35.2	30.6		25.3	17.3		100	100	

EQUATION

among the top 16 species in all districts. Yellowtail rockfish, the only deep-water species of significance in Del Norte/Humboldt, ranked eighth with an IRI of 2.7.

Mendocino/Sonoma showed a more diverse rockfish assemblage than Del Norte/Humboldt, with six species having IRIs greater than 10 (Figure 22). Blue rockfish ranked first with an IRI of 41.3, and had the highest percent by number (16.6%). Yellowtail rockfish ranked second with an IRI of 37.3, but had the highest percent by weight (13.9%) and percent frequency of occurrence in bags (12.8%). Canary rockfish ranked third with an IRI of 22.7. Almost half this value was due to a high frequency of occurrence in bags (10%). Black rockfish, copper rockfish, chilipepper, bocaccio, and brown rockfish ranked fourth through eighth with IRIs ranging from 17.7 to 6.9.

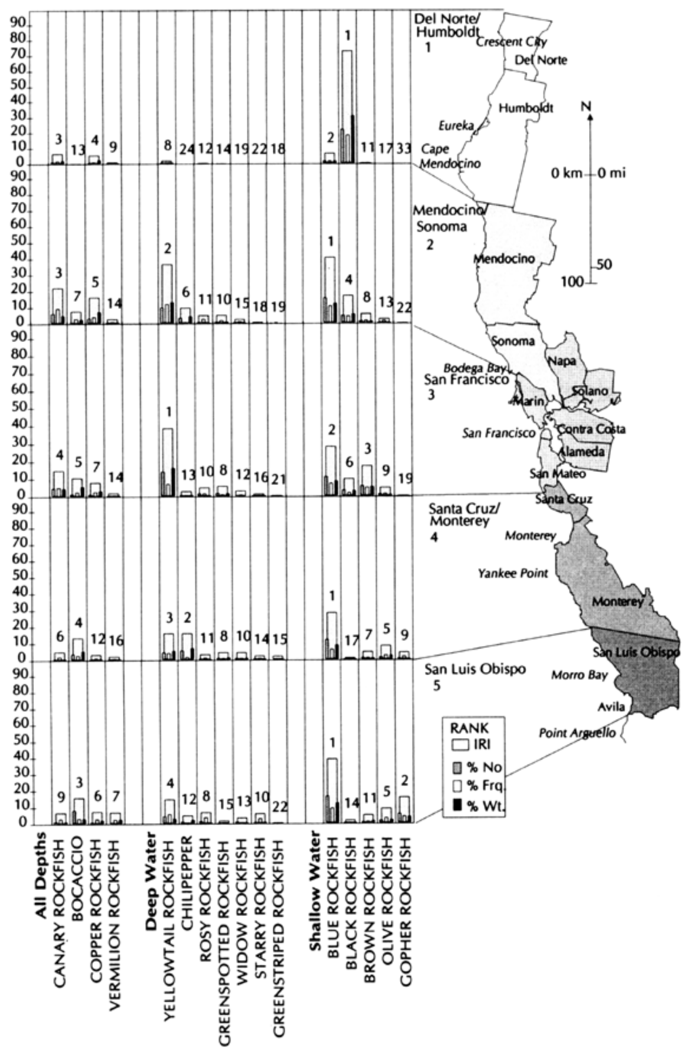


FIGURE 22. Sixteen most commonly landed rockfish in the northern and central California marine recreational fishery, 1980–86, ranked by IRI among rockfish only.

FIGURE 22. Sixteen most commonly landed rockfish in the northern and central California marine recreational fishery, 1980–86, ranked by IRI among rockfish only

The San Francisco district showed diversity similar to Mendocino/Sonoma, with six species having IRIs greater than 10 (Figure 22). Yellowtail rockfish was the top ranking species with an IRI of 39.2; blue rockfish was second with an IRI of 28.2. Although blue rockfish had a higher frequency of occurrence (7.9%) than yellowtail rockfish (7.7%), the latter dominated with higher percentages by number and weight. Brown rockfish, canary rockfish, bocaccio, black rockfish, copper rockfish, and greenspotted rockfish ranked third through eighth with IRIs ranging from 17.9 to 6.4.

Santa Cruz/Monterey had four species with IRIs greater than 10 (Figure 22). Blue rockfish was first in number (12.7%), weight (9.3%), frequency of occurrence (7.0%), and IRI (29.0). Chilipepper ranked second with an IRI of 16.6, and was also second in number (6.4%) and weight (7.8%), but was seventh in frequency of occurrence (2.4%). Yellowtail rockfish, bocaccio, olive rockfish, canary rockfish, brown rockfish, and greenspotted rockfish ranked third through eighth with IRIs ranging from 16.5 to 5.3.

San Luis Obispo was similar to Santa Cruz/Monterey, with four species having IRIs greater than 10 (Figure 22). Blue rockfish and gopher rockfish, both shallow-water species, had the highest IRIs (39.9 and 16.4 respectively). As in Santa Cruz/Monterey, blue rockfish was first in number (17.0%), weight (13.0%), and frequency of occurrence (9.9%). Bocaccio (16.3) and yellowtail rockfish (15.3) ranked third and fourth. Yellowtail rockfish had a higher frequency of occurrence (6.4%) than both gopher rockfish (5.0%) and bocaccio (3.7%), but lower percentages by number and weight. Olive rockfish, copper rockfish, vermilion rockfish, and rosy rockfish ranked fifth through eighth with IRIs ranging from 9.7 to 7.5.

If San Francisco (bay) is excluded, rockfish showed a consistent cline of decrease in mean weight from Del Norte/Humboldt (1.13 kg/fish) south through San Luis Obispo (0.48 kg/fish) in 1981–86 (Table 6). San Francisco (bay) had the smallest rockfish (0.25 kg/fish). Although the same cline of lower mean weight to the south was generally evident among each of the depth groups, trends among individual species were less consistent. The smaller sizes of some species in Del Norte/Humboldt are difficult to interpret because the number of rockfish other than black rockfish was small, and because the PRB mode, which on the average takes smaller fish than the CPFV mode (Table 5), was the only boat mode adequately sampled there in 1981–86 (Figure 9).

5.1.4.2. Depth Groups

The shallow-water rockfish was the most important depth group in 1981–86, with a total 1,547,000 fish weighing 919,000 kg landed, or 44.4% by number and 37.3% by weight of all rockfish (Table 6). Blue rockfish was the most important species, with 823,000 fish weighing 417,000 kg. Blue rockfish also ranked first by number and weight landed among all rockfishes. Another important species was black rockfish, with 277,000 fish weighing 265,000 kg landed. Black rockfish ranked third among all rockfishes in number and weight landed.

The shallow-water rockfish catch was dominated by the San Luis Obispo and Santa Cruz/Monterey districts (Table 6); those two districts accounted for 28.9% and 28.7% respectively of the total number of shallow-water rockfish taken. Blue rockfish dominated both districts in number and weight caught, with 561,000 fish weighing 238,000 kg, over half the blue rockfish landed in all northern and central California. Although Del Norte/Humboldt ranked last in catch by number, catch by weight (206,000 kg) ranked second due to catch of large black rockfish. Most black rockfish (64%) were taken in Del Norte/Humboldt.

Blue rockfish and black rockfish, the two most frequently taken shallow-water rockfishes, showed distinct north-south clines in mean weight (blue rockfish: 0.85 to 0.41 kg/fish; black rockfish: 1.08 to 0.38 kg/fish) (Table 6). Size differences for those two species are discussed further in the length-frequency analysis section (page 67). Brown rockfish and olive rockfish showed no trends. The largest gopher rockfish were in Mendocino/Sonoma (0.62 kg/fish) and the smallest were in Santa Cruz/Monterey (0.33 kg/fish).

The seven deep-water rockfishes comprised 934,000 fish weighing 659,000 kg, or 26.8% by number and 26.8% by weight of all rockfish landed (Table 6). Yellowtail rockfish and chilipepper dominated the group. Yellowtail rockfish was the second most important species in number and weight of all rockfishes, with 434,000 fish weighing 350,000 kg. Chilipepper was fourth in number and fifth in weight with 213,000 fish weighing 167,000 kg.

Santa Cruz/Monterey had the greatest deep-water rockfish catch of all districts; 431,000 fish (46.1%) weighing 285,000 kg (43.3%) (Table 6). The dominant species by weight and number was chilipepper, with 160,000 fish weighing 118,000 kg. Yellowtail rockfish was also important in Santa Cruz/Monterey (145,000 fish weighing 104,000 kg) and also in San Francisco (119,000 fish weighing 108,000 kg). Del Norte/Humboldt had the lowest number of deep-water species (11,000 fish weighing 8000 kg); most were yellowtail rockfish.

Among the deep-water rockfishes, all species except chilipepper showed a general trend of smaller fish to the south (Table 6). Rosy rockfish were slightly smaller in Santa Cruz/Monterey than in San Luis Obispo. Size differences for chilipepper and yellowtail rockfish are discussed further in the length-frequency analysis section (page 82 and page 75).

The four all-depth rockfishes comprised 443,000 fish weighing 446,000 kg (Table 6). Bocaccio was the most important species, with 180,000 fish weighing 174,000 kg. Bocaccio ranked sixth in number and fourth in weight of all rockfishes. Santa Cruz/Monterey dominated the all-depths catch with 145,000 fish (32.7%) weighing 136,000 kg (30.5%). Bocaccio was the dominant species with 90,000 fish weighing 90,000 kg taken; that catch was about half the total bocaccio landings.

All species of the all-depths group, except vermilion rockfish, were smallest in San Luis Obispo (Table 6). The small average weight of bocaccio in San Luis Obispo (0.28 kg/fish) results from the catch of juveniles from piers. The mean weight cline for the other three species cannot be explained by differences in mode since most were taken by boat modes and not from shore. Size differences in bocaccio and canary rockfish are examined in greater detail in the length-frequency analysis section (page 79 and page 83).

5.1.4.3. Catch by Month

The catch of most rockfishes, especially the shallow and all-depths species, peaked between July and September (Figure 23). Among the deep-water species, the catch of yellowtail rockfish, rosy rockfish, greenspotted rockfish, and starry rockfish also peaked between July and September. The catch of brown rockfish, copper rockfish, and chilipepper peaked in June; widow rockfish peaked in February. A minor February to March peak was apparent for a number of the other species including blue rockfish, black rockfish, olive rockfish, bocaccio, yellowtail rockfish, rosy rockfish, and greenstriped rockfish. The composite of all rockfish species showed most caught from June through October with a minor increase in February.

5.1.4.4. Commercial Trawl Catch

of our top 16 rockfishes, six (widow rockfish, bocaccio, chilipepper, yellowtail rockfish, canary rockfish, and greenspotted rockfish) were among the top 11 commercial trawl-caught species in California during 1981–86 (Pearson and Ralston 1990). The port-of-landing areas used by Pearson and Ralston (1990) approximate our coastal county districts (Figure 1). Combined sport catch for those species was a significant portion of combined sport and trawl landings in some districts during that period (Figure 24). The portion of recreational catch for all six species increased south of Mendocino/Sonoma to Santa Cruz/Monterey, where 23% of the combined landings were recreational.

The sport catch of three of the six species exceeded trawl landings in central California districts from San Francisco to San Luis Obispo (Table 7). The proportion of canary rockfish taken by the sport fishery ranged from 53.4%

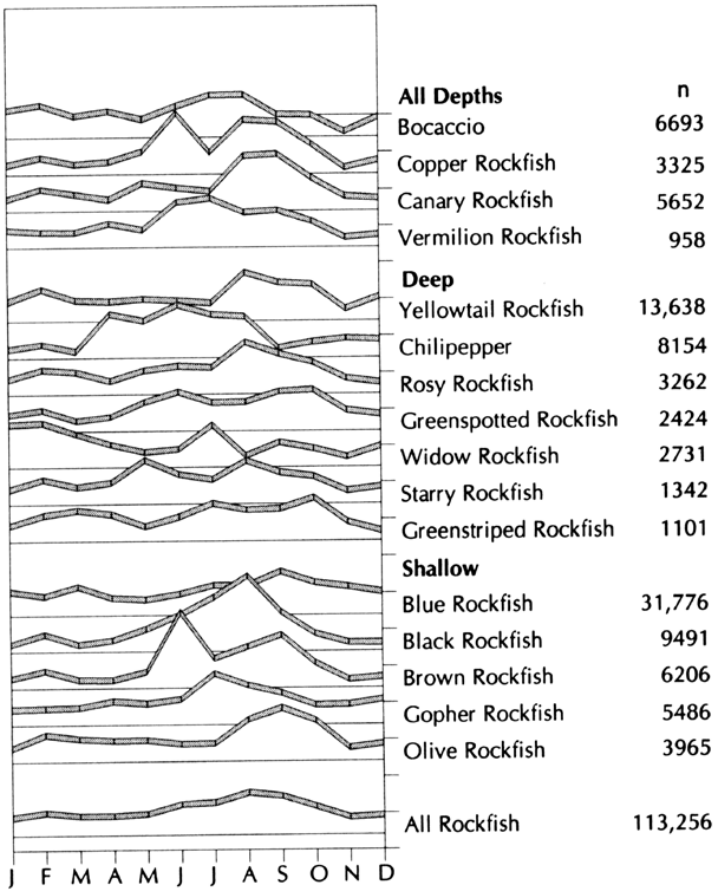


FIGURE 23. Relative monthly catch frequency of the top 16 rockfishes in the MRFSS creel survey in northern and central California, 1980–86.

FIGURE 23. Relative monthly catch frequency of the top 16 rockfishes in the MRFSS creel survey in northern and central California, 1980–86

to 83.9%, and for greenspotted rockfish from 45.6% to 83.3%. Yellowtail rockfish were taken mainly by the sport fishery from Mendocino/Somona (52.0%) to San Luis Obispo (74.3%). In Del Norte/Humboldt most canary rockfish, greenspotted rockfish, and yellowtail rockfish were taken by trawlers; sport landings of these species comprised 4.1%, 0.4%, and 3.2%, respectively.

Bocaccio, chilipepper, and widow rockfish were taken mostly by trawlers in a decreasing proportion to the south. Recreational catches of bocaccio and chilipepper were greatest in Santa Cruz/Monterey (14.2% and 21.5%, respectively). The largest trawl catches of bocaccio and chilipepper were in Mendocino/Sonoma, where recreational catches made up 1.9% and 2.6% of the respective landings.

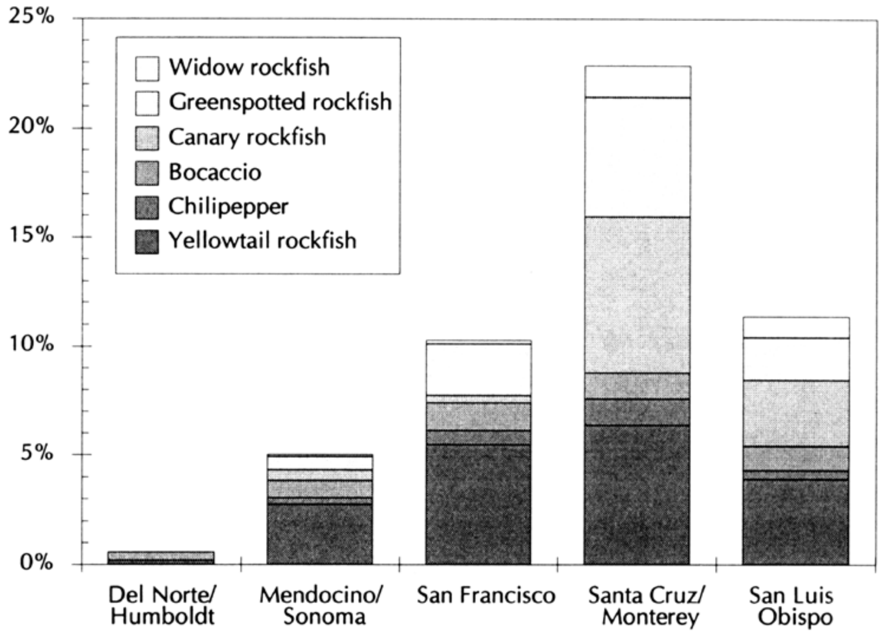


FIGURE 24. Recreational landings as a percentage of combined recreational and commercial trawl landings for six rockfish species in northern and central California, 1981–86.

FIGURE 24. Recreational landings as a percentage of combined recreational and commercial trawl landings for six rockfish species in northern and central California, 1981–86

Widow rockfish had the largest trawl landings of the six species, averaging 4916 MT; sport landings were 38 MT (0.8%). The largest trawl catch was in Del Norte/Humboldt, averaging 2685 MT (0.03% sport), and the lowest was in San Luis Obispo, averaging 52 MT (13.1% sport).

5.1.5. Length-frequency Analysis

5.1.5.1. Blue Rockfish

Length data for blue rockfish spanned the years 1959 through 1986, and were the most extensive of any of our top 16 rockfishes. Prior to 1980, blue rockfish lengths were most consistently sampled from CPFVs in Santa Cruz/ Monterey and San Luis Obispo. We therefore restricted our length-frequency comparisons among modes to 1980–86, and our comparisons among districts in 1960–63 to the CPFV mode. Uniform sampling among modes during 1980–86 allowed combining the CPFV and PRB data for purposes of comparing districts and analyzing recruitment patterns. Similarity in yearly recruitment patterns between Santa Cruz/Monterey and San Luis Obispo allowed us to

TABLE 7. Mean annual commercial trawl and sport landings (MT) of major rockfish species in northern and central California districts, 1981–86.

		Yellowtail rockfish	Greenspotted rockfish	Canary rockfish	Chilipepper	Bocaccio	Widow rockfish	Total
Del Norte/	*Trawl*	213.7	40.2	375.5	160.7	556.5	2685	4031.5
Humboldt	*Sport*	7	0.2	16.2	0	0.3	0	23.6
	% Sport	3.2	0.4	4.1	0	0.1	0	0.6
Mendocino/	*Trawl*	92	29	175.8	680.4	1129.4	1357.3	3463.9
Sonoma	*Sport*	99.6	11.2	29.1	17.8	21.6	3.7	182.9
	% Sport	52	27.8	14.2	2.6	1.9	0.3	5
San	*Trawl*	36.5	2.8	6.4	544.3	614.5	563.5	1767.9
Francisco	*Sport*	107.6	13	25.1	6.9	46.6	3.5	202.6
	% Sport	74.6	82.6	79.7	1.2	7	0.6	10.3
Santa Cruz/	*Trawl*	28.9	4.1	3.7	431.2	541.6	258.1	1267.5
Monterey	*Sport*	104.3	20.4	19.4	117.9	89.8	23.4	375.2
	% Sport	78.3	83.3	83.9	21.5	14.2	8.3	22.8
San Luis	*Trawl*	11.1	3.7	8.1	264.4	386.9	51.6	725.8
Obispo	*Sport*	32	3.1	9.2	24.9	16.1	7.8	93.1
	% Sport	74.3	45.6	53.4	8.6	4	13.1	11.4
Total	*Trawl*	382.1	79.7	569.5	2080.9	3228.9	4915.5	11256.5
	Sport	350.4	47.9	98.9	167.4	174.4	38.4	877.3
	% Sport	47.8	37.5	14.8	7.4	5.1	0.8	7.2

TABLE 7. Mean annual commercial trawl and sport landings (MT) of major rockfish species in northern and central California districts, 1981–86

combine CPFV and PRB data from those districts for a long-term (1959–86) analysis of recruitment, growth rate, and birth years of major cohorts.

The two-way ANOVA test found that in 1980–86 mean lengths of blue rockfish in northern California (344 mm) and central California (295 mm) were significantly different ($p < 0.00001$), that mean lengths of the CPFV catch (316 mm) and the PRB catch (299 mm) were significantly different ($p < 0.0001$), and that the interaction of area and mode was also significant ($p < 0.0001$). Comparison of size distributions showed that in the central districts, CPFVs took larger blue rockfish (mean length of 303 mm) than PRBs (mean length of 286 mm) (Figure 25). The distributions were significantly different (KS test, $p < 0.0001$). Comparison of the northern districts showed no substantial difference in mean length between the two modes; the distributions were not significantly different (KS test; $p = 0.8204$).

In central and northern California, 50% of male and female blue rockfish are sexually mature at 270 mm and 290 mm, respectively (Echeverria 1987). Thus during 1980–86 most of the PRB and CPFV catch in the northern districts, and about half the PRB and two-thirds the CPFV catch in the central districts, had reached the size at which 50% are sexually mature (Figure 25).

We examined length and recruitment patterns among districts in 1960–63 for the CPFV mode and in 1980–86 for the CPFV and PRB modes combined. Dominance by one or more strong year-classes in 1960–63, reported by Miller and Geibel (1973), was apparent in Santa Cruz/Monterey and in San Luis Obispo, but not to the north (Figure 26). The length-frequency modes of strong

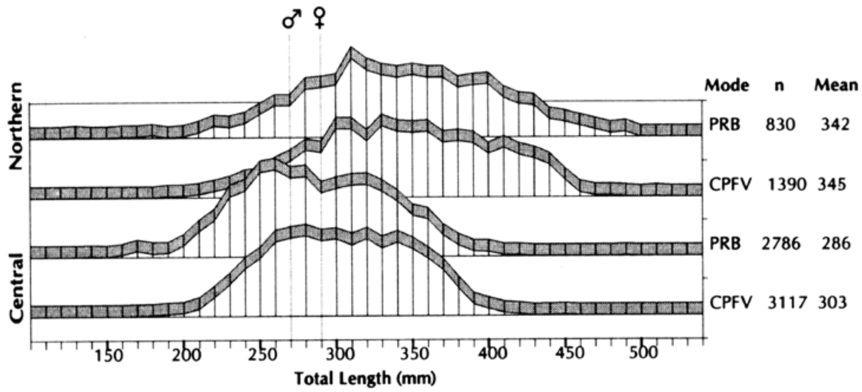


FIGURE 25. Length-frequency distibution of blue rockfish in the northern and central California marine recreational fishery, boat modes, 1980–86. Lengths at 50% sexual maturity for male and female fish are shown.

FIGURE 25. Length-frequency distribution of blue rockfish in the northern and central California marine recreational fishery, boat modes, 1980–86. Lengths at 50% sexual maturity for male and female fish are shown

year-classes and their progression from year to year are most distinguishable in San Luis Obispo, but are also apparent in Santa Cruz/Monterey. In a selected comparison for a representative year (1962), the length-frequency distributions in Santa Cruz/Monterey and San Luis Obispo were significantly different (KS test; $p < 0.0001$), however both distributions were platykurtic and skewed to the right. The 1962 length-frequency distributions for San Luis Obispo, Monterey/Santa Cruz, and Mendocino/Sonoma-San Francisco were all significantly different from one another ($p < 0.0001$ for each comparison). The results suggest that in 1960–63, the catches in San Luis Obispo and Santa Cruz/Monterey were both dominated by strong year-classes, and the degree of dominance was less in San Mateo to Mendocino counties

In 1960–63 mean length was slightly greater in San Luis Obispo (309 mm) than in Santa Cruz/Monterey (301 mm) and much greater to the north (336 mm). Two-way ANOVA comparison by area and year showed the differences were significant by area ($p < 0.0001$), year ($p < 0.0001$), and interaction ($p < 0.0001$).

In 1980–86 smaller sizes and dominant year-classes were again evident in the central but not the northern districts (Figure 27). In the central districts a mode at 320 mm in 1980 progressed to 340 mm by 1983 and disappeared in 1984. Average length declined from 308 mm in 1983 to 275 mm in 1984. The distribution in 1983 was skewed to the left by the dominance of the older cohort(s) and became skewed to the right in 1984; the distributions were significantly different (KS test; $p < 0.0001$). In the northern districts the distributions, though based on small sample sizes, showed no dominance by strong

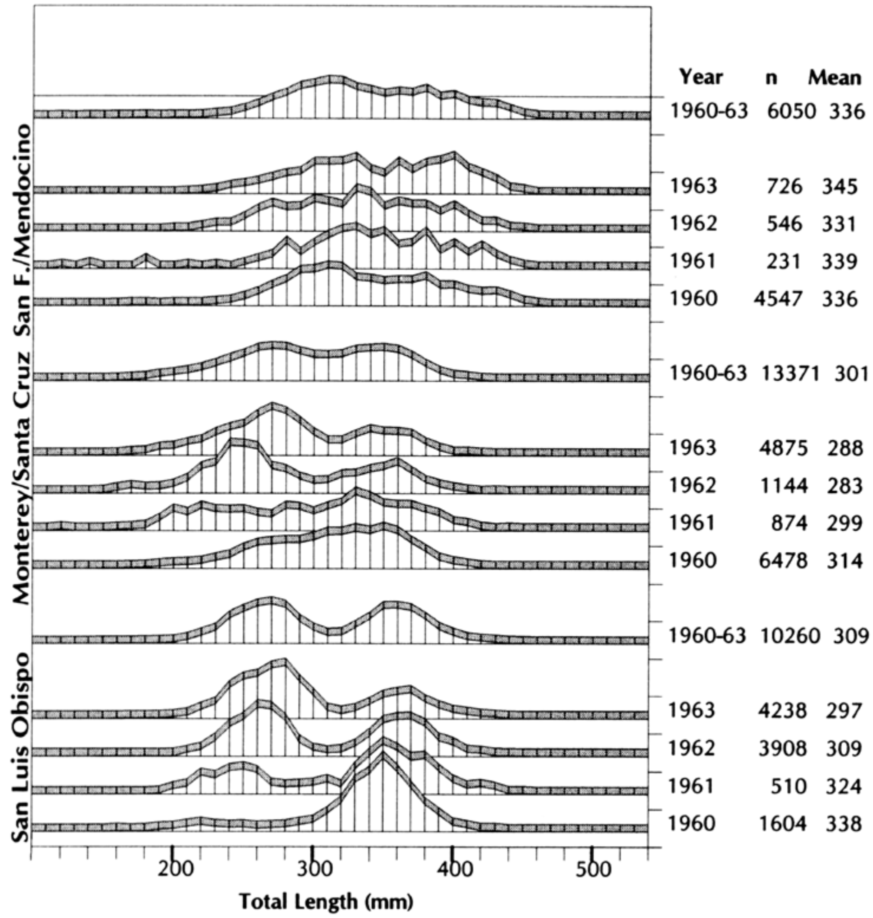


FIGURE 26. Length-frequency distribution of blue rockfish from northern and central California CPFVs in 1960–63

year-classes. The 1983 and 1984 distributions in the northern districts were not significantly different (KS test; $p = 0.271$). As in the 1960–63 period, mean lengths were greater in the northern districts (344 mm) than in the central districts (295 mm). ANOVA comparison by area and year showed the differences were significant by area ($p < 0.00001$) and year ($p < 0.0001$). Interaction between factors was also significant ($p < 0.0001$).

Mean lengths of blue rockfish taken from CPFVs showed no long-term decline from 1960 through 1986 (Figure 28). In the northern districts mean length increased from 336 mm in 1960–63 to 345 mm in 1980–86. The distributions in both periods were skewed to the right and platykurtic but significantly different (KS test; $p < 0.0001$). In the central districts mean length

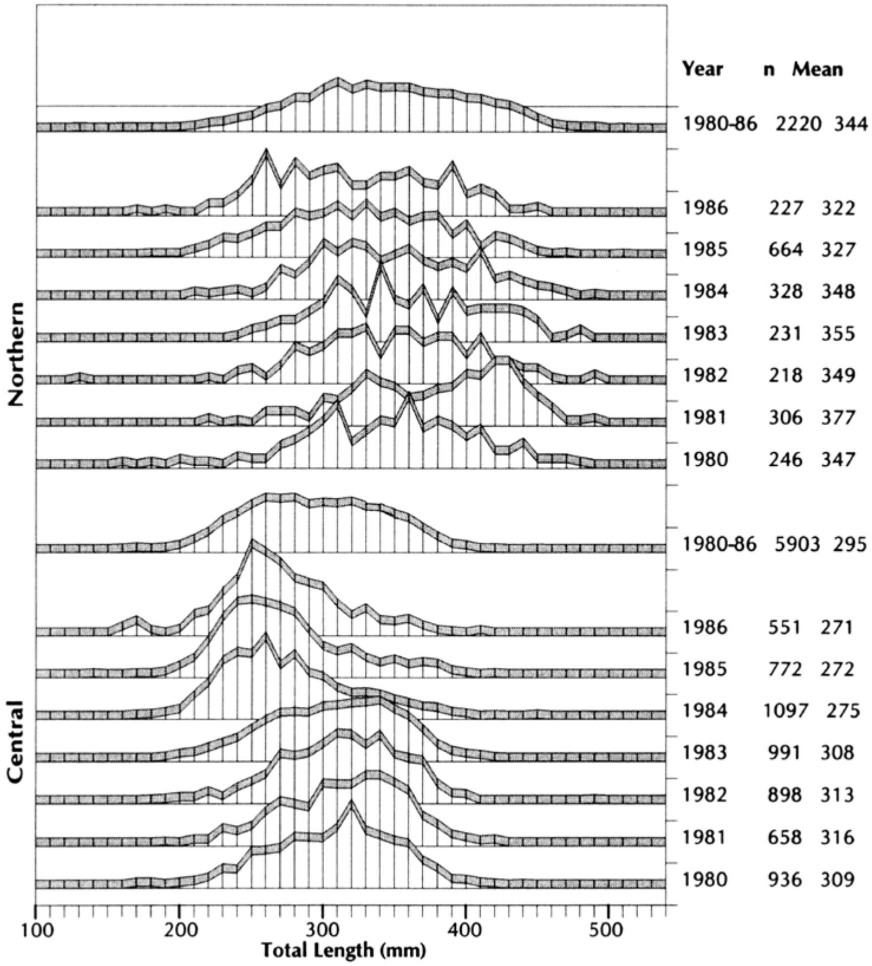


FIGURE 27. Length-frequency distribution of blue rockfish in northern and central California CPFVs and PRBs from 1980–86.

FIGURE 27. Length-frequency distribution of blue rockfish in northern and central California CPFVs and PRBs from 1980–86

decreased from 304 mm in 1960–63, when the distribution was strongly bimodal and skewed to the left, to 291 mm in 1966–72, when the distribution was less platykurtic and skewed to the right. In 1980–86 mean length increased to 303 mm and the distribution regained a more platykurtic shape.

Those results appear to contradict our earlier observation that the mean weight of blue rockfish decreased slightly for all of northern and central California from 1958–61 (0.56 kg/fish) to 1981–86 (0.51 kg/fish)(Table 5). However, that decrease was for all modes combined, and the above comparison was for CPFVs.

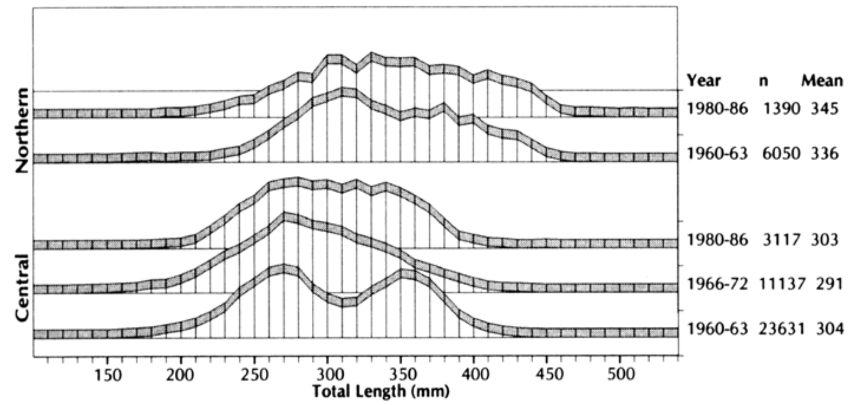


FIGURE 28. Length-frequency distibution of blue rockfish in northern and central California CPFVs for 1960–63, 1966–72, and 1980–86.

FIGURE 28. Length-frequency distibution of blue rockfish in northern and central California CPFVs for 1960–63, 1966–72, and 1980–86

Combined PRB and CPFV data from the central districts show three periods when length-frequency modes, each representing one or more strong year-classes, could be followed through time: 1959 to 1964, 1970 to 1972, and 1980 to 1983 (Figure 29). Two periods, 1967 to 1970 and 1984 to 1986, show no evidence of length-frequency modes progressing through time.

Miller and Geibel (1973), whose study spanned 1959 to 1971, interpreted lack of older year-classes between 1966 and 1971 to overfishing of localized populations. Post-1971 data suggest that environmental factors play a role in producing strong year-classes that are large enough to withstand existing levels of fishing pressure. Examination of the four major length-frequency modes (Figure 29) shows fluctuations in population growth rates under varying environmental conditions. The growth rate, as depicted by shift to the right of the length-frequency modes, was most pronounced for B, C, and A and lowest for D. Also of interest was the abrupt disappearance of D following 1983, while A showed a more gradual attenuation that could be followed for large sizes and presumably older fish.

A major environmental change during the years of mode D was the 1982–83 ENSO, which had major impacts on numerous fish and invertebrate species (Dayton and Tegner 1989). As nearshore planktonic feeders, blue rockfish are more dependent on cycles of upwelling and downwelling than other fishes (Hobson and Chess 1988). The ENSO in the spring of 1983 showed reduced upwelling in central California (Roughgarden et al. 1988). Blue rockfish in the Monterey area were unusually emaciated during 1982 and 1983 (D. VenTresca, CDFG, pers. comm.). Bodkin et al. (1987) observed three incidents of fish mass mortality in central California in 1982–83 that corresponded

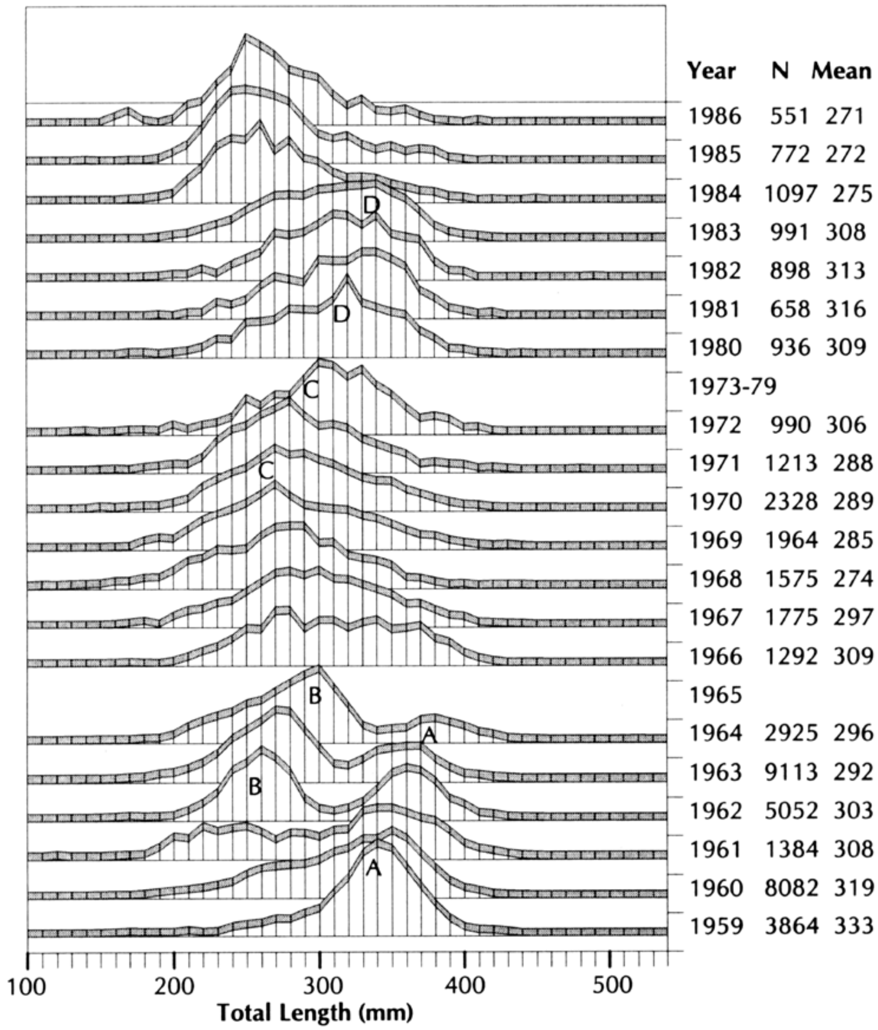


FIGURE 29. Length-frequency distribution of blue rockfish from central California CPFVs and PRBs, 1959–86. Modal progressions of dominant cohorts are identified by the letters A to D.

FIGURE 29. Length-frequency distribution of blue rockfish from central California CPFVs and PRBs, 1959–86. Modal progressions of dominant cohorts are identified by the letters A to D

to periods of high-amplitude, long-period swells; 72% of the observed mortalities were blue rockfish that averaged 283 mm in length. The depressed growth rate from 1981 to 1983 and termination of the mode following 1983 may reflect the collective impact of the ENSO with an increase in fishing pressure since the 1960s.

Ford-Walford plot analysis applied to growth intervals of modes A through D produced a Von Bertalanffy growth equation of l_t+1 = 0.888 l_t + 48 where

$$l_\infty = 427.$$

EQUATION

Our growth rates were slower than those obtained by Miller and Geibel (1973), who used both scale and tag-and-recapture methods for central California fish, and much slower than those by McClure (1982), who used surface otolith aging for Oregon fish (Figure 30). Surface aging of otoliths may have underestimated age at size. Recent work on rockfish age determination shows surface aging of otoliths to be less reliable than a "break-and-burn" technique

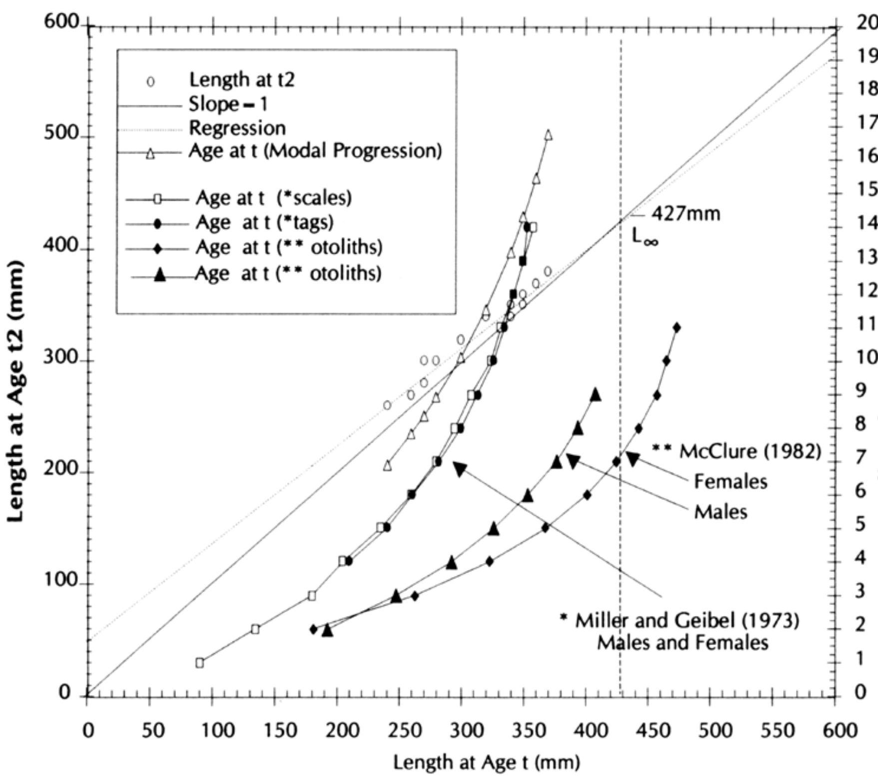


FIGURE 30. Ford-Walford analysis of blue rockfish 1959–84 in central California

(Kimura et al. 1979; Pearson et al. 1991). The larger sizes at age observed in Oregon for both males and females could also reflect increased growth rates in the north. There is no general trend of increased growth by latitude among rockfish (Haldorson and Love 1991). Some species of rockfish such as split-nose rockfish and olive rockfish have been found to have higher growth rates to the north while others such as canary rockfish have not (Love 1978; Boehlert and Kappenman 1980). Tag-and-recapture methods used by Miller and Geibel (1973) are considered reliable but do not account for long-term environmental effects such as ENSO. Haaker et al. (in prep.) found that growth rates decreased dramatically for tagged red abalone Haliotis rufescens during the 1982–84 ENSO when compared to the preceding four years off Santa Rosa Island in southern California.

Applying our Von Bertalanffy growth rate estimate to length-frequency modes A through D and assuming 1) each mode represents a single cohort and 2) environmental conditions were similar throughout the life span of each cohort, we estimated the following birth years: A–1946, B–1954, C–1962, and D–1968 or 1969. Our results clearly suggest blue rockfish recruitment in central California varies greatly; the significance is discussed in context with other species later in this paper. Our growth rate estimate is from a period that included depressed growth during the 1982–84 ENSO. In assigning birth-dates to A and B, we assumed similar effects during the previous major ENSO of 1957–58. Modes C and D did not experience a similar event and may represent fish born in 1963 and 1970 respectively, based on growth rates from Miller and Geibel (1973) tag data.

5.1.5.2. Yellowtail Rockfish

In northern California during 1980–86, the mean length of trawl-caught yellowtail rockfish was 48 mm longer than CPFV-caught fish, which in turn was 29 mm longer than PRB-caught fish (Figure 31). The northern California trawl length-frequency distribution was monomodal while both the CPFV and PRB distributions were bimodal. The CPFV distribution was skewed to the left by a dominant mode of larger fish while the PRB distribution had a dominant mode of smaller fish. In central California, mean length of the trawl catch was similar to that of northern California, but interpretation is difficult due to small sample size (*n* = 272). Pearson and Ralston (1990) found similar average lengths of trawl-caught yellowtail rockfish in Morro Bay and Eureka catches, and the longest average lengths in the Bodega Bay catch. Mean lengths of the CPFV and PRB catches were respectively 68 mm and 69 mm smaller in central California than in northern California. The length-frequency distributions of CPFVs and PRBs in central California were less clearly bimodal than in northern California and were strongly skewed to a mode of smaller fish.

Two-way ANOVA comparisons of mean length differences were significant by northern California versus central California ($p < 0.0001$), mode ($p < 0.0001$), and interaction ($p < 0.0001$). In spite of univariate similarities among modes within areas, all paired KS comparisons were significantly different. A cline of larger sizes and older ages to the north among yellowtail rockfish was first reported from a 1977 federal trawl survey which encompassed our study area and extended to northern Washington (Fraidenburg 1980).

In central and northern California, 50% of male and female yellowtail rockfish are sexually mature as 6- and 7-year olds at 350 mm and 360 mm length, respectively (Echeverria 1987). Thus, during 1980–86, approximately half the northern California PRB and CPFV catch exceeded the size at which 50% are sexually mature, while very little of the central area recreational catch reached that size (Figure 31).

Yearly length-frequency plots show modes of dominant year-classes in the recreational catch in both central and northern California in 1980–86 (Figure 32). Mean length of the northern California trawl catch decreased from 476 mm in 1980 to 436 mm in 1986; the length-frequency distribution had one

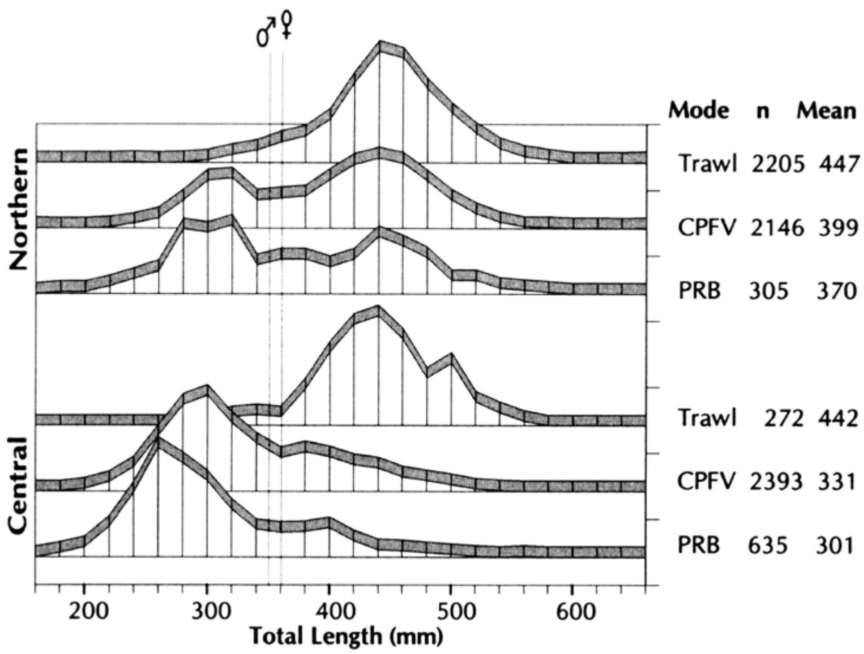


FIGURE 31. Length-frequency distribution of yellowtail rockfish from CPFVs, PRBs, and trawlers in northern and central California, 1980–86. Lengths at 50% sexual maturity for male and female fish are shown.

FIGURE 31. Length-frequency distribution of yellowtail rockfish from CPFVs, PRBs, and trawlers in northern and central California, 1980–86. Lengths at 50% sexual maturity for male and female fish are shown

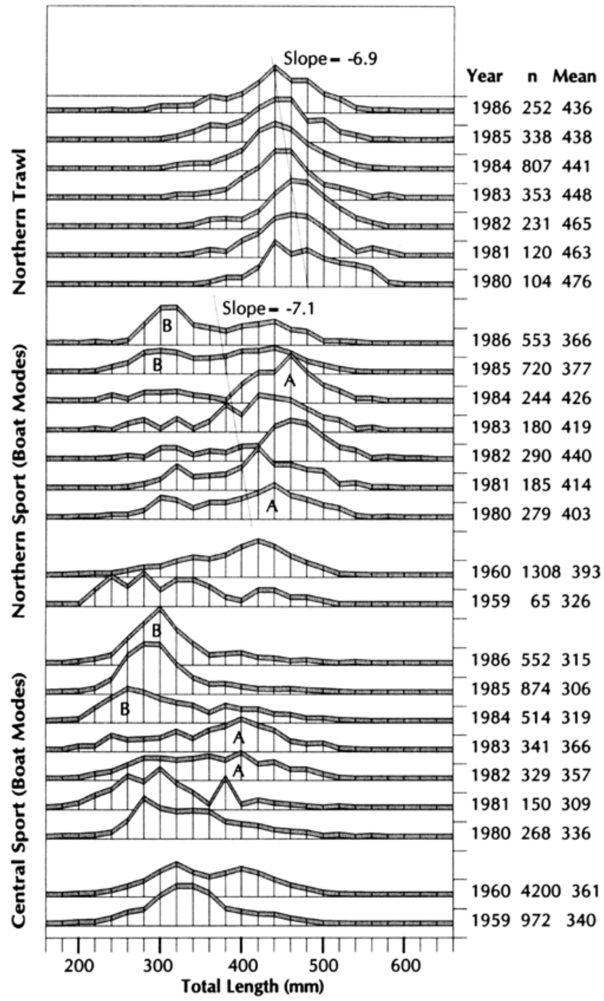


FIGURE 32. Length-frequency distribution of yellowtail rockfish from CPFVs, PRBs, and trawlers in northern and central California from 1980–86. Modal progressions of dominant cohorts are identified by the letters A and B.

FIGURE 32. Length-frequency distribution of yellowtail rockfish from CPFVs, PRBs, and trawlers in northern and central California from 1980–86. Modal progressions of dominant cohorts are identified by the letters A and B

major mode during those years. Age-at-size data were unavailable for the recreational fishery, but careful examination of modes suggests they may correspond in northern and central California. As with blue rockfish, the older mode (A) decreased abruptly in 1983 in central California. The following year catch shifted to a mode of younger fish (B) at 260 mm in 1984 that grew to 300 mm by 1986. In northern California the mode of older fish (A) did not decline after 1983 but persisted into 1986, attenuating more gradually. In the north the mode of younger fish (B) did not become important until 1985 and was dominant in 1986 at about 310 mm.

Tagart (1991), in a detailed stock analysis of yellowtail rockfish in the trawl fishery, reported that ages (based on otoliths) showed that a single dominant mode, comprising 1974, 1975, and 1976 cohorts, led landings during the 1980–86 period as the last of the strong 1963 cohort was fished down in the Eureka/S. Columbia INPFC area. He also described the 1980 and 1981 year-classes as major cohorts that were important but would not be part of the commercial size distribution during 1980–86. Lenarz and Echeverria (1986) described decreases in gonadal and visceral fat in yellowtail rockfish in 1983 (during the 1982–83 ENSO). As with blue rockfish, the effects of starvation brought on by the ENSO may have contributed to the decrease in a mode of larger fish in central California following 1983. Alternative explanations for our results include greater fishing pressure or availability of young recruits in central California. Greater effort in the central area could have eliminated the older cohort (A) earlier than in the north where lower fishing pressure allowed mode A to dominate catches for an additional two years. Likewise increased availability of young fish by a relatively larger recruitment event in central California could produce the same effect. The most plausible explanation, considering the parallel decline in blue rockfish, is a combination of stress from fishing pressure and ENSO on adult stocks.

Pearson and Ralston (1990) described a decline in average size among commercially taken yellowtail rockfish during 1978–88 that they attributed to fishing down a virgin stock. Such a decline was apparent in our northern trawl length data but was obscured in the recreational take by the succession of dominant modes (Figure 32). A regression comparison for northern California using ANCOVA produced slopes of decline for trawlers (-9.2 mm/year) and recreational boats (-4.7 mm/year) (Figure 32). The slopes were significantly different from 0 ($p < 0.001$) and from each other ($p < 0.0001$).

5.1.5.3. Black Rockfish

In 1980–86 lengths of black rockfish from CPFVs and PRBs from central California were narrowly distributed with a mean length of 311 mm, while those of northern California were more broadly distributed with a mean length of 402 mm (Figure 33). The central California distribution had nearly normal kurtosis while the northern California distribution was platykurtic. The distributions were significantly different from each other (KS test, $p < 0.0001$).

In northern and central California, 50% of male and female black rockfish are sexually mature at a length of 360 mm and at 410 mm as 6- and 7-year olds, respectively (Echeverria 1987). Thus nearly all the central California catch, and approximately one-third the northern California catch, were smaller than the size at which 50% are sexually mature (Figure 33).

In spite of the small the sample sizes, a strong mode of young fish was evident in central California, but not in northern California (Figure 34). The central California mode grew approximately 20 mm each year from 1984 to 1986. The availability of black rockfish increased in 1984 and 1985 due to what appears to be an isolated cohort (Figure 18).

5.1.5.4. Bocaccio

The largest bocaccio taken were from northern California, where mean lengths of the CPFV catch and trawl catch averaged 573 mm and 537 mm, respectively (Figure 35). Fish were smaller in central California, where mean lengths of CPFV and trawler catches were 418 mm and 491 mm, respectively. Pearson and Ralston (1990) found a cline of larger bocaccio from Monterey to Eureka in trawl catches averaged from 1978 to 1988. The central California CPFV length-frequency distribution was strongly skewed to the right by a strong mode of young fish. The length-frequency distributions of the CPFV and trawl catches were significantly different in both northern and central California (KS test; $p < 0.0001$).

In central and northern California 50% of male and female bocaccio are sexually mature as 3- and 4-year olds at 420 mm and 480 mm, respectively (Echeverria 1987). Thus much of the 1980–86 central California CPFV catch

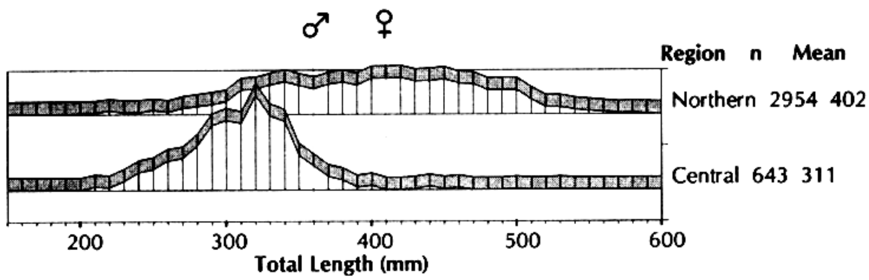


FIGURE 33. Length-frequency distribution of black rockfish from CPFVs and PRBs in northern and central California in 1980–86. Lengths at 50% sexual maturity for male and female fish are shown.

FIGURE 33. Length-frequency distribution of black rockfish from CPFVs and PRBs in northern and central California in 1980–86. Lengths at 50% sexual maturity for male and female fish are shown

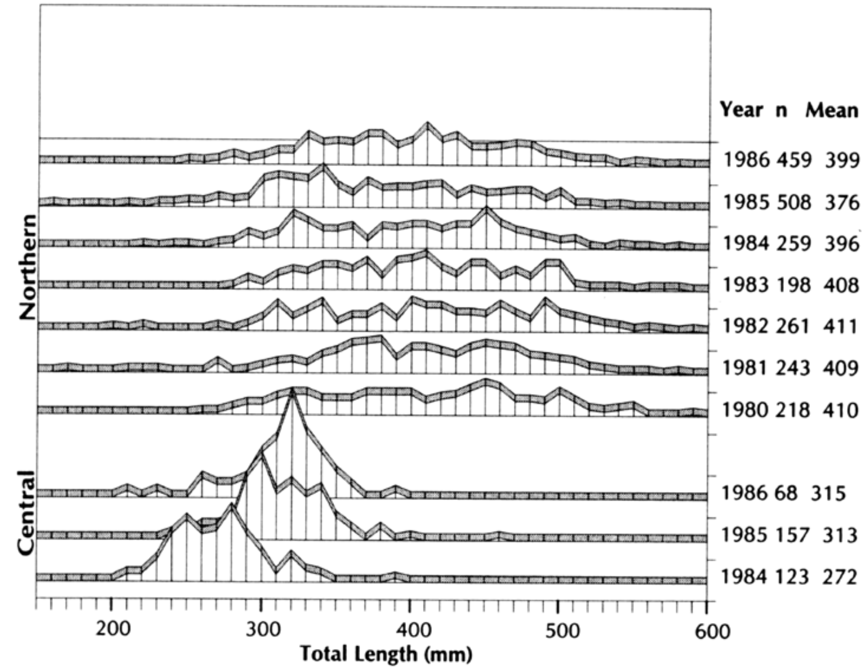


FIGURE 34. Length-frequency distribution of black rockfish from PRBs in northern California from 1984–86 and central California from 1980–86.

FIGURE 34. Length-frequency distribution of black rockfish from PRBs in northern California from 1984–86 and central California from 1980–86

was sexually immature. Most of the central California trawl catch and the northern California CPFV and trawl catches had reached sexual maturity (Figure 35).

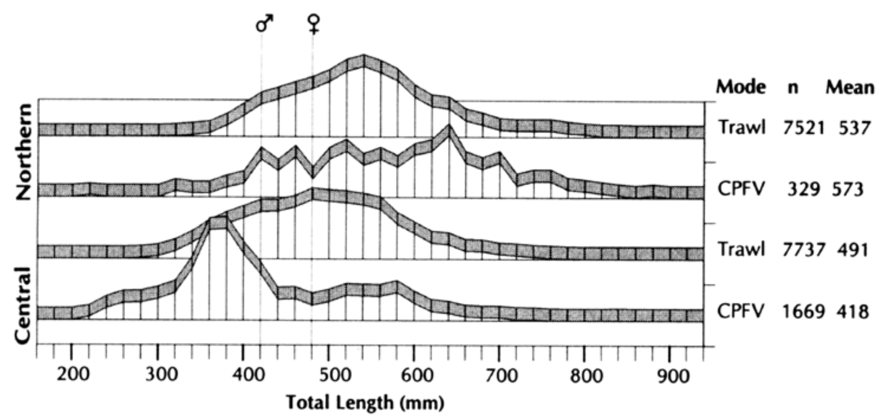


FIGURE 35. Length-frequency distribution of bocaccio from CPFVs and trawlers in northern and central California from 1980–86.

FIGURE 35. Length-frequency distribution of bocaccio from CPFVs and trawlers in northern and central California from 1980–86

Two strong modes were apparent in the annual length-frequency distributions of recreationally caught fish from central California and trawl-caught fish from northern and central California (Figure 36). Trawl fishery age data (otolith break-and-burn technique) (Bence and Rogers 1993) indicate the two modes represent the strong 1984 (A) and 1977 (B) year-classes. The strong mode of young fish for the central area is the 1984 cohort that was first observed in 1984 as juveniles (approximately 240 mm in length) taken from piers.

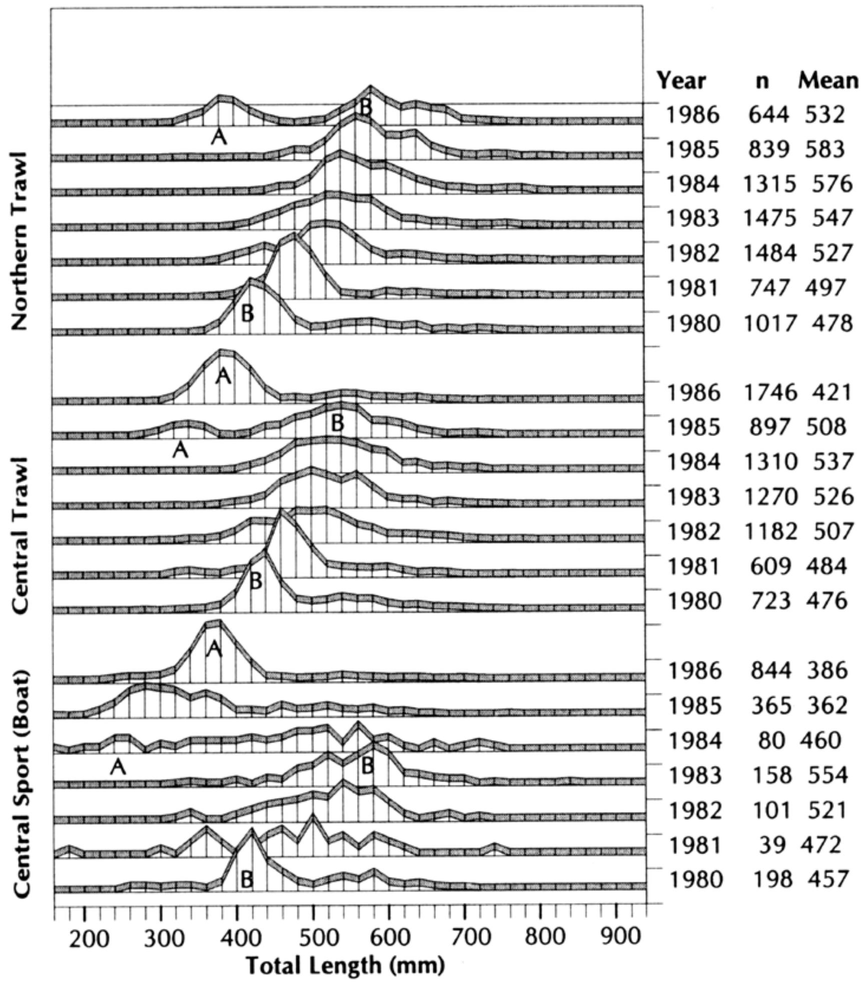


FIGURE 36. Length-frequency distribution of bocaccio from CPFVs, PRBs, and trawlers in northern and central California, 1980–86. Modal progression of the 1984 and 1977 year-classes are designated by the letters A and B.

FIGURE 36. Length-frequency distribution of bocaccio from CPFVs, PRBs, and trawlers in northern and central California, 1980–86. Modal progression of the 1984 and 1977 year-classes are designated by the letters A and B

The much larger average sizes found in northern California are partially the result of earlier recruitment to the central California recreational and trawl fisheries of the dominant year-classes. Both the 1984 and 1977 cohorts were recruited a year earlier in the central California trawl fishery than in the northern California trawl fishery. Unlike blue rockfish and black rockfish, bocaccio did not show greater dominance by strong year-classes in central California than in northern California.

5.1.5.5. Chilipepper

Like bocaccio, chilipepper from northern California were much larger than those from central California; the northern California trawl catch averaged 425 mm while the central California trawl and CPFV catches averaged 391 mm and 381 mm, respectively (Figure 37). All three distributions were significantly different from one another (KS test; $p < 0.0001$).

In central and northern California, 50% of male and female chilipepper are sexually mature as 3-year olds at 310 mm and 340 mm, respectively (Echeverria 1987). Thus most fish taken by CPFVs and trawlers were sexually mature.

Yearly length-frequency distributions showed more than one mode in both northern and central California, though the modes in the central California recreational boat catch were mixed and less discernible than for bocaccio (Figure 38). A distinct mode of young fish among central California recreational boats and not among trawls suggests that recruitment to the recreational

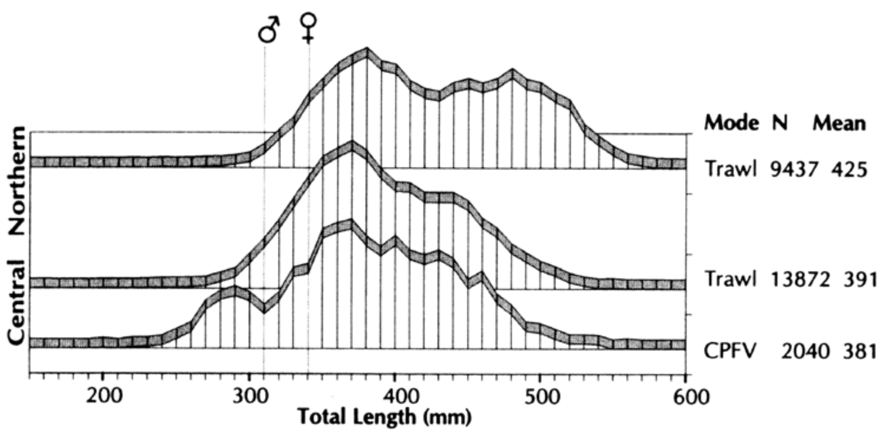


FIGURE 37. Length-frequency distribution of chilipepper from CPFVs and trawlers in northern and central California from 1980–86. Lengths at 50% sexual maturity for male and female fish are shown.

FIGURE 37. Length-frequency distribution of chilipepper from CPFVs and trawlers in northern and central California from 1980–86. Lengths at 50% sexual maturity for male and female fish are shown

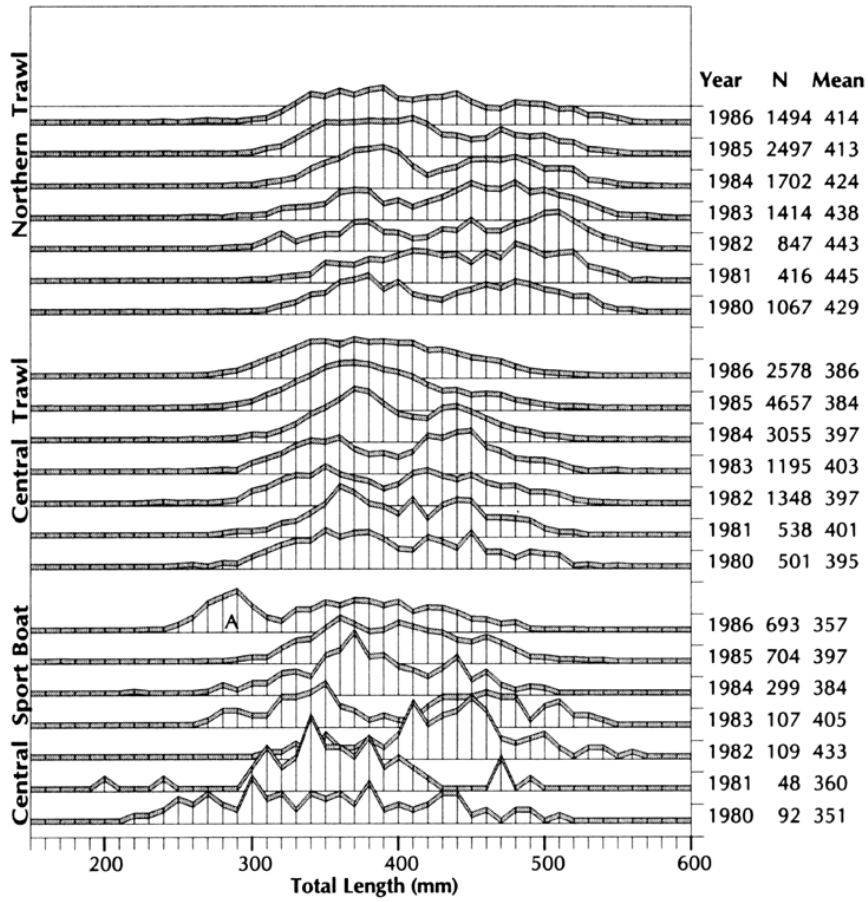


FIGURE 38. Length-frequency distribution of chilipepper from CPFVs, PRBs, and trawlers in northern and central California from 1980–86. The dominant 1984 year-class is labeled A.

FIGURE 38. Length-frequency distribution of chilipepper from CPFVs, PRBs, and trawlers in northern and central California from 1980–86. The dominant 1984 year-class is labeled A

boat fisheries occurs at a smaller size. Rogers and Bence (1992), using otolith break-and-burn technique on trawl-caught fish, identified 1975 and 1984 as two dominant year-classes. The strong mode of young fish (A) in the recreational boat catch in 1986 probably represents the 1984 year-class.

5.1.5.6. Canary Rockfish

In northern California in 1980–86, size distributions and mean lengths of PRB-caught and CPFV-caught canary rockfish were similar, while trawl-caught fish were much larger and had a more platykurtic distribution (Figure 39). The northern California CPFV and PRB distributions were skewed to the

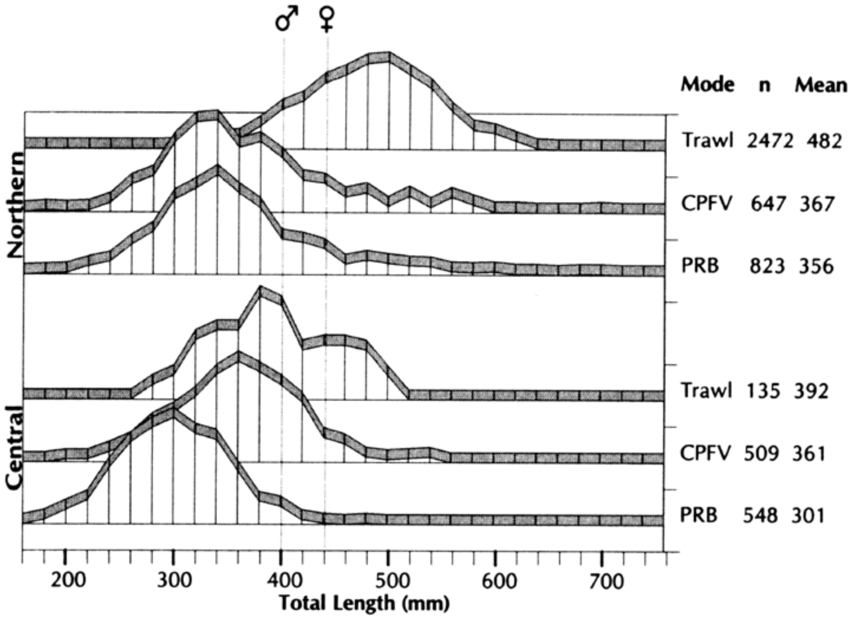


FIGURE 39. Length-frequency distribution of canary rockfish from CPFVs, PRBs, and trawlers in northern and central California from 1980–86. Lengths at 50% sexual maturity for male and female fish are shown.

FIGURE 39. Length-frequency distribution of canary rockfish from CPFVs, PRBs, and trawlers in northern and central California from 1980–86. Lengths at 50% sexual maturity for male and female fish are shown

right by a similar dominant mode at 340 mm; the distributions were significantly different (KS test; $p = 0.0336$). Mean length of the CPFV catch (367 mm) was slightly greater than that of the PRB catch (356 mm) but much less than that of the trawl catch (482 mm). In central California, mean length of the CPFV catch (361 mm) was greater than that of the PRB catch (301 mm). Both distributions were skewed slightly to the left and were significantly different (KS test; $p < 0.0001$).

A study by Boehlert and Kappenman (1980), encompassing our study area, showed that canary rockfish growth rates did not vary by latitude. This implies the smaller sizes we found in central California represent catches of younger fish. Fifty percent of canary rockfish in central and northern California are sexually mature at 400 mm as 7-year olds for males and 440 mm as 9-year olds for females (Echeverria 1987). Thus most of the recreationally caught canary rockfish in both northern and central California were sexually immature, with a higher proportion of immature fish in central California.

Mean length of both recreationally caught and trawl-caught canary rockfish declined from 1980 to 1986 (Figure 40). Mean length in the northern California recreational boat catch declined from 390 mm in 1980 to 352 mm in 1986. Mean length in the northern California trawl catch declined from 498

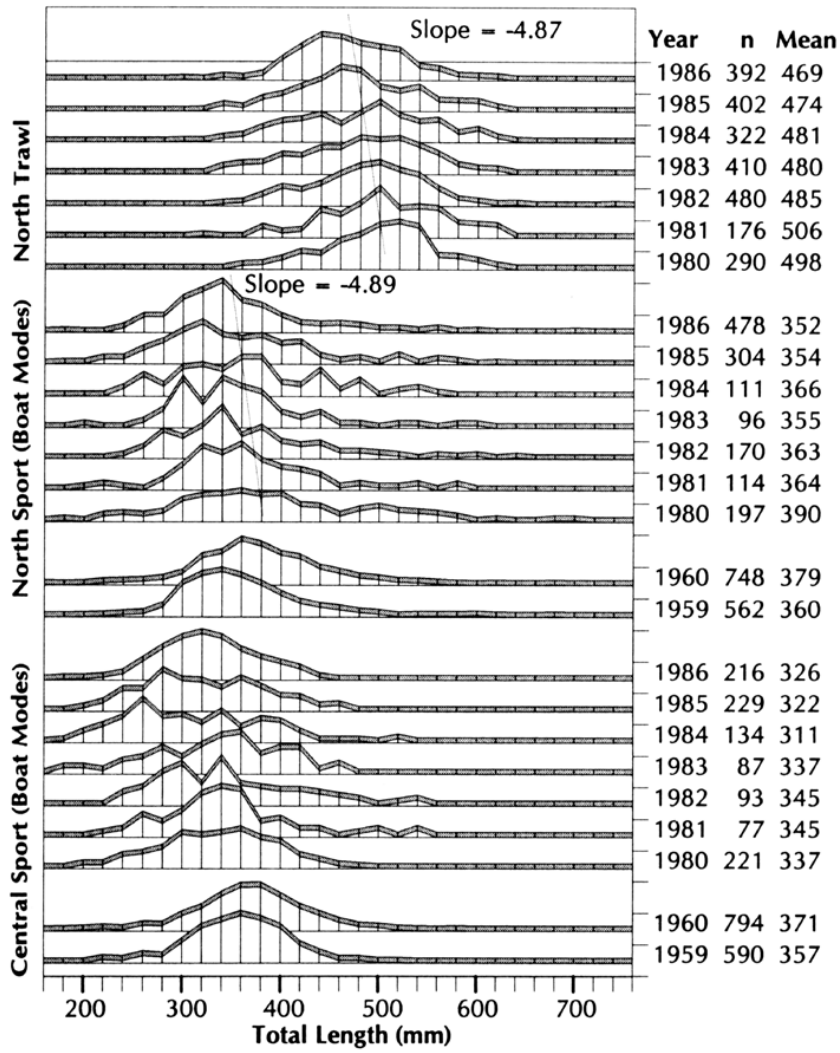


FIGURE 40. Length-frequency distribution of canary rockfish from CPFVs, PRBs, and trawlers in northern and central California from 1959–60 and 1980–86.

FIGURE 40. Length-frequency distribution of canary rockfish from CPFVs, PRBs, and trawlers in northern and central California from 1959–60 and 1980–86

mm to 469 mm during the same period. In central California, low sample sizes in 1980–84 obscured any trends, and an apparent strong year-class mode increased mean length from 311 mm in 1984 to 326 mm in 1986. A similar occurrence in the northern California recreational boat catch in 1985–86 suggests the strong year-class was also present there. Pearson and Ralston (1990) described the declines in mean length of trawl-caught canary rockfish from

1978 to 1991 in California as indicative of fishing down of surplus stocks. An ANCOVA comparison between northern California trawlers and recreational boats showed parallel significant declines, with slopes of -4.87 mm/year and -4.89 mm/year for trawlers and recreational boats, respectively (Figure 40). Both slopes were significantly different from 0 ($p < 0.00001$) but not from each other ($p = 0.983$).

Mean lengths of central California sport-caught canary rockfish were greater in 1959–60 than in 1980–86; the decline in northern California was not as pronounced (Figure 40). The declines affecting the stock taken by recreational fisheries appear greater in central California than in northern California.

5.1.5.7. Brown Rockfish

Due to small sample sizes, brown rockfish length-frequency data should be examined cautiously. Between 1959–60 and 1980–86, mean length of brown rockfish appears to have declined substantially (Figure 41). In northern California, mean length of the CPFV catch declined from 389 mm to 344 mm, while mean length of the PRB catch declined from 363 mm to 274 mm. In central California mean length of the PRB catch declined from 402 mm to 310 mm.

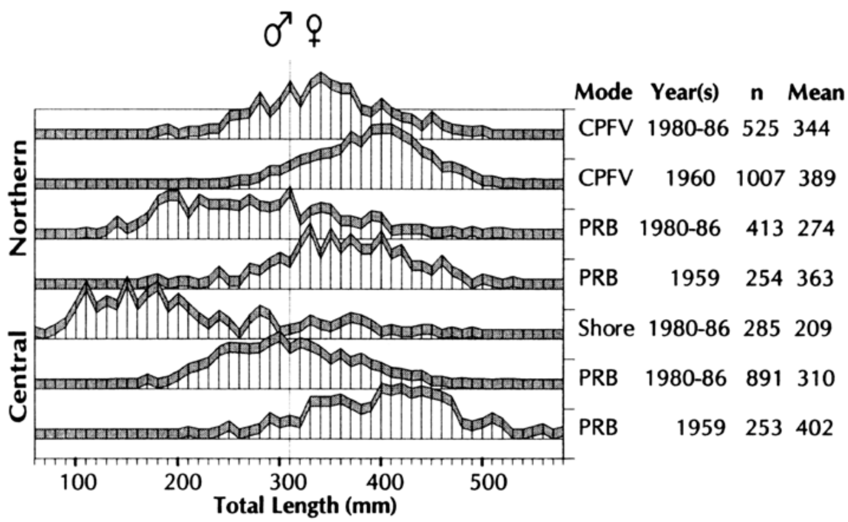


FIGURE 41. Length-frequency distribution of brown rockfish from CPFVs and PRBs in northern and central California from 1959-60 and 1980-86. Lengths at 50% sexual maturity for male and female fish are shown.

FIGURE 41. Length-frequency distribution of brown rockfish from CPFVs and PRBs in northern and central California from 1959–60 and 1980–86. Lengths at 50% sexual maturity for male and female fish are shown

In central and northern California 50% of male and female brown rockfish reach sexual maturity as 5-year olds at 310 mm (Echeverria 1987). Our results indicate that in 1959–60 most brown rockfish taken had reached sexual maturity, but by 1980–86 few fish taken from shore and about half taken from PRBs had reached the size at which 50% are sexually mature (Figure 41).

5.2. Lingcod

Lingcod, a large carnivorous fish of the family Hexagrammidae, is an important and highly sought species in the northern and central California marine recreational fishery. In 1980–86, lingcod ranked among the top 10 most important species (as defined by our IRI) in all fishing modes except pier and dock (Figures 10, 13–17). Lingcod ranked first for spear, third for PRB, and fifth for CPFV and beach and bank fishing. Much of the contribution to IRI resulted from the percentage by weight of total catch. The desirability of lingcod is evidenced by its top rank for the spear mode, where prey species can be targeted. Anglers also commonly target lingcod by jigging large artificial lures, anchovies, or squid.

Lingcod range from Kodiak Island, Alaska to Point San Carlos, Baja California (Miller and Lea 1972). The area of greatest abundance is north of California (Phillips 1959). Commercial landings decrease from northern to southern California, with the sharpest decrease occurring south of Santa Barbara (Miller and Geibel 1973). Percentages of lingcod in the sampled recreational catch from 1980 to 1986 also indicate lingcod abundance drops sharply south of San Luis Obispo (Figure 42). No obvious changes in occurrence appeared during the 1982–83 ENSO. Mendocino/Sonoma had the highest annual average percent of total catch (4.3%) throughout Oregon and California.

In California, lingcod egg masses are deposited from November to early March in rocky habitats (Miller and Geibel 1973). Lingcod egg masses have been observed to depths of 97 m (O'Connell 1993). Water current flow is necessary for gas exchange and prevention of high mortality within the egg mass (Giorgi and Congleton 1984), and nests are typically located in areas of water movement. Male lingcod guard the egg mass from predators during incubation (Hart 1973). Removal of the male causes a high incidence of egg loss to predators (Low and Beamish 1978). Incubation takes about seven weeks in the Puget Sound area, and is probably briefer in California (Miller and Geibel 1973). Newly hatched larvae are 7–10 mm in length (Hart 1973).

After hatching, young lingcod are pelagic until they are about 70 mm long. Larvae and juveniles have been commonly found in the upper 30 m of the water column in the Gulf of the Farallones, with density decreasing with distance from shore (Adams et al. 1993). Phillips and Barraclough (1977) found

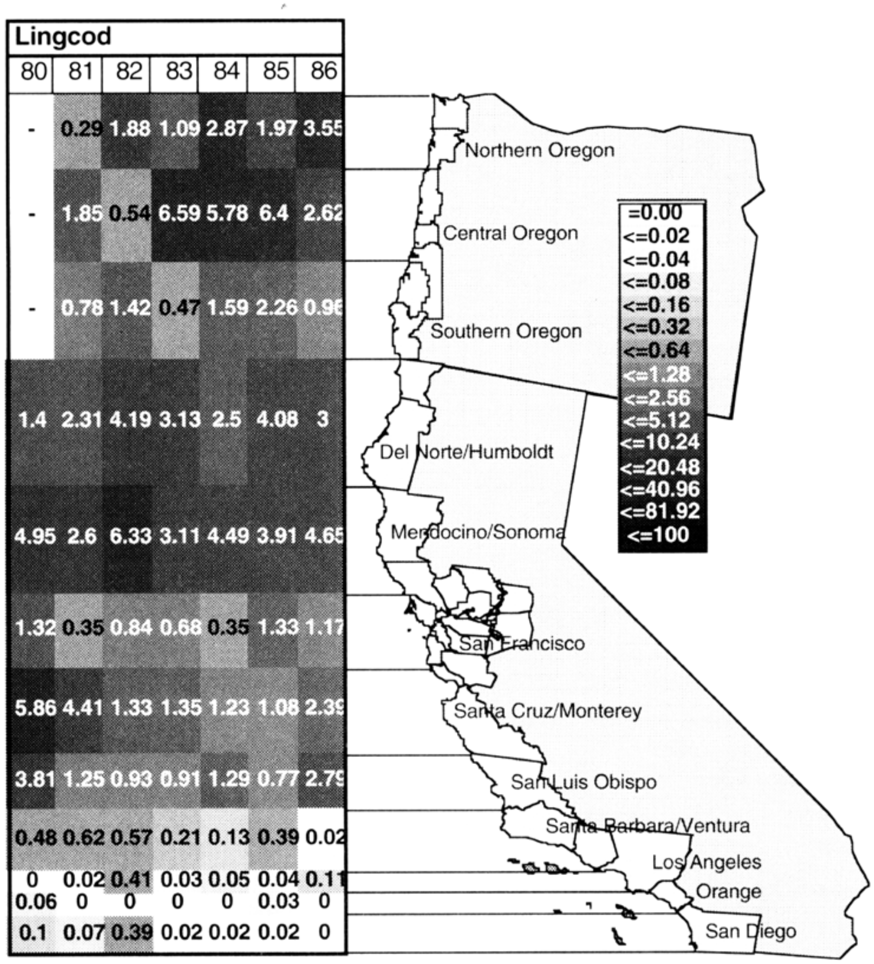


FIGURE 42. Percent of total sampled catch by number of lingcod by district and year in Oregon and California marine recreational fisheries, 1980–86.

FIGURE 42. Percent of total sampled catch by number of lingcod by district and year in Oregon and California marine recreational fisheries, 1980–86

that the pelagic stage lasts from about early March to early June in British Columbia waters, and that the young lingcod move progressively inshore during their pelagic existence. Timing of the pelagic stage appears to be about one month earlier in California (Adams 1986).

Lingcod lack a swim bladder, and after the pelagic stage they are typically found near the bottom. Newly settled juveniles about 70 mm long are found in sandy areas (Miller and Geibel 1973). At lengths of about 350 mm, they move onto rocky reef areas. Growth of lingcod is rapid in comparison to the rockfish.

Lingcod from northern and central California reach 330 mm total length at age one and attain the present recreational fishery minimum size limit of 22 inches (560 mm) as 3-year olds (Miller and Geibel 1973). Adults can be found to depths of 420 m (Miller and Lea 1972).

Most tagging studies have found lingcod to be relatively nonmigratory. In a central California study, nearly all lingcod recovered were caught within about 5 km of the location where they were tagged (Miller and Geibel 1973). However, they reported that catch data indicate that at least a portion of the adult population occupying deeper habitats (over 90 m) annually migrates inshore to spawn. A portion of the adult male population appears to be residential in shallower areas and is available to recreational fisheries year around. Large gravid females become more frequent in the recreational catch in the fall months prior to spawning. An Oregon tagging study found no movement between inshore and offshore locations (Barss and Demory 1989). However, of 149 fish recaptured after being tagged near the San Juan Islands, 61 had moved from 8.1 to 50 km, and 13 had moved more than 50 km (Mathews and LaRiviere 1987). The general direction of movement was seaward. Nearly all those fish were tagged during March through May, which is during the December through May nesting period for the San Juan Islands (LaRiviere et al. 1981). Thus the movement may represent a tendency of some fish to return to more seaward habitats after spawning and nesting. Jagielo (1990) tagged lingcod within 3 miles of shore in March and April near Neah Bay, Washington; he found that 19% of the recaptured fish were recovered more than 5 miles from the tagging site, and the general direction of movement of those fish was seaward. If a tendency to migrate inshore to spawn in relatively shallow habitats exists, it may be related to a need for water circulation past the egg mass provided by surge and tidal currents. An important management question is whether offshore fish taken mainly by commercial fisheries are different stocks from inshore fish taken mainly by recreational fisheries.

The take of lingcod off California is subject to regulation by both federal and state governments. Since 1983 the PFMC has specified an annual acceptable biological catch (ABC) for Washington, Oregon, and California of 7000 MT, within which 500 MT, 1000 MT, and 400 MT are allocated to the Eureka, Monterey, and Conception INPFC areas, respectively (PFMC 1992) (Figure 1). Due to lack of knowledge of lingcod population dynamics, the ABCs are based on harvest levels rather than stock condition (PFMC 1982). For recreational fishing in California, federal and state regulations specify a five-fish bag limit and a 22-inch minimum total length. The bag limit was initiated in 1980 and the minimum length in 1981. Prior to 1980 the bag limit was 10 fish.

5.2.1. *Catch*

The estimated average annual number of lingcod landed in northern and central California recreational fisheries, excluding PRB fishing in San Francisco Bay, rose from 65,000 in the 1958–61 survey to 112,000 in the 1981–86 survey (Figure 6). Average annual weight landed rose 74%, from 232 MT to 403 MT. Average weight per fish did not change between the two surveys (3.6 kg).

Total 1981–86 average annual recreational lingcod catch in northern and central California, including skiff fishing in San Francisco Bay, was 113,000 fish weighing 405 MT (Table 8). Nearly all fish were landed by boat modes. The Del Norte/Humboldt, Mendocino/Sonoma, and Santa Cruz/Monterey districts made strong contributions to total landings. Mean weight per fish exhibited a north-south cline, from 4.6 kg in Del Norte/Humboldt to 2.6 kg in San Luis Obispo.

As discussed earlier, CPFV log data are not reliable for use as annual catch estimates but may indicate fishery trends. CPFV log data indicate that lingcod catch, percent of total catch, and catch per fishing day peaked in 1972, 1980, and 1989, and have been in slow oscillating decline since the early 1970s (Figures 43 and 44).

There is presently no closed season for recreational or commercial harvest of lingcod in California. Monthly trends in recreational and commercial landings show that lingcod are taken year around, with highest landings in June through October (Figure 45). Relatively calm sea conditions during those months are at least partial cause for the higher landings. Thirty-seven percent of the recreational landings are made during the 6 months of greatest nest guarding activity, November through April. Miller and Geibel (1973) found

TABLE 8. Average annual number (thousands) and weight (MT) of lingcod landed in the northern and central California marine recreational fishery, 1981–86.

	Pier & *Dock*		Jetty & Break-water		Beach & Bank		PRB		CPFV		Spear		Total	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Del Norte/Humboldt	-	-	1	2	1	3	23	109	0	1	-	-	25	115
Mendocino (Boat)	-	-	-	-	-	-	12	45	3	13	-	-	15	58
Sonoma (Boat)	-	-	-	-	-	-	5	19	1	4	-	-	6	23
Mendo./Sonoma (Non-Boat)	-	-	1	1	1	3	-	-	-	-	2	4	3	9
San Francisco (Ocean)	-	-	0	1	0	0	5	14	10	34	-	-	15	49
San Francisco (Bay)	0	0	-	-	0	1	1	2	0	0	-	-	2	3
Santa Cruz/Monterey	1	1	-	-	0	1	12	31	22	83	4	9	38	125
San Luis Obispo	0	1	-	-	0	0	6	16	2	7	-	-	9	24
Total	1	2	1	3	3	8	64	236	38	142	5	13	113	405

TABLE 8. Average annual number (thousands) and weight (MT) of lingcod landed in the northern and central California marine recreational fishery, 1981–86

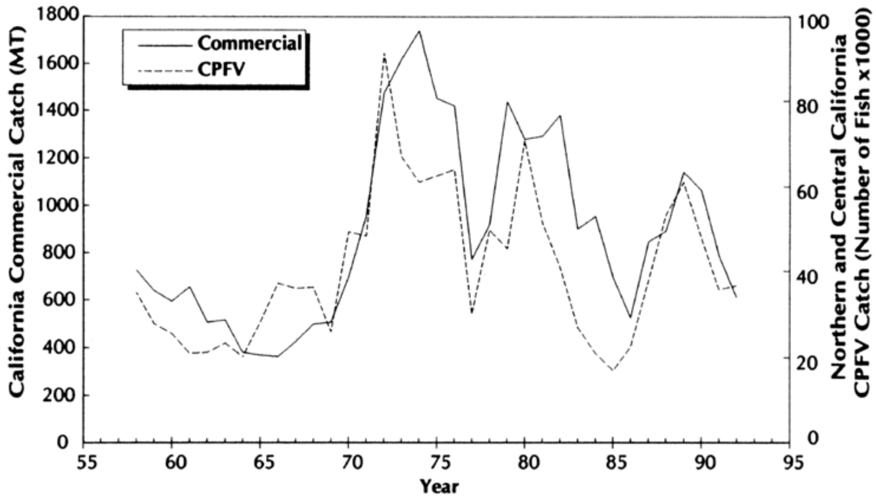


FIGURE 43. CPFV and commercial lingcod landings, 1958–91. CPFV data are from CPFV logs for northern and central California, and commercial data are from CDFG landing receipts for all California ports.

FIGURE 43. CPFV and commercial lingcod landings, 1958–91. CPFV data are from CPFV logs for northern and central California, and commercial data are from CDFG landing receipts for all California ports

recreational catch per day generally peaked in the winter months, a time of relatively low fishing effort. They attributed the peak to increased availability of fish in nearshore areas.

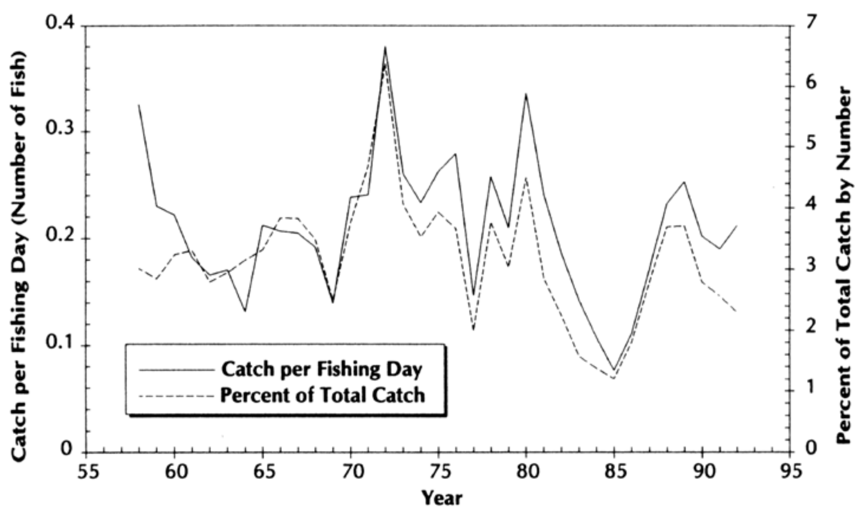


FIGURE 44. Lingcod catch per fishing day and percent of total catch from northern and central California CPFV logs (CDFG data).

FIGURE 44. Lingcod catch per fishing day and percent of total catch from northern and central California CPFV logs (CDFG data)

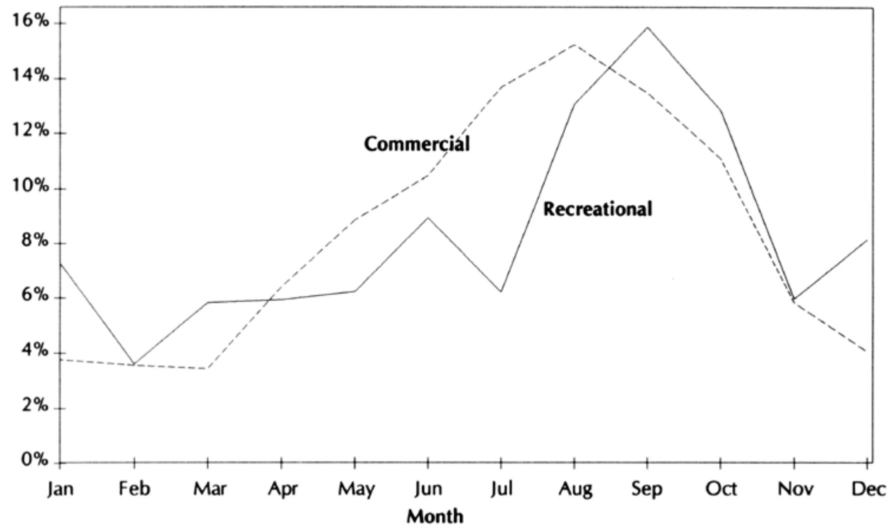


FIGURE 45. Percentage of commercial and recreational lingcod catch by month. (Commercial data from 1980–91 CDFG landing receipts; recreational data from 1980–86 MRFSS creel survey.)

FIGURE 45. Percentage of commercial and recreational lingcod catch by month. (Commercial data from 1980–91 CDFG landing receipts; recreational data from 1980–86 MRFSS creel survey.)

Northern and central California commercial landings of lingcod rose from 606 MT in 1958–61 to 942 MT in 1981–86, an increase of 55% (Figure 5). Weight of commercial landings was about twice the weight of recreational landings in 1981–86. Long-term trends in commercial landings nearly parallel the CPFV log landings, showing a sharp increase between 1969 and 1972 and an oscillating decline since then (Figure 43). The correlation between the commercial and CPFV landing data indicates the two fisheries are fishing the same stocks, or if the stocks are different, that the same factors are affecting abundance and year-class strength.

The decline in CPFV catch since the early 1980s was probably caused partially by the five-fish bag limit that began in 1980 and the 22-inch minimum size limit that began in 1981. However the decline lasted well beyond those two years, and commercial landings not subject to those limits also declined.

The percentage of the commercial catch taken by hook and line and entangling net gear has risen since the early 1980s (Figure 46). Trawl fisheries now account for only about half the commercial catch.

5.2.2. *Length-frequency Analysis*

Mean length of recreationally caught lingcod during 1980–86 was significantly different in northern California (695 mm) from central California (626 mm) ($p < 0.0001$), and was significantly different in the CPFV catch (674

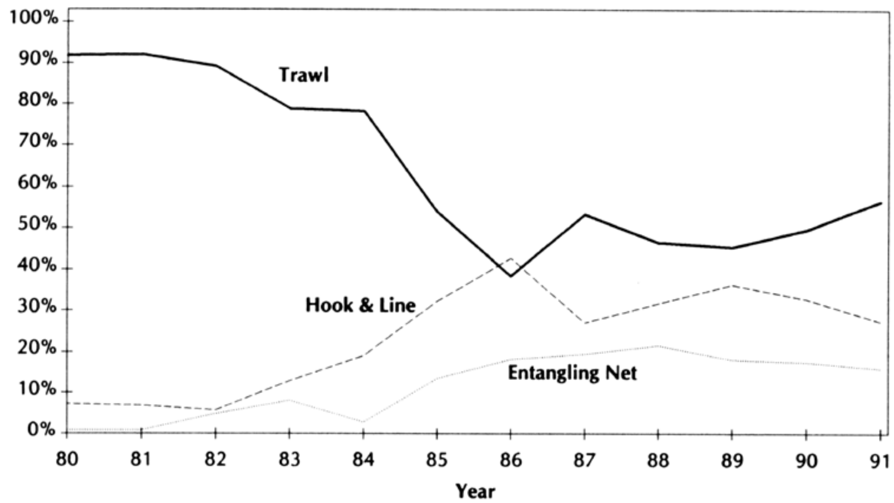


FIGURE 46. Percentage of California commercial catch of lingcod by gear type, 1980–91 (CDFG landing receipt data).

FIGURE 46. Percentage of California commercial catch of lingcod by gear type, 1980–91 (CDFG landing receipt data)

mm) from the PRB catch (653 mm) ($p < 0.0001$); the interaction between geographical area and mode was also significant ($p < 0.0001$; two-way ANOVA).

Comparison of the northern California and central California length-frequency distributions segregated by mode showed that the shapes of the distributions did not differ greatly, and that the difference in mean length between the CPFV and PRB modes was much greater in central California (70 mm) than in northern California (11 mm) (Figure 47).

Since historical length sampling was not uniform with respect to time, location, or different fishing modes, sufficient length data existed to analyze historical length-frequency trends only for the CPFV catch in central California. Mean length in 1959–64 (601 mm) was significantly different from 1966–72 (659 mm) ($p < 0.0001$) and was also significantly different from 1980–86 (663 mm) ($p < 0.0001$; one-way ANOVA followed by Scheffe test) (Figure 48). Because the 22-inch (560-mm) size limit began in 1981, we applied the same tests to the data excluding all lengths less than 560 mm. For lengths greater than or equal to 560 mm, mean length in 1959–64 (671 mm) was significantly different from 1966–72 (710 mm) ($p < 0.0001$) and was also significantly different from 1980–86 (684 mm) ($p = 0.05$); mean length in 1966–72 was significantly different from 1980–86 ($p < 0.0001$). The length-frequency differences were probably not caused as much by differences in take as by presence of strong year-classes, as discussed below.

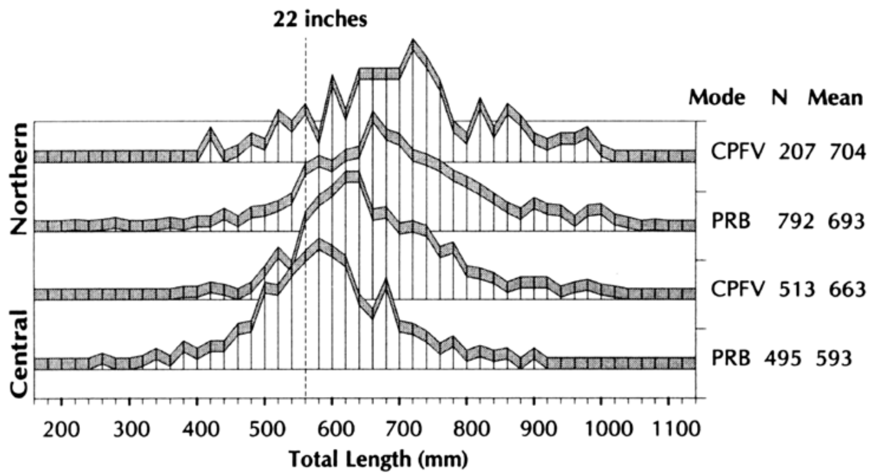


FIGURE 47. Length-frequency distribution of lingcod sampled from CPFVs and PRBs in northern and central California, 1980–86.

FIGURE 47. Length-frequency distribution of lingcod sampled from CPFVs and PRBs in northern and central California, 1980–86

Plots of annual length-frequency data for boat modes from central California show four length-frequency modes of one or more dominant year-classes progressing through the fishery (Figure 49), modes A through D). Discerning length-frequency modes after 1980 is difficult due to small sample sizes. Ford-Walford analysis of the annual increments in length indicated by progression of the length-frequency peaks yields an age-length relationship similar to the age-length relationship for northern and central California males developed through surface reading of otoliths by Miller and Geibel (1973), except the Ford-Walford analysis failed to model the rapid growth occurring in the first year of life (Figure 50). Ford-Walford plot analysis applied to growth intervals of length-frequency peaks A through D produced a Von Bertalanffy growth equation of $l\,t_{+1} = 0.794l + 152$ where

$$L_\infty = 741.$$

EQUATION

The similarity in slope between the two age-length relationships supports the Miller and Geibel (1973) relationship and also indicates length-frequency peaks A through D (Figure 49) actually do track growth of one or more dominant cohorts.

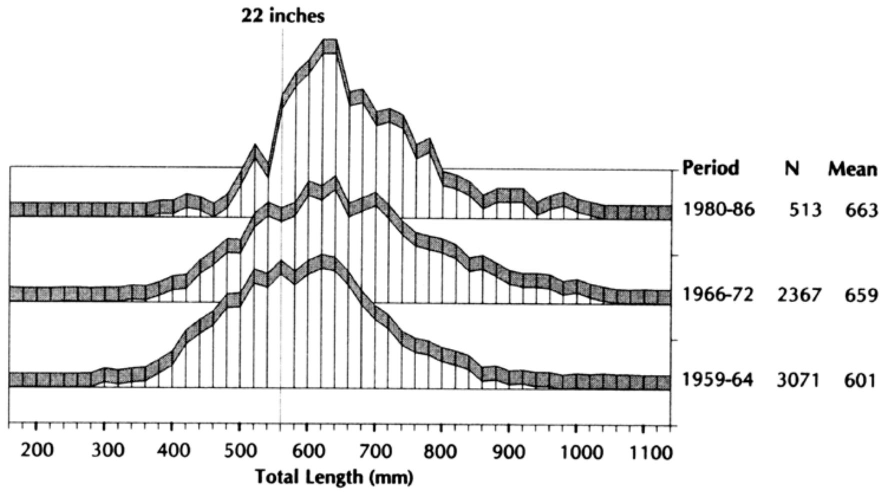


FIGURE 48. Length-frequency distribution of lincod from CPFVs in central California for the periods 1959–64, 1966–72, and 1980–86.

FIGURE 48. Length-frequency distribution of lincod from CPFVs in central California for the periods 1959–64, 1966–72, and 1980–86

Using the Miller and Geibel (1973) age-length relationship for males (since males dominate recreational catches), we assigned approximate birth years for the dominant cohorts as follows (Figure 49): A-1956, B-1960, C-1968, and D-1977. The ecological implications of those dominant cohort birth years are discussed later.

The strong 1960 year-class affected the length-frequency analysis, contributing many relatively small fish in 1962–64, and many relatively large fish during 1966–72 (Figure 49); that strong year-class and the 1968 year-class are at least partially responsible for peak landings in the early 1970s and the apparent declines since then. Strong year-classes probably also caused the peaks in CPFV and commercial catch around 1980 and 1989. Since the early 1970s, the coincidence of strong year-classes with peaks in CPFV and commercial landings data (Figure 43) indicates that the CPFV and commercial landings data probably do reflect trends in stock abundance.

5.2.3. *Length at Maturity*

Knowledge of the length at which fish become sexually mature is important in evaluating the length-frequency composition of the catch, and also in evaluating a minimum size limit as exists for lingcod. The length at which lingcod mature has been found to vary within the species' geographic range, with males maturing at smaller lengths than females. British Columbia lingcod males and females examined in December through April matured at 520

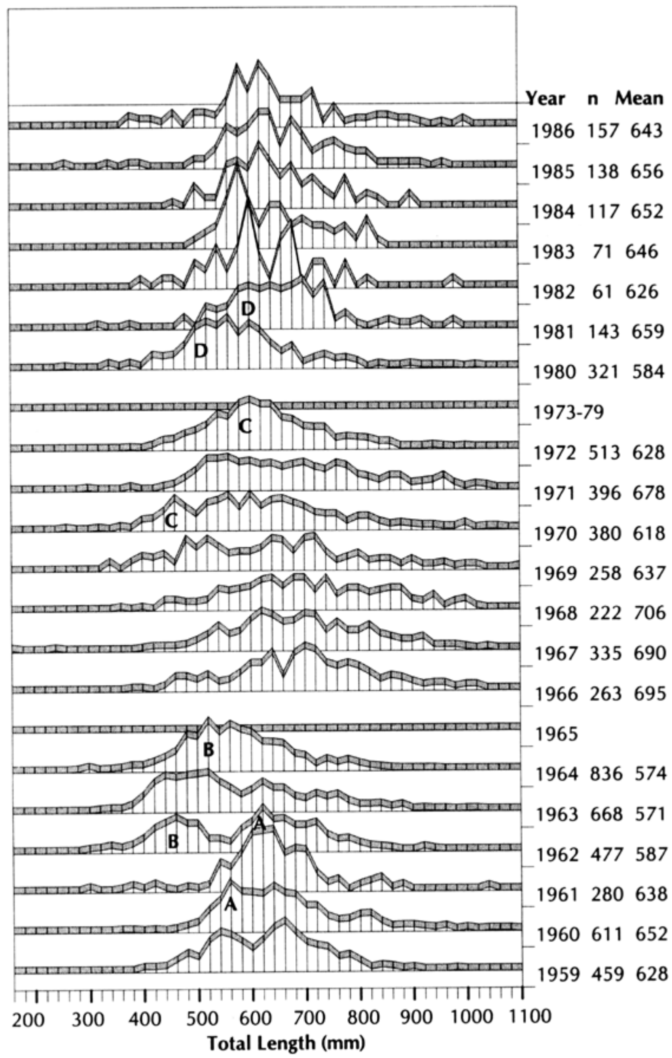


FIGURE 49. Annual length-frequency of lingcod caught from CPFVs and PRBs in central California, 1959–86. Modal progressions of dominant cohorts are identified by the letters A to D.

FIGURE 49. Annual length-frequency of lingcod caught from CPFVs and PRBs in central California, 1959–86. Modal progressions of dominant cohorts are identified by the letters A to D

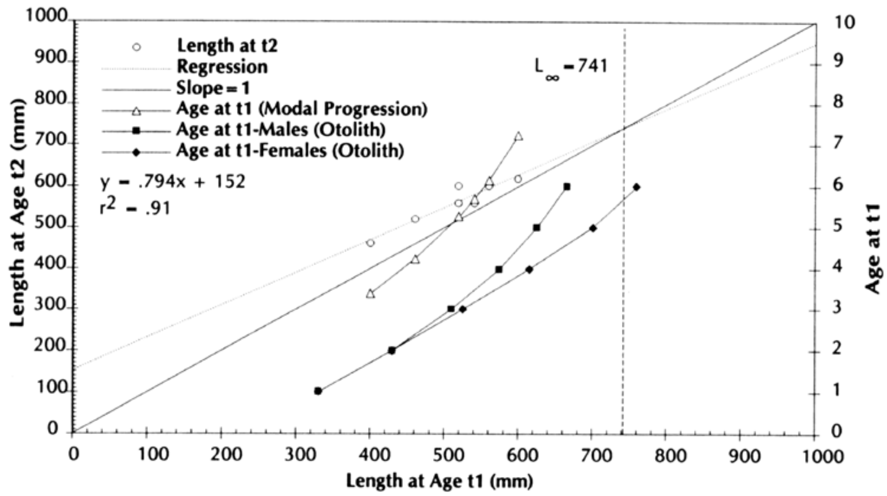


FIGURE 50. Ford-Walford analysis of annual growth increments, based on progression of length-frequency modes, of lingcod from CPFVs and PRBs in central California, 1958–81. Age-at-length data from otoliths are from Miller and Geibel (1973).

FIGURE 50. Ford-Walford analysis of annual growth increments, based on progression of length-frequency modes, of lingcod from CPFVs and PRBs in central California, 1958–81. Age-at-length data from otoliths are from Miller and Geibel (1973)

mm and 768 mm, respectively (Wilby 1937). Fort Bragg lingcod males and females examined in October and November matured at 580 to 648 mm (Phillips 1959). Miller and Geibel (1973) examined 111 males and 180 females taken by CPFVs in the Monterey and Morro Bay areas in December through mid-February, and found that males matured at 390 to 590 mm, and females matured at 510 to 765 mm.

Richards et al. (1990) examined length and maturity relationships of lingcod from three areas in British Columbia; they found that males began to mature at 500 mm and were all mature at 700 mm, and females began to mature at 500 mm and were all mature at 750 mm. Length at maturity increased with increasing latitude for the three areas. They also found that the Miller and Geibel (1973) lingcod maturity data supported a conclusion that length at maturity increases with increasing latitude for both sexes coastwide.

The difference in length at maturity between central California and British Columbia is much larger for males than females (Figure 51). Length at maturity for Fort Bragg males (Phillips 1959) appears nearer to that of British Columbia males than to central California males. The central California data indicate that the 22-inch size limit allows for about 90% of the males but only about 30% of the females to mature before entering the recreational fishery.

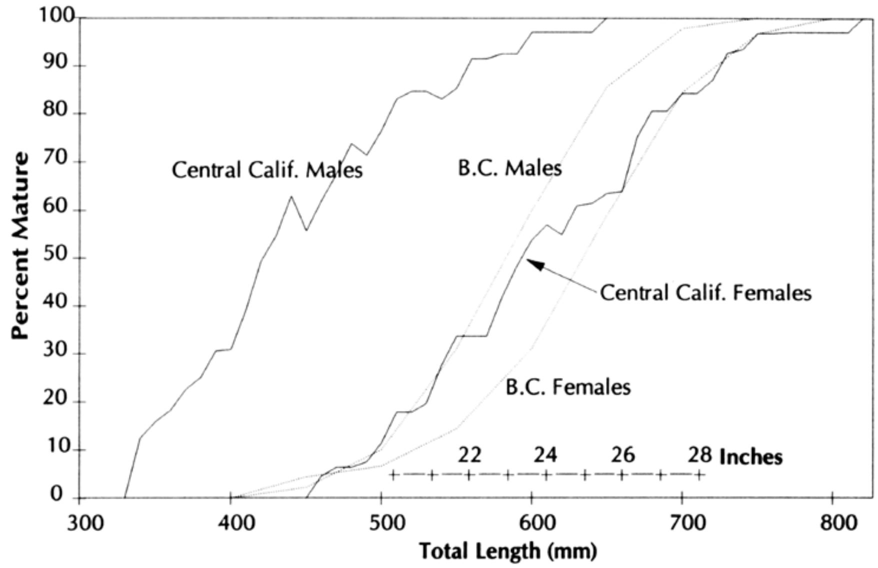


FIGURE 51. Maturity at length of lingcod from central California (Miller and Geibel 1973) and British Columbia (Richards et al. 1990). To smooth the curves, central California data shown are the 11-point running average and the British Columbia data shown are the 3-point running average.

FIGURE 51. Maturity at length of lingcod from central California (Miller and Geibel 1973) and British Columbia (Richards et al. 1990). To smooth the curves, central California data shown are the 11-point running average and the British Columbia data shown are the 3-point running average

The Fort Bragg data indicate that the 22-inch size limit allows a low percentage of both males and females in northern California to mature before entering the recreational fishery.

The difference in male length at maturity between central California and northern California is surprisingly great relative to the difference between northern California and British Columbia. Since male lingcod play a critical nest-guarding role in reproduction and they are commonly taken in the recreational fishery, the difference is significant to fishery management.

5.3. Rockfish and Lingcod: Yearly Trends and Conclusions

An examination of yearly recreational trends in landings from 1981 to 1986 for northern and central California for rockfish, lingcod, and salmon suggests dynamic fisheries (Figure 52). In northern California, salmon and lingcod played dominant roles, and there was no discernible pattern of landings over the 6-year period among most of the species examined. In central California, salmon and lingcod play reduced roles, and there was a trend of decline in blue rockfish from 1982 to 1986 that was offset by increases among other

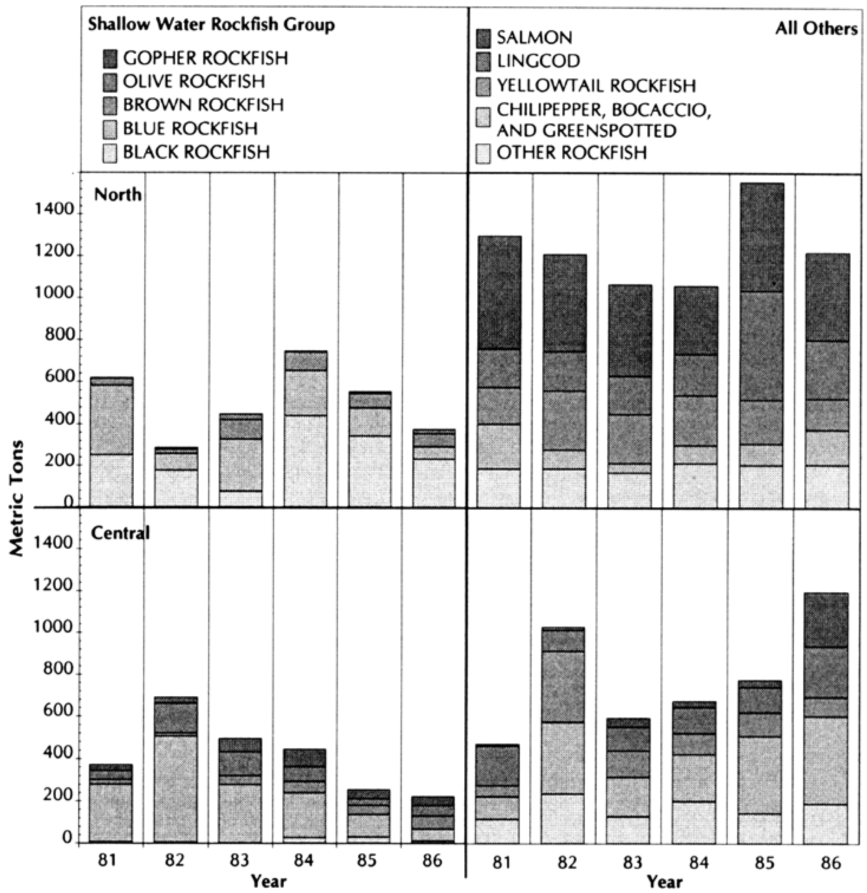


FIGURE 52. Total recreational catch of bottom fishing complex in northern and central California, 1981–86.

FIGURE 52. Total recreational catch of bottom fishing complex in northern and central California, 1981–86

species such as bocaccio, chilipepper, greenspotted rockfish, and salmon. Thus the fisheries, especially in central California, are in a state of flux and depend on availability of the desirable species.

It is difficult to argue, based on the data we examined, that any one stock of rockfish or lingcod is in immediate danger of collapse. The 1958 to 1986 recreational data had much variance and, except for the more common species such as blue rockfish and yellowtail rockfish, were too discontinuous over time to document interannual variation. The long-term average trends we were able to follow do not yet show the dramatic stock declines seen in some commercial fisheries such as those for abalone (Karpov and Tegner 1992) and California halibut (Barsky 1990).

Documenting stress in a stock is inherently difficult for recreational fisheries. One problem is a lack of reliable yearly landing data such as is available for commercial fisheries. The survey data we relied on was beset by problems of small sample size, resulting in high annual variance in species' catch estimates (Miller and Gotshall 1965; Miller and Geibel 1973; Albin et al. 1993). The dynamic nature of recreational fisheries in shifting among species such as salmon, lingcod, bocaccio, and chilipepper as they become available, or as other desirable species decline, obscures catch trends. Increases in fishing power further mask evidence of stock decline (Gulland 1969; Ricker 1975). The shift to deep-water rockfish by PRB and CPFV modes as shallow-water rockfish declined is an example of an increase in recreational fishing power. Sonar fish finders have become cheaper, more sophisticated, and common on both CPFVs and PRBs. We have observed that fishing grounds previously inaccessible to PRBs have become accessible as vessel size and horsepower have increased. Boats now go further from port as near-port assemblages have been fished down (J. Mason, NMFS, pers. observ.).

Since 1958, average weight per fish declined for 12 of the 16 rockfishes we examined, including bocaccio, canary rockfish, vermilion rockfish, chilipepper, greenstriped rockfish, widow rockfish, starry rockfish, blue rockfish, black rockfish, brown rockfish, gopher rockfish, and olive rockfish. Among species also examined for length-frequency distribution only bocaccio, a fast growing species that reaches 50% sexual maturity in three to four years (Echeverria 1987), had a decline in size that could be attributed to an incoming strong year-class (1984). Blue rockfish, yellowtail rockfish, canary rockfish, and brown rockfish showed declines that may be related to environmental factors or fishing pressure.

Evidence of stress on lingcod and rockfish stocks was greatest in central California where sport effort was also greatest. A north-south cline of decreasing mean weight was evident for lingcod and most of the rockfishes (Tables 6 and 8). Length-frequency comparisons of lingcod, blue rockfish, yellowtail rockfish, canary rockfish, and brown rockfish showed that sizes taken were significantly larger in the north.

Our results suggest that, of the rockfishes, blue rockfish, yellowtail rockfish, canary rockfish, and brown rockfish are the main species requiring management attention. Blue rockfish and yellowtail rockfish are the most recreationally important rockfish in central and northern California. Annual average recreational catches of blue rockfish and yellowtail rockfish doubled between 1958–61 and 1981–86 to 416 and 350 MT respectively (Table 5), together representing 31% by weight of the 1981–86 recreational rockfish landings. Both species showed a loss of large adult sizes in central California during 1982–83 ENSO.

Since 1982 the central California blue rockfish catch showed a dramatic 88% decline from 500 MT in 1982 to 60 MT in 1986 (Figure 52). Whether the decline resulted more from fishing pressure or environmental factors could not be established from our study. Miller and Geibel (1973) warned that blue rockfish are localized as adults and could be fished out of an area. The difference in blue rockfish recruitment patterns we observed between central California and northern California suggests that separate stocks may exist that warrant separate management approaches. The large proportion of sexually immature fish in the central California catch is cause for added caution in managing this stock.

Yellowtail rockfish showed a significant slope of decline in length among both recreational and commercial fisheries that, when viewed in conjunction with the higher proportion of sexually immature fish taken by the recreational fisheries, suggests a need for management attention. Evidence suggests a California-Oregon substock. Fraidenburg (1980) and Tagart (1991) both reported north to south differences in yearly recruitment patterns as reflected in surviving dominant cohorts. Tagart (1991) interpreted the differences as suggesting a southern stock that corresponded to the Eureka/S. Columbia INPFC area. Our length-frequency analysis suggested similar recruitment patterns among fish taken in recreational fisheries in northern and central California. We also found that the 1982–83 ENSO and/or greater fishing pressure eliminated an older cohort in central California and not northern California. The result was that by 1986 most recreationally caught fish in the central area were sexually immature (Figures 31 and 32).

Canary rockfish and brown rockfish ranked only sixth and seventh in weight landed (Table 5) but also showed evidence of stress, requiring management attention. Canary rockfish declined in length and weight per fish between the 1958–61 and 1981–86 surveys as recreational landings doubled to 99 MT (Figure 40). A significant slope of decline in mean length is apparent in recent years for both commercial trawl and recreational catches in northern California (Figure 40). There was a high portion of sexually immature fish in the recreational catch (Figures 39 and 40). Canary rockfish are slow growing, taking seven to nine years to reach sexual maturity (Echeverria 1987). Adams (1992b) noted declines in commercial length and suggested the species needs additional monitoring in the future.

The annual average recreational catch of brown rockfish increased from 26 MT to 91 MT between 1958–61 and 1981–86 (Table 5). Brown rockfish showed the greatest drop in average weight per fish of all 16 rockfishes, declining from 1.14 to 0.58 kg/fish, a 49% decrease. Lengths declined to the point where, as with canary rockfish, most of the recreational catch in 1980–86 was sexually immature.

Recreational and commercial catches of lingcod rose by 74% and 55%, respectively, between the 1958–61 and 1981–86 surveys (Figure 5). The CPFV catch, percent of CPFV catch, CPFV catch per fishing day, and commercial catch have been in slow oscillating decline since the early 1970s, with the oscillations caused by strong year-classes (Figures 43 and 44). The average slope of decline has been about 2% per year for the commercial catch and 3% per year for the CPFV catch. Mean length in the central California CPFV catch, adjusted for the 22-inch size limit, decreased significantly between 1966–72 and 1980–86; the average decrease was 1.9 mm per year. The decreases in catch and mean length may partially be artifacts of the strong 1960 year-class, and the decreases in CPFV catch statistics since 1980 may partially be artifacts of bag and size limit changes. Adjusted mean length in the central California CPFV catch increased significantly between 1959–64 and 1980–86. Considering the above, we are uncertain if the decreases in catch statistics and mean length since the early 1970s have been caused by stress to the population and represent a trend that will continue, or if they are effects of ongoing natural variations. The rates of the apparent decreases do not portend imminent fishery collapse. In 1993, relatively large numbers of juvenile lingcod were seen in underwater surveys (D. VenTresca, CDFG, pers. comm.), so landings may rise again in the near future. However lingcod stocks are vulnerable to overfishing. Stocks have become depressed, probably due to overfishing, in Puget Sound, Washington and in the Strait of Georgia, British Columbia (Yamanaka and Richards 1993). The desirability of lingcod combined with the decline of salmon and nearshore gill net fisheries provide a high likelihood that additional fishing pressure will focus on lingcod stocks, and more specific and efficient fishing methods will develop. For example, nearshore commercial hook-and-line fishing for lingcod and rockfish has increased greatly in recent years.

5.4. Management Options for Rockfish and Lingcod

Several approaches to the management of the recreational fishery for rockfish have been recommended including reduced bag limits, size limits, seasonal closure, and rotating area closure (Miller and Geibel 1973; VenTresca 1991). Problems associated with recreational management of rockfish include 1) difficulty in identifying individual species and 2) mortality associated with swim bladder expansion and stomach eversion that precludes catch and release as a management tool for most species. Studies of blue rockfish (Miller et al. 1967), a shallow-water species, showed that it would not suffer undue mortalities from capture and release if a size limit of 254 mm (10 inches) were imposed. Miller and Geibel (1973) suggested such a size limit would protect the stock from excessive mortality of sexually immature individuals. Blue rockfish are also easy to distinguish from other species except black rockfish (Miller and Lea 1972). The size minimum could be applied to both species. Relatively few black rockfish are taken in central California, while in northern California almost all were larger than 254 mm in 1980–86 (Figure 34).

Another strategy, which would decrease recreational impact on rockfish stocks collectively, would be to reduce the current bag limit of 15 fish in combination of species. A 10-fish limit would reduce the number taken by 9% while a six-fish limit would reduce the number taken by 25%. A 10-fish limit would affect only 6% and a six-fish limit 14% of the anglers with catches larger than the proposed limits (Figure 53).

Seasonal closure is another alternative that could be applied individually or collectively to the rockfish complex. One or more months could be closed during the peak rockfish take period of June through October (Figure 23). A closure to all species of rockfish would be less palatable for the recreational fishery of central California where an alternate fishery for salmon is less available.

Rotating area closure is another management option that could be used to reduce impact on species such as blue rockfish and yellowtail rockfish that have been described as residential and subject to localized exploitation (Miller and Geibel 1973; Carlson 1986). Carlson and Haight (1972) described evidence of home site and homing by adult yellowtail rockfish. Carlson (1986)

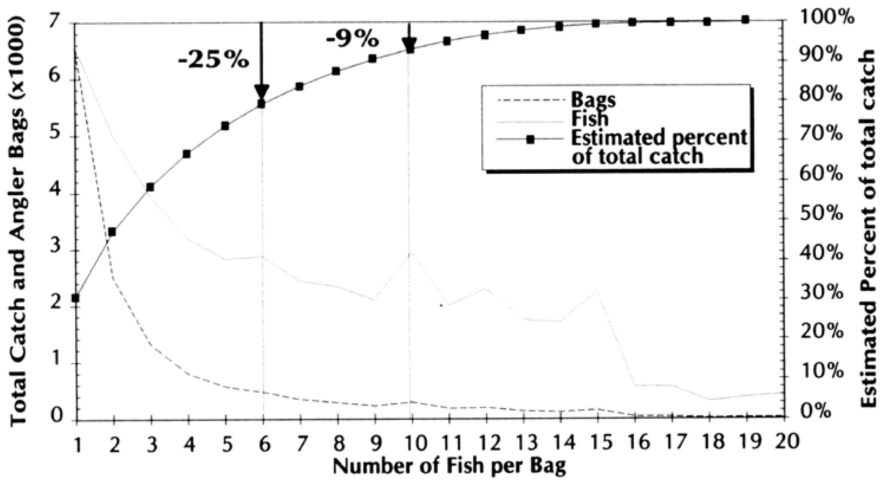


FIGURE 53. Rockfish bag frequency and cumulative catch by number of fish per bag from single-angler bags, 1980–86

FIGURE 53. Rockfish bag frequency and cumulative catch by number of fish per bag from single-angler bags, 1980–86

studied a school of yellowtail rockfish on a sunken ship over an 11-year period and found negligible recruitment as a residential cohort grew. Miller and Geibel (1973) found little movement among tagged adult blue rockfish. Matthews (1990) displaced tagged copper rockfish, quillback rockfish, and brown rockfish. The fish showed homing behavior, returning to areas of quality habitat. Miller and Geibel (1973) described rotating area closures as feasible if two to three areas were rotated for periods of three to five years for each port area. They argued that such closures could allow increased sizes for heavily exploited stocks to develop provided that such closures were enforceable and applied to both inshore recreational and commercial fisheries. Increased pressure on areas left open could be addressed by simultaneously imposing decreased bag limits, size limits, or seasonal closures.

An alternative to rotating closures is permanent closure of selected areas to both recreational and commercial fisheries (Davis 1989). Such areas could provide refuge for brood stocks of large residential adult rockfish and other nonmigratory species, which could provide recruitment for other areas of the coast. An alternative to recreational and commercial closure of specified areas would be commercial closure only. For example, selected nearshore areas could be closed to commercial take of rockfish.

As our human population has grown, fishing technology has rapidly advanced and demands on fishery resources have rapidly increased. Management actions have frequently been too little and too late to stem fishery declines. Permanent closure of selected areas may become one of the few reliable management strategies for protecting fishery stocks (particularly rockfish that are late-maturing, long-lived, and have low natural mortality) for use by future generations.

Trends in lingcod catch should be closely monitored. If the downward trend continues, actions to reduce harvest should be taken. Since lingcod and rock-fish are taken by both the recreational and commercial fisheries, management strategies that reduce overall fishing effort, such as area or seasonal closures that prohibit all fishing, would reduce harvest of lingcod. Options that might apply only to lingcod include decreasing the bag limit, increasing the minimum size limit, and prohibiting take of lingcod during the egg incubation season.

Decreasing the bag limit for lingcod would decrease recreational harvest. Decreasing the bag limit to three fish would reduce recreational harvest by 11% and decrease the catch of 10% of the anglers; a two-fish limit would reduce harvest by 21% and reduce the catch of 17% of the anglers (Figure 54).

Increasing the minimum size limit for lingcod would decrease take, and may provide additional opportunity for fish to reproduce before being caught, resulting in a higher quality fishery of larger fish. Miller and Geibel (1973)

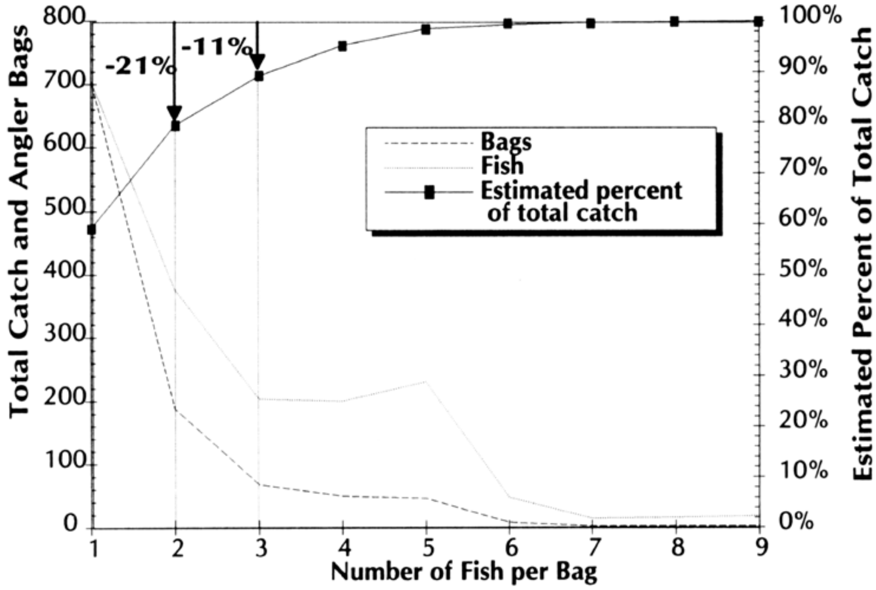


FIGURE 54. Lingcod bag frequency and cumulative catch by number of fish per bag from single-angler bags, 1980–86

FIGURE 54. Lingcod bag frequency and cumulative catch by number of fish per bag from single-angler bags, 1980–86

suggested a limit of 24 inches (610 mm), with an interim limit of 22 inches (560 mm) gradually progressing to 24 inches (610 mm) to minimize economic impacts to recreational fisheries. The present 22-inch limit could be increased to the 24-inch recommendation of Miller and Geibel (1973). Adams (1986) estimated that increasing the size at recruitment increased yield of lingcod biomass only under conditions of high fishing mortality (F = 0.7), but it increased yield of eggs under both high (F = 0.7) and low (F = 0.2) fishing mortality. Any effective program to increase size at recruitment should apply to commercial as well as recreational fisheries. One relatively simple and logical action would be to apply the recreational minimum size limit to commercial hook-and-line fisheries.

Prohibiting take of lingcod during the egg incubation season would decrease overall take and may also avoid take of nest-guarding males and decrease egg mortality. The aggressive behavior of nest-guarding males makes them especially susceptible to spear fishing and may also make them more susceptible to lures or bait. The State of Alaska has closed some nearshore areas to lingcod harvest from January through May to protect nest-guarding males from hook-and-line fisheries (V. O'Connell, Alaska DFG, pers. comm.). In northern and central California, closure of lingcod harvest during the egg incubation season (November–April) could be accomplished without affecting the period of major harvest (Figure 45).

A minimum size limit requires unhooking and releasing any undersize fish caught. Bag limits and seasonal closures also require release of fish if other species are being targeted after the limit has been reached or the season closed. Those management strategies require high survival of hooked-and-released fish. Survival of hooked-and-released lingcod is not known, but has been presumed high since they lack a swim bladder and have relatively tough mouth tissues. The use of bait, which the fish frequently swallow, probably results in lower survival than the use of artificial lures.

5.4.1. *Areas for Future Work*

Future research should be directed towards both the principal species taken and also those undergoing stress. Types of research needed include identifying units of stock by region, assessing stock size, exploring feasibility of rotating area closures, and identifying the impacts of other fisheries. Species that should be considered include blue rockfish, yellowtail rockfish, canary rockfish, brown rockfish, and lingcod. Stock size assessment models such as stock synthesis or cohort analysis could be developed for both blue rockfish and yellowtail rockfish. A precursor to such assessments should include agestructure analysis of recruitment patterns by area in central and northern California to identify more clearly what areas constitute isolated stocks. Our blue rockfish length-frequency analysis found little modal dominance from San Mateo County north, and similar modal progressions from Santa Cruz County south. Age data are needed, especially in the north, where modal dominance may be obscured by larger and perhaps older fish that have yet to be fished down.

Stocks of yellowtail rockfish off California are not clearly understood (Tagart 1991). Age analyses have been applied exclusively to trawl catch, not to recreational catch which comprises the majority of landings south of Sonoma County. Recruitment patterns could be used to determine whether the same unit stock is being exploited by both fisheries throughout California (Tagart 1991). The same types of questions applied to yellowtail rockfish and blue rockfish should be addressed for canary rockfish and brown rockfish. Unfortunately, recreational fisheries for those species may not be large or important enough to warrant the level of research effort needed for stock assessment.

Fugure investigations of lingcod should focus on whether lingcod stocks are in decline and on what management measures may be necessary. Such work should include estimation of current recreational catch, further analysis and evaluation of total commercial and recreational catch, and age-structured stock assessment. Since population levels and harvest are apparently driven by strong year-classes, monitoring year-class strength at an early age could be beneficial to management. Tagging studies and spawning-nest surveys using submersibles or remote cameras would help define inshore and offshore stocks. A study of the survival of fish that are hooked and released would help evaluate management alternatives involving catch and release of lingcod. A study of the impact of fishing on nest-guarding males and resultant egg mortality would help determine the value of a seasonal closure. Additional study of lingcod length at sexual maturity in different northern and central California locations would clarify length-maturity relationships and the value of the present recreational size limit and alternatives.

The feasibility of rotating area closures should be investigated as a management alternative. A precursor to such an investigation would be establishment of reserves in presently exploited areas. Each reserve should consist of several miles of coastline at depths encompassing the ranges of residential species. Residential species such as blue rockfish, subadult brown rockfish, black-and-yellow rockfish, gopher rockfish, kelp rockfish, treefish, yellowtail rockfish, china rockfish, cabezon, kelp greenling, and nest-guarding male lingcod (Miller and Geibel 1973; Feder et al. 1974; Matthews 1989; Larson 1992) could be monitored in the newly established reserves and in adjacent areas. Such studies could involve intensive creel survey, tagging studies, and research collections. Initially, intensive surveys would be needed to establish baseline species composition, stock abundance, and length frequencies. Changes in size and CPUE could be monitored over time to establish species recovery rates.

Our findings, based indirectly on species composition, are that CPFVs and PRBs have shifted toward the utilization of deep-water rockfish stocks since the 1958–62 survey period. Location and depth-at-capture data are needed from future marine recreational fishery surveys to more effectively evaluate changes in fishing power and the effects of competing fisheries.

of most immediate management importance is an assessment of the impacts on nearshore (within three miles) stocks of the commercial long-line and other "alternate gear" fisheries that in recent years have replaced set-net fisheries (Haseltine and Thornton 1990) and have expanded greatly into nearshore areas formerly subject mainly to sport fishing.

5.5. Implications of Dominant Cohorts for Rockfish and Lingcod

Five of the six rockfish species with sufficient length-frequency data for interannual comparisons showed clear evidence of modal progressions indicating dominant periods of recruitment. The modal progressions were evident in spite of limitations, such as differential growth rates between sexes, inherent in using length distributions to follow year-classes. The sixth species, chilipepper, lacked a clear length-frequency pattern in the data we examined, but had strong year-class dominance determined from aging studies (Rogers and Bence 1992). Lingcod was also found to follow a pattern of year-class dominance. Year-class dominance is probably common among rockfish and lingcod in central California.

Using Ford-Walford plot analysis for blue rockfish and published ages for lingcod, chilipepper, bocaccio, and yellowtail rockfish, we plotted approximate birth years for major cohorts discussed in the text (Figure 55). The only cohorts examined were for the period when length-frequency data were available.

ENSO events (Dayton and Tegner 1989; Norton and McLain 1994), sea level height, southward transport, and zooplankton volume (Chelton et al. 1982) were compared to the timing of the recruitment events (Figure 55). Chelton et al. (1982) provided a time series of zooplankton volume and southward transport in the California Current that was continuous from 1950 through 1969. Their time series is intermittent following 1969 when CalCOFI cruises were cut back. They reported that San Diego, Los Angeles, and San Francisco averages of low sea levels corresponded to above normal southward transport and zooplankton biomass. Sea level heights provide a longer time series for comparison of changes affecting the California Current. Extremely high sea levels correspond to the three most recent major ENSOs in 1941, 1958, and 1983 (Chelton et al. 1982; Hollowed and Wooster 1992). Norton (1987) and Hollowed and Wooster (1992) used combinations of such physical parameters to characterize "cold" or "warm" years that were related to recruitment events for 14 species of groundfish.

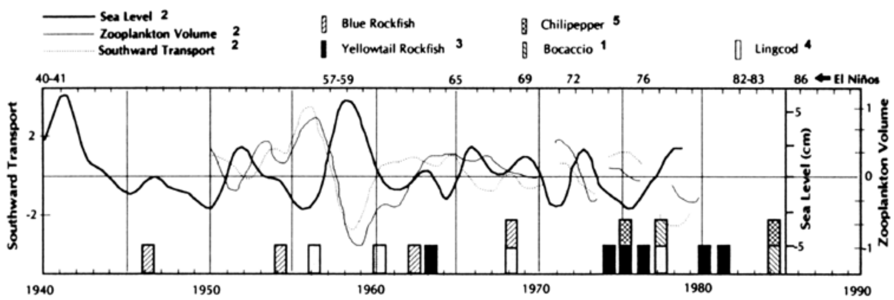


FIGURE 55. Large cohort recruitment events, ENSOs (1940–90), southward transport, sea level height, and zooplankton volume in offshore waters of California (1950–80) ([1]Bence and Rogers 1993; [2]Chelton et al. 1982; [3]Tagart 1991; [4]Miller and Geibel 1973; [5]Rogers and Bence 1992).

FIGURE 55. Large cohort recruitment events, ENSOs (1940–90), southward transport, sea level height, and zooplankton volume in offshore waters of California (1950–80) ([1]Bence and Rogers 1993; [2]Chelton et al. 1982; [3]Tagart 1991; [4]Miller and Geibel 1973; [5]Rogers and Bence 1992)

The limited number of species we examined, imprecise methods used to assign birth year, and short time series for some species preclude any strong inferences from our results. However some generalizations can be drawn and comparisons made to the results of Norton (1987) and Hollowed and Wooster (1992).

Generally, except for bocaccio and chilipepper in 1984 and lingcod in 1960, we did not find major recruitment events during or immediately following the 1957–59 or 1982–83 ENSO periods. Hollowed and Wooster (1992) found synchrony of extremely weak or strong year-classes for various species of northeastern Pacific groundfish. Synchrony of extremely weak year-classes occurred in 1953, 1954, 1958, 1959, and 1983 supporting our result that recruitment failure is likely during major ENSO events. They also found synchronous strong recruitment events in 1961, 1970, 1977, and 1984 that were associated with "warm" periods following major ENSOs characterized by reduced southward transport in the California Current. Among the species we examined, only bocaccio and lingcod had major cohorts in 1977 and bocaccio and chilipepper in 1984.

Norton (1987) compared sizes of year-classes recruited into California commercial catches of widow rockfish and chilipepper to the ocean climate for the 1965 to 1980 period. Most widow rockfish were recruited during "warm" years, and most chilipepper during "cold" years. The strong 1975 year-class for chilipepper fits the pattern—a year of low sea levels, high zooplankton, and southward transport—while the 1984 "warm" year (Hollowed and Wooster 1992) does not (Figure 55).

Generally, major recruitment events for blue rockfish or yellowtail rockfish occurred during years of elevated southward transport and zooplankton abundance (1954, 1968, 1974, and 1975) (Figure 55). Exceptions occurred for blue rockfish in 1962, a year of elevated southward transport but not zooplankton. Exceptions for yellowtail rockfish occurred in 1976, a year of high southward transport, average zooplankton, and low sea level, and in 1980, a year of low southward transport.

Lingcod showed no pattern of year-class strength and oceanic conditions other than absence of recruitment during the two major ENSOs (Figure 55). The 1956 and 1968 year-classes were during years of high southward transport and zooplankton production, while 1960 and 1977 were both years of low southward transport.

Recruitment failure of yellowtail rockfish and blue rockfish during major ENSO events seems likely considering the reduced growth and increased mortality of both species during the 1982–83 ENSO. Direct impacts on gonadal development of yellowtail rockfish (Lenarz and Echeverria 1986) would reduce the number of larvae released. Direct mortality of adult blue rockfish described by Bodkin et al. (1987), or implied by our length-frequency analysis for both species, would directly affect the number of spawners. An additional source of mortality not addressed in our study is juvenile mortality in nearshore nursery areas. Warm water and decreased upwelling of nutrients associated with ENSO events directly reduced kelp canopy in southern California (Dayton and Tegner 1989) and would be expected to impact survival of juvenile blue rockfish that utilize those areas as nurseries.

Blue rockfish and yellowtail rockfish have epipelagic larvae and juveniles found in the California current (Miller and Geibel 1973; Ahlstrom et al. 1978; Lenarz et al. 1991). The larvae and juveniles of lingcod are also epipelagic with a strong nearshore distribution (Adams et al. 1993). Periods of southward transport associated with high zooplankton productivity (Chelton et al. 1982) may favor survival of larvae or presettled juveniles of blue rockfish, yellowtail rockfish, and lingcod.

5.5.1. *Areas for Future Work*

Additional studies are needed to assess environmental effects on rockfish and lingcod including 1) studies to establish population age structure; 2) studies to determine life stages contributing to establishment of strong year-classes (e.g. spawning success, larval or juvenile survival); and 3) the relative effects of ocean climate change by area of California.

To clearly identify periods of year-class success, aging based on age structures is needed for more rockfish and lingcod. Our study, which based age indirectly on size data and published age determinations from commercial trawl samples, is of limited value and cannot be applied to all species nor to all areas for the same species. Except for brown rockfish, all species we examined have differential growth rates for males and females (Miller and Geibel 1973; Echeverria 1987), which would obscure modal-progression analysis, especially at larger sizes where differences are most pronounced. In northern California, where blue rockfish stocks had not been fished down to the sizes seen in central California, the lack of discernible modes may in part reflect an accumulation of many year-classes of older fish. Age data derived from trawl fisheries may not be representative of inshore catches of all species. Trawl samples of yellowtail rockfish represented larger fish taken mostly in northern California, while recreational catches were of smaller fish taken throughout California.

Accurate age-structure analysis of adults would identify strong cohorts to match ongoing larval, juvenile, and adult assessments to identify the genesis of strong year-classes. Quantitative data from CalCOFI larval assessments and juvenile rockfish surveys, both offshore using trawl surveys (Lenarz et al. 1991; Adams 1992a) and nearshore in nursery areas, could be compared to results from adult age-structure analysis. Ongoing studies on the condition of adults reflecting gonadal condition (e.g. Lenarz and Echeverria (1986) on yellowtail rockfish) are needed to establish when year-class success or failure can be tied to spawning success.

Roughgarden et al. (1988) described a cline of diminishing nearshore Ekman-based upwelling from central California to Oregon that collapsed during the 1983 ENSO. The effects of the upwelling and ENSO events on growth could be more fully tested using adult age structures. A recent study by D. Woodbury (NMFS, unpublished data) on yellowtail rockfish showed that significant decreases in otolith deposition occurred during the 1982–83 ENSO. Similar effects were observed with otoliths of chilipepper (J. Mello, CDFG, pers. comm.) and canary rockfish (M. Yoklavich, NMFS, pers. comm.). Such work could logically be applied to blue rockfish. Blue rockfish are known to feed in response to periods of upwelling (Hobson and Chess 1988) and showed depressed growth during the 1982–83 ENSO (D. VenTresca, CDFG, pers. comm.). Otoliths from different locations along the California coast should be examined for evidence of clinal effects of the 1982–83 and 1992 ENSO events.

5.6. Surfperch

Earlier in this bulletin we described the importance of surfperch (family Embiotocidae) to the catch of the shore-based modes during both the 1958–61 and 1980–86 survey periods (Figure 6; Figures 14–17). The surfperch were also the only major species category where both sport and commercial catch decreased substantially between the two surveys (Figure 5). of the 21 species in the surfperch family, 19 are found in California (Eschmeyer et al. 1983). Seventeen of those were found in the 1980–86 MRFSS creel surveys in northern and central California (Table 9). The more commonly taken species were barred surfperch, redtail surfperch, silver surfperch, walleye surfperch, striped seaperch, white seaperch, shiner perch, and pile perch. Our analysis focuses on those species. Black perch and rubberlip seaperch were relatively uncommon but were included in some analyses.

The surfperch family ranges mainly from subtropical Baja California to subarctic Alaska; two species are found in the Sea of Japan and one California species is restricted to freshwater (Tarp 1952). The primary factor affecting distribution is temperature. Southern California is the latitudinal center of distribution (Tarp 1952). of the 18 species found in California marine waters, eight have northern range limits and one has a southern range limit in northern

TABLE 9. Distribution, habitat, and reproductive ecology summary for marine surfperches found in California.

Common Name	Main Habitat	Subfamily	Estuary Use	Males in Estuaries	Sperm Storage	Ave. Brood Size
Barred surfperch	Sandy beaches	Amphistichinae	No	-	None	33.4
Shiner perch	Several habitats	Embiotocinae	Yes	Yes	Long	9.5
Walleye surfperch	Several habitats	Amphistichinae	Yes	Yes	None	9
Redtail surfperch	Sandy beaches	Amphistichinae	Yes	No	~	25
Striped seaperch	Reefs and kelp	Embiotocinae	Yes	Yes	Long	18
Silver surfperch	Sandy beaches	Amphistichinae	Yes	-	Short	10
White seaperch	Several habitats	Embiotocinae	Yes	-	Short	~
Pile perch	Several habitats	Embiotocinae	Yes	-	~	30
Black perch	Reefs and kelp	Embiotocinae	No	-	Short	14.4
Rubberlip seaperch	Several habitats	Embiotocinae	Yes	-	~	~
Calico surfperch	Sandy beaches	Amphistichinae	No	-	~	~
Rainbow seaperch	Reefs and kelp	Embiotocinae	Yes	No	~	11.6
Sharpnose seaperch	Reefs and kelp	Embiotocinae	No	-	~	~
Spotfin surfperch	Sandy beaches	Amphistichinae	No	-	~	8
Kelp perch	Reefs and kelp	Embiotocinae	No	-	~	~
Reef perch	Reefs and kelp	Embiotocinae	No	-	Long	~
Dwarf perch	Reefs and kelp	Embiotocinae	No	-	Long	~
Pink surfperch	Reefs and kelp	Embiotocinae	No	-	Long	3.5

~ Insufficient data - No data

(Sources: Tarp 1952; Carlisle et al. 1960; Gordon 1965; Miller and Lea 1972; Feder et al. 1974; Odenweller 1975; Behrens 1977; Bennett and Wydoski 1977;

TABLE 9. Distribution, habitat, and reproductive ecology summary for marine surfperches found in California

and central California. The other species have northern limits north of California and southern limits in southern California or Baja California (Table 9).

Common names of the surfperches indicate habitats they frequently use (Table 9). "Surfperch" generally use sandy and rocky surf areas, "seaperch" generally use kelp forests and open ocean reef areas, and "perch" use a variety of habitats (McClane 1965). The naming convention is not entirely indicative of habitat use, and habitat use may also change during mating and birthing.

Life history differences within the surfperch are many, and include differences in growth rate, longevity, fecundity, breeding habitat, age at first reproduction, and size of young. Surfperch are viviparous and have low fecundity with an average brood size of 15 (Table 9). Newborn are large (3–6 cm long) (Odenweller 1975; Behrens 1977) and highly developed (Eschmeyer et al. 1983). Females of many species generally migrate to bays and estuaries, if available nearby, presumably to give birth (Gordon 1965; Bennett and Wydoski 1977; DeMartini et al. 1983).

Distribution in catch	Latitude Range (° North)	Depth Range (m)	Temp. Range (° C)	Number Sampled 1980-86	Mean Annual Sport Catch 1981-86 (x1000)
Southern, common	38-29	0-73	11-21.5	6211	1031
Coastwide, common	56-30	0-146	4-18	4156	623
Coastwide, common	49-29	0-18	7-21	3944	560
Northern, common	49-36	0-7	7-19	3935	400
Northern, common	56-31	0-24	4-21	3263	271
Northern, common	49-30	0-110	7-21	2646	414
Coastwide, common	49-31	0-43	7-21	1560	278
Coastwide, common	56-29	0-46	4-21	1055	477
Southern, infrequent	39-27	0-55	11-21	752	219
Southern, infrequent	39-28	0-55	11-21	735	218
Coastwide, infrequent	46-31	0-9	10-21	680	~
Southern, infrequent	40-32	0-40	12-21	426	~
Southern, infrequent	38-28	0-230	11-21	76	~
Southern, rare	44-29	0-90	11-21	38	~
Coastwide, rare	50-28	0-30	7-21	8	~
Southern, rare	38-30	0-6	11-21	2	~
Southern, rare	38-28	0-9	11-21	1	~
Southern, not seen	38-27	9-90	11-21	0	~

Ellison et al. 1979; DeMartini et al. 1983; Eschmeyer et al. 1983; Fritzsche and Hassler 1989; Fritzsche et al. 1992; Brookins MS[a]; CDFG data)

EQUATION

Some species use eelgrass (Zostera spp.) beds in estuaries for birthing and nursery habitat. The birthing period varies among species but generally occurs in spring and early summer (Hubbs 1921; Turner 1938; Lagios 1965; Odenweller 1975), with birthing delayed with increasing latitude. Age at sexual maturity varies. Dwarf seaperch males are mature at birth (Hubbs 1921); other species reach maturity as late as the third year.

Surfperch are a significant trophic component of many nearshore marine habitats, where they glean small invertebrates and fish eggs from substrates (Carlisle et al. 1960; McClane 1965; Odenweller 1975; Bennett and Wydoski 1977; Ellison et al. 1979). Habitats used by various species include sandy beaches, rocky reefs and inlets, kelp forests, and estuaries. In the spring months, juvenile and adult surfperch consume breeding adult and larval stages of sand crabs (Emerita analoga) over sandy beaches (Ricketts and Calvin 1939; Morris et al. 1980). In winter and spring, young surfperch in estuaries may feed on herring and silverside eggs deposited on eelgrass or other substrates (Carlisle et al. 1960; Hardwick 1973). Shiner surfperch in Anahiem Bay feed primarily on zooplankton (Odenweller 1975). Surfperch are eaten by piscivorous fish, marine mammals, birds, and humans.

The prevalence of surfperch in the catch of shore fisheries (Figure 7, 14–17) attests to their nearly exclusive use of relatively shallow nearshore habitats that includes bays and estuaries (Figure 56). The depth distribution of most species is limited to waters less than 100 m deep, and many are limited to waters less than 30 m deep (Table 9).

5.6.1. *Season and Habitat*

The surfperch family is divided into two subfamilies, the Amphistichinae and the Embiotocinae (Table 9), which differ morphologically in the joining of prefrontal bones, in the male anal fins and glands, and in the female ovarian structure (Tarp 1952; Hopkirk 1962). Males of the Embiotocinae have a specialized flask-shaped anal gland that contains sperm during the breeding season. In some species of the Embiotocinae, males accompany females to birthing areas, mating occurs immediately after birthing, and females store sperm for several months before fertilization occurs (Hubbs 1921; Gnose 1967; Warner and Harlan 1982) (Table 9). The use of estuaries by males tends to be more common in the Embiotocinae than the Amphistichinae (Brookins MS[a]). In the 1980–86 MRFSS, the Embiotocinae were more frequently caught in bays and estuaries than the Amphistichinae, and the converse was true in the open ocean (Figure 56). Except for shiner perch, catch of the Embiotocinae in bays and estuaries peaked in the winter and spring months. Among the Amphistichinae, barred surfperch, redtail surfperch, and silver surfperch were taken more frequently in the ocean than in bays and estuaries, but 58% of the walleye surfperch were taken in bays and estuaries.

5.6.2. *Historical Comparison*

Between the 1958–61 and 1981–86 surveys, surfperch average weights and catches declined (Figure 57). The average annual catch of surfperch, excluding the San Francisco Bay PRB fishery, dropped from 1,254,000 fish to 761,000 fish (-39%); the average annual catch by weight declined from 420 to 193 MT (-54%) (Table 10). The percentage of surfperch in the hook-and-line sport catch dropped from 48% to 29% from piers and docks and from 72% to 55% from other shore locations. The downward trend in catch was due mainly to reductions in barred surfperch, redtail surfperch, shiner perch, silver surfperch, and walleye surfperch (Table 10). Two of the most important species by number and weight in 1958–61 and 1981–86, barred surfperch and redtail surfperch, had the largest reductions in weight landed. However, catches of pile perch, black perch, and rubberlip seaperch increased.

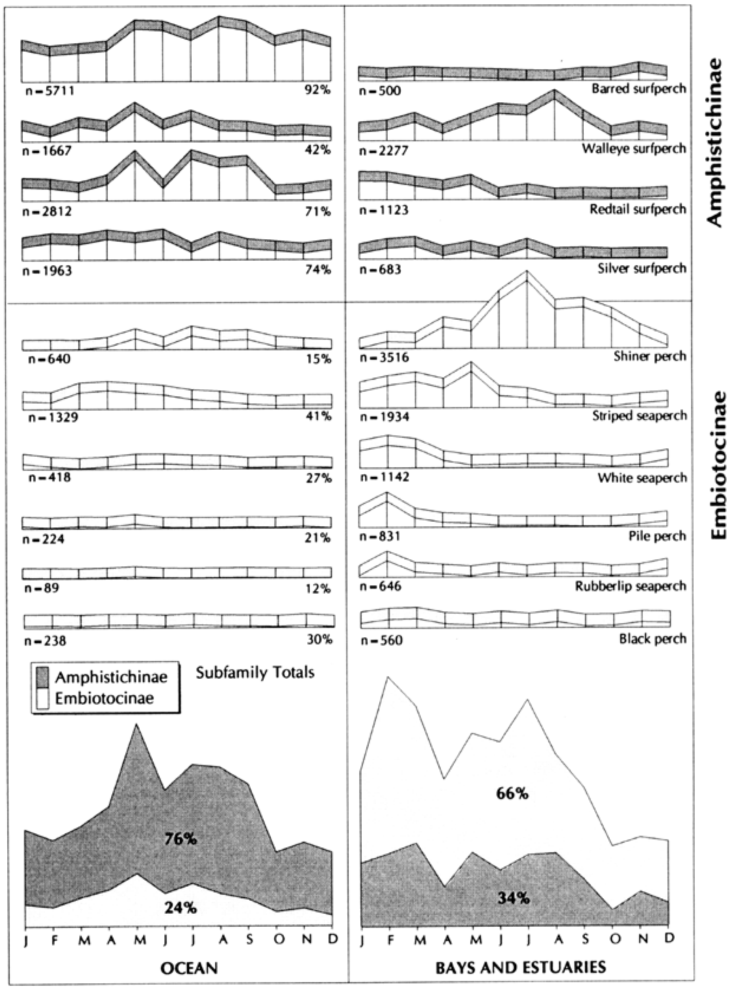


FIGURE 56. Monthly sampled catch by number of common surfperch species in MRFSS creel samples from 1980–86 for the open ocean and in bays and estuaries.

FIGURE 56. Monthly sampled catch by number of common surfperch species in MRFSS creel samples from 1980–86 for the open ocean and in bays and estuaries

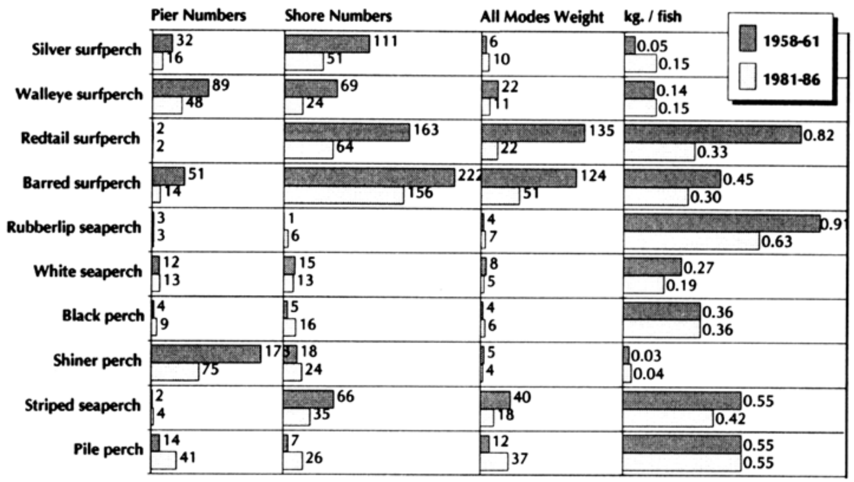


FIGURE 57. Historical comparison of surfperch catch by numbers (thousands), weight (metric tons), and average weight (kg/fish) by mode for northern and central California from 1981–86.

FIGURE 57. Historical comparison of surfperch catch by numbers (thousands), weight (metric tons), and average weight (kg/fish) by mode for northern and central California from 1981–86

TABLE 10. Average annual number (thousands) and weight (MT) of surfperches caught in northern and central California marine recreational fisheries, 1958–61 and 1981–86.

	Pier & Dock				Shore				PRB*			
	58-61		81-86		58-61		81-86		58-61		81-86	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Barred surfperch	51	10	14	5	222	30	156	34	0	0	0	4
Black perch	4	1	9	3	5	1	16	4	1	10	1	6
Pile perch	14	3	41	14	7	1	26	6	1	7	0	4
Redtail surfperch	2	0	2	1	163	22	64	14	0	2	1	10
Rubberlip seaperch	3	1	3	1	1	0	6	1	0	3	1	5
Shiner perch	173	35	75	27	18	2	24	5	0	2	0	3
Silver surfperch	32	6	16	6	111	15	51	11	0	2	1	4
Striped seaperch	2	0	4	2	66	9	35	8	2	18	2	18
Walleye surfperch	89	18	48	17	69	9	24	5	3	37	1	11
White seaperch	12	2	13	5	15	2	13	3	2	20	1	10
Other surfperches	114	23	56	20	65	9	46	10	0	1	3	25
All surfperches	498	100	282	100	743	100	461	100	9	100	11	100
All fish	1034	48	966	29	1025	72	834	55	337	3	1830	1

TABLE 10. Average annual number (thousands) and weight (MT) of surfperches caught in northern and central California marine recreational fisheries, 1958–61 and 1981–86

CPFV				Spear				Total*							
58-61		81-86		58-61		81-86		58-61		58-61		81-86		81-86	
No.	%	No.	%	No.	%	No.	%	No.	%	Wt.	%	No.	%	Wt.	%
-	-	0	9	-	-	-	-	274	22	124	30	170	22	51	26
-	-	-	-	0	9	1	9	11	1	4	1	27	4	6	3
-	-	-	-	1	25	1	16	22	2	12	3	68	9	37	19
0	16	-	-	-	-	-	-	165	13	135	32	67	9	22	11
-	-	-	-	0	8	1	11	5	0	4	1	11	1	7	3
-	-	-	-	-	-	-	-	192	15	5	1	100	13	4	2
-	-	-	-	-	-	-	-	143	11	6	2	67	9	10	5
0	44	-	-	3	53	3	40	73	6	40	9	44	6	18	9
-	-	-	-	-	-	-	-	161	13	22	5	73	10	11	6
-	-	-	-	-	-	-	-	29	2	8	2	27	4	5	3
0	40	1	91	0	5	2	24	180	14	59	14	107	14	22	12
0	100	1	100	5	100	7	100	1254	100	420	100	761	100	193	100
1231	<1	2433	<1	22	23	40	17	3649	34	2441	17	6274	12	4524	4

*Excludes San Francisco Bay

EQUATION

Between the 1958–61 and 1981–86 surveys average weight per surfperch caught, excluding San Francisco Bay, declined from 0.34 to 0.25 kg/fish. Decline in size occurred among barred surfperch, redtail surfperch, striped seaperch, rubberlip seaperch, and white seaperch (Figure 57). Redtail surfperch, the second most important species in number and weight landed, had the greatest decline in size from 0.82 to 0.33 kg/fish. The dominant species, barred surfperch, declined from 0.45 to 0.30 kg/fish.

Several factors may have contributed to the decline in surfperch landings and sizes including low fecundity, degradation of estuarine nursery areas (Carlisle et al. 1960), and increases in natural or fishing mortality (Ricker 1975). The low fecundity of surfperch reduces the possibility of strong year-classes (Carlisle et al. 1960). Royce (1975) warned that species with low fecundity have limited recruitment potential and are more vulnerable to overharvest than highly fecund species.

Surfperch declines may also be caused by loss of nursery and nearshore habitat along coastal California. Destruction of habitat and pollution of inshore areas has occurred (California Coastal Commission 1987), but their effect on surfperch populations has not been quantified.

5.6.3. *1981–86 Catch*

The average annual recreational catch of all surfperch species in 1981–86, including San Francisco Bay PRB fishing, was 875,000 fish weighing 240 MT (Tables 11 and 12). The top species by number caught were barred surfperch, shiner perch, walleye surfperch, and the perch. The top species by weight caught were barred surfperch, pile perch, rubberlip seaperch, and redtail surfperch. Large portions of the catch came from San Francisco Bay and the Santa Cruz/Monterey district. Surfperch were caught mainly from shore-based modes (85%) (Table 11). PRBs accounted for most of the remaining catch. Relatively few surfperch were caught by the spear mode (1%) and fewer by CPFV anglers.

The mean weight of all surfperch declined in a north-south gradient from 0.33 kg/fish in Del Norte/Humboldt to 0.22 kg/fish in San Luis Obispo (Table 12); the gradient was somewhat evident within individual species. The mean weight of surfperch from all districts ranged from 0.04 kg/fish (shiner perch) to 0.68 kg/fish (rubberlip seaperch). The mean weight also varied by fishing mode (Table 11). Spear mode averaged 0.58 kg/fish, followed by PRB (0.40 kg/fish), beach and bank (0.29 kg/fish), jetty and breakwater (0.28 kg/fish), CPFV (0.22 kg/fish) and pier and dock (0.18 kg/fish). The spear mode may

TABLE 11. Number (thousands), percent by number, weight (MT), and average weight (kg/fish) of surfperch caught in northern and central California marine recreational fisheries, 1981–86, by fishing mode.

	Pier & Dock				Jetty & Breakwater				Beach & Bank			
	No.	%	Wt.	Ave.	No.	%	Wt.	Ave.	No.	%	Wt.	Ave.
Barred surfperch	14	5	2	0.18	2	7	1	0.41	154	36	47	0.31
Black perch	9	3	2	0.21	1	5	0	0.25	15	3	4	0.24
Pile perch	41	14	19	0.46	1	4	1	0.72	25	6	17	0.67
Redtail surfperch	2	1	0	0.25	1	4	1	0.44	63	14	20	0.32
Rubberlip seaperch	3	1	2	0.68	1	2	0	0.83	5	1	3	0.51
Shiner perch	75	27	3	0.04	2	8	0	0.05	22	5	1	0.04
Silver surfperch	16	6	2	0.14	2	8	0	0.13	49	11	7	0.15
Striped seaperch	4	2	1	0.33	5	19	2	0.33	30	7	13	0.43
Walleye surfperch	48	17	6	0.13	6	20	1	0.19	19	4	4	0.19
White seaperch	13	5	2	0.17	2	6	0	0.25	11	3	2	0.18
Other surfperch	56	20	10	0.17	5	18	1	0.25	41	9	10	0.24
All surfperch	282	100	51	0.18	28	100	8	0.28	433	100	127	0.29
All Fish	966	29	230	0.24	84	33	41	0.49	750	58	253	0.34

TABLE 11. Number (thousands), percent by number, weight (MT), and average weight (kg/fish) of surfperch caught in northern and central California marine recreational fisheries, 1981–86, by fishing mode

PRB				CPFV				Spear				Total			
No.	%	Wt.	Ave.	No.	%	Wt.	Ave.	No.	%	Wt.	Ave.	No.	%	Wt.	Ave.
2	2	1	0.45	0	9	0	0.20	-		-		172	20	51	0.30
10	8	3	0.28	-		-		1	9	0	0.40	37	4	9	0.25
12	10	7	0.58	-		-		1	16	1	0.68	79	9	44	0.55
1	1	1	0.45	-		-		-		-		67	8	22	0.33
26	21	18	0.70	-		-		1	11	1	0.93	36	4	25	0.68
4	3	0	0.04	-		-		-		-		104	12	4	0.04
2	2	0	0.22	-		-		-		-		69	8	10	0.15
3	2	1	0.42	-		-		3	40	1	0.48	45	5	19	0.41
21	17	6	0.27	-		-		-		-		93	11	17	0.18
20	16	6	0.28	-		-		-		-		46	5	10	0.22
23	18	8	0.34	1	91	0	0.22	2	24	1	0.58	127	15	29	0.23
125	100	51	0.40	1	100	0	0.22	7	100	4	0.58	875	100	240	0.27
2165	7	2282	1.05	2352	0	2179	0.93	40	18	41	1.04	6357	24	5026	0.79

EQUATION

have had the highest weight per fish because larger fish can be selected. The pier and dock mode may have had the lowest weight per fish due to the predominance of shiner perch in San Francisco Bay catches.

5.6.4. *1980–86 Species Catch and Distribution Summary*

The species composition of surfperch in the 1980–86 MRFSS-sampled catch varied by fishing mode and latitude. In the beach and bank fishery, barred surfperch, silver surfperch, walleye surfperch, and calico surfperch were the major species of surfperch in central California, while redtail surfperch and striped seaperch were the major species in northern California (Figure 14). In the jetty and breakwater fishery, the main species were walleye surfperch in central California and striped seaperch in northern California (Figure 15). In the pier and dock fishery, walleye surfperch, shiner perch, and barred surfperch were the major surfperch species in central California, while walleye surfperch, white seaperch, shiner perch, striped seaperch, silver surfperch, and pile perch were the main species in northern California (Figure 16). The spear fishery took mainly pile perch, black perch, and striped seaperch in central California, while striped seaperch was the main species in northern California (Figure 17). PRB catch was mainly in San Francisco Bay, and consisted mostly of rubberlip seaperch, walleye surfperch, shiner perch, and pile perch (Table 11). In the CPFV fishery, where surfperch were rarely taken, a few black perch and striped seaperch were sampled in central and northern California respectively.

TABLE 12. Number (thousands), percent by number, weight (MT), and average weight (kg/fish) of surfperches caught in northern and central California marine recreational fisheries, 1981–86, by district.

	Del Norte/ Humboldt				Mendocino/ Sonoma				S. Francisco (Ocean)			
	No.	%	Wt.	Ave.	No.	%	Wt.	Ave.	No.	%	Wt.	Ave.
Barred surfperch	0	0	0	0.20	0	1	0	0.27	25	22	8	0.34
Black perch	-		-		0	1	0	0.30	1	0	0	0.27
Pile perch	2	2	1	0.72	1	1	1	0.80	12	11	9	0.77
Redtail surfperch	30	37	12	0.40	10	20	3	0.36	23	21	5	0.22
Rubberlip seaperch	0	0	0	0.80	1	1	1	0.75	1	1	1	0.84
Shiner perch	1	1	0	0.08	6	13	0	0.03	2	2	0	0.05
Silver surfperch	10	13	2	0.15	2	3	0	0.16	22	20	4	0.19
Striped seaperch	15	18	6	0.44	17	36	8	0.43	4	4	2	0.40
Walleye surfperch	6	7	1	0.16	1	2	0	0.18	9	8	2	0.20
White seaperch	3	4	1	0.29	2	4	0	0.20	3	3	0	0.16
Other surfperch	15	18	4	0.24	8	17	2	0.25	9	8	3	0.31
All surfperch	81	9	27	0.33	48	6	15	0.32	110	13	35	0.31
All fish	518		507		684		636		799		680	

*Total percentages are portions of combined district surfperch catch.

TABLE 12. Number (thousands), percent by number, weight (MT), and average weight (kg/fish) of surfperches caught in northern and central California marine recreational fisheries, 1981–86, by district

We developed distribution maps for the top eight surfperches using the percent of catch by number from the 1980–86 California and Oregon MRFSS data (Figures 58 59 60). We classified the surfperches into three categories of latitudinal distribution: 1) northern, 2) coastwide, and 3) southern. Northern species were those generally found only north of Point Conception: striped seaperch, silver surfperch, and redtail surfperch. Coastwide species were those that did not appear bounded to the north or south in Oregon and California: pile perch, shiner perch, walleye surfperch, and white seaperch. Southern species were generally found south of Cape Mendocino; barred surfperch was the only southern species.

5.6.4.1. Northern Species

Striped seaperch were taken from Los Angeles County northward through Oregon (Figure 58). The highest annual average percentage of total sampled catch in California occurred in Del Norte/Humboldt (5.9%), and the highest annual average in all districts occurred in Northern Oregon (6.6%). The highest annual percentage of sampled catch occurred in southern Oregon in 1985 (14.8%). Occurrence in the creel survey south of San Luis Obispo County was relatively low, and they were absent there after 1983.

S. Francisco (Bay)				Santa Cruz/ Monterey				San Luis Obispo				Total			
No.	%	Wt.	Ave.	No.	%	Wt.	Ave.	No.	%	Wt.	Ave.	No.	%	Wt.	Ave.
5	1	2	0.41	93	51	26	0.28	50	43	15	0.30	172	20	51	0.30
30	9	7	0.24	4	2	1	0.28	2	1	1	0.33	37	4	9	0.25
61	18	31	0.50	3	2	2	0.56	1	1	1	0.50	79	9	44	0.55
3	1	1	0.28	1	0	0	0.27	0	0	0	0.28	67	8	22	0.33
32	10	21	0.65	2	1	2	0.90	1	1	1	1.00	36	4	25	0.68
82	24	3	0.04	5	3	0	0.03	8	7	0	0.03	104	12	4	0.04
7	2	1	0.20	6	3	1	0.10	22	19	2	0.11	69	8	10	0.15
5	1	1	0.25	3	2	1	0.41	1	1	0	0.43	45	5	19	0.41
45	13	10	0.21	24	13	3	0.13	9	8	1	0.15	93	11	17	0.18
27	8	7	0.25	11	6	2	0.15	0	0	0	0.20	46	5	10	0.22
42	13	12	0.27	30	17	5	0.18	23	20	4	0.19	127	15	29	0.23
338	39	95	0.28	182	21	43	0.24	116	13	25	0.22	875	100	240	0.27
1120		1262		2013		1223		1223		718		6357		5026	

EQUATION

Striped seaperch were found mostly in bays and estuaries (59%) (Figure 56), where capture peaked in March and May. Secondary peaks occurred in early summer in some years. Occurrence in Mendocino/Sonoma bays and estuaries dropped steadily from 156 fish in 1981 to none in 1986. The Del Norte/Humboldt and Mendocino/Sonoma districts accounted for 71% (32,000 fish weighing 14 MT) of the estimated total catch of striped seaperch (Table 12). The highest IRIs for striped seaperch were in shore and diver modes north of San Francisco (Figures 14–17).

Silver surfperch were found in catches from Orange County northward through Oregon (Figure 58). The highest annual average percentage of total sampled catch in California occurred in Del Norte-Humboldt (2.2%). Northern Oregon had the highest annual average percentage of all districts (3.0%), and the highest single-year percentage (5.9% in 1983). Occurrence south of San Luis Obispo County was relatively low, and none were sampled south of Santa Barbara/Ventura after 1983.

Most silver surfperch sampled were from the open ocean (74%) (Figure 56). Peak catch in the ocean was in April and in the bays in March. Catch in bays and estuaries was mainly in Humboldt and San Francisco bays, while catch in the open ocean was mainly in San Luis Obispo County. The San

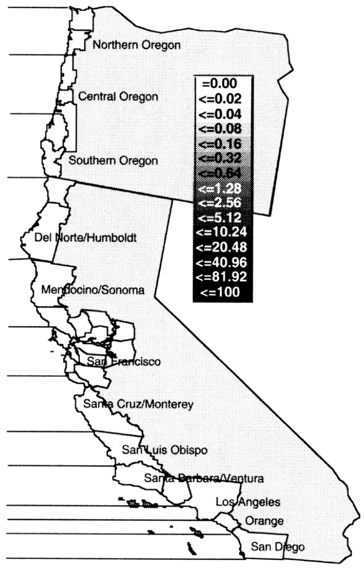
Striped Seaperch							Silver Surfperch							Redtail Surfperch						
80	81	82	83	84	85	86	80	81	82	83	84	85	86	80	81	82	83	84	85	86
-	10.4	1.88	4.74	6.09	11.4	5.15	-	2.33	3.77	5.88	0.97	2.17	3.13	-	37	1.88	33.8	15.2	12.7	13.4
-	8.16	0.27	6.88	6.18	6.42	2.2	-	0.4	0.27	1.09	0.06	0	0.02	-	13.3	3.27	13.9	8.65	17.4	9.64
-	4.76	1.42	3.79	5.58	14.8	3.46	-	3.61	2.85	3.62	1.11	0.93	0.06	-	25.3	0.95	20.3	34.2	9	3.12
8.87	4.78	5.58	7.97	6.1	2.35	5.76	3.16	1.15	0.03	2.3	2.21	4.81	1.78	16.2	16.8	17.5	13	7.98	4.98	4.87
5.42	4.9	3.86	2.64	1.95	0.71	1.2	0.51	0.43	0.11	0.15	0.09	0.16	0.14	4.69	0.7	0.48	2.77	0.83	0.69	0.33
0.56	0.18	0.4	0.44	0.22	0.2	0.18	1.01	0.9	1.45	0.51	0.28	0.71	0.16	0.59	1.96	0.93	0.74	0.19	0.2	0.02
0.12	0.11	0.53	0.07	0.04	0.07	0.04	0.99	1.04	0.2	0.58	0.36	0.18	0.25	0.02	0.01	0.23	0	0.01	0	0
0.09	0.05	0.06	0.05	0.02	0.09	0.18	1.01	3.64	4.03	0.32	2.09	1.75	1.28	0.03	0.03	0.08	0	0.21	0	0
0.02	0.04	0.57	0.01	0	0	0	0.08	0	0.57	0.29	0	0.2	1.19	0	0	0	0	0	0	0
0	0.05	0	0.17	0	0	0	0.03	0.05	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0.02	0	2.27	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FIGURE 58. Percent by number of total sampled catch of striped seaperch, silver surfperch, and redtail surfperch by district and year in California and Oregon, 1980–86.

FIGURE 58. Percent by number of total sampled catch of striped seaperch, silver surfperch, and redtail surfperch by district and year in California and Oregon, 1980–86

Francisco district (ocean and bay) accounted for 42% (29,000 fish weighing 5 MT) of the total catch of silver surfperch (Table 12). The highest IRIs were in beach/bank mode from San Francisco southward (Figure 14) and in the pier and dock mode in all districts except Mendocino/Sonoma (Figure 16).

Redtail surfperch were found in catches from San Luis Obispo northward through Oregon (Figure 58). The highest annual average percentage of total sampled catch in California occurred in Del Norte/Humboldt (11.6%). Northern Oregon had the highest single-year percentage of all districts (37.0% in 1981) and the highest average annual percentage (19.0%). Occurrence from Santa Cruz through San Luis Obispo counties was relatively low, with no fish in 1983, 1985, or 1986. The southern range limit reported by Miller and Lea (1972) is Monterey. The 27 fish sampled in San Luis Obispo County in the MRFSS support the species' range extension southward to Avila, as reported by Dentler and Grossman (1980).



EQUATION

Redtail surfperch were sampled mainly from the open ocean (71%) (Figure 56), where catch peaked in May and July–September. Catch in bays and estuaries peaked in January–March. The Del Norte/Humboldt district accounted for 45% (30,000 fish weighing 12 MT) of the total catch, and 98% (66,000 fish weighing 21 MT) of the total was from the San Francisco district northward (Table 12). The highest IRIs were from beach and bank mode from San Francisco northward and were particularly high in the Del Norte/Humboldt district (Figure 14).

The number of redtail surfperch sampled annually decreased 77% between 1980 and 1986. The decline averaged 21% per year, and was steepest between 1982 and 1983 (32%) during the ENSO. After 1983, redtail surfperch continued to decline in catches off California (Figure 58). The most dramatic decline occurred in the Mendocino/Sonoma and San Francisco districts where the number sampled in the creel survey decreased from 298 fish in 1981 to only 20 fish five years later. Occurrence in bays and estuaries in those districts declined from 154 fish in 1980–83 to only one fish in 1984–86. An exception to the general decline was the bay and estuarine catch in the Del Norte/Humboldt district, which remained stable. Disappearance of redtail populations in Humboldt Bay and in Oregon estuaries has been observed in recent years (P. Collier, CDFG, pers. comm.; Brookins MS[b]). Redtail surfperch are the main surfperch taken commercially in northern California.

5.6.4.2. Coastwide Species

Pile perch were sampled throughout California and Oregon (Figure 59). The highest annual average in California occurred in the San Francisco district (1.2%). Northern Oregon had the highest annual average of all districts in both states (6.3%), and the highest single-year percentage (11.4% in 1986).

Pile Perch							Shiner Perch							Walleye Surfperch						
80	81	82	83	84	85	86	80	81	82	83	84	85	86	80	81	82	83	84	85	86
-	3.49	1.88	5.02	7.38	8.42	11.4	-	4.75	1.88	1.13	0	0.05	0.22	-	2.52	7.54	2.51	1.05	1.01	1.19
-	7.81	0.82	5.85	6.88	3.46	1.62	-	0.27	1.63	0.35	0.09	0.12	0.3	-	1.75	0.54	0.77	1.79	7.2	7.01
-	3.81	0.47	3.62	6.41	6.06	11	-	1.3	4.76	0.71	2.73	0.87	0.13	-	6.53	12.4	3.4	3.57	0.81	0.75
2.62	0.55	0.42	0.49	0.73	0.75	0.57	7.57	0.66	1.89	0.86	3.6	0.16	0.57	6.23	2.5	3.36	6.12	3.28	1.72	1.39
0	0	0.52	0.02	0.02	0	0.03	0.46	1.58	2.26	1.29	0.26	0.5	2.92	0.03	0.19	0.38	0.29	0	0.2	0.03
1.38	0.84	1.2	1.02	1.2	0.33	2.74	5.03	3.04	5.6	4.02	2.4	5.51	4.12	3.24	3.01	2.61	2.27	1.15	0.89	0.85
0.44	0.17	0.17	0.14	0.07	0.04	0.08	0.12	1.2	0.68	0.34	0.56	0.26	0.02	1.77	2.23	1.67	1.89	0.92	0.91	0.26
0.18	0.03	0.01	0.24	0.03	0.06	0.14	1.68	2.39	0.31	1.03	0.57	0.19	0.4	1.55	1.35	0.67	1.38	1.82	0.62	0.87
0.03	0	0	0.06	0	0.01	0.01	0.42	0.16	1.72	0.17	0.17	0.04	0.16	2.36	2.61	0.57	1.94	1.26	0.69	1.12
0.3	0.19	0.41	0.07	0.42	0.65	0.24	0.33	0.52	0.41	0.14	0.01	0.04	0	1.2	0.1	0.83	0.39	0.24	0.49	0.03
0.08	0.03	0.75	0.14	0.03	0.1	0	0.04	0.13	0.75	0	0.03	0	0	3.02	1.34	1.51	0.62	0.62	0.2	0.08
0.05	0	0.39	0.16	0	0	0	0.08	0	0.76	0.11	0	0.04	0.74	0.9	0.63	5.09	0.48	0.06	0.19	0.09

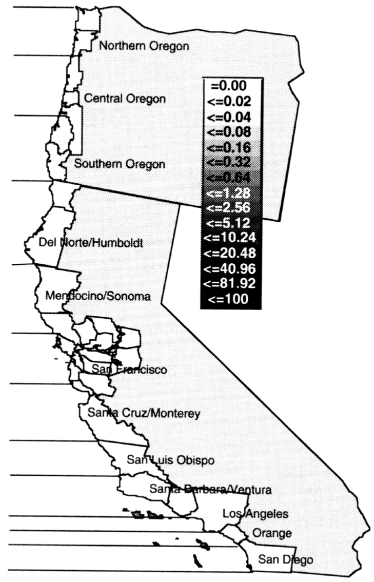
FIGURE 59. Percent by number of total sampled catch of pile perch, shiner perch, and walleye surfperch by district and year in California and Oregon, 1980–86.

FIGURE 59. Percent by number of total sampled catch of pile perch, shiner perch, and walleye surfperch by district and year in California and Oregon, 1980–86

Occurrence was patchy in the Mendocino/Sonoma, Santa Barbara/Ventura, Orange, and San Diego districts.

Pile perch were caught mainly from bays and estuaries (79%) (Figure 56). Catch peaked in February. The San Francisco district accounted for 92% (73,000 fish weighing 40 MT) of the estimated total catch of pile perch with 77% (61,000 fish weighing 31 MT) from within San Francisco Bay (Table 12). The highest IRIs for pile perch were for the pier mode in Humboldt/Del Norte (Figure 16) and spear fishing from Santa Cruz through San Luis Obispo districts (Figure 17).

Shiner perch were sampled throughout California and Oregon (Figure 59). The highest annual average percentage in the creel survey in California and Oregon occurred in the San Francisco district (4.3%) (Figure 59). Del Norte/ Humboldt had a relatively high annual average percentage (2.2%) and the



EQUATION

highest single-year percentage (7.6% in 1980). Occurrence south of the Santa Barbara/Ventura district was relatively low.

Shiner perch were taken mainly from bays and estuaries (85%) (Figure 56). Catch peaked in July (Figure 57). San Francisco Bay accounted for 79% (82,000 fish weighing 3 MT) of the total catch (Table 12). The highest IRIs were from the pier mode (Figure 16).

Walleye surfperch were sampled throughout California and Oregon (Figure 59). The highest annual average percentage of total sampled catch in California occurred in Del Norte/Humboldt (3.5%). Southern Oregon had the highest annual average of both states (4.6%) and the highest annual percentage (12.4% in 1982). Occurrence in Mendocino/Sonoma was relatively low.

Walleye surfperch were taken by anglers mainly in bays and estuaries (56%) (Figure 56) where occurrence peaked in August. Capture in the ocean peaked in May and July and in August in bays and estuaries. Bay and estuarine occurrences were mainly from Humboldt and San Francisco bays. Open ocean occurrences were mainly in the Santa Cruz/Monterey district. The San Francisco district accounted for 56% (54,000 fish weighing 12 MT) of the estimated total catch of walleye surfperch (Table 12). The highest IRIs were in beach/bank and pier modes throughout northern and central California and in jetty/breakwater mode in the Santa Cruz/Monterey district (Figures 14, 15, and 16). The annual number of walleye surfperch sampled decreased 72% between 1980 and 1986.

White seaperch were sampled throughout California and Oregon (Figure 60). Del Norte/ Humboldt had the highest annual average percentage of total sampled catch (2.53%) and highest annual percentage (6.08% in 1980). Occurrence in San Luis Obispo County was patchy.

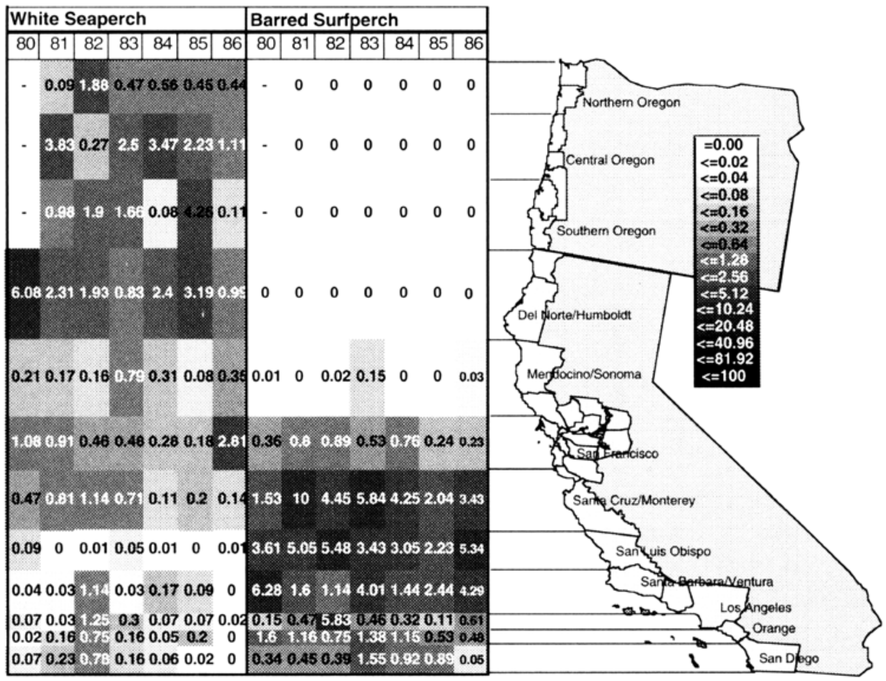


FIGURE 60. Percent by number of total sampled catch of white seaperch and barred surfperch by district and year in California and Oregon, 1980–86.

FIGURE 60. Percent by number of total sampled catch of white seaperch and barred surfperch by district and year in California and Oregon, 1980–86

White seaperch were taken mainly from bays and estuaries (73%) (Figure 56), especially from Humboldt and San Francisco bays. In January—March, catch in bays and estuaries peaked. Catch was lowest in the ocean in March, so this species probably enters bays and estuaries to spawn at that time. Catch in the ocean peaked in January and in May, mainly in the Santa Cruz/Monterey district. The number of white seaperch sampled annually decreased 61% between 1980 and 1986; a decline occurred each year except between 1985 and 1986. The San Francisco district accounted for 64% (30,000 fish weighing 7 MT) of the estimated total sport catch of white seaperch (Table 12). The highest IRIs for the species were from pier mode, with the highest value coming from Del Norte/Humboldt (Figure 16). White seaperch were formerly the most important commercial surfperch species in the state (Tarp 1952), but are no longer a significant component.

5.6.4.3. Southern Species

Barred surfperch were not found in Oregon MRFSS samples, and in California were found only from Mendocino/ Sonoma southward (Figure 60). Santa Cruz/Monterey had the highest annual average percent of total catch

(4.5%) and the highest single-year percentage (10.0% in 1981). Occurrence in Mendocino/Sonoma was relatively low.

Barred surfperch were taken mainly from the ocean (92%) (Figure 56), where catch peaked in May–June and August—September. The creel survey data show that those peaks were sporadic, occurring in only three of the seven years. The minor occurrence from bays and estuaries was mainly from the Santa Cruz/Monterey district, where the majority of the ocean catch was also sampled, and where 54% (93,000 fish weighing 26 MT) of the estimated total catch of barred surfperch were caught (Table 12). The highest IRIs were from shore modes from the San Francisco district southward (Figures 14–16), particularly in beach/bank catches in the Santa Cruz/Monterey and San Luis Obispo districts.

5.6.5. Length Frequency

Northern and central California MRFSS samples measured approximately 11,000 surfperch from 1980 through 1986. The largest species was pile perch and the smallest was dwarf perch (Table 13). We examined the length-frequency data by species and year, and no year-class dominance was apparent. The average lengths of all species of surfperch sampled in bays and estuaries were greatest from January through June, evidence that birthing and/or breeding adults were present. In the ocean, average lengths for most surfperches were also greatest during January through June; exceptions were black perch, shiner perch, and redtail surfperch, which were longest from October through December.

Length at maturity has not been studied for many surfperches. Two of the species that were well sampled for lengths during the 1980–86 MRFSS, barred surfperch and redtail surfperch, have also been studied for length at maturity (Carlisle et al. 1960; Bennett and Wydoski 1977). Most of the barred surfperch (99.5%) sampled exceeded the minimum length at maturity of 130 mm reported by Carlisle et al. (1960) (Figure 61); the length at which 50% are mature was not reported in the study. Most (66.5%) sampled redtail surfperch exceeded 258 mm, the length at which 50% of females are mature (Bennett and Wydoski 1977) (Figure 62).

5.6.6. Commercial Fisheries

Most of the commercial surfperch catch is composed of larger species that become locally concentrated (Table 14). Adult surfperches typically aggregate during mating or birthing seasons, although barred surfperch and pile perch may form large schools year around (Feder et al. 1974). Commercial landings of redtail surfperch, walleye surfperch, and white seaperch are made

TABLE 13. Length (mm) statistics of surfperches found in northern and central California, 1980–86. Record lengths are from Miller and Lea (1972).

Common Name	N	Record	Mode	Skewness	Minimum Length at Maturity	Mean
Barred Surfperch	2623	430	200	0.328	130	240
Redtail Surfperch	1525	410	280	0.106	240	277
Walleye Surfperch	1508	305	180	0.42	~	206
Striped Seaperch	1411	381	300	-0.311	~	286
Silver Surfperch	932	267	190	0.868	165	197
White Seaperch	663	317	277	-0.353	~	254
Shiner Perch	631	180	118	0.915	92	132
Pile Perch	502	444	355	-0.895	~	328
Black Perch	395	394	~	~	146	234
Calico Surfperch	321	305	~	~	~	231
Rubberlip Seaperch	288	470	~	~	~	290
Rainbow Seaperch	189	305	~	~	131	233
Sharpnose Seaperch	35	292	~	~	~	258
Spotfin Surfperch	6	203	~	~	81	152
Kelp Perch	5	216	~	~	~	215
Reef Perch	1	180	~	~	~	203
Dwarf Perch	1	159	~	~	~	114
Pink Seaperch	0	203	~	~	~	~

~ Insufficient Data

TABLE 13. Length (mm) statistics of surfperches found in northern and central California, 1980–86. Record lengths are from Miller and Lea (1972)

primarily during the birthing season when they are concentrated inshore (Fritzsche et al. 1992; CDFG unpublished landing data). Minor landings of surfperches are made incidental to landings of other species.

The northern and central California commercial surfperch fishery is much smaller than the recreational fishery; the 1981–86 commercial landings were 54 MT (Figure 5) while recreational landings were 240 MT (Table 12). Total California commercial surfperch landings have fluctuated, but linear regression shows a decline of 25% (-22 MT) from 1953 through 1992 (Figure 63).

Gears used in commercial take of surfperch in northern and central California include hook and line, dip nets, encircling nets, and trawl nets (Figure 64). Historically, a significant portion of the catch was incidental to nearshore net fisheries. Now hook and line is the main gear used. In 1980–91 the average landing was 19.5 kg (Figure 64), or about 62 fish (assuming an average weight per fish of 0.315 kg, which is the average weight of barred surfperch and redtail surfperch sampled in the 1980–86 MRFSS). Redtail surfperch and barred surfperch comprised nearly all the landings where species were identified (Figure 65). Species were not identified in 52% of the landings, comprising 42% of the catch by weight.

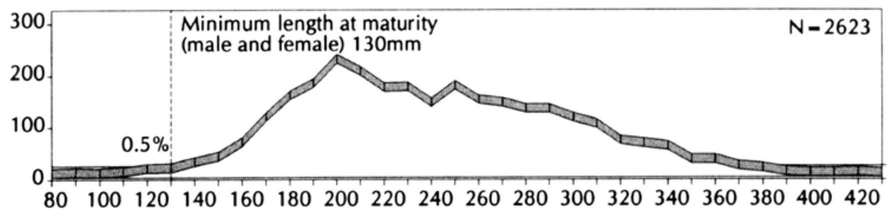


FIGURE 61. Length-frequency distribution of barred surfperch sampled in northern and central California marine recreational fisheries, 1980–86, and minimum length at sexual maturity (Carlisle et al. 1960).

FIGURE 61. Length-frequency distribution of barred surfperch sampled in northern and central California marine recreational fisheries, 1980–86, and minimum length at sexual maturity (Carlisle et al. 1960)

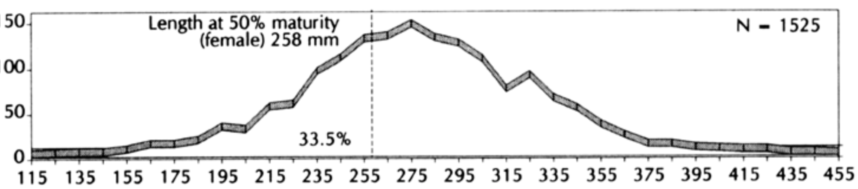


FIGURE 62. Length-frequency distribution of redtail surfperch sampled in northern and central California marine recreational fisheries, 1980–86, and length at which 50% of females are sexually mature (Bennett and Wydoski 1977).

FIGURE 62. Length-frequency distribution of redtail surfperch sampled in northern and central California marine recreational fisheries, 1980–86, and length at which 50% of females are sexually mature (Bennett and Wydoski 1977)

The largest landings of surfperch in northern and central California in 1980–91 occurred in Crescent City and Humboldt Bay ports (Figures 1 and 66). Morro Bay and San Francisco Bay ports also had relatively large surfperch landings. Landings in Crescent City and Humboldt Bay were typically of redtail surfperch. Morro Bay landings typically consisted of barred surfperch. of the San Francisco Bay port landings, 98% were not identified by species; of those that were, redtail surfperch, pile perch, white seaperch, shiner perch, and rainbow surfperch were common.

TABLE 14. Commercial value of surfperches (Bureau of Commercial Fisheries 1937; Bureau of Marine Fisheries 1949; Roedel 1948, Tarp 1952; Feder et al. 1974; Fritzsche et al. 1992).

Commercial	Incidental/ Minor	No Value	Bait
Barred surfperch	Striped seaperch	Dwarf perch	Shiner perch
White seaperch	Black perch	Sharpnose seaperch	
Redtail surfperch	Rainbow perch	Spotfin surfperch	
Walleye surfperch	Calico surfperch	Silver surfperch	
Pile perch	Pink perch	Reef perch	
Rubberlip seaperch	Kelp perch		

TABLE 14. Commercial value of surfperches (Bureau of Commercial Fisheries 1937; Bureau of Marine Fisheries 1949; Roedel 1948, Tarp 1952; Feder et al. 1974; Fritzsche et al. 1992)

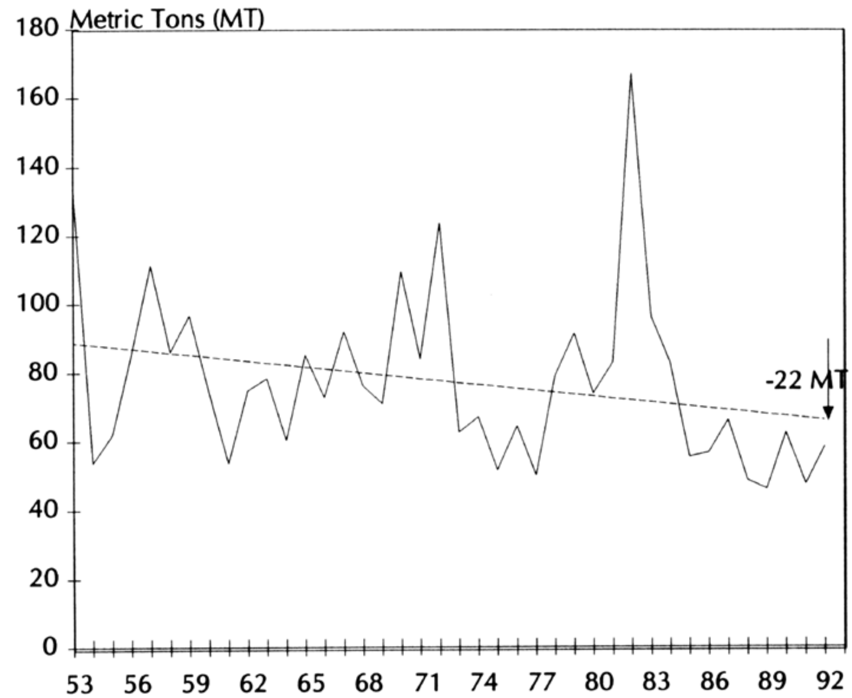


FIGURE 63. Commercial surfperch landings for all California ports, 1953–92 (CDFG data).

FIGURE 63. Commercial surfperch landings for all California ports, 1953–92 (CDFG data)

5.6.6.1. Redtail Surfperch Fishery

The commercial redtail surfperch fishery is centered in the Crescent City and Humboldt Bay port areas (Del Norte/ Humboldt district). Historical commercial landing statistics for those ports are summarized under the Eureka area that includes Del Norte, Humboldt, and Mendocino counties (McAllister

Gear	Landings	Metric Tons	Mean Landing	% by Weight
Hook and Line	1767	31.5	17.7 kg	62
Unknown	652	14.7	22.7 kg	29
Encircling Nets	25	1.9	75.9 kg	4
Trawl Nets	32	1	32.7 kg	2
Dip Nets	63	0.8	12.7 kg	1.5
Total	2592	51	19.5 kg	100

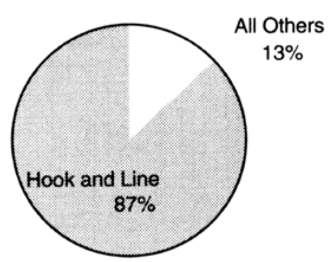


FIGURE 64. Gear composition of commercial surfperch landings in northern and central California, 1980–91, and percentage of hook-and-line landings among all landings where gear type was identified (CDFG data).

FIGURE 64. Gear composition of commercial surfperch landings in northern and central California, 1980–91, and percentage of hook-and-line landings among all landings where gear type was identified (CDFG data)

Commercial Group	Landings	Metric Tons	Average (kg)
Surfperches	1077	26.5	24
Redtail Surfperch	913	17.8	20
Barred surfperch	514	5.7	11
Shiner perch	40	0.3	9
Rainbow seaperch	14	0.2	14
Black perch	20	0.2	8
Pile perch	2	0.1	73
White seaperch	5	0.1	27
Walleye surfperch	2	0.03	12
Rubberlip seaperch	3	0.03	10

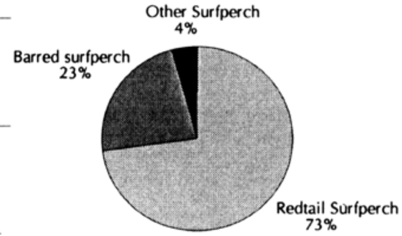


FIGURE. 65. Average annual commercial landings of surfperch in northern and central California, 1980–91, and percentages (by weight) of redtail surfperch and barred surfperch among landings where species was identified (CDFG data).

FIGURE. 65. Average annual commercial landings of surfperch in northern and central California, 1980–91, and percentages (by weight) of redtail surfperch and barred surfperch among landings where species was identified (CDFG data)

1976), but commercial surfperch landings from Mendocino County are negligible (CDFG data; Figure 66). The Eureka area fishery is characterized by surf netting for night smelt at night and hook-and-line fishing for surfperch by day (R. Warner, CDFG, pers. comm.). Trucks are used on beaches to haul gear and fish and for illumination of the surf while seeking night smelt. In 1980–91, average landing size in the area was 22 kg (Figure 66) or about 27 redtail surfperch of average sport size. In 1991, price paid by wholesalers in the Eureka port area was about $1.00 per pound ($2.20 per kg) (CDFG data; Figure 67). Applying that value to the Eureka area landings, the average annual ex-vessel value was $47,073 from 1980 through 1991.

Commercial landings have fluctuated, but linear regression shows a decline of 54% (-20 MT) from 1953 through 1992 in the Eureka area (Figure 68). The decline was independent of consumer demand because the price per pound grew slightly faster then the San Francisco area Consumer Price Index (CPI). After accounting for inflation, between 1953 and 1992 the price per pound increased by about $0.27 (1992 dollars) (Figure 68).

Port Area	Landings	Metric Tons	Average (kg)	%
Crescent City	502	11.9	24	23
Morro Bay	1023	11.1	12	22
San Francisco Bay	321	11.2	32	22
Humboldt Bay	480	9.5	20	19
All Other Areas	264	7.2	27	14

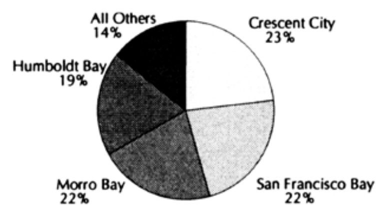


FIGURE 66. Average annual commercial landings of surfperch (all species) in northern and central California by port, 1980–91 (CDFG data).

FIGURE 66. Average annual commercial landings of surfperch (all species) in northern and central California by port, 1980–91 (CDFG data)

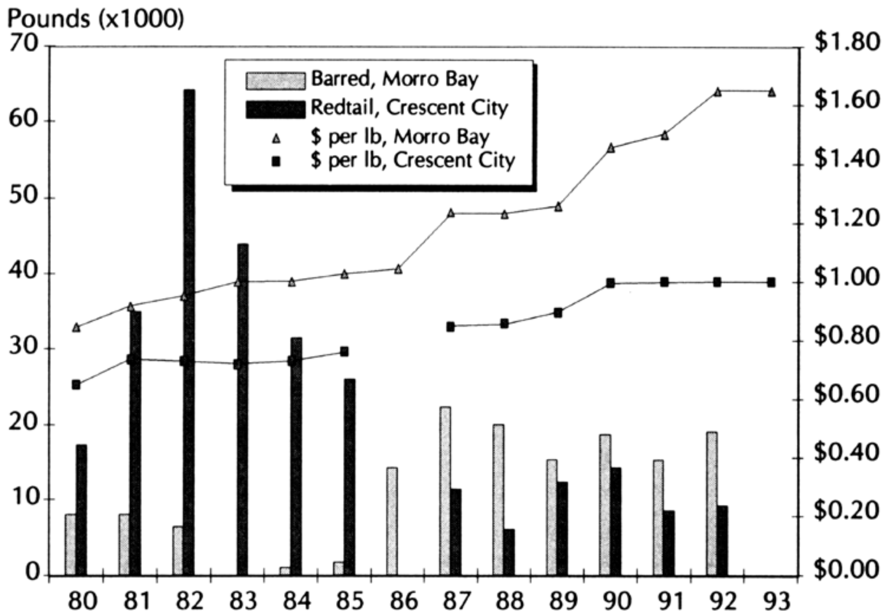


FIGURE 67. Annual landings and value of barred surfperch and redtail surfperch at the two major commercial surfperch ports 1980 through 1993 (1993 price was for April).

FIGURE 67. Annual landings and value of barred surfperch and redtail surfperch at the two major commercial surfperch ports 1980 through 1993 (1993 price was for April)

5.6.6.2. Barred Surfperch Fishery

The commercial barred surfperch fishery occurs mainly in the vicinity of the ports of Cayucos and Morro Bay in San Luis Obispo County (Figure 66). Historical commercial landing statistics for those ports are included in the Santa Barbara Area that includes San Luis Obispo, Santa Barbara, and Ventura counties (McAllister 1976). The fishery is characterized by hook-and-line fishing on beaches when the fish are available nearshore (R. Hardy, CDFG, pers. comm.). Trucks are used to haul fish and gear on beaches where access is allowed. The average landing size is 12 kg (Figure 66) or about 30 barred surfperch (applying average sport sizes). In 1991, price paid by wholesalers was about $1.50 per pound ($3.30 per kg) (Figure 67). The price paid is increased by $0.05 per pound if tags are fastened to the fish. The tags allow the fish to be shipped south of Point Arguello. The average annual ex-vessel value in San Luis Obispo County from 1980–91 was $40,986.

Commercial landings have fluctuated, but linear regression shows an increase of 118% (+10 MT) from 1953 through 1992 in the Santa Barbara Area (Figure 69). The increase may be influenced by consumer demand because

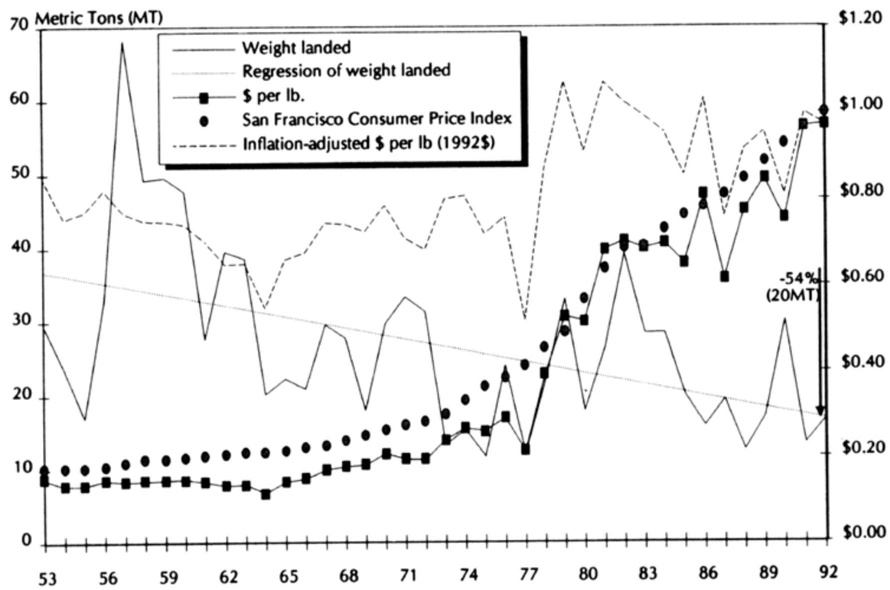


FIGURE 68. Commercial surfperch (principally redtail surfperch) landings, price, and value trends in the Eureka area, 1953–92 (CDFG and Calif. Dept. of Finance unpublished data).

FIGURE 68. Commercial surfperch (principally redtail surfperch) landings, price, and value trends in the Eureka area, 1953–92 (CDFG and Calif. Dept. of Finance unpublished data)

the price per pound has grown faster than the Los Angeles area consumer price index. After accounting for inflation, between 1953 and 1992 the price per pound increased by about $0.65 (1992 dollars) (Figure 69). Recent economic downturns may have generated increased effort and catch (R. Hardy, CDFG, pers. comm.). At Morro Bay, average annual landings of barred surfperch increased from 3630 kg (8002 lb.) in 1980–81 to 9070 kg (19,996 lb.) in 1990–91 (Figure 67).

5.6.7. *Species Composition Changes*

Since the 1930s, the species composition of California's commercial surfperch landings has changed greatly. California's commercial surfperch fishery in 1935 was dominated by white seaperch (50%), and rubberlip surfperch (31%) (Bureau of Commercial Fisheries 1937). In 1947, the fishery was not dominated by two species but had become more diverse, including white seaperch (29%); walleye surfperch (15%); and barred surfperch, pile perch, striped seaperch and rubberlip seaperch (9% each) (Bureau of Marine Fisheries 1949). Recent data show that the fishery is now dominated by two different species, redtail surfperch (73%) and barred surfperch (23%) (Figure 65). White seaperch now comprises less than 1% of the identified commercial surfperch catch.

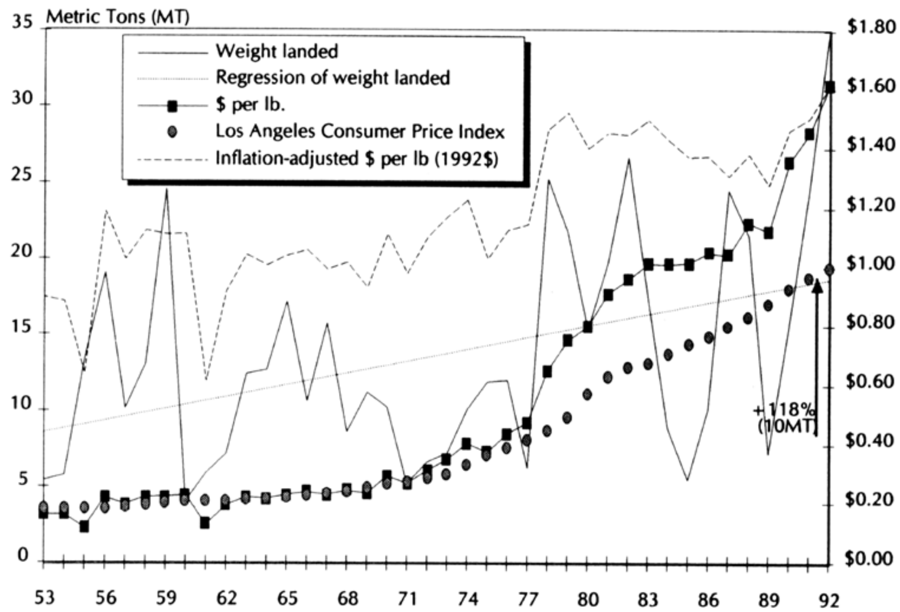


FIGURE 69. Commercial surfperch (principally barred surfperch) landings, price, and value trends in the Santa Barbara area, 1953–92 (CDFG and Calif. Dept. of Finance unpublished data)

FIGURE 69. Commercial surfperch (principally barred surfperch) landings, price, and value trends in the Santa Barbara area, 1953–92 (CDFG and Calif. Dept. of Finance unpublished data)

The species composition changes over the years appear to be related to bay and estuarine habitat use. Nearly all the formerly important commercial species (white seaperch, rubberlip surfperch, pile perch, and striped seaperch) are in the subfamily Embiotocinae and have relatively high occurrence in bays and estuaries (Figure 56). Walleye surfperch is in the subfamily Amphistichinae but also has relatively high occurrence in bays and estuaries. The two major remaining species of commercial importance, redtail surfperch and barred surfperch, are in the subfamily Amphistichinae and have relatively low occurrence in bays and estuaries. Between those two, redtail surfperch has higher occurrence in bays and estuaries and had a 25% decrease in commercial landings between 1953 and 1992. Barred surfperch has the lowest occurrence in bays and estuaries of the major species and supported a 110% increase in commercial landings between 1953 and 1992. Thus the degree of use of bays and estuaries by major surfperch species appears related to their changes in the commercial catch.

Causative factors associated with bay and estuarine use and declining catches probably include:

1) Estuarine habitat degradation caused by filling and alteration of intertidal areas, water pollution, and water diversion.

2) Overfishing of stocks relating to ease of taking fish that aggregate as part of their lifecycle.

3) Changes in commercial fishing regulations. Much of the historical surfperch catch was incidental in nearshore net fisheries directed at other species. Regulations on nearshore gillnetting and trawling have changed greatly since the 1930s. Thus changes in commercial species composition may not absolutely reflect relative abundance. For example, in recent years pile perch comprised less than 1% of the identified commercial catch (Figure 65), but comprised 18% (by weight) of the 1981–86 sport catch (Table 11).

It is difficult to determine the relative importance of the above factors. However it appears that white seaperch and rubberlip seaperch stocks underwent major declines prior to the 1958–61 survey, and that other species that make major use of bays and estuaries have declined as well. The "survivor" species in the commercial catch are the ones that use mainly open ocean habitats.

5.6.8. *Management*

5.6.8.1. Recreational

Present sport fishing regulations provide no specific restrictions for surfperch. The general finfish limitations allow a daily bag and possession limit of 10 fish of one species and 20 fish in combination of species. Permissible gears are hook and line, slurp gun, bow and arrow, and spear. For shiner perch, there are no bag or possession limits. They may be taken with dip nets of any size in all waters, with baited traps not over 3 feet in size in San Francisco Bay and in the ocean and bays of Marin, Sonoma, and Mendocino counties, and with throw nets north of Point Conception. There are no size limits or seasons for sport take of surfperch.

5.6.8.2. Commercial

Presently, commercial take of surfperch is closed from May 1 through July 15, except shiner perch may be taken any time (Fish and Game Code Section 8395). South of Point Arguello, barred surfperch, redtail surfperch, and calico surfperch may not be taken (redtail surfperch are not found south of Avila). Approximately 25% of the recreational take of surfperch occurs during the time the commercial season is closed.

The commercial closure is effective, especially with barred surfperch, in reducing user conflict by allowing a period of high sport take closed to commercial harvest. However, the closure may afford little protection to female aggregations of redtail surfperch. Sixty-eight percent of bay and estuary sport catch of redtail surfperch occurs from January through April, before the commercial closure, while only 17% occurs during the closure (Figure 56), suggesting that redtail surfperch are most numerous in bays and estuaries before the closure.

5.6.9. *Conclusions*

Their nearshore distribution, periods of aggregation in bays and estuaries, and low fecundity make the surfperch generally vulnerable to decline. As a group, the surfperch underwent substantial decreases in sport catch, commercial catch, and in their relative contribution to the sport catch of the shore modes between the 1958–61 and 1981–86 surveys. Redtail surfperch and barred surfperch had particularly large decreases in weight landed and average weight per fish in the sport fishery. Commercial catches of redtail surfperch declined by 25% between the 1950s and the early 1990s, but commercial catch of barred surfperch increased. The decrease in commercial catch of redtail surfperch occurred despite an increase in inflation-adjusted price.

Large reductions of commercial landings of species in the subfamily Embiotocinae, including white seaperch, rubberlip seaperch, pile perch, and striped seaperch, occurred after 1935. The apparent high use of bays and estuaries by these species compared to the other surfperches may be related to catch declines, through some combination of habitat degradation, vulnerability to fisheries, and changes in fishery regulations.

5.6.10. *Management Options*

A proactive approach needs to be directed at restricting or eliminating commercial harvest and to limit sport impacts. Eliminating commercial take in central and northern California would decrease the total take of surfperch by 21%. Earlier in this century, commercial take of American shad, striped bass, and white sturgeon was eliminated to conserve stocks.

Although most surfperch are taken by hook and line at this time, commercial take by alternative gears, such as nets and longline, should be eliminated. Such a change would prevent a future nonsustainable growth in commercial take if market demand should increase dramatically.

February, March, and April could be added as additional months of closure before the current commercial closure. Such a closure would add protection to redtail surfperch, pile perch, white seaperch, and striped seaperch. The closure would be most effective in bays and estuaries in protecting these species when they are aggregating for spawning and are most vulnerable to over-exploitation. The closure could also be applied to the sport fishery.

The bag limit on sport-caught surfperch could be lowered from 10 to 5 fish of any one species. A total 3320 barred surfperch and 1715 redtail surfperch single-angler bags were examined (Figures 70 and 71). Ninety-eight percent of both species were sampled from bags that did not exceed the limit (10) for a single species. A five-fish limit would reduce barred surfperch by 15% and redtail surfperch by 19%. For each species only 14% of the anglers would have a reduced catch at a five-fish limit.

Minimum size requirements for selected species could be developed, based on size-at-maturity studies. Surfperch, unlike most species of rockfish, are taken from shallow water where damage from swim bladder expansion is reduced.

Harvest refugia could be established on surfperch breeding, feeding, or birthing grounds.

5.6.11. *Areas for Future Work*

Research into both the ecological and human factors surrounding the surfperch fisheries should be undertaken to improve stock management. Redtail and barred surfperch, as the dominant species taken and showing evidence of decline in numbers and average weight in the sport catch, should be examined more closely. White surfperch, once historically important, should also be included.

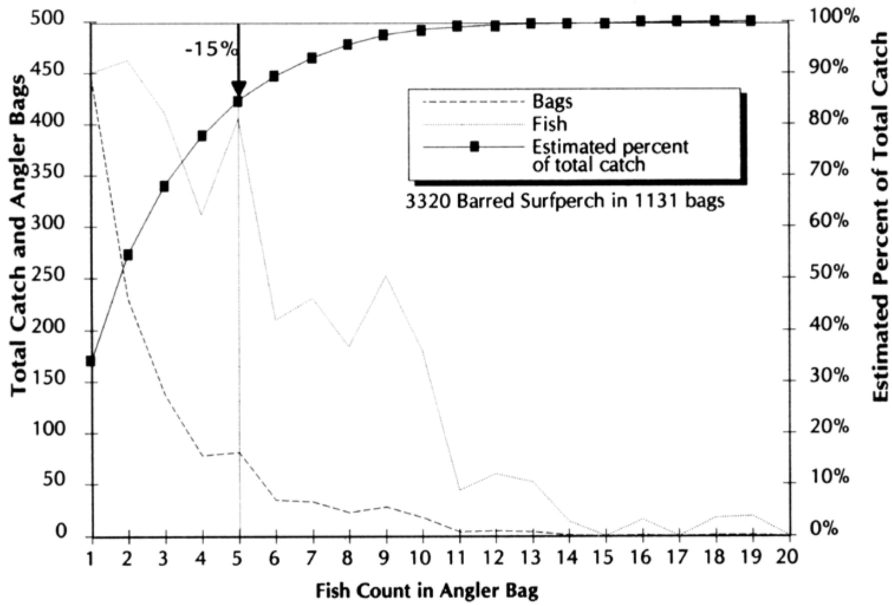


FIGURE 70. Barred surfperch bag frequency and cumulative catch by fish count per bag from single angler bags 1980–86

FIGURE 70. Barred surfperch bag frequency and cumulative catch by fish count per bag from single angler bags 1980–86

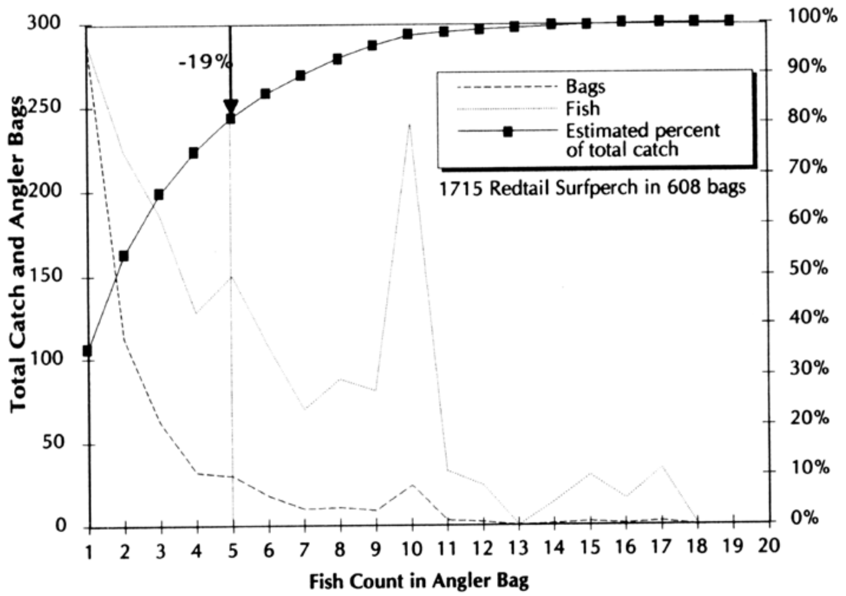


FIGURE 71. Redtail surfperch bag frequency and cumulative catch by fish count per bag from single angler bags 1980–86

FIGURE 71. Redtail surfperch bag frequency and cumulative catch by fish count per bag from single angler bags 1980–86

Additional studies on the ecology of select surfperch species are needed, including reproduction, habitat selection, and energetics. Further analysis is needed of differences between surfperch subfamilies in sexual distribution during breeding season and selection of sites for parturition.

Studies of human impact on surfperch and their habitat are needed. An assessment of changes in estuarine environments that have occurred since 1960 and an attempt to quantify their effect on surfperch populations may be useful.

Research is needed on barred surfperch, redtail surfperch, and perhaps white seaperch on size at sexual maturity and timing of reproductive period. Determination of the relative success of early or late parturition may be helpful in optimizing reproductive success by timing of fishing closure months. Determination of length at which 50% are sexually mature is needed for barred and redtail surfperch in California to set size limits as a management alternative and for neonate-per-recruit modeling. Hooking mortality by length for major species is needed for setting a size limit based on catch and release survival rates as a management alternative.

The shore-based sport surfperch fishery is expensive and difficult to survey due to its seasonal and spatial patchiness. Improved MRFSS methods to estimate total effort and take of all sport fisheries are desirable. A random-based telephone expansion survey such as employed under MRFSS produces large variances. Using a sportfishing license telephone directory, as is currently being tested in Oregon (J. Witzig, NMFS, pers. comm.), could reduce variance.

6. DISTRIBUTIONAL SHIFTS RELATED TO THE 1982–83 ENSO

Shifts in the distributions of organisms due to large-scale changes in Pacific coast oceanographic currents have been investigated for many years (Radovich 1961; Parrish et al. 1981; Chelton et al. 1982; Roesler and Chelton 1987). Changes in currents are evidenced by measurements of physical factors such as temperature, salinity, nutrients, and sea level, and correlated to distribution and abundance of dependent organisms such as phytoplankton, invertebrates, and fish. Radovich (1961) described temperature as an important factor in distributions of numerous marine fishes off the Pacific coast of North America during the 1957–59 ENSO.

The 1957–59 and 1982–83 ENSO events have been described as among the major ENSO events in this century (Cannon et al. 1985; Squire 1987; Dayton and Tegner 1989). ENSO events are characterized by unusually warm water temperatures, disruption of nearshore upwelling, and subsequent decreases in primary and secondary production (Radovich 1961; Roughgarden et al. 1988; Dayton and Tegner 1989). Radovich (1961) described incidents of fish and invertebrates north of their usual ranges during the 1957–59 ENSO. The take of southern species of fish and invertebrates north of their usual ranges during the 1982–83 ENSO was qualitatively described for the state of Washington by Schoener and Fluharty (1985). Klingbeil et al. (1984) described changes in catch and northward shifts of southern species during 1983 in the commercial and recreational fisheries off central and southern California. Squire (1987) examined average "catch temperature" for recreationally important pelagic southern species determined from non-ENSO periods and, based on 1983 sea surface temperatures, predicted their northward distributions during that year. He used qualitative reports of catches from Alaska, Washington, Oregon, and California to support his hypothesized distributional changes.

Evidence for changes in distributions of fish species is dependent on collections made during research cruises or on samples from the catches of commercial or recreational fisheries (Radovich 1961; Klingbeil et al. 1984). The 1980–86 MRFSS data span the period of the 1982–83 ENSO with a random survey of recreational fishery catch composition. Distribution maps made from the data track variations in occurrence (percent of sampled catch, by

1 *Miller and Lea (1972) reported a total of 58 species of rockfish from California waters; however, two of these, the whitebelly rockfish (* S. vexillaris *) and the copper rockfish (* S. caurinus *), have since been synonomized (Chen 1975, 1986).*

district) of recreationally important species before, during, and after the 1982–83 ENSO. Examining the maps for all species sampled, we identified the species whose occurrence changed during the 1982–83 ENSO, and compared the changes to those reported during the 1957–59 ENSO.

We found 28 species with differences in distribution that may have been related to the 1982–83 ENSO (Table 11). Ten of those species, all of which are pelagic (Miller and Lea 1972; Feder et al. 1974), showed obvious northward shifts in occurrence during one or more years of the ENSO. The 10 species consisted of eight scombrids (albacore, bigeye tuna, bluefin tuna, bullet mackerel, Pacific bonito, Pacific mackerel, skipjack, yellowfin tuna), one coryphaenid (dolphinfish) and one sphyraenid (California barracuda).

TABLE 11. Species with changes in occurrence that may be related to the 1982–83 ENSO. Habitat types from Miller and Lea (1972) and Feder et al. (1974).

		Year(s) of ENSO Related Shifts in Distribution	
Bottom Fishes	**Sources >**	**Radovich (1961)**	**MRFSS 1980-86**
Barred sand bass	*Paralabrax nebulifer*	None	None
California sheephead	*Pimelometopon pulchrum*	1958	None
Chilipepper	*Sebastes goodei*	None	None
Greenstriped rockfish	*Sebastes elongatus*	None	None
Ocean whitefish	*Caulolatilus princeps*	1957	None
Petrale sole	*Eopsetta jordani*	None	None
Sand sole	*Psettichthys melanostictus*	None	None
Spiny dogfish	*Squalus acanthias*	None	None
Widow rockfish	*Sebastes entomelas*	None	None
Nearshore Fishes			
Redtail surfperch	*Amphistichus rhodoterus*	None	None
Striped seaperch	*Embiotoca lateralis*	None	None
Black croaker	*Cheilotrema saturnum*	None	None
Opaleye	*Girella nigricans*	None	None
Señorita	*Oxyjulis californica*	None	None
Shovelnose guitarfish	*Rhinobatos productus*	None	None
Pelagic or Epipelagic Fishes			
Albacore	*Thunnus alalunga*	1957, 58	1982, 83, 84
Bigeye tuna	*Thunnus obesus*	1959	1982, 83, 84
Bluefin tuna	*Thunnus thynnus*	1958	1983, 84
Bullet mackerel	*Auxis rochei*	1957, 59	1983, 84
Dolphinfish	*Coryphaena hippurus*	1957	1983, 84
California barracuda	*Sphyraena argentea*	1958	1982, 83, 84
Pacific bonito	*Sarda chiliensis*	1957	1982, 83, 84
Pacific hake	*Merluccius productus*	None	None
Pacific mackerel	*Scomber japonicus*	None	1982, 83, 84
Skipjack	*Katsuwonus pelamis*	1957, 58, 59	1983, 84
White seabass	*Atractoscion nobilis*	1957, 58, 59	None
Yellowfin tuna	*Thunnus albacares*	1957	1983, 84
Yellowtail	*Seriola lelandi*	None	None

TABLE 11. Species with changes in occurrence that may be related to the 1982–83 ENSO. Habitat types from Miller and Lea (1972) and Feder et al. (1974)

6.1. Major Shifts

6.1.1. *Pacific Mackerel*

of the eight scombrids, Pacific mackerel showed the greatest northward shift in occurrence during 1982–83. The range of Pacific mackerel is described as transpacific by Miller and Lea (1972). Pacific mackerel in the Mendocino/ Sonoma catch increased from nothing in 1981 to 1.8% of the total catch in 1982. In 1983 and 1984 Pacific mackerel represented about 1% of the central Oregon recreational catch. By 1986 Pacific mackerel were no longer taken north of the San Francisco district (Figure 72).

Pacific mackerel in northern and central California were smaller than in southern California (Figure 73). The modal progression of a cohort was seen from 1984 to 1986 in the northern and central California catch and also in the southern California catch (Figure 73). During the three years, average length increased from 234 mm to 252 mm in northern and central California, and from 297 to 323 mm in southern California.

A strong 1981 year-class dominated southern California commercial landings of Pacific mackerel in 1985, based on otolith age-at-size data (CDFG unpublished data). In the 1980–86 MRFSS data, dominant modes are apparent in the length-frequency distributions for southern and for northern and central California (Figure 73). Assuming mode A represents the 1981 year-class, a comparable mode was not present in northern and central California. Mode B to the north may represent younger fish that grew more slowly than expected from the Von Bertalanffy growth equation published by Knaggs and Parrish (1973). Mode B moved from 200 mm to 250 mm over a 4-year period from 1983 to 1986. Knaggs and Parrish (1973) found 1-year-old fish that were 273 mm long growing to 358 mm in four years. In the absence of age-at-size data, we can only speculate that either growth rates were markedly depressed or a series of young of the year were taken in the north. Klingbeil et al. (1984) reported a commercial landings shift northward to the Monterey area during 1982 and 1983, with 10% of the 1983 commercial landings in the Monterey area. The 1983 Monterey landings represent the largest landings of Pacific mackerel from that port area since the inception of the fishery five decades previously. Schoener and Fluharty (1985) reported increased abundance in 1983 from catches off Washington and in Puget Sound. Northward shift of Pacific mackerel was not noted during the 1957–59 ENSO by Radovich (1961). The lack of a shift may reflect low stock biomass during 1957–59, estimated at one-third the 1982–83 biomass (MacCall et al. 1985).

Pacific Mackerel

80	81	82	83	84	85	86
-	0	0	0	0.15	0	0
-	0	0	0.93	0.76	0.02	0
-	0.11	0	0.01	0	0	0
0	0	0	0	0.02	0	0
0	0	1.76	2.27	1.02	0.02	0
0	0	0.06	4.17	0.79	0.35	0.74
0.72	4.81	5.49	7.2	12.5	4.27	2.65
4.17	11.5	8.02	12.5	12.7	7.57	1.27
12.4	12	0.57	18	14.8	11.9	7.53
22.5	18.9	2.91	19.2	18.5	17.3	8.79
22.6	23.6	0.75	32.4	24.2	25.3	16.8
44.2	36.5	2.35	31.9	40.1	34.7	19.6

Bullet Mackerel

80	81	82	83	84	85	86
-	0	0	0	0	0	0
-	0	0	0	0	0	0
-	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0.74	0	0
0	0	0	0	0.09	0.13	0
0	0	0	0.1	0.03	0.03	0
0	0	0	0.11	0	0.11	0.05

Albacore

80	81	82	83	84	85	86
-	0	0	0	0	0	0
-	0	0	0	0	0	0
-	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0.02	0	0	0	0
0	0	0	0.01	0	0	0
0	0	0	0	0.29	1.18	0.25
0	0	0	0.12	0.48	1.8	1.82
0	0	0	0.68	0	0	0.16
0	0	2.08	0	1.42	0	0
0	0	0.75	0	2.25	0.07	0
0	0.25	0.39	0.34	2.24	0	0.05

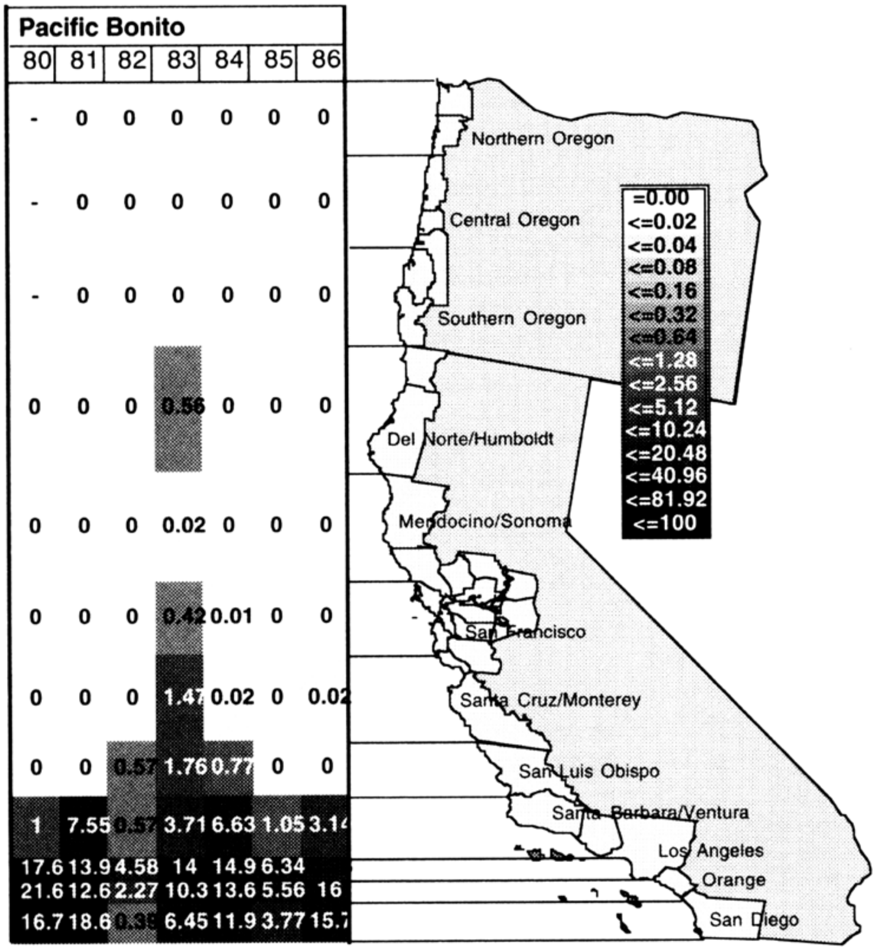
FIGURE 72. Percent by number of total sampled catch of Pacific mackerel, bullet mackerel, albacore, and Pacific bonito by district and year for Oregon and California.

FIGURE 72. Percent by number of total sampled catch of Pacific mackerel, bullet mackerel, albacore, and Pacific bonito by district and year for Oregon and California

6.1.2. *Bullet Mackerel and Albacore*

Bullet mackerel and albacore persisted to the north into 1986 following the ENSO. Bullet mackerel were caught in southern California in 1983–86 (Figure 72). Their northernmost and peak occurrence (0.74%) was in the Santa Barbara/Ventura district in 1984. Radovich (1961) described the range of the species as common off Mexico and Central America, with one fish collected off Los Coronados Islands in 1957 and 40 collected between Santa Catalina Island and San Clemente Island in 1959.

Northward catch of albacore was first apparent in 1982 (Figure 72). Catches persisted off Santa Cruz through San Luis Obispo counties through 1986. Klingbeil et al. (1984) reported albacore taken in Monterey Bay in September



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1983; they were not found by the MRFSS (Figure 73). Schoener and Fluharty (1985) described increases in albacore landings off Washington following the 1957–58 ENSO and in 1983. Radovich (1961) described the presence of albacore as clearly related to ocean temperature and available inshore farther to the north during the 1931, 1957, and 1958 warm-water years.

6.1.3. *Pacific Bonito*

Pacific bonito displayed a pronounced but transitory shift north of Point Conception in 1982–84 (Figure 72). In 1983, they were caught as far north as the Del Norte/Humboldt district. Radovich (1961) described the range of Pacific bonito as uncommon north of Point Conception until numerous specimens were found off the Farallon Islands and northwest of Eureka during 1957. Klingbeil et al. (1984) noted an increased northward occurrence in recreational fisheries starting in September 1982. The increase extended as far north as Crescent City by fall 1983. Schoener and Fluharty (1985) described Pacific bonito as more abundant than usual off Washington in 1983.

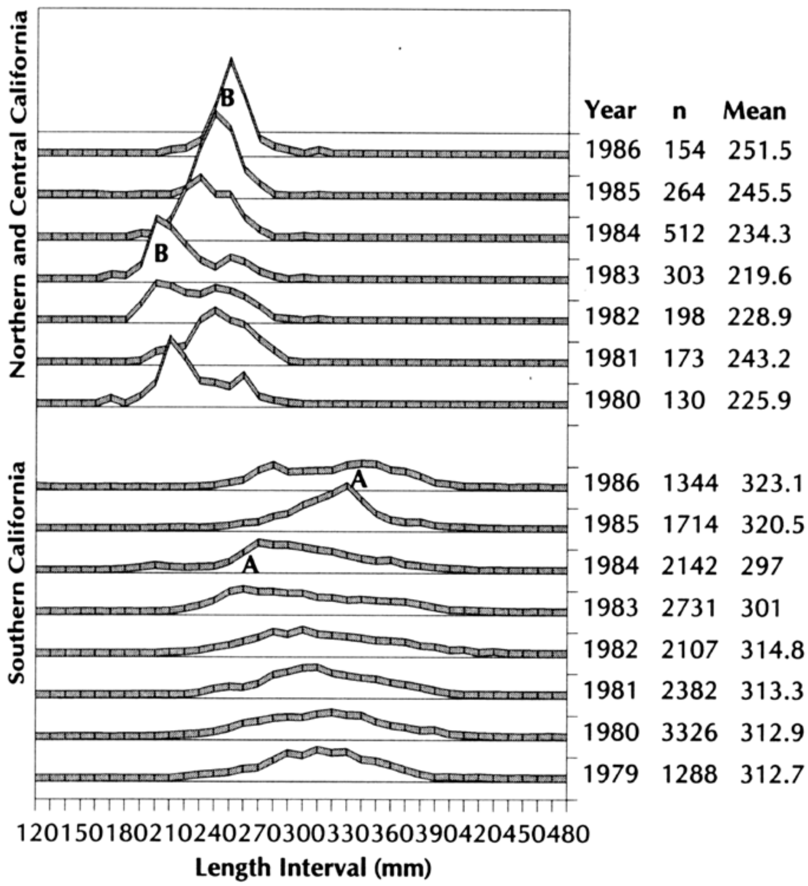


FIGURE 73. Length-frequency distribution of Pacific mackerel in northern and central California (Oregon border through San Luis Obispo County) and southern California (Santa Barbara County through San Diego County) from 1980–86 MRFSS data. Modal progression of dominant cohorts are identified by letter with A representing the 1981 year-class and B unknown.

FIGURE 73. Length-frequency distribution of Pacific mackerel in northern and central California (Oregon border through San Luis Obispo County) and southern California (Santa Barbara County through San Diego County) from 1980–86 MRFSS data. Modal progression of dominant cohorts are identified by letter with A representing the 1981 year-class and B unknown

6.1.4. *Skipjack Tuna and Yellowfin Tuna*

In 1983, skipjack tuna and yellowfin tuna both showed increased occurrence northward to the Santa Barbara/Ventura district (Figure 74). In 1984, skipjack tuna continued to be taken at reduced levels as far north as the Santa Barbara/Ventura district, while yellowfin tuna were taken only off Orange County. Klingbeil et al (1984) reported recreational catches of both species as far north as Ventura County in August 1983. Radovich (1961) described skip-jack tuna as uncommon in southern California and rare north of Point Conception. During the 1957–59 ENSO, skipjack tuna were reported to be numerous as far north as Cape Blanco, Oregon and were commonly taken off southern California in 1957 (Radovich 1961).

6.1.5. Bigeye Tuna

Bigeye tuna were first taken off San Diego County in 1982 (0.78%) and as far north as Orange County in 1983 (Figure 74). Radovich (1961) reported the first bigeye tuna collected in California in 1959 and a range extension to Iron Springs, Washington in the same year. Klingbeil et al. (1984) reported the first landing of bigeye tuna off San Diego in July 1983, with 1700 fish reported on CPFVs from August through September of 1983.

6.1.6. Bluefin Tuna

Bluefin tuna were taken off San Diego County in 1983 and as far north as Santa Barbara/Ventura in 1984 (Figure 74). Klingbeil et al (1984) reported commercial catches of bluefin tuna in southern California during 1983. Radovich (1961) reported a bluefin tuna taken near Kodiak, Alaska in 1958.

6.1.7. Dolphinfish

Dolphinfish were available off Orange and San Diego counties in 1982 and 1983 at low levels of occurrence (0.05% to 0.3%) (Figure 75). Radovich (1961) described the species' distribution as worldwide in warm seas. He also reported numerous collections off San Diego and the Farallon Islands in California, and off Grays Harbor, Washington in 1957. In August through September 1983, 997 dolphin were reported taken by CPFVs off southern California (Klingbeil et al. 1984).

6.1.8. California Barracuda

California barracuda showed the least quantitative shift to the north of the 10 species. The species was described as nearshore pelagic by Feder et al. (1974). In 1982, occurrence was low (0.03%) as far north as Del Norte/Humboldt (Figure 75). Low occurrence (0.01%) persisted in Santa Cruz/Monterey during 1983 and 1984. Klingbeil et al. (1984) reported recreational fishery take of barracuda off central California in 1983. Radovich (1961) reported numerous catches off British Columbia in 1958.

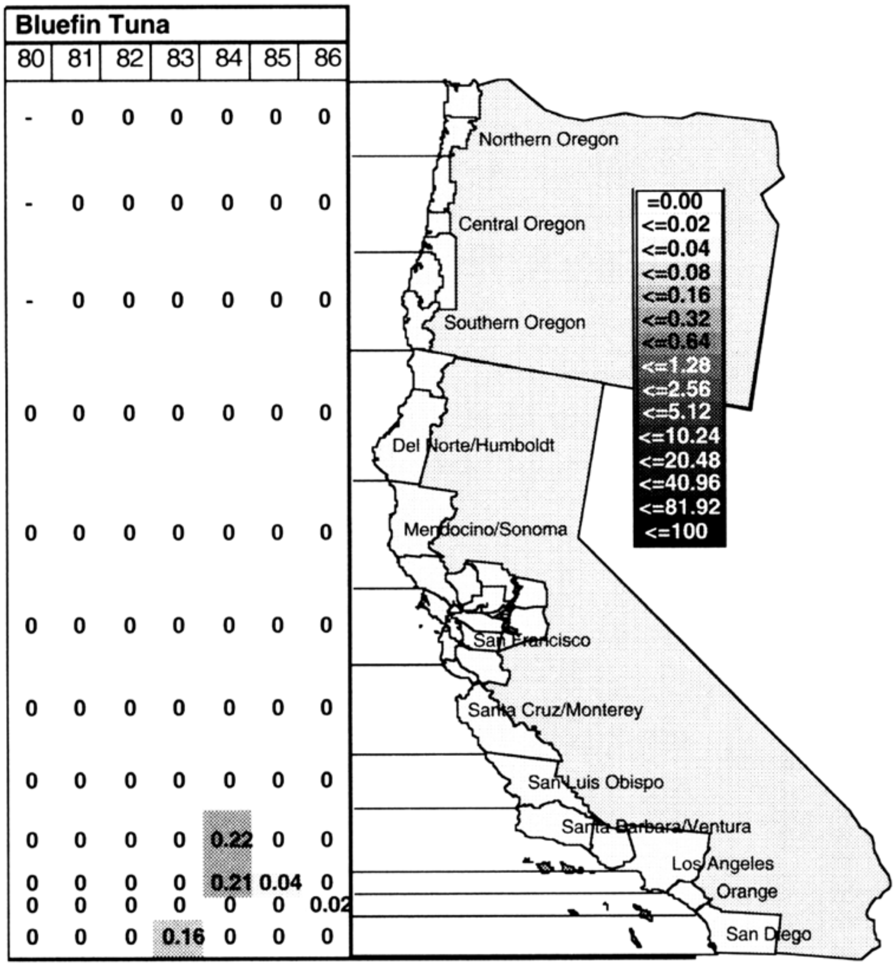
Skipjack Tuna							Yellowfin Tuna							Bigeye Tuna						
80	81	82	83	84	85	86	80	81	82	83	84	85	86	80	81	82	83	84	85	86
-	0	0	0	0	0	0	-	0	0	0	0	0	0	-	0	0	0	0	0	0
-	0	0	0	0	0	0	-	0	0	0	0	0	0	-	0	0	0	0	0	0
-	0	0	0	0	0	0	-	0	0	0	0	0	0	-	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1.87	0.03	0	0	0	0	0	0.49	0	0	0	0	0	0	0	0	0	0
0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1.54	0.11	0	0	0	0	0	1.83	0.03	0	0	0	0	0	0.02	0	0	0
0	0	0	2.39	0.54	0	0	0	0	0	3.5	0	0	0	0	0	0.78	0.05	0.02	0	0

FIGURE 74. Percent by number of total sampled catch of skipjack tuna, yellowfin tuna, bigeye tuna, and bluefin tuna by district and year for Oregon and California.

FIGURE 74. Percent by number of total sampled catch of skipjack tuna, yellowfin tuna, bigeye tuna, and bluefin tuna by district and year for Oregon and California

6.2. Minor Changes

Earlier in this bulletin we examined distributions of 16 rockfishes, eight surfperches, and lingcod in 1980–86 (Figures 18–21, 42, and 58–60). None of those species showed clear evidence of latitudinal displacement during the 1982–83 ENSO. However, three rockfishes (chilipepper, widow rockfish, and greenstriped rockfish) and two surfperches (redtail surfperch and striped seaperch) did show interannual shifts in occurrence during or after the ENSO that were not clearly related to the ENSO (Table 11). Chilipepper displayed an increase in occurrence in San Luis Obispo through Mendocino counties in 1985 and 1986 (Figure 19); the strong 1984 year-class was present during that period (Rogers and Bence, 1992). Widow rockfish were caught by recreational fisheries off Oregon from 1983 through 1986; none were seen there before



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1983 (Figure 18). Greenstriped rockfish were not found in Oregon until after 1983 (Figure 21). Occurrence of redtail surfperch and striped seaperch decreased off Oregon in 1982 relative to the other five years investigated (Figure 58). The decreases may have been related to the warmwater event, but did not constitute latitudinal displacement from the species' normal ranges (Table 11). During the 1957–59 ENSO, only one rockfish species (greenspotted rockfish) and no surfperch showed evidence of northward shift (Radovich 1961). Greenspotted rockfish distribution showed no evidence of northward shift during the 1982–83 ENSO (Figure 19). Thus available data suggest that rockfish and surfperch do not undergo obvious latitudinal shifts in distribution during warmwater periods.

In addition to the three rockfishes and two surfperches, 13 other species showed increases or decreases in occurrence during 1982, 1983, or 1984 that may have reflected effects of the ENSO (Table 11). The differences were not pronounced enough north or south to be described as latitudinal shifts in distribution.

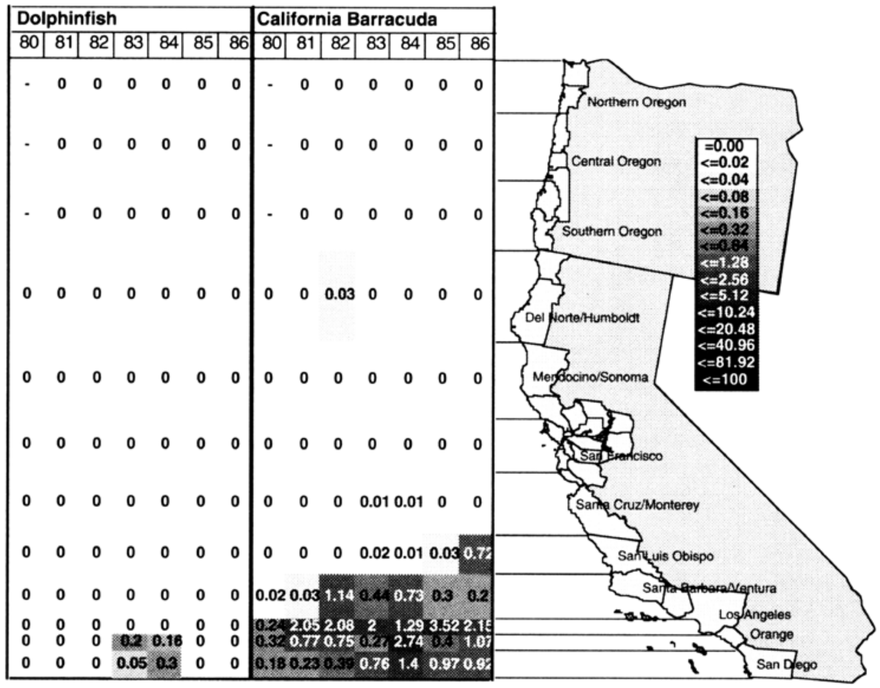

FIGURE 75. Percent by number of total sampled catch of dolphin and California barracuda by district and year for Oregon and California.

FIGURE 75. Percent by number of total sampled catch of dolphin and California barracuda by district and year for Oregon and California

The 13 species included six species of bottom fish (barred sand bass, California sheephead, ocean whitefish, petrale sole, sand sole, and spiny dogfish), four nearshore species (black croaker, opaleye, señorita, and shovelnose guitarfish), and three pelagic species (Pacific hake, yellowtail, and white seabass) (Appendix G). Radovich (1961) reported northward shifts during the 1957–59 ENSO for three of those species: California sheephead, white seabass, and ocean whitefish (Table 11). Squire (1987) reported catches of yellowtail off central California and the catch of a single yellowtail in 1983 off Port Orford, Oregon. The MRFSS did not sample any yellowtail north of Point Conception during the ENSO.

White seabass were frequently taken north of their typical range during the 1957–58 ENSO (Radovich 1961); they were typically uncommon north of Point Conception, but were abundant off San Francisco in 1958 and numerous off Monterey in 1959. Catches were reported off Oregon, Alaska, and British Columbia in 1957 and 1958. The range of white seabass has contracted with a decrease in population from the 1950s to the 1980s. CPFV catches in southern

California in the 1980s were only 3% of what they were from 1947–59 (Vojkovich 1992). Squire (1987) described isolated catches off California and Oregon in 1983. The MRFSS data show increased occurrence off southern California only in 1982 and low occurrence (0.01%) off Santa Cruz/Monterey, also in 1982 (Appendix G).

6.3. Conclusions

The northward increases in occurrence for the 10 pelagic species should be compared cautiously to the 1957–59 ENSO reports by Radovich (1961). The latitudinal shifts described here are based on MRFSS data that 1) quantify gross movement as a percentage of all species taken by district, 2) consider only the take of recreational fisheries, mainly from inshore areas (except in southern California), and 3) did not record depth of capture. The MRFSS is a random survey targeting broad geographic areas and offers a coarse level of resolution by district and year. The movements north or south described by Radovich (1961) and Squire (1987) often represented rare events targeted by scientists focused on identifying an anomaly. In general, ranges reported in the literature for marine fish reflect a similar focus on unusual events and say little about actual quantitative distribution of a species. Rarely are resources devoted to conduct species distribution and abundance surveys. An example of such were the two federal rockfish surveys of 1977 and 1980 (Gunderson and Sample 1980; Dark et al. 1983). The MRFSS data fall short of quantifying true abundance but do quantify relative abundance in the sampled catch.

Recreational fisheries in central and northern California and Oregon are generally concentrated nearshore due to weather, the narrow continental shelf, and types of vessels used. Recreational fisheries in southern California access both nearshore and offshore areas, targeting both groundfish and pelagic species. In northern and central California, offshore commercial troll fisheries target salmon and occasionally albacore. Most recreational boat fisheries target bottomfish or salmon. Radovich (1961) reported landings from both recreational and commercial vessels in the north, with many of the pelagic species noted well offshore and out of the range of recreational boats sampled by the MRFSS.

Distance offshore and depth of fishing should be included in future marine recreational surveys for improved quantification of species distributions during ENSO events. Our findings on the status of rockfish reveal a shift to deepwater rockfish species between 1958–62 and 1980–86 by PRB and CPFV anglers that suggests a need for caution when evaluating species' distributions as an index of ENSO effects. Apparent changes in distribution could also reflect targeting shifts to deep-water species.

Squire (1987) hypothesized shifts north of Point Conception of the southern pelagic species yellowtail, California barracuda, Pacific bonito, Pacific mackerel, yellowfin tuna, striped marlin, and white seabass. He suggested that as sea surface temperatures increased to the north, those species would follow their typical "mean catch temperature" ranges into northern waters. Squire (1987) suggested that Pacific bonito, with the lowest "low mean catch temperature" (LMCT) (12.2° C) would exhibit a further shift to the north during 1983 than white sea bass, California barracuda, Pacific mackerel, and yellowtail (with LMCTs of 13.3° C, 13.9° C, 13.9° C, and 13.9° C respectively). Our MRFSS data indicate that the northward populations shifts, within Oregon and California, were led by Pacific mackerel, followed by Pacific bonito, and yellowfin tuna. California barracuda and white seabass showed little evidence of northward shift. Ally and Miller (1992) suggested that declines in California barracuda populations since the 1957–59 ENSO account for the less pronounced northward movement observed during what they described as the equally intense 1982–83 ENSO. We suggest the same effect for white seabass, based on declines in abundance reported by Vojkovich (1992).

All 10 of the species we identified as dislocated to the north during the 1982–83 ENSO event were also named by Radovich (1961) for the 1957–59 ENSO. The fact that Radovich's (1961) list of dislocated species (49 fishes) was larger then ours does not imply that the 1957–59 ENSO had a greater effect on species distributions. Radovich (1961) utilized both inshore and offshore sport and commercial samples over a wide range from California to Alaska. Our study relied on samples only from sportfish anglers in California and Oregon. The Radovich (1961) study counted rare events (51% of the species he listed were based on a single observation) while our graphical analysis included only species with multiple observations. Added factors such as decreases in population density for white seabass and California barracuda or population recovery for Pacific mackerel obscure or exaggerate apparent shifts in distribution. Hopefully, surveys such as MRFSS will be active during future ENSO events, providing a basis for quantitative comparison of pelagic species dislocations to our results. Ultimately such comparisons could provide a basis for classifying the relative magnitude of ENSO impacts on pelagic fishes.

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APPENDICES

APPENDIX A

Species groups, common names, and scientific names of finfish found in the Marine Recreational Fisheries Statistics Survey in northern and central California, 1980–86. Rockfish distribution indicates whether rockfish species were found in northern California (n: Del Norte through San Mateo counties) and/or central California (c: Santa Cruz through San Luis Obispo counties).

Species Group	Common Name	Scientific Name	Rockfish Distribution
LEOPARD SHARK	Leopard shark	*Triakis semifasciata*	
SPINY DOGFISH	Spiny dogfish	*Squalus acanthias*	
SHARK, OTHER	Sharks	Chondrichthyes	
	Horn shark	*Heterodontus francisci*	
	Sixgill shark	*Hexanchus griseus*	
	Sevengill shark	*Notorynchus cepedianus*	
	Mackerel sharks	Lamnidae	
	Thresher shark	*Alopias vulpinus*	
	Soupfin shark	*Galeorhinus zyopterus*	
	Smoothhounds	*Mustelus* spp.	
	Gray smoothhound	*Mustelus californicus*	
	Brown smoothhound	*Mustelus henlei*	
	Blue shark	*Prionace glauca*	
	Angel sharks	Squatinidae	
	Pacific angel shark	*Squatina californica*	
STURGEONS	Sturgeons (unidentified)	Acipenseridae	
	Green sturgeon	*Acipenser medirostris*	
	White sturgeon	*Acipenser transmontanus*	
PACIFIC HERRING	Pacific herring	*Clupea pallasi*	
NORTHERN ANCHOVY	Anchovies	Engraulidae	
	Northern anchovy	*Engraulis mordax*	
SURF SMELT	Surf smelt	*Hypomesus pretiosus*	
SMELTS, OTHER	Smelts	Osmeridae	
	Smelts (general)	*Hypomesus* spp.	
	Night smelt	*Spirinchus starksi*	
SALMONIDS	Trouts	Salmonidae	
	Salmon	*Oncorhynchus* spp.	
	Pink salmon	*Oncorhynchus gorbuscha*	
	Coho salmon	*Oncorhynchus kisutch*	
	Chinook salmon	*Oncorhynchus tshawytscha*	
	Cutthroat trout	*Oncorhynchus clarkii*	
	Rainbow trout	*Oncorhynchus mykiss*	
PACIFIC COD	Pacific cod	*Gadus macrocephalus*	
PACIFIC HAKE	Pacific hake	*Merluccius productus*	
PACIFIC TOMCOD	Pacific tomcod	*Microgadus proximus*	
SILVERSIDES	Silversides	Atherinidae	
	Topsmelt	*Atherinops affinis*	

APPENDIX A

APPENDIX A (CONTINUED)

Species Group	Common Name	Scientific Name	Rockfish Distribution
JACKSMELT	Jacksmelt	*Atherinopsis californiensis*	
BLACK ROCKFISH	Black rockfish	*Sebastes melanops*	n,c
BLUE ROCKFISH	Blue rockfish	*Sebastes mystinus*	n,c
BROWN ROCKFISH	Brown rockfish	*Sebastes auriculatus*	n,c
BOCACCIO	Bocaccio	*Sebastes paucispinis*	n,c
CANARY ROCKFISH	Canary rockfish	*Sebastes pinniger*	n,c
CHILIPEPPER	Chilipepper	*Sebastes goodei*	n,c
COPPER ROCKFISH	Copper rockfish	*Sebastes caurinus*	n,c
GOPHER ROCKFISH	Gopher rockfish	*Sebastes carnatus*	n,c
GREENSPOTTED ROCKFISH	Greenspotted rockfish	*Sebastes chlorostictus*	n,c
GREENSTRIPED ROCKFISH	Greenstriped rockfish	*Sebastes elongatus*	n,c
OLIVE ROCKFISH	Olive rockfish	*Sebastes serranoides*	n,c
QUILLBACK ROCKFISH	Quillback rockfish	*Sebastes maliger*	n,c
ROSY ROCKFISH	Rosy rockfish	*Sebastes rosaceus*	n,c
STARRY ROCKFISH	Starry rockfish	*Sebastes constellatus*	n,c
VERMILION ROCKFISH	Vermilion rockfish	*Sebastes miniatus*	n,c
WIDOW ROCKFISH	Widow rockfish	*Sebastes entomelas*	n,c
YELLOWTAIL ROCKFISH	Yellowtail rockfish	*Sebastes flavidus*	n,c
ROCKFISHES, OTHER	Rockfishes (unidentified)	Scorpaenidae	
	Rougheye rockfish	*Sebastes aleutianus*	n,c
	Pacific ocean perch	*Sebastes alutus*	n,c
	Aurora rockfish	*Sebastes aurora*	c
	Redbanded rockfish	*Sebastes babcocki*	n,c
	Silvergray rockfish	*Sebastes brevispinis*	n
	Splitnose rockfish	*Sebastes diploproa*	c
	Rosethorn rockfish	*Sebastes helvomaculatus*	n,c
	Shortbelly rockfish	*Sebastes jordani*	n,c
	China rockfish	*Sebastes nebulosus*	n,c
	Tiger rockfish	*Sebastes nigrocinctus*	n,c
	Yelloweye rockfish	*Sebastes ruberrimus*	n,c
	Stripetail rockfish	*Sebastes saxicola*	c
	Sharpchin rockfish	*Sebastes zacentrus*	c
	Black-and-yellow rockfish	*Sebastes chrysomelas*	n,c
	Kelp rockfish	*Sebastes atrovirens*	n,c
	Calico rockfish	*Sebastes dalli*	c
	Squarespot rockfish	*Sebastes hopkinsi*	n,c
	Cowcod	*Sebastes levis*	n,c
	Speckled rockfish	*Sebastes ovalis*	n,c
	Grass rockfish	*Sebastes rastrelliger*	n,c
	Flag rockfish	*Sebastes rubrivinctus*	n,c

APPENDIX A—Cont'd.

APPENDIX A (CONTINUED)

Species Group	Common Name	Scientific Name	Rockfish Distribution
ROCKFISHES, OTHER	Bank rockfish	*Sebastes rufus*	c
	Treefish	*Sebastes serriceps*	c
	Redstripe rockfish	*Sebastes proriger*	n
	Swordspine rockfish	*Sebastes ensifer*	n
	Greenblotched rockfish	*Sebastes rosenblatti*	n
	Rockfishes (general)	*Sebastes* spp.	
	Thornyheads (general)	*Sebastolobus* spp.	
	Shortspine thornyhead	*Sebastolobus alascanus*	
SABLEFISH	Sablefish	*Anoplopoma fimbria*	
KELP GREENLING	Kelp greenling	*Hexagrammos decagrammus*	
LINGCOD	Lingcod	*Ophiodon elongatus*	
GREENLINGS, OTHER	Greenlings (unidentified)	Hexagrammidae	
	Rock greenling	*Hexagrammos lagocephalus*	
CABEZON	Cabezon	*Scorpaenichthys marmoratus*	
PAC. STAGHORN SCULPIN	Pacific staghorn sculpin	*Leptocottus armatus*	
SCULPINS, OTHER	Sculpins	Cottidae	
	Coastrange sculpin	*Cottus aleuticus*	
	Buffalo sculpin	*Enophrys bison*	
	Red Irish lord	*Hemilepidotus hemilepidotus*	
	Brown Irish lord	*Hemilepidotus spinosus*	
BARRED SAND BASS	Barred sand bass	*Paralabrax nebulifer*	
KELP BASS	Kelp bass	*Paralabrax clathratus*	
STRIPED BASS	Striped bass	*Morone saxatilis*	
YELLOWTAIL	Yellowtail	*Seriola lalandi*	
WHITE CROAKER	White croaker	*Genyonemus lineatus*	
QUEENFISH	Queenfish	*Seriphus politus*	
CROAKERS, OTHER	White seabass	*Atractoscion nobilis*	
	Spotfin croaker	*Roncador stearnsi*	
OPALEYE	Opaleye	*Girella nigricans*	
HALFMOON	Halfmoon	*Medialuna californiensis*	
BARRED SURFPERCH	Barred surfperch	*Amphistichus argenteus*	
BLACK PERCH	Black perch	*Embiotoca jacksoni*	
PILE PERCH	Pile perch	*Rhacochilus vacca*	
REDTAIL SURFPERCH	Redtail surfperch	*Amphistichus rhodoterus*	
RUBBERLIP SEAPERCH	Rubberlip seaperch	*Rhacochilus toxotes*	
SHINER PERCH	Shiner perch	*Cymatogaster aggregata*	

APPENDIX A—Cont'd.

APPENDIX A (CONTINUED)

Species Group	Common Name	Scientific Name	Rockfish Distribution
SILVER SURFPERCH	Silver surfperch	*Hyperprosopon ellipticum*	
STRIPED SEAPERCH	Striped seaperch	*Embiotoca lateralis*	
WALLEYE SURFPERCH	Walleye surfperch	*Hyperprosopon argenteum*	
WHITE SEAPERCH	White seaperch	*Phanerodon furcatus*	
SURFPERCHES, OTHER	Surfperches	Embiotocidae	
	Kelp perch	*Brachyistius frenatus*	
	Spotfin surfperch	*Hyperprosopon anale*	
	Sharpnose seaperch	*Phanerodon atripes*	
	Calico surfperch	*Amphistichus koelzi*	
	Rainbow seaperch	*Hypsurus caryi*	
	Reef perch	*Micrometrus aurora*	
	Dwarf perch	*Micrometrus minimus*	
PACIFIC BARRACUDA	Pacific barracuda	*Sphyraena argentea*	
PACIFIC BONITO	Pacific bonito	*Sarda chiliensis*	
PACIFIC MACKEREL	Chub mackerel	*Scomber japonicus*	
TUNAS	Mackerels and tunas		
	Skipjack tuna	*Katsuwonus pelamis*	
	Albacore	*Thunnus alalunga*	
	Bluefin tuna	*Thunnus thynnus*	
CALIFORNIA HALIBUT	California halibut	*Paralichthys californicus*	
PACIFIC SANDDAB	Pacific sanddab	*Citharichthys sordidus*	
STARRY FLOUNDER	Starry flounder	*Platichthys stellatus*	
ROCK SOLE	Rock sole	*Pleuronectes bilineatus*	
FLATFISHES, OTHER	Flatfishes	Pleuronectiformes	
	Lefteye flounders	Bothidae	
	Sanddabs	*Citharichthys* spp.	
	Speckled sanddab	*Citharichthys stigmaeus*	
	Longfin sanddab	*Citharichthys xanthostigma*	
	Fantail sole	*Xystreurys liolepis*	
	Righteye flounders	Pleuronectidae	
	Arrowtooth flounder	*Atheresthes stomias*	
	Petrale sole	*Eopsetta jordani*	
	Rex sole	*Errex zachirus*	
	Butter sole	*Pleuronectes isolepis*	
	Dover sole	*Microstomus pacificus*	
	English sole	*Pleuronectes vetulus*	
	Diamond turbot	*Hypsopsetta guttulata*	
	Hornyhead turbot	*Pleuronichthys verticalis*	
	Sand sole	*Psettichthys melanostictus*	
	Greenland halibut	*Reinhardtius hippoglossoides*	
	Pacific halibut	*Hippoglossus stenolepis*	
OTHER FISHES	Unidentified fishes		
	Bottomfishes (groundfish)		
	Sicklefin smoothhound	*Mustelus lunulatus*	

APPENDIX A—Cont'd.

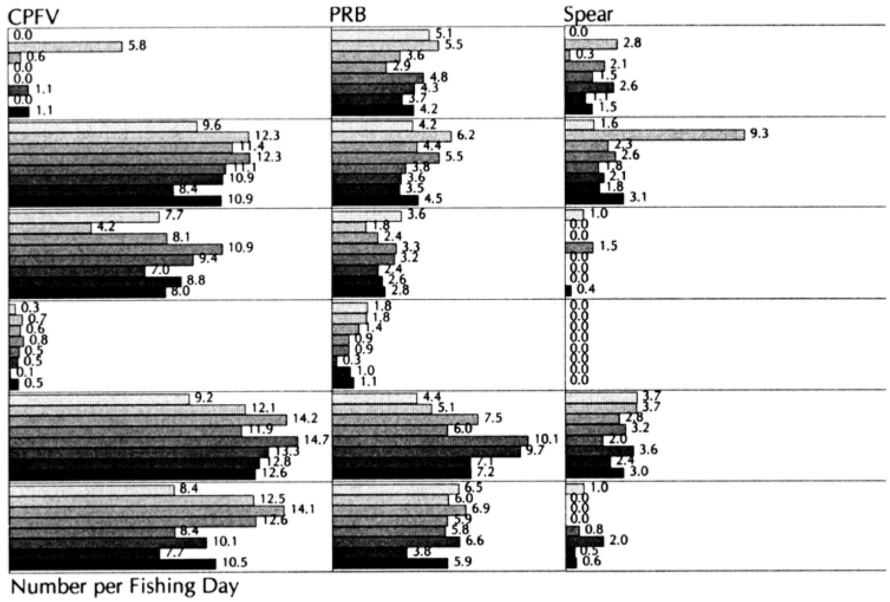
APPENDIX A (CONTINUED)

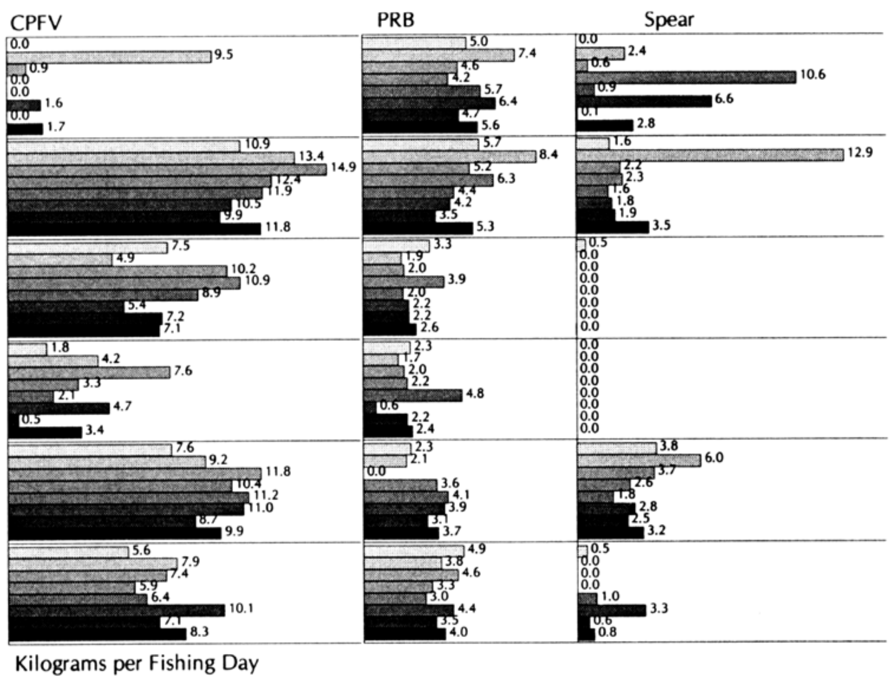
Species Group	Common Name	Scientific Name	Rockfish Distribution
OTHER FISHES	Shovelnose guitarfish	*Rhinobatos productus*	
	Thornback	*Platyrhinoidis triseriata*	
	Pacific electric ray	*Torpedo californica*	
	Skates	Rajidae	
	Big skate	*Raja binoculata*	
	California skate	*Raja inornata*	
	Longnose skate	*Raja rhina*	
	Stingrays	Dasyatidae	
	Diamond stingray	*Dasyatis dipterura*	
	Eagle rays	Myliobatidae	
	Bat ray	*Myliobatis californica*	
	Spotted ratfish	*Hydrolagus colliei*	
	Pacific sardine	*Sardinops sagax*	
	California lizardfish	*Synodus lucioceps*	
	Plainfin midshipman	*Porichthys notatus*	
	Codfishes	Gadidae	
	Opah	*Lampris guttatus*	
	Longspine thornyhead	*Sebastolobus altivelis*	
	Rosylip sculpin	*Ascelichthys rhodorus*	
	Gulf grouper	*Mycteroperca jordani*	
	Ocean whitefish	*Caulolatilus princeps*	
	Jack mackerel	*Trachurus symmetricus*	
	Zebra perch	*Hermosilla azurea*	
	Garibaldi	*Hypsypops rubicundus*	
	Barracudas	Sphyraenidae	
	Senorita	*Oxyjulis californica*	
	Pacific sandfish	*Trichodon trichodon*	
	Bay blenny	*Hypsoblennius gentilis*	
	Wolf-eel	*Anarrhichthys ocellatus*	
	Striped kelpfish	*Gibbonsia metzi*	
	Sarcastic fringehead	*Neoclinus blanchardi*	
	Onespot fringehead	*Neoclinus uninotatus*	
	Giant kelpfish	*Heterostichus rostratus*	
	Pricklebacks	Stichaeidae	
	Rock prickleback	*Xiphister mucosus*	
	Monkeyface prickleback	*Cebidichthys violaceus*	
	Pacific sandlance	*Ammodytes hexapterus*	
	Gobies	Gobiidae	
	Blackeye goby	*Coryphopterus nicholsi*	
	Yellowfin goby	*Acanthogobius flavimanus*	
	Gulf sierra	*Scomberomorus concolor*	
	Pacific pompano	*Peprilus simillimus*	
	Molas	Molidae	
	Ocean sunfish	*Mola mola*	

APPENDIX A—Cont'd.

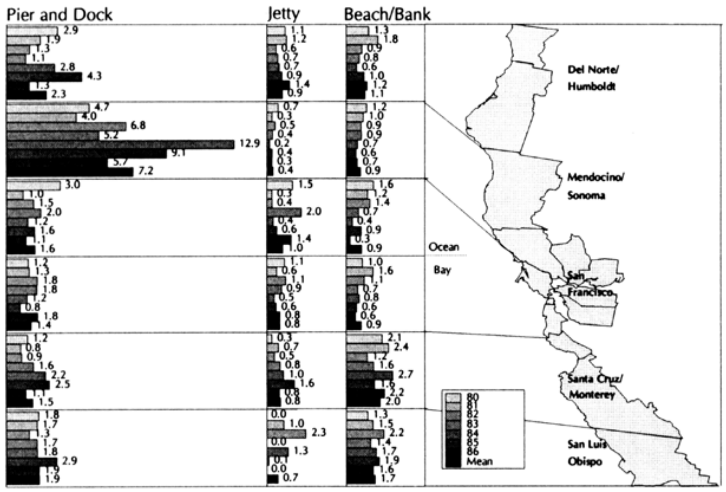
APPENDIX B

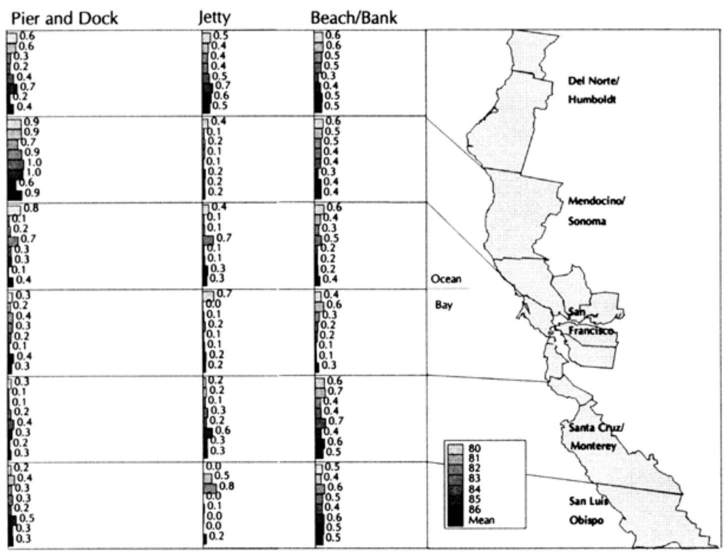
Catch per unit of effort in the marine recreational fishery in northern and central California 1980–86.





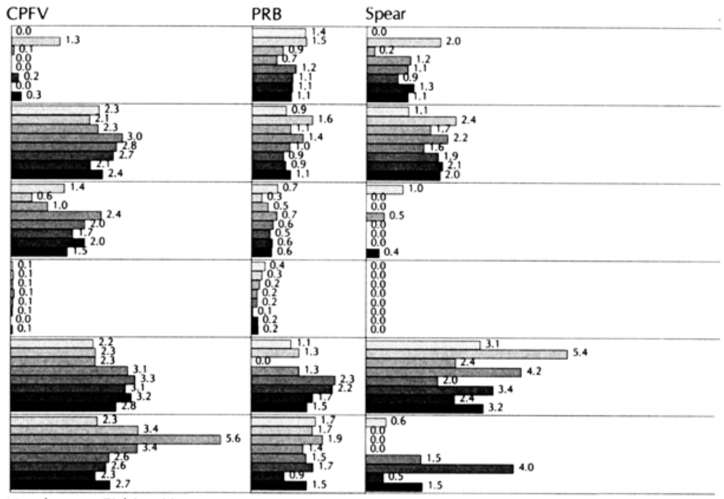
APPENDIX B



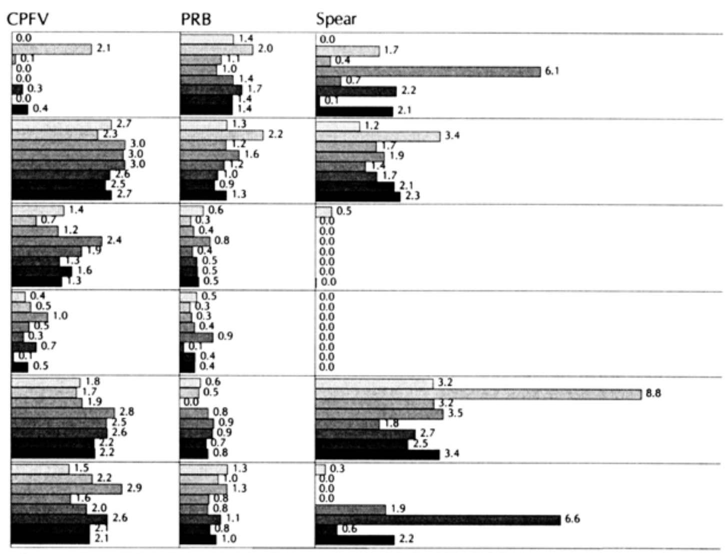


APPENDIX B—Cont'd.

APPENDIX B (CONTINUED)

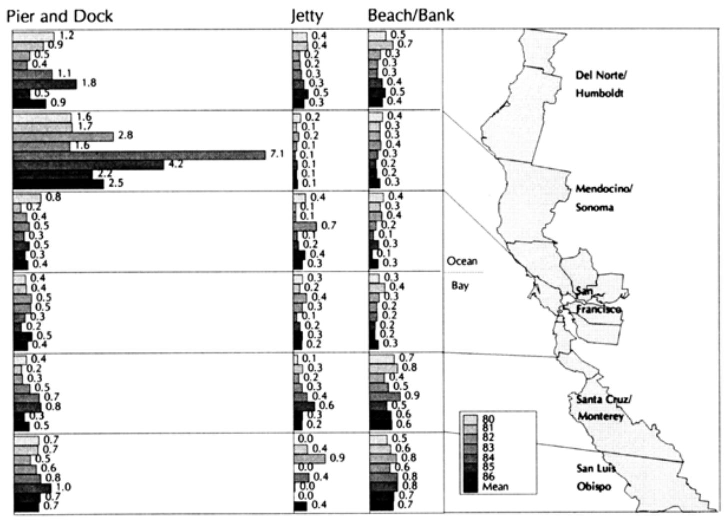


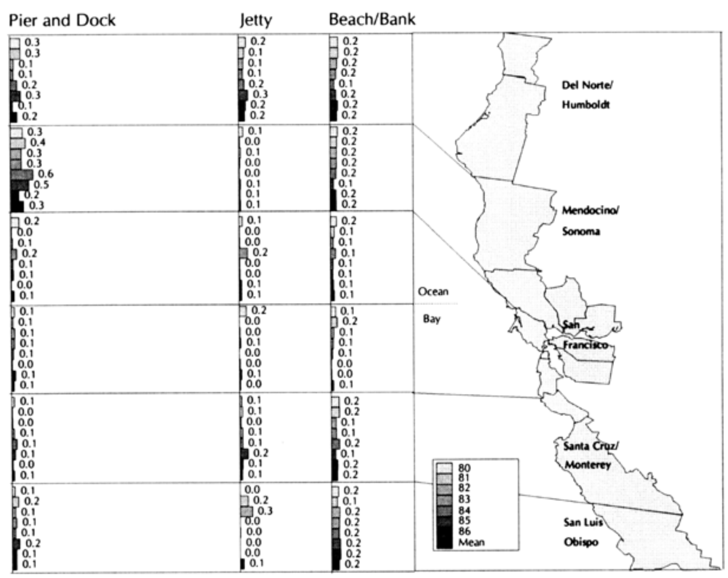
Number per Fishing Hour



Kilograms per Fishing Hour

APPENDIX B—Cont'd.





APPENDIX B—Cont'd.

APPENDIX C

Percentage of commercial passenger fishing vessel (CPFV) effort and catch in northern and central California reported by CPFV logs.

	1981	1982	1983	1984	1985	1986	Mean
CPFV log data							
Anglers	212,472	220,011	189,068	195,035	220,228	200,925	206,290
Lingcod	51,230	41,008	26,985	20,900	16,928	22,416	29,911
Rockfish	1,602,891	1,622,583	1,522,176	1,292,231	1,188,340	1,070,981	1,383,200
All fish	1,798,888	1,824,228	1,715,823	1,518,843	1,405,362	1,240,100	1,583,874
MRFSS estimates							
Anglers	396,000	363,000	438,000	251,000	280,000	276,000	334,000
Lingcod	42,000	34,000	25,500	24,000	41,000	63,500	38,333
Rockfish	1,922,000	2,400,500	2,143,000	1,845,500	2,084,000	2,125,000	2,086,667
All fish	2,074,000	2,599,000	2,357,000	2,166,500	2,449,500	2,465,000	2,351,833
CDFG salmon data							
Anglers	61,129	79,903	56,862	61,479	85,065	86,417	71,809
Salmon	65,629	102,575	49,556	71,491	108,807	88,870	81,155
MRFSS + CDFG (best estimate of actual effort and catch)							
Anglers	457,129	442,903	494,862	312,479	365,065	362,417	405,809
Lingcod	42,000	34,000	25,500	24,000	41,000	63,500	38,333
Rockfish	1,922,000	2,400,500	2,143,000	1,845,500	2,084,000	2,125,000	2,086,667
All fish	2,139,629	2,701,575	2,406,556	2,237,991	2,558,307	2,553,870	2,432,988
Percentage of MRFSS + CDFG reported by CPFV logs							
Anglers	46%	50%	38%	62%	60%	55%	51%
Lingcod	122%	121%	106%	87%	41%	35%	78%
Rockfish	83%	68%	71%	70%	57%	50%	66%
All fish	84%	68%	71%	68%	55%	49%	65%

APPENDIX C

APPENDIX D

Average annual number (thousands) and percent of fish caught in the marine recreational fishery in northern and central California by depth grouping and mode, 1981–86 and 1958–61.

Species or Group	Pier & Dock 58-61 No.	Pier & Dock 58-61 %	Pier & Dock 81-86 No.	Pier & Dock 81-86 %	Jetty & Breakwater + Beach & Bank 58-61 No.	Jetty & Breakwater + Beach & Bank 58-61 %	Jetty & Breakwater + Beach & Bank 81-86 No.	Jetty & Breakwater + Beach & Bank 81-86 %
SHARKS	4	0.4	6	0.6	1	0.1	4	0.5
LEOPARD SHARK	2	0.2	4	0.4	0	0.0	3	0.3
SPINY DOGFISH	0	0.0	0	0.0	0	0.0	0	0.0
SHARK, OTHER	1	0.1	2	0.2	1	0.1	1	0.1
STURGEONS	-	-	0	0.0	0	0.0	0	0.0
PACIFIC HERRING	0	0.0	70	7.3	0	0.0	2	0.2
NORTHERN ANCHOVY	10	1.0	17	1.8	-	-	4	0.5
SALMONIDS	0	0.0	5	0.5	0	0.0	4	0.4
SURF SMELT	1	0.1	2	0.2	-	-	94	11.2
PACIFIC COD	1	0.1	0	0.0	-	-	-	-
PACIFIC HAKE	-	-	-	-	-	-	0	0.0
PACIFIC TOMCOD	1	0.1	3	0.3	7	0.7	0	0.0
SILVERSIDES	43	4.1	7	0.7	0	0.0	4	0.5
JACKSMELT	190	18.3	184	19.0	69	6.7	50	6.0
ROCKFISH	12	1.2	71	7.3	35	3.4	37	4.4
BLACK ROCKFISH	2	0.2	1	0.1	11	1.1	7	0.9
BLUE ROCKFISH	1	0.1	1	0.1	14	1.4	6	0.7
BROWN ROCKFISH	2	0.2	19	1.9	0	0.0	8	1.0
BOCACCIO	4	0.4	44	4.5	0	0.0	0	0.0
CANARY ROCKFISH	-	-	0	0.0	0	0.0	1	0.1
CHILIPEPPER	-	-	0	0.0	-	-	-	-
COPPER ROCKFISH	0	0.0	0	0.0	0	0.0	2	0.2
GOPHER ROCKFISH	-	-	0	0.0	0	0.0	0	0.0
GREENSPOTTED ROCKFISH	-	-	0	0.0	-	-	-	-
GREENSTRIPED ROCKFISH	-	-	-	-	-	-	-	-
OLIVE ROCKFISH	1	0.1	-	-	0	0.0	0	0.0
QUILLBACK ROCKFISH	-	-	-	-	-	-	-	-
ROSY ROCKFISH	-	-	0	0.0	-	-	0	0.0
STARRY ROCKFISH	-	-	-	-	-	-	-	-
VERMILION ROCKFISH	0	0.0	0	0.0	-	-	0	0.0
WIDOW ROCKFISH	-	-	-	-	-	-	-	-
YELLOWTAIL ROCKFISH	-	-	0	0.0	-	-	0	0.0
ROCKFISHES, OTHER	3	0.3	6	0.6	10	0.9	13	1.5
GREENLINGS	3	0.2	3	0.3	68	6.7	36	4.3
KELP GREENLING	1	0.1	1	0.1	49	4.8	19	2.2
LINGCOD	1	0.1	1	0.1	3	0.3	4	0.5
GREENLINGS, OTHER	0	0.0	1	0.1	16	1.6	13	1.6

* Excludes San Francisco Bay

APPENDIX D (CONTINUED)

Private and Rental Boat *				CPFV				Spear				Total			
58-61		81-86		58-61		81-86		58-61		81-86		58-61		81-86	
No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
0	0.1	4	0.2	0	0.0	5	0.2	-	-	0	0.4	5	0.1	19	0.3
0	0.0	1	0.0	-	-	3	0.1	-	-	-	-	2	0.1	10	0.2
0	0.0	2	0.1	0	0.0	1	0.1	-	-	-	-	0	0.0	4	0.1
0	0.0	2	0.1	0	0.0	1	0.1	-	-	0	0.4	2	0.1	6	0.1
-	-	0	0.0	-	-	7	0.3	-	-	-	-	0	0.0	7	0.1
-	-	0	0.0	-	-	-	-	-	-	-	-	0	0.0	72	1.1
-	-	1	0.0	-	-	-	-	-	-	-	-	10	0.3	23	0.4
16	4.6	61	3.3	58	4.7	87	3.6	-	-	-	-	74	2.0	157	2.5
-	-	-	-	-	-	-	-	-	-	-	-	2	0.1	95	1.5
-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0.0
0	0.0	2	0.1	0	0.0	35	1.4	-	-	-	-	0	0.0	37	0.6
0	0.0	-	-	0	0.0	-	-	-	-	-	-	8	0.2	95	1.5
-	-	-	-	15	1.2	-	-	-	-	-	-	43	1.2	0	0.0
12	3.6	6	0.3	3	0.2	0	0.0	-	-	-	-	273	7.5	240	3.8
169	50.0	1217	66.5	1050	85.3	2087	85.8	10	45.3	20	50.3	1287	35.3	3431	54.7
30	8.8	224	12.2	29	2.4	37	1.5	2	11.0	4	9.3	74	2.0	272	4.3
72	21.4	303	16.6	331	26.9	506	20.8	3	14.2	6	15.8	421	11.5	822	13.1
7	2.1	71	3.9	14	1.1	58	2.4	0	0.0	-	-	22	0.6	156	2.5
1	0.4	5	0.3	59	4.8	131	5.4	0	0.6	0	0.2	64	1.8	180	2.9
10	3.1	63	3.4	52	4.3	76	3.1	-	-	0	0.6	63	1.7	140	2.2
0	0.0	2	0.1	3	0.3	212	8.7	-	-	-	-	3	0.1	213	3.4
19	5.7	40	2.2	39	3.2	42	1.7	0	1.0	1	1.3	59	1.6	84	1.3
10	2.9	104	5.7	29	2.3	28	1.1	0	0.9	1	1.9	39	1.1	132	2.1
0	0.0	6	0.3	22	1.8	61	2.5	-	-	-	-	22	0.6	67	1.1
-	-	1	0.1	4	0.3	27	1.1	-	-	-	-	4	0.1	28	0.5
5	1.3	61	3.3	66	5.3	58	2.4	0	2.0	2	3.8	71	2.0	121	1.9
1	0.2	5	0.3	0	0.0	4	0.2	-	-	0	0.2	1	0.0	9	0.1
4	1.2	27	1.5	35	2.8	55	2.2	-	-	-	-	39	1.1	82	1.3
1	0.2	9	0.5	26	2.1	36	1.5	-	-	-	-	27	0.7	44	0.7
5	1.4	20	1.1	46	3.8	18	0.7	0	0.6	0	0.4	51	1.4	38	0.6
0	0.0	3	0.1	32	2.6	63	2.6	-	-	-	-	33	0.9	65	1.0
5	1.4	49	2.7	224	18.2	384	15.8	0	0.0	0	0.8	228	6.3	434	6.9
11	3.3	226	12.3	38	3.1	293	12.1	3	14.9	6	16.0	65	1.8	538	8.6
22	6.6	75	4.1	40	3.3	40	1.7	5	23.9	8	19.6	138	3.8	161	2.6
4	1.1	11	0.6	1	0.1	2	0.1	2	9.7	2	5.7	57	1.6	34	0.5
18	5.5	64	3.5	39	3.2	38	1.6	3	13.5	5	12.6	65	1.8	112	1.8
0	0.1	1	0.0	-	-	0	0.0	0	0.7	1	1.3	16	0.5	15	0.2

APPENDIX D—Cont'd.

APPENDIX D (CONTINUED)

Species or Group	Pier & Dock 58-61 No.	%	Pier & Dock 81-86 No.	%	Jetty & Breakwater + Beach & Bank 58-61 No.	%	Jetty & Breakwater + Beach & Bank 81-86 No.	%
SCULPINS	17	1.6	37	3.8	30	2.9	56	6.8
CABEZON	2	0.2	1	0.1	28	2.7	16	1.9
PAC. STAGHORN SCULPIN	15	1.4	36	3.7	0	0.0	38	4.6
SCULPINS, OTHER	0	0.0	0	0.0	1	0.1	3	0.3
BARRED SAND BASS	-	-	0	0.0	-	-	0	0.0
KELP BASS	-	-	-	-	0	0.0	1	0.2
STRIPED BASS	5	0.5	4	0.4	39	3.8	9	1.1
YELLOWTAIL	-	-	-	-	-	-	-	-
CROAKERS*	222	21.5	110	11.4	15	1.5	8	1.0
WHITE CROAKER	218	21.1	98	10.1	15	1.5	8	0.9
QUEENFISH	4	0.4	12	1.3	-	-	-	-
CROAKERS, OTHER	-	-	-	-	0	0.0	0	0.0
OPALEYE	-	-	-	-	-	-	1	0.1
HALFMOON	-	-	-	-	-	-	-	-
SURFPERCH	498	48.1	282	29.1	743	72.5	461	55.3
BARRED SURFPERCH	51	5.0	14	1.4	222	21.7	156	18.7
BLACK PERCH	4	0.4	9	0.9	5	0.5	16	2.0
PILE PERCH	14	1.3	41	4.2	7	0.6	26	3.1
REDTAIL SURFPERCH	2	0.2	2	0.2	163	15.9	64	7.6
RUBBERLIP SEAPERCH	3	0.3	3	0.4	1	0.1	6	0.7
SHINER PERCH	173	16.8	75	7.8	18	1.8	24	2.9
SILVER SURFPERCH	32	3.1	16	1.7	111	10.8	51	6.1
STRIPED SEAPERCH	2	0.2	4	0.4	66	6.5	35	4.2
WALLEYE SURFPERCH	89	8.6	48	4.9	69	6.7	24	2.9
WHITE SEAPERCH	12	1.2	13	1.4	15	1.5	13	1.5
SURFPERCHES, OTHER	114	11.0	56	5.8	65	6.4	46	5.5
CALIFORNIA BARRACUDA	0	0.0	-	-	-	-	-	-
PACIFIC BONITO	-	-	1	0.1	-	-	1	0.1
PACIFIC MACKEREL	0	0.0	51	5.2	-	-	12	1.4
TUNAS	-	-	-	-	-	-	-	-
FLATFISH	23	2.2	86	8.9	14	1.4	20	2.4
STARRY FLOUNDER	7	0.7	11	1.1	4	0.4	14	1.7
CALIFORNIA HALIBUT	-	-	1	0.1	0	0.0	1	0.1
PACIFIC SANDDAB	5	0.5	61	6.3	1	0.1	1	0.1
ROCK SOLE	-	-	-	-	0	0.0	0	0.0
FLATFISHES, OTHER	10	1.0	13	1.3	9	0.9	4	0.5
OTHER FISH	5	0.5	30	3.1	3	0.3	29	3.5
TOTAL	1034		966		1025		834	

* Excludes San Francisco Bay

APPENDIX D—Cont'd.

APPENDIX D (CONTINUED)

Private and Rental Boat *				CPFV				Spear				Total			
58-61		81-86		58-61		81-86		58-61		81-86		58-61		81-86	
No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
6	1.7	22	1.2	3	0.2	3	0.1	1	5.9	4	9.5	56	1.5	122	1.9
5	1.6	19	1.0	3	0.2	3	0.1	1	5.9	4	9.3	39	1.1	43	0.7
0	0.0	2	0.1	-	-	-	-	-	-	0	0.2	15	0.4	76	1.2
0	0.1	1	0.0	0	0.0	-	-	0	0.1	-	-	2	0.0	4	0.1
0	0.0	0	0.0	-	-	-	-	0	0.0	-	-	0	0.0	1	0.0
0	0.0	1	0.0	-	-	0	0.0	0	0.2	0	0.6	0	0.0	3	0.0
0	0.0	6	0.3	47	3.8	11	0.4	-	-	-	-	91	2.5	30	0.5
0	0.0	0	0.0	-	-	-	-	-	-	-	-	0	0.0	0	0.0
55	16.2	204	11.1	2	0.1	1	0.0	-	-	-	-	294	8.0	322	5.1
55	16.2	203	11.1	2	33	1	0.0	-	-	-	-	289	7.9	310	4.9
-	-	0	0.0	-	-	-	-	-	-	-	-	4	0.1	12	0.2
0	0.0	0	0.0	0	0.0	-	-	-	-	-	-	0	0.0	1	0.0
-	-	-	-	-	-	-	-	0	0.4	-	-	0	0.0	1	0.0
-	-	0	0.0	-	-	-	-	0	0.0	0	0.2	0	0.0	95	1.5
9	2.5	11	0.6	0	0.0	1	0.0	5	22.8	7	16.8	1254	34.4	761	12.1
0	0.0	0	0.0	-	-	0	0.0	-	-	-	-	274	7.5	170	2.7
1	0.2	1	0.0	-	-	-	-	0	2.0	1	1.5	11	0.3	27	0.4
1	0.2	0	0.0	-	-	-	-	1	5.6	1	2.7	22	0.6	68	1.1
0	0.0	1	0.1	0	0.0	-	-	-	-	-	-	165	4.5	67	1.1
0	0.1	1	0.0	-	-	-	-	0	1.8	1	1.9	5	0.1	11	0.2
0	0.0	0	0.0	-	-	-	-	-	-	-	-	192	5.3	100	1.6
0	0.0	1	0.0	-	-	-	-	-	-	-	-	143	3.9	67	1.1
2	0.5	2	0.1	0	0.0	-	-	3	12.0	3	6.7	73	2.0	44	0.7
3	1.0	1	0.1	-	-	-	-	-	-	-	-	161	4.4	73	1.2
2	0.5	1	0.1	-	-	-	-	0	0.2	-	-	29	0.8	27	0.4
0	0.0	3	0.2	0	0.0	1	0.0	0	1.1	2	4.0	180	4.9	107	1.7
0	0.0	1	0.0	0	0.0	-	-	-	-	-	-	1	0.0	2	0.0
0	0.1	13	0.7	0	0.0	0	0.0	-	-	-	-	1	0.0	15	0.2
5	1.5	93	5.1	6	0.5	73	3.0	-	-	-	-	11	0.3	229	3.6
-	-	5	0.3	0	0.0	11	0.5	-	-	-	-	0	0.0	16	0.3
30	8.9	99	5.4	7	0.6	54	2.2	0	0.1	0	1.1	74	2.0	260	4.1
3	0.8	3	0.2	0	0.0	9	0.4	-	-	-	-	14	0.4	37	0.6
1	0.2	6	0.3	0	0.0	2	0.1	0	0.1	0	0.8	1	0.0	10	0.2
21	6.2	67	3.7	3	0.2	39	1.6	-	-	0	0.2	30	0.8	168	2.7
2	0.6	2	0.1	1	0.1	1	0.0	0	0.0	-	-	3	0.1	3	0.0
4	26	21	1.1	2	0.2	3	0.1	0	0.0	-	-	25	0.7	41	0.7
2	0.6	8	0.4	15	1.2	18	0.7	0	1.2	1	1.5	26	0.7	73	1.2
337		1830		1231		2433		22		40		3649		6274	

APPENDIX D—Cont'd.

APPENDIX E

Average annual number (thousands), weight (metric tons), and weight per fish caught in the marine recreational fishery in northern and central California for 1981–86 with total comparisons to 1958–61.

Species or Group	Pier & Dock No.	Pier & Dock Wt.	Pier & Dock Kg/F.	Jetty & Breakwater No.	Jetty & Breakwater Wt.	Jetty & Breakwater Kg/F.	Beach & Bank No.	Beach & Bank Wt.	Beach & Bank Kg/F.
SHARKS	6	26	4.67	1	3	6.23	3	11	3.28
LEOPARD SHARK	4	23	5.80	0	3	8.15	2	8	3.47
SPINY DOGFISH	0	0	0.90	0	0	1.00	-	-	-
SHARK, OTHER	2	3	2.09	0	0	3.80	1	3	2.91
STURGEONS	0	4	21.40	-	-	-	0	1	8.30
PACIFIC HERRING	70	7	0.10	1	0	0.15	1	0	0.13
NORTHERN ANCHOVY	17	0	0.01	4	0	0.01	-	-	-
SALMONIDS	5	10	2.19	2	3	1.82	2	3	1.66
SURF SMELT	2	0	0.03	-	-	-	94	4	0.04
PACIFIC COD	0	0	1.00	-	-	-	-	-	-
PACIFIC HAKE	-	-		-	-	-	0	0	1.20
PACIFIC TOMCOD	3	0	0.06	0	0	0.20	0	0	0.20
SILVERSIDES	7	1	0.14	0	0	0.20	4	1	0.28
JACKSMELT	184	39	0.21	4	1	0.30	47	14	0.29
ROCKFISH	71	8	0.11	11	5	0.43	26	17	0.65
BLACK ROCKFISH	1	1	1.02	2	1	0.52	5	5	0.98
BLUE ROCKFISH	1	0	0.33	2	0	0.23	4	2	0.46
BROWN ROCKFISH	19	2	0.11	2	0	0.21	6	1	0.22
BOCACCIO	44	2	0.05	0	0	0.20	0	0	0.50
CANARY ROCKFISH	0	0	0.80	0	0	0.80	1	0	0.77
CHILIPEPPER	0	0	0.90	-	-	-	-	-	-
COPPER ROCKFISH	0	0	1.40	1	1	0.78	1	1	1.09
GOPHER ROCKFISH	0	0	0.40	0	0	0.40	-	-	-
GREENSPOTTED ROCKFISH	0	0	1.00	-	-	-	-	-	-
GREENSTRIPED ROCKFISH	-	-	-	-	-	-	-	-	-
OLIVE ROCKFISH	-	-	-	0	0	0.60	0	0	0.40
QUILLBACK ROCKFISH	-	-	-	-	-	-	-	-	-
ROSY ROCKFISH	0	0	0.20	-	-	-	0	0	0.30
STARRY ROCKFISH	-	-	-	-	-	-	-	-	-
VERMILION ROCKFISH	0	0	1.20	0	0	2.80	0	0	1.80
WIDOW ROCKFISH	-	-	-	-	-	-	-	-	-
YELLOWTAIL ROCKFISH	0	0	0.80	0	0	0.40	0	0	0.60
ROCKFISHES, OTHER	6	2	0.32	4	2	0.45	9	7	0.76
SABLEFISH	-	-	-	-	-	-	-	-	-
GREENLINGS	3	3	1.04	6	5	0.80	29	18	0.63
KELP GREENLING	1	0	0.27	4	1	0.30	15	6	0.41
LINGCOD	1	2	1.65	1	3	2.87	3	8	2.72
GREENLINGS, OTHER	1	0	0.57	1	1	0.45	12	4	0.37

* Excludes fishery-specific estimates developed by California Department of Fish and Game.
** Excludes San Francisco Bay

APPENDIX E

APPENDIX E (CONTINUED)

P/R Boat **			CPFV			Spear			Total 1958-61**			Total 1981-86		
No.	*Wt.*	*Kg/F.*	*No.*	*Wt.*	*Kg/F.*	*No.*	*Wt.*	*Kg/F.*	*No.*	*Wt.*	*Kg/F.*	*No.*	*Wt.*	*Kg/F.*
4	33	7.56	5	76	14.63	0	1	6.20	5	15	2.90	19	150	7.82
1	5	7.70	3	31	12.46	-	-	-	2	9	3.64	10	70	7.21
2	5	2.19	1	3	1.99	-	-	-	0	1	2.24	4	7	2.03
2	23	14.56	1	42	31.33	0	1	6.20	2	5	2.18	6	73	12.46
-	-	-	7	93	13.64	-	-	-	0	0	6.82	7	98	13.70
0	0	0.20	-	-	-	-	-	-	0	0	0.07	72	8	0.10
1	0	0.02	-	-	-	-	-	-	10	0	0.04	23	0	0.01
61	163	2.67	87	237	2.72	-	-	-	74	265	3.57	156	416	2.67
-	-	-	-	-	-	-	-	-	2	0	0.04	95	4	0.04
-	-	-	-	-	-	-	-	-				0	0	1.00
2	2	0.99	35	34	0.97	-	-	-	0	0	0.51	37	36	0.97
-	-	-	-	-	-	-	-	-	8	1	0.07	95	4	0.04
-	-	-	-	-	-	-	-	-	43	5	0.11	0	0	1.00
6	2	0.26	0	0	0.20	-	-	-	273	50	0.18	240	55	0.23
1217	824	0.68	2087	1581	0.76	20	13	0.65	1287	1051	0.82	3431	2448	0.71
224	220	0.98	37	32	0.88	4	4	0.98	74	94	1.26	272	263	0.97
303	135	0.45	506	275	0.54	6	4	0.63	421	236	0.56	822	416	0.51
71	41	0.58	58	46	0.79	-	-	-	22	26	1.14	156	91	0.58
5	4	0.77	131	168	1.28	0	0	0.40	64	100	1.55	180	174	0.97
63	39	0.62	76	59	0.78	0	0	0.33	63	47	0.75	140	99	0.71
2	1	0.40	212	167	0.79	-	-	-	3	4	1.19	213	167	0.78
40	52	1.30	42	61	1.45	1	0	0.73	59	69	1.16	84	115	1.37
104	39	0.38	28	12	0.42	1	0	0.38	39	21	0.53	132	51	0.39
6	4	0.68	61	44	0.72	-	-	-	22	14	0.62	67	48	0.72
1	0	0.34	27	8	0.29	-	-	-	4	1	0.32	28	8	0.30
61	38	0.62	58	47	0.81	2	1	0.63	71	62	0.88	121	86	0.71
5	8	1.48	4	5	1.43	0	0	0.80	1	1	0.82	9	13	1.45
27	7	0.27	55	13	0.24	-	-	-	39	8	0.21	82	21	0.25
9	5	0.60	36	21	0.60	-	-	-	27	17	0.64	44	26	0.60
20	26	1.34	18	30	1.69	0	0	1.10	51	91	1.78	38	57	1.51
3	1	0.46	63	37	0.59	-	-	-	33	25	0.77	65	38	0.59
49	28	0.58	384	322	0.84	0	0	0.85	228	180	0.79	434	350	0.81
226	175	0.77	293	235	0.80	6	3	0.49	65	56	0.86	538	421	0.78
1	0	0.42	12	10	0.87	-	-	-				13	11	0.83
75	242	3.24	40	144	3.56	8	15	1.93	138	259	1.87	161	427	2.65
11	7	0.66	2	1	0.76	2	1	0.56	57	22	0.38	34	17	0.51
64	234	3.68	38	142	3.71	5	13	2.64	65	232	3.56	112	403	3.59
1	1	2.53	0	0	0.60	1	1	1.07	16	6	0.36	15	7	0.49

APPENDIX E—Cont'd.

APPENDIX E (CONTINUED)

Species or Group	Pier & Dock No.	Pier & Dock Wt.	Pier & Dock Kg/F.	Jetty & Breakwater No.	Jetty & Breakwater Wt.	Jetty & Breakwater Kg/F.	Beach & Bank No.	Beach & Bank Wt.	Beach & Bank Kg/F.
SCULPINS	37	2	0.05	10	2	0.22	47	13	0.27
CABEZON	1	1	0.74	2	2	0.65	13	11	0.84
PAC. STAGHORN SCULPIN	36	1	0.03	6	0	0.04	32	1	0.03
SCULPINS, OTHER	0	0	0.20	1	0	0.29	1	1	0.39
BARRED SAND BASS	0	0	0.20	-	-		0	0	0.35
KELP BASS	-	-	-	0	0	0.12	1	0	0.33
STRIPED BASS*	4	5	1.46	1	1	1.93	9	18	2.04
YELLOWTAIL	-	-	-	-	-	-	-	-	
CROAKERS	110	18	0.17	2	1	0.21	6	2	0.28
WHITE CROAKER	98	17	0.18	2	1	0.21	6	1	0.22
QUEENFISH	12	1	0.10	-	-	-	-	-	
CROAKERS, OTHER	-	-	-	-	-	-	0	0	2.30
OPALEYE	-	-	-	-	-	-	1	0	0.24
HALFMOON	-	-	-	-	-	-	-	-	
SURFPERCH	282	51	0.18	28	8	0.28	433	127	0.29
BARRED SURFPERCH	14	2	0.18	2	1	0.41	154	47	0.31
BLACK PERCH	9	2	0.21	1	0	0.25	15	4	0.24
PILE PERCH	41	19	0.46	1	1	0.72	25	17	0.67
REDTAIL SURFPERCH	2	0	0.25	1	1	0.44	63	20	0.32
RUBBERLIP SEAPERCH	3	2	0.68	1	0	0.83	5	3	0.51
SHINER PERCH	75	3	0.04	2	0	0.05	22	1	0.04
SILVER SURFPERCH	16	2	0.14	2	0	0.13	49	7	0.15
STRIPED SEAPERCH	4	1	0.33	5	2	0.33	30	13	0.43
WALLEYE SURFPERCH	48	6	0.13	6	1	0.19	19	4	0.19
WHITE SEAPERCH	13	2	0.17	2	0	0.25	11	2	0.18
SURFPERCHES, OTHER	56	10	0.17	5	1	0.25	41	10	0.24
CALIFORNIA BARRACUDA	-	-	-	-	-	-	-	-	-
PACIFIC BONITO	1	1	1.63	0	0	1.00	1	1	2.10
PACIFIC MACKEREL	51	14	0.28	7	2	0.31	5	2	0.39
TUNAS	-	-		-	-		-	-	
FLATFISH	86	15	0.18	5	3	0.63	15	6	0.42
STARRY FLOUNDER	11	4	0.35	3	2	0.94	12	5	0.44
CALIFORNIA HALIBUT	1	4	3.00	0	0	0.80	0	1	1.72
PACIFIC SANDDAB	61	6	0.10	1	0	0.20	1	0	0.17
ROCK SOLE	-	-	-	0	0	0.20	0	0	0.20
FLATFISHES, OTHER	13	2	0.14	1	0	0.28	3	1	0.21
OTHER FISH	30	25	0.83	3	7	2.82	27	14	0.52
TOTAL	966	230		84	41		750	253	

* Excludes fishery-specific estimates developed by California Department of Fish and Game.
** Excludes San Francisco Bay

APPENDIX E—Cont'd.

APPENDIX E (CONTINUED)

P/R Boat **			CPFV			Spear			Total 1958-61**			Total 1981-86		
No.	*Wt.*	*Kg/F.*	*No.*	*Wt.*	*Kg/F.*	*No.*	*Wt.*	*Kg/F.*	*No.*	*Wt.*	*Kg/F.*	*No.*	*Wt.*	*Kg/F.*
22	34	1.55	3	6	1.96	4	4	1.12	56	39	0.69	122	61	0.50
19	33	1.74	3	6	1.96	4	4	1.12	39	37	0.94	43	57	1.34
2	0	0.05	-	-		0	0	0.80	15	1	0.09	76	2	0.03
1	0	0.64	-	-		-	-	-	2	1	0.36	4	1	0.40
0	0	0.53	-	-	-	-	-	-	0	0	0.91	1	0	0.40
1	1	1.02	0	0	0.60	0	0	1.13	0	0	0.68	3	2	0.61
6	12	1.87	11	20	1.89	-	-	-	91	216	2.36	30	55	1.87
0	0	0.20	-	-	-	-	-	-	0	0		0	1	
204	46	0.22	1	0	0.38	-	-	-	294	68	0.23	322	66	0.21
203	44	0.22	1	0	0.38	-	-	-	289	67	0.23	310	63	0.20
0	0	0.20	-	-	-	-	-	-	4	0	0.09	12	1	0.10
0	2	5.25	-	-	-	-	-	-	0	1	8.57	1	2	4.27
-	-	-	-	-	-	-	-	-	0	0	0.91	1	0	0.24
0	0	0.60	-	-	-	0	0	0.40	0	0	0.57	95	4	0.04
												0	0	
11	4	0.35	1	0	0.22	7	4	0.58	1254	420	0.34	761	193	0.25
0	0	0.24	0	0	0.20	-	-	-	274	124	0.45	170	51	0.30
1	0	0.32	-	-	-	1	0	0.40	11	4	0.36	27	6	0.24
0	0	0.68	-	-	-	1	1	0.68	22	12	0.55	68	37	0.55
1	1	0.47	-	-	-	-	-	-	165	135	0.82	67	22	0.33
1	1	0.91	-	-	-	1	1	0.93	5	4	0.91	11	7	0.63
0	0	0.05	-	-		-	-		192	5	0.03	100	4	0.04
1	0	0.30	-	-		-	-		143	6	0.05	67	10	0.15
2	1	0.48	-	-		3	1	0.48	73	40	0.55	44	18	0.42
1	0	0.16	-	-		-	-		161	22	0.14	73	11	0.15
1	0	0.28	-	-		-	-		29	8	0.27	27	5	0.19
3	1	0.21	1	0	0.22	2	1	0.58	180	59	0.33	107	22	0.21
1	1	1.31	-	-	-	-	-	-	1	1	1.82	2	3	1.75
13	30	2.30	0	1	2.96	-	-	-	1	2	3.62	15	33	2.26
93	41	0.44	73	38	0.52	-	-	-	11	3	0.26	229	98	0.43
5	56	10.36	11	121	11.04	-	-	-	0	2	6.82	16	178	10.81
99	46	0.46	54	29	0.54	0	2	5.48	74	27	0.37	260	102	0.39
3	5	1.62	9	4	0.45	-	-	-	14	8	0.58	37	20	0.55
6	24	3.84	2	14	7.44	0	2	6.80	1	3	3.36	10	44	4.41
67	9	0.13	39	7	0.17	0	0	0.20	30	3	0.11	168	22	0.13
2	1	0.69	1	1	0.83	-	-	-	3	2	0.65	3	2	0.71
21	7	0.31	3	3	0.95	-	-	-	25	10	0.40	41	12	0.30
7	23	3.28	6	4	0.66	1	1	2.49	26	17	0.66	73	74	1.02
1830	1559		2433	2395		40	41		3649	2441		6274	4524	

APPENDIX E—Cont'd.

APPENDIX F

Average number (thousands), weight (metric tons), and weight per fish caught in the marine recreational fishery by coastal county district, 1981–86.

	Del Norte/ Humboldt			Mendocino/ Sonoma			S. Francisco (Ocean)		
Species or Group	*No.*	*Wt.*	*Kg./F.*	*No.*	*Wt.*	*Kg./F.*	*No.*	*Wt.*	*Kg./F.*
SHARKS	1	7	7.08	1	5	5.52	2	12	5.28
LEOPARD SHARK	0	4	25.20	0	1	3.10	1	2	2.89
SPINY DOGFISH	0	0	1.60	0	1	2.13	0	0	1.80
SHARK, OTHER	1	2	4.26	0	4	8.52	1	10	6.75
STURGEONS	-	-	-	-	-	-	-	-	-
PACIFIC HERRING	3	0	0.13	69	7	0.10	-	-	-
NORTHERN ANCHOVY	-	-	-	3	0	0.02	2	0	0.01
SALMONIDS*	4	5	1.48	4	9	2.34	8	24	3.11
SURF SMELT	94	4	0.04	1	0	0.02	0	0	0.05
PACIFIC COD	-	-		-	-	-	0	0	1.00
PACIFIC HAKE	0	0	1.20	0	0	1.40	0	0	0.87
PACIFIC TOMCOD	0	0	0.20	-	-	-	1	0	0.07
SILVERSIDES	-	-	-	0	0	0.20	0	0	0.20
JACKSMELT	3	1	0.22	5	1	0.21	6	2	0.26
ROCKFISH	277	314	1.13	458	462	1.01	559	486	0.87
BLACK ROCKFISH	177	192	1.08	40	41	1.02	23	17	0.72
BLUE ROCKFISH	15	13	0.85	133	99	0.75	112	66	0.59
BROWN ROCKFISH	1	1	0.82	18	15	0.83	49	34	0.70
BOCACCIO	0	0	1.27	10	22	2.07	23	47	2.03
CANARY ROCKFISH	17	16	0.95	41	29	0.71	33	25	0.76
CHILIPEPPER	-	-	-	16	18	1.09	9	7	0.73
COPPER ROCKFISH	8	17	2.23	22	36	1.63	19	28	1.45
GOPHER ROCKFISH	-	-	-	2	1	0.62	2	1	0.54
GREENSPOTTED ROCKFISH	0	0	1.00	12	11	0.96	18	13	0.73
GREENSTRIPED ROCKFISH	0	0	0.70	4	1	0.37	2	1	0.38
OLIVE ROCKFISH	-	-	-	6	5	0.87	11	7	0.64
QUILLBACK ROCKFISH	2	4	1.63	4	6	1.61	2	2	1.33
ROSY ROCKFISH	1	1	0.49	10	4	0.36	14	4	0.28
STARRY ROCKFISH	0	0	1.00	2	2	0.93	4	4	0.86
VERMILION ROCKFISH	2	3	2.17	4	10	2.39	4	7	1.84
WIDOW ROCKFISH	0	0	0.40	4	4	0.88	5	4	0.73
YELLOWTAIL ROCKFISH	9	7	0.78	83	100	1.20	119	108	0.90
ROCKFISHES, OTHER	44	59	1.34	48	59	1.25	110	113	1.03
SABLEFISH	0	0	2.40	-	-	-	-	-	-
GREENLINGS	36	121	3.33	50	102	2.04	20	51	2.60
KELP GREENLING	9	5	0.51	15	7	0.51	4	3	0.58
LINGCOD	25	115	4.59	24	90	3.71	15	49	3.31
GREENLINGS, OTHER	2	1	0.65	11	5	0.44	1	0	0.44

* Excludes fishery-specific estimates developed by California Department of Fish and Game.

APPENDIX F

APPENDIX F (CONTINUED)

S. Francisco (Bay)			Santa Cruz/ Monterey			San Luis Obispo			Total		
No.	*Wt.*	*Kg./F.*	*No.*	*Wt.*	*Kg./F.*	*No.*	*Wt.*	*Kg./F.*	*No.*	*Wt.*	*Kg./F.*
39	256	6.56	3	19	6.28	2	7	3.37	48	305	6.34
26	159	6.25	1	2	3.86	0	2	4.95	28	170	6.18
2	3	1.96	1	2	1.75	1	3	2.34	5	9	1.98
12	93	7.89	1	14	12.36	1	3	4.37	16	126	7.87
24	369	15.38	-	-	-	-	-	-	24	369	15.38
-	-	-	-	-	-	-	-	-	72	8	0.10
18	0	0.01	-	-	-	-	-	-	23	0	0.01
3	8	2.42	1	2	2.98	4	13	3.56	23	61	2.70
-	-	-	-	-	-	-	-	-	95	4	0.04
-	-	-	-	-	-	-	-	-	0	0	1.00
-	-	-	36	35	0.97	1	1	0.91	37	36	0.97
2	0	0.07	1	0	0.03	-	-	-	4	0	0.07
10	2	0.19	-	-	-	0	0	0.10	11	2	0.19
234	58	0.25	24	7	0.29	23	6	0.25	296	74	0.25
84	21	0.25	1227	753	0.61	880	426	0.48	3484	2462	0.71
5	2	0.43	12	6	0.48	20	8	0.38	277	265	0.96
2	1	0.47	297	129	0.43	264	109	0.41	823	417	0.51
59	10	0.18	44	22	0.51	23	17	0.75	193	100	0.52
-	-		90	90	1.00	57	16	0.28	180	174	0.97
1	0	0.60	30	19	0.65	19	9	0.49	140	99	0.71
-	-		160	118	0.74	28	25	0.90	213	167	0.78
1	0	0.77	15	16	1.02	20	18	0.92	85	115	1.36
-	-	-	33	11	0.33	96	39	0.40	132	51	0.39
-	-	-	32	20	0.64	6	3	0.55	67	48	0.72
-	-	-	20	6	0.28	2	0	0.24	28	8	0.30
-	-	-	59	47	0.79	45	27	0.61	121	86	0.71
-	-	-	1	1	0.65	0	0	0.20	9	13	1.45
0	0	0.20	26	5	0.21	31	7	0.23	82	21	0.25
-	-	-	16	8	0.53	22	13	0.57	44	26	0.60
-	-	-	9	11	1.16	19	25	1.36	38	57	1.51
-	-	-	33	23	0.72	24	8	0.33	65	38	0.59
-	-	-	145	104	0.72	79	32	0.41	434	350	0.81
16	7	0.41	206	117	0.57	128	70	0.54	552	425	0.77
-	-	-	13	10	0.83	0	0	0.47	13	11	0.83
4	4	0.98	42	126	3.02	11	25	2.27	163	430	2.63
2	1	0.36	3	1	0.44	2	1	0.51	35	18	0.50
2	3	1.84	38	125	3.25	9	24	2.60	113	405	3.58
0	0	0.50	0	0	0.60	0	0	1.47	15	7	0.49

APPENDIX F—Cont'd.

APPENDIX F (CONTINUED)

Species or Group	Del Norte/ Humboldt No.	Wt.	Kg./F.	Mendocino/ Sonoma No.	Wt.	Kg./F.	S. Francisco (Ocean) No.	Wt.	Kg./F.
SCULPINS	9	15	1.62	15	16	1.06	8	5	0.62
CABEZON	8	14	1.88	13	15	1.17	5	5	1.12
PAC. STAGHORN SCULPIN	0	0	0.20	0	0	0.33	4	0	0.03
SCULPINS, OTHER	1	1	0.43	2	1	0.39	-	-	
BARRED SAND BASS	-	-	-	-	-	-	-	-	-
KELP BASS	-	-	-	0	0	0.30	0	0	1.20
STRIPED BASS*	-	-	-	1	1	1.08	11	26	2.38
YELLOWTAIL	-	-	-	-	-	-	-	-	-
CROAKERS	0	0	0.40	-	-	-	29	6	0.21
WHITE CROAKER	-	-	-	-	-	-	29	6	0.21
QUEENFISH	-	-	-	-	-	-	-	-	-
CROAKERS, OTHER	0	0	0.40	-	-	-	-	-	-
OPALEYE	-	-	-	-	-	-	-	-	-
HALFMOON	-	-	-	-	-	-	-	-	-
SURFPERCH	81	27	0.33	48	15	0.32	110	35	0.31
BARRED SURFPERCH	0	0	0.20	0	0	0.27	25	8	0.34
BLACK PERCH	-	-	-	0	0	0.30	1	0	0.27
PILE PERCH	2	1	0.72	1	1	0.80	12	9	0.77
REDTAIL SURFPERCH	30	12	0.40	10	3	0.36	23	5	0.22
RUBBERLIP SEAPERCH	0	0	0.80	1	1	0.75	1	1	0.84
SHINER PERCH	1	0	0.08	6	0	0.03	2	0	0.05
SILVER SURFPERCH	10	2	0.15	2	0	0.16	22	4	0.19
STRIPED SEAPERCH	15	6	0.44	17	8	0.43	4	2	0.40
WALLEYE SURFPERCH	6	1	0.16	1	0	0.18	9	2	0.20
WHITE SEAPERCH	3	1	0.29	2	0	0.20	3	0	0.16
SURFPERCHES, OTHER	15	4	0.24	8	2	0.25	9	3	0.31
CALIFORNIA BARRACUDA	-	-	-	-	-	-	-	-	-
PACIFIC BONITO	0	1	4.00	0	0	4.40	1	2	1.69
PACIFIC MACKEREL	-	-	-	4	2	0.51	27	8	0.28
TUNAS	-	-	-	0	0	4.80	-	-	-
FLATFISH	7	2	0.34	18	8	0.46	9	14	1.60
STARRY FLOUNDER	1	1	1.04	1	2	1.62	3	2	0.60
CALIFORNIA HALIBUT	-	-	-	1	3	5.29	2	11	5.40
PACIFIC SANDDAB	4	1	0.14	12	2	0.15	2	0	0.12
ROCK SOLE	-	-	-	1	1	0.84	0	0	0.60
FLATFISHES, OTHER	2	1	0.43	3	1	0.25	3	1	0.55
OTHER FISH	2	10	5.18	6	7	1.04	4	8	1.87
TOTAL	518	507		684	636		799	680	

* Excludes fishery-specific estimates developed by California Department of Fish and Game.

APPENDIX F—Cont'd.

APPENDIX F (CONTINUED)

S. Francisco (Bay)			Santa Cruz/ Monterey			San Luis Obispo			Total		
No.	*Wt.*	*Kg./F.*	*No.*	*Wt.*	*Kg./F.*	*No.*	*Wt.*	*Kg./F.*	*No.*	*Wt.*	*Kg./F.*
65	3	0.04	25	7	0.29	12	16	1.27	136	62	0.46
1	1	0.55	6	7	1.19	11	16	1.40	43	58	1.33
63	2	0.03	20	1	0.04	1	0	0.04	88	3	0.03
0	0	0.32	0	0	0.40	-	-		4	2	0.40
-	-	-	-	-	-	1	0	0.40	1	0	0.40
0	0	0.20	1	1	1.03	1	0	0.20	3	2	0.58
48	84	1.73	1	1	1.31	0	0	4.20	62	112	1.83
-	-	-	-	-	-	0	0	0.20	0	0	0.20
69	18	0.27	203	41	0.20	51	11	0.22	352	76	0.22
69	18	0.27	203	41	0.20	39	8	0.20	339	73	0.21
-	-	-	-	-	-	12	1	0.10	12	1	0.10
-	-	-	-	-	-	0	2	5.04	1	2	4.27
-	-	-	-	-	-	1	0	0.24	1	0	0.24
-	-	-	0	0	0.50	-	-	-	0	0	0.50
338	95	0.28	182	43	0.24	116	25	0.22	875	240	0.27
5	2	0.41	93	26	0.28	50	15	0.30	172	51	0.30
30	7	0.24	4	1	0.28	2	1	0.33	37	9	0.25
61	31	0.50	3	2	0.56	1	1	0.50	79	44	0.55
3	1	0.28	1	0	0.27	0	0	0.28	67	22	0.33
32	21	0.65	2	2	0.90	1	1	1.00	36	25	0.68
82	3	0.04	5	0	0.03	8	0	0.03	104	4	0.04
7	1	0.20	6	1	0.10	22	2	0.11	69	10	0.15
5	1	0.25	3	1	0.41	1	0	0.43	45	19	0.41
45	10	0.21	24	3	0.13	9	1	0.15	93	17	0.18
27	7	0.25	11	2	0.15	0	0	0.20	46	10	0.22
42	12	0.27	30	5	0.18	23	4	0.19	127	29	0.23
-	-		0	0	0.80	1	1	1.40	1	1	1.31
1	1	1.69	4	10	2.50	9	20	2.17	15	34	2.23
4	2	0.50	117	56	0.48	80	32	0.40	232	99	0.43
0	0	2.60	7	71	9.72	9	106	11.76	17	178	10.77
115	69	0.60	120	30	0.25	16	18	1.14	284	142	0.50
45	23	0.52	4	4	0.89	2	2	1.07	55	33	0.60
7	37	5.64	2	7	4.32	4	13	2.99	15	71	4.69
53	6	0.11	92	13	0.14	6	1	0.15	169	22	0.13
0	0	1.50	2	1	0.69	1	0	0.60	3	2	0.75
10	3	0.31	21	6	0.26	3	1	0.49	42	13	0.31
62	272	4.37	7	10	1.47	6	11	1.88	88	318	3.62
1120	1262		2013	1223		1223	718		6357	5026	

APPENDIX F—Cont'd.

APPENDIX G

Annual distribution of species in the sample possibly affected by the 1982–83 ENSO.

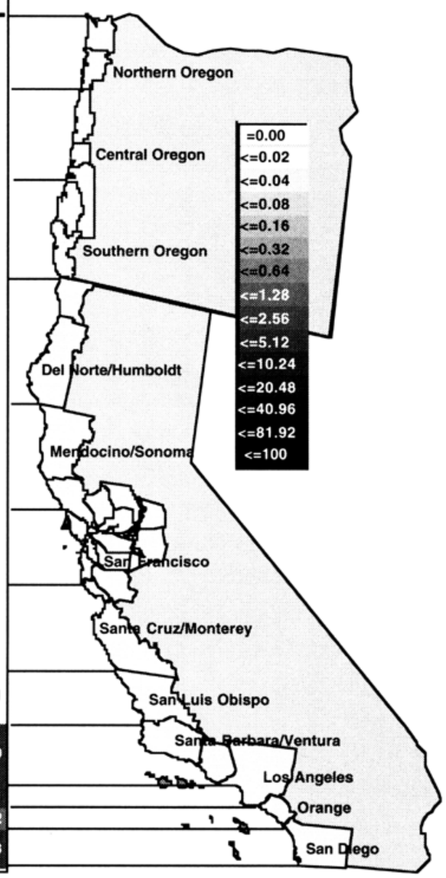
Barred Sand bass							California Sheephead						
80	81	82	83	84	85	86	80	81	82	83	84	85	86
-	0	0	0	0	0	0	-	0	0	0	0	0	0
-	0	0	0	0	0	0	-	0	0	0	0	0	0
-	0	0	0	0	0	0	-	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0.04	0.07	0.12	0	0	0	0	0	0	0
1.07	1.57	2.87	1.34	1.8	3.96	2.84	0.25	0.51	0.57	0.16	0.71	0.74	1.24
4	2.87	0.41	5.66	3.71	9.88	12.8	0.09	0.34	0.41	1.78	0.91	1.3	1.55
5.67	7.13	0.75	9.09	6.12	16.9	15.3	0.61	0.71	0.75	3.49	1.34	1.1	2.08
5.5	5.81	1.56	4.6	6.03	10.9	8.34	0.55	0.65	0.39	2.61	0.68	0.48	0.54

APPENDIX G

APPENDIX G (CONTINUED)

Ocean Whitefish

80	81	82	83	84	85	86
-	0	0	0	0	0	0
-	0	0	0	0	0	0
-	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0.01	0	0	0	0
0	0	0	0	0	0	0.01
0.3	0.53	0.57	0.36	1.83	5.27	3.29
0.18	0.15	0.41	0.97	1.36	7.22	4.11
0.1	0.69	6.81	0.14	0.51	1.6	0.92
0.78	0.72	1.17	1.4	0.4	2.08	3.48



APPENDIX G—Cont'd.

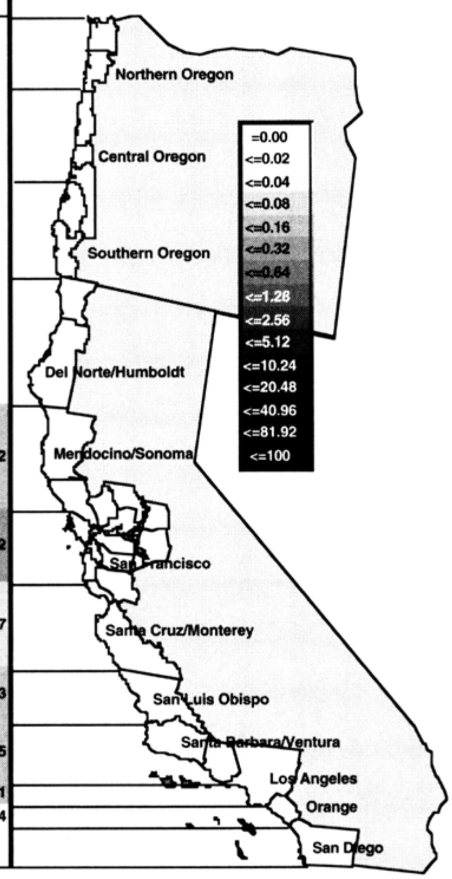
APPENDIX G (CONTINUED)

Petrale Sole							Sand Sole						
80	81	82	83	84	85	86	80	81	82	83	84	85	86
-	0	0	0.03	0	0	0.03	-	0	1.88	0	0.02	0	0
-	0	0.54	0.06	0	0	0	-	0.17	0.27	0.22	0.03	0.04	0
-	0	0	0	0	0	0	-	0.05	0.47	0.07	0	0.37	0.02
0.04	0.11	0	0.07	0.05	0.06	0.02	0.1	0.02	0.57	1.85	0.2	0.06	0.11
0.01	0	0.02	0.02	0.02	0	0.05	0.16	0.04	0.22	1.29	0.04	0.07	0.07
0.02	0.02	0.09	0	0.01	0	0.03	0.01	0	0.09	0	0.01	0.02	0
0.06	0	0	0	0	0.13	0.05	0.71	0.94	0.41	0.24	0.03	0.01	0.04
0	0.01	0.14	0	0	0.04	0	0.47	0.2	0.01	0.01	0	0	0
0.03	0.08	0.57	0.03	0.08	0.04	0.01	0.01	0	0	0	0	0	0
0	0	0	0.03	0.02	0.16	0	0	0	0	0	0	0	0
0	0.06	0.75	0.02	0.05	0.03	0.02	0	0	0	0	0	0	0
0	0	0	0	0.02	0.02	0	0	0	0	0	0	0	0

APPENDIX G—Cont'd.

Spiny Dogfish

80	81	82	83	84	85	86
-	0.09	0	0	0	0	0
-	0	0	0	0.03	0	0
-	0	0	0	0	0	0
0	0.05	0.03	0.03	0.02	0	0
0.03	0	0	0.07	0	0.01	0.12
0.24	0.1	0.07	0.02	0.23	0.03	0.22
0.01	0	0	0	0.03	0.11	0.07
0.25	0.13	0.26	0.19	0.3	0.19	0.13
0.08	0.22	4.02	0.04	0.06	0.14	0.15
0.1	0.03	1.25	0.03	0.01	0.25	0.11
0.04	0.19	0.75	0.02	0	0	0.04
0.03	0	0.39	0.02	0.06	0.02	0



APPENDIX G—Cont'd.

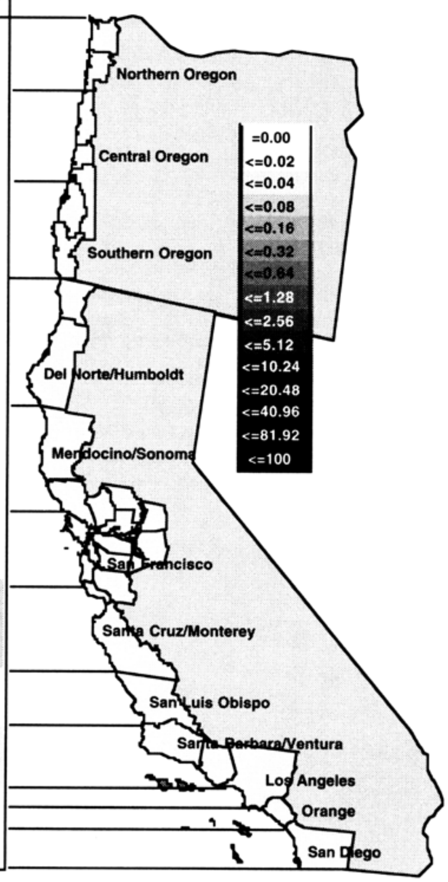
APPENDIX G (CONTINUED)

Black Croaker							Opaleye						
80	81	82	83	84	85	86	80	81	82	83	84	85	86
-	0	0	0	0	0	0	-	0	0	0	0	0	0
-	0	0	0	0	0	0	-	0	0	0	0	0	0
-	0	0	0	0	0	0	-	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0.01	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0.06	0.11	0.01	0.06	0.82	0.14
0.02	0.03	0.57	0.07	0.02	0	0.01	0.19	0.12	0.57	0.04	0.03	0.14	0.06
0.02	0.06	0.41	0.15	0.16	0.04	0	1.08	1.11	7.91	1.15	1.71	1.23	0.81
0	0.03	0.75	0.39	0.35	0.03	0.11	0.47	0.61	0.75	0.88	1.29	0.47	0.67
0.05	0.09	0	0.12	0.04	0.09	0.09	0.41	0.38	0.39	0.71	1.32	0.58	0.83

APPENDIX G—Cont'd.

Senorita

80	81	82	83	84	85	86
-	0	0	0	0	0	0
-	0	0	0	0	0	0
-	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0.05	0.08	0.07
0	0	0	0.01	0	0	0
0.03	0	0	0	0.02	0	0.04
0.01	0.03	0.41	0.01	0.11	0.02	0
0	0	2.27	0	0	0	0
0.01	0	0	0	0	0	0



APPENDIX G—Cont'd.

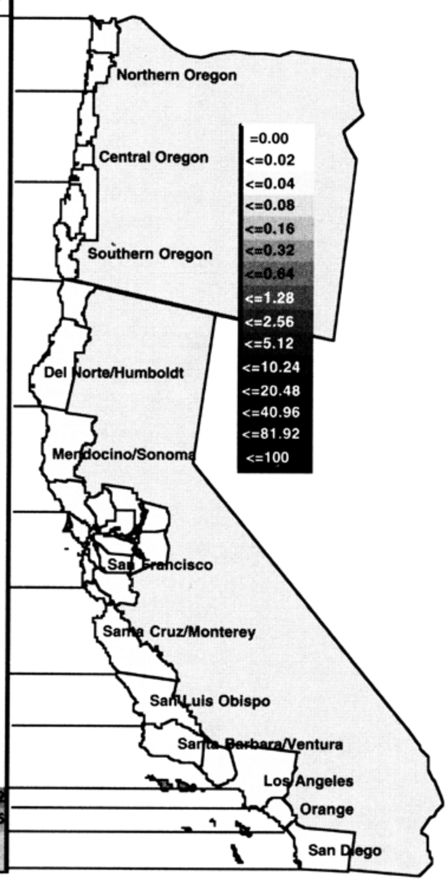
APPENDIX G (CONTINUED)

Shovelnose Guitarfish							Pacific Hake						
80	81	82	83	84	85	86	80	81	82	83	84	85	86
-	0	0	0	0	0	0	-	0	0	0.11	0	0	0
-	0	0	0	0	0	0	-	0	0	0	0	0	0
-	0	0	0	0	0	0	-	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0.02	0	0	0	0	0.04
0	0	0	0	0	0	0	0.12	0	0	0.05	0.04	0	0
0	0.05	0	0	0	0	0	0	0	0	0	0	0.39	0
0	0	0	0	0	0	0	1.5	0.31	0.11	0	1.57	4.79	3.31
0	0	0.03	0.08	0.07	0.05	0.05	0	0	0	0	0.03	0.04	0.09
0	0.01	0.57	0.07	0.05	0.01	0.02	0.04	0.01	0	0.03	0	0.09	0.02
0.05	0.02	12.1	0	0.06	0.04	0.06	0	0	0.41	0	0	0	0
0.1	0.08	[illegible]	0.04	0.13	0	0.08	0	0	0.75	0	0	0	0.08
0.04	0.09	0	0.03	0	0	0	0	0	5.88	0	0	0	0.19

APPENDIX G—Cont'd.

Yellowtail

80	81	82	83	84	85	86
-	0	0	0	0	0	0
-	0	0	0	0	0	0
-	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0.01	0
0.01	0.01	0.57	2.41	1.15	0.15	0
0.02	0.06	0.83	2.67	2.29	2.08	0.42
0	0.53	0.75	1.99	1.96	0.43	0.25
0.05	0.18	0.39	5.63	1.26	0.15	0.1

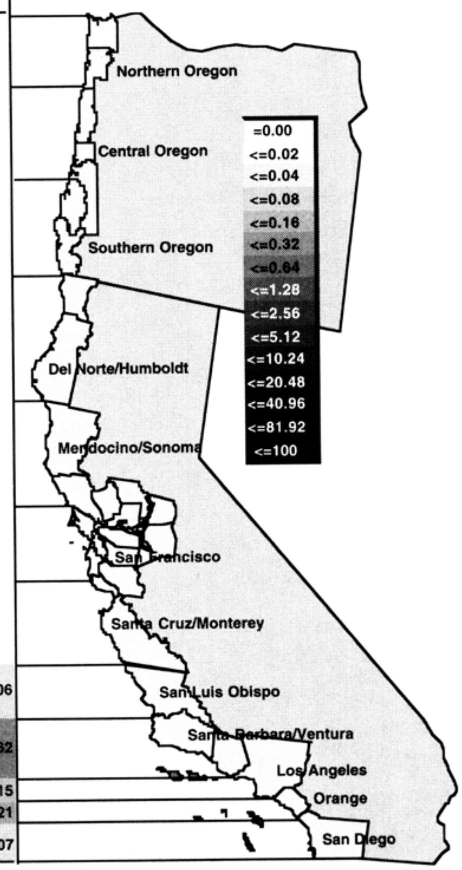


APPENDIX G—Cont'd.

APPENDIX G (CONTINUED)

White Seabass

80	81	82	83	84	85	86
-	0	0	0	0	0	0
-	0	0	0	0	0	0
-	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0.01	0	0	0	0
0	0	0	0	0.01	0	0.06
0.01	0.3	0.57	0.07	0.17	0.14	0.62
0.1	0.06	1.25	0.08	0.04	0.16	0.15
0.16	0.18	0.75	0.04	0.24	0.07	0.21
0.12	0.05	0.39	0.11	0.06	0.11	0.07



APPENDIX G—Cont'd.

Scientific names of fish encountered in the northern and central California marine recreational fisheries are provided in Appendix A.