Declining Rockfish Lengths in the Monterey Bay, California, Recreational Fishery, 1959–94

JANET E. MASON

Introduction

Marine recreational bottom fishing from commercial passenger fishing vessels (CPFV's), known as partyboats and charter boats, has been popular in the Monterey Bay area of central California since the late 1920's (Clark and Croker, 1933). Passengers pay a fee to be taken to one or more offshore fishing sites, where they fish while the boat drifts over bottoms from 9 to 274 m deep (Sullivan, 1995). The skipper locates concentrations of fish on the bottom or in midwater, and anglers catch an average of 11–12 fish per day (Karpov et al., 1995). For the purpose of this paper, the Monterey Bay area, approximately 100 km south of San Francisco, includes all sites normally fished by CPFV's from the ports of Santa Cruz, Moss Landing, and Monterey (Fig. 1) and extends from Año Nuevo, about 35 km north of Santa Cruz, to Point Sur, about 35 km south of Monterey. This area received 24% of CPFV effort and produced 43% of CPFV landings in northern California from 1981 to 1986 (Karpov et al., 1995). Most of the fish caught (85%) are of the genus *Sebastes*, commonly called rockfish (Miller and Geibel, 1973; Karpov et al., 1995).

Rockfish have dominated the catch from CPFV's in the Monterey Bay area from the 1950's to the present (Miller and Geibel, 1973; Karpov et al., 1995; Reilly et al.[1]; Wilson-Vandenberg et al.[2]). At least 29 species of rockfish appear in the CPFV catch (Miller and Geibel, 1973), but the fishery heavily targets the few aggregating species found in limited areas. Over 72% of the catch in 1960–86 (Mason, 1995) and 76% in 1987–91(Reilly et al.[1]) came from six aggregating species: bocaccio, *S. paucispinis*; chilipepper, *S. goodei*; blue rockfish, *S. mystinus*; yellowtail rockfish, *S. flavidus*; widow rockfish, *S. entomelas*; and olive rockfish, *S. serranoides*. Over the years the proportions of these species in the catch have changed from predominantly blue rockfish in the 1950's, to both blue and yellowtail rockfish in the 1960's (Miller and Geibel, 1973), to more chilipepper and bocaccio in the 1980's (Mason, 1995), and back to more blue rockfish in the 1990's (Wilson-Vandenberg et al.[2,3]; Wilson et al.[4]).

The continuous harvest of rockfish by the CPFV fishery has raised questions about the sustainability and health of this fishery. Some anglers and boat operators believe that rockfish are smaller

The author is with the Pacific Fisheries Environmental Laboratory, National Marine Fisheries Service, NOAA, 1352 Lighthouse Ave., Pacific Grove, CA 93950.

ABSTRACT—California's Monterey Bay area is an important center of recreational fishing for rockfish of various Sebastes *species. The species composition of commercial passenger fishing vessel catches from 1959 to 1994 varied with changes in fishing location and depth. The shift from shallow nearshore locations to deeper offshore locations in the late 1970's and 1980's changed the emphasis from the blue rockfish,* S. mystinus, *of shallow waters to the deeper, commercially fished chilipepper,* S. goodei, *and bocaccio,* S. paucispinis. *The mean size of rockfish in the catch increased as the latter species were targeted at greater depths but then declined as stocks of older fish disappeared by the mid 1980's. During 1960–94 the mean size of all ten leading species in the recreational catch declined. The declines ranged from 1% for canary rockfish,* S. pinniger, *to 27% for chilipepper. The sizes of the deeper living species declined more than those of shallower species. The low frequency of strong recruitment events and increase in fishing mortality and natural mortality appear to have contributed to the declining mean size. The scarcity of older fish, observed as a drop in mean size to below the size of maturity for 50% of females, leads to concern for future recruitment of the larger species, especially bocaccio, chilipepper, yellowtail rockfish,* S. flavidus, *and canary rockfish.*

[1] Reilly, P. N., D. Wilson-Vandenberg, D. L. Watters, J. E. Hardwick, and D. Short. 1993. On board sampling of the rockfish and lingcod commercial passenger fishing vessel industry in northern and central California, May 1987 to December 1991. Calif. Dep. Fish Game, Mar. Res. Div. Admin. Rep. 93-4, 242 p.

[2] Wilson-Vandenberg, D., P. N. Reilly, and L. Halko. 1995. Onboard sampling of the rockfish and lingcod commercial passenger fishing vessel industry in northern and central California, January through December 1993. Calif. Dep. Fish Game, Mar. Res. Div. Admin. Rep. 95-2, 122 p.

[3] Wilson-Vandenberg, D., P. N. Reilly, and C. E. Wilson. 1996. Onboard sampling of the rockfish and lingcod commercial passenger fishing vessel industry in northern and central California, January through December 1994. Calif. Dep. Fish Game, Mar. Res. Div. Admin. Rep. 96-6, 96 p.

[4] Wilson, C. E., L. A. Halko, D. Wilson-Vandenberg, and P. N. Reilly. 1996. Onboard sampling of the rockfish and lingcod commercial passenger fishing vessel industry in northern and central California, 1992. Calif. Dep. Fish Game, Mar. Res. Div. Admin. Rep. 96-2, 103 p.

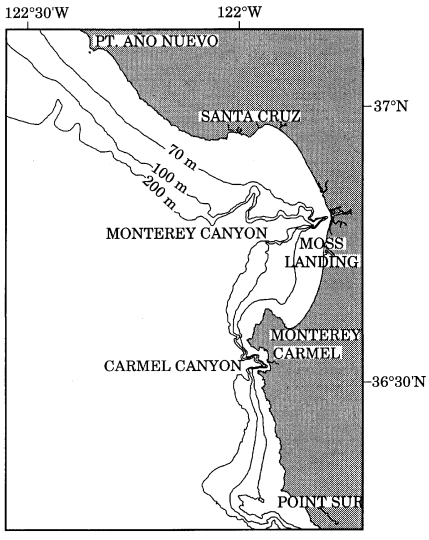

Figure 1.—Extent of the Monterey Bay CPFV fishing area on the central coast of California.

and less available than in the past, especially close to port. Reilly and coworkers[1] studied the species composition, mean length, and catch per angler hour in the fishery from 1987 to 1991. They found variation in the mean length of individual species and recommended a longer study to determine trends. In this paper, I combined 8 years of their studies with earlier data to provide a longer historical perspective on mean lengths of the ten dominant rockfish species over a 34-year period. These changes will be reviewed in light of the relative abundance of the species in the catch and the effect of new recruitment on mean length in the catch.

The relative importance of particular rockfish species has changed with their availability over the years and with the CPFV fleet's response. Blue rockfish dominated the catch in the first CPFV survey by the California Department of Fish and Game (CDFG) in 1959–60 (Miller and Gotshall, 1965). Miller and Gotshall expressed concern about the declining availability of blue rockfish which dropped that year from 54% to 18% of the local Santa Cruz catch. Blue rockfish aggregate in shallow water <70 m deep (Miller and Geibel, 1973). Like most rockfish species, they do not migrate and are therefore easily depleted in local areas. Miller and Geibel (1973) found that 95% of blue rockfish recaptured from tagging releases inside kelp beds were found at the release site over a 3-year period, and that 85% of recaptured adult blue rockfish from tagging outside kelp beds moved <1.6 km. Length distributions of the catch from fishing areas 15 km apart remained distinct over several years, confirming the isolation of local populations and the lack of replenishment by adults from other areas despite differences in fish density (Miller and Geibel, 1973).

As catches of blue rockfish declined near Santa Cruz in the 1960's, CPFV skippers maintained high catch rates through two strategies: fishing farther from port for blue rockfish or shifting to deeper water to target other species such as yellowtail rockfish (Miller and Geibel, 1973). Boats from Santa Cruz located concentrations of blue rockfish at Año Nuevo, 15 km from port, but after a few years even these distant stocks declined in mean length and in availability. In the area nearer port, yellowtail rockfish became the leading species in the catch, taken in midwater over banks from 66 to 100 m deep (Miller and Gotshall, 1965).

A second shift to fishing in even deeper water occurred by 1977 as chilipepper rockfish, caught near the bottom at depths averaging 116–135 m (Sullivan, 1995), became the dominant species (Mason, 1995). Bocaccio, greenspotted rockfish, *S. chlorostictus*, and greenstriped rockfish, *S. elongatus*, were also caught at these depths. These four species are used in this report as indicators of deepwater fishing (depths of 75 m or deeper). Bocaccio occur in shallow water as juveniles and in deep water as adults, and are considered mixed-depth species in some studies (Karpov et al., 1995). In the Monterey Bay area they are generally taken by CPFV's at 75 m and deeper (Thomas and Bence 1992; Sullivan, 1995; Reilly et al.[1]), and thus are deepwater species for this fishery.

The Monterey Bay area had the highest proportion of deepwater species in the total recreational catch of any area in northern and central California during 1981–86 (Karpov et al., 1995). The proximity of deepwater fishing sites along the Monterey Canyon and Carmel Canyon makes these species more available to CPFV's from Monterey Bay than from other ports. The percentage of CPFV trips to deepwater areas in Monterey Bay recorded by CDFG increased from 56% in 1987 to a maximum of 72% in 1990–91(Reilly et al.[1], Wilson-Vandenberg et al.[2,3]; Wilson et al.[4]). Deepwater trips dropped to 28% by 1994 as effort shifted back to blue rockfish in shallow water after 1992 (Wilson-Vandenberg et al.[2,3]).

The sport and commercial fisheries targeted different species until the 1970's, but as CPFV's moved into deeper water, that distinction disappeared. Chilipepper and bocaccio have dominated commercial rockfish landings in Monterey Bay for more than 100 years. Bocaccio and chilipepper together accounted for 70% of the landings from set lines in 1937–38; yellowtail rockfish, vermilion rockfish, *S. miniatus*, and canary rockfish, *S. pinniger*, totaled another 21% (Phillips, 1939). Bocaccio and chilipepper remained dominant despite changes in commercial fishing gear from set lines in the 1930's, to balloon trawls in the 1950's, to gillnets in the late 1980's (Heimann, 1963; Pearson and Ralston, 1990). From 1980 to 1994 chilipepper and bocaccio have dropped from 80% to 54% of the rockfish catch. The relative importance has shifted from mostly bocaccio before 1984 to mostly chilipepper after 1990. The commercial hook-and-line fishery has increased in both landings and proportion of the commercial catch since 1990 (Pearson and Almany, 1995). A nearshore hook-and-line fishery for live fish has developed throughout the state since 1989 (California Department of Fish and Game, 1998). As the CPFV fleet moved into deep water and the commercial fleet into shallow water, fisheries interactions increased.

Changes in the relative abundance of particular species of rockfish can be inferred from their proportion in the CPFV catch, but relative importance may be affected by trends in abundance of other target species, as well as changes in fishing locations. Another

indicator of the condition of the fishery may be the size of fish caught. The annual mean length of the total CPFV rockfish catch reflects the average size of all species combined, and a drop in this mean may indicate either an increased proportion of smaller species in the catch or a decreased size of the dominant species. It is necessary to look at both the size of individual species and their changing proportions in the catch to evaluate changes in overall size.

A decline in the mean length of a fished species is often considered an indicator of increased fishing mortality. A large proportion of the biomass for unexploited rockfish populations consists of older, larger, slower growing fish (Leaman and Beamish, 1984). Increased fishing pressure removes these older fish more rapidly than they are replaced, so if recruitment and growth are stable, higher fishing mortality will reduce the mean length. In rockfish populations, however, recruitment varies from year to year, and the size distribution of young fish varies with the presence or absence of successful year classes. A strong year class can dominate the catch as it recruits to the fishery, first reducing and then increasing the mean length as the year class grows. If another strong year class recruits to the fishery, the mean length may drop again.

I examined the CPFV fisheries from Monterey Bay for: 1) changes in fishing effort and success, 2) changes in relative importance of species from different depths, 3) changes in the size of the ten leading species, 4) the mean length caught relative to size at maturity, 5) the effects of new recruitment on the mean length of these species, and 6) similar trends in the mean length of species from CPFV and commercial landings.

Methods

Total catch of rockfish was taken from annual summaries of the logbooks submitted by CPFV skippers to the California Department of Fish and Game. Individual rockfish species are not recorded in the logbooks, so I estimated the annual catch by species by multiplying the total rockfish caught by the annual proportion of each species derived from the sampling programs. The total number of anglers is also recorded in the CPFV logbooks, and since all trips out of the Monterey Bay area are day trips, the number of anglers represents angler days. The years covered by the various sampling programs are displayed in Figure 2.

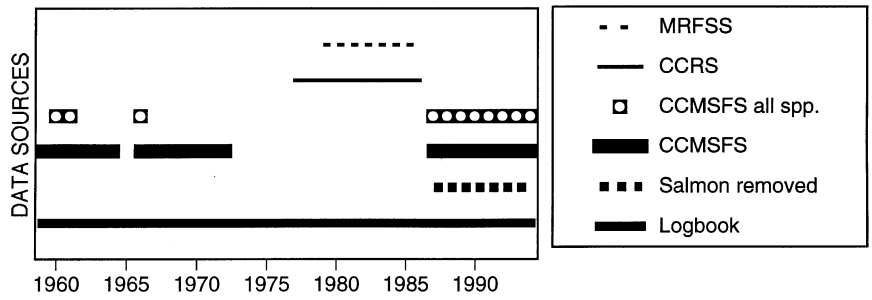

Figure 2.—Sources of data. Logbook data provide total CPFV catch and effort; salmon removed indicates years salmon effort was subtracted from the logbook total to calculate catch and effort for just rockfish trips. Surveys measuring species composition and length frequency in various years include: CCMSFS — Central California Marine Sport Fishing Survey, years when only blue rockfish were measured; CCMSFS all spp., years when all species were measured; CCRS — California Cooperative Rockfish Survey; and MRFSS — Marine Recreational Finfish Statistical Survey.

Catch per angler day (CPAD) was calculated in two ways. Simple CPAD was calculated from the total catch divided by the total anglers. This included all types of CPFV fishing in the Monterey Bay area. CPAD from rockfish trips was what remained after the effort and catch from trips targeting Pacific salmon, *Oncorhynchus* spp., were removed from the total trips. For most of the time series, the effect of salmon trips on CPAD is negligible, but CPFV logbooks indicate more salmon have been caught since 1986. Boats trolling for salmon catch very few rockfish. From 1987 to 1994 CDFG examined the logbook records for each fishing trip and removed salmon trips (CPFV trips that caught salmon and averaged less than 4 fish per angler) from the calculation of rockfishing effort (Reilly et al.[1]; Wilson-Vandenberg et al.[2,3]; Wilson et al.[4]). Data were not available to make this correction for previous years.

The CDFG also compared the number of anglers and fish reported in logbooks for observed trips with the actual numbers observed by CDFG samplers to determine the unreported catch and effort for 1987–94. Adjusted total rockfish and rockfish effort were calculated from these rates. The CDFG also categorized the trips by fishing depth during this period (Reilly et al.[1]; Wilson-Vandenberg et al.[2,3]; Wilson et al.[4]).

Data on species composition and length frequency were gathered from several sampling programs spanning a 34-year period in the Monterey Bay area (Fig. 2). The earliest data are from the Central California Marine Sport Fish Survey (Miller and Gotshall, 1965; Miller and Geibel, 1973). Species composition and lengths of blue rockfish were recorded each year from 1959 to 1972 except for 1965. Lengths of all rockfish species were sampled from CPFV's only in 1960, 1961, and 1966. The California Cooperative Rockfish Survey collected species composition and length information from CPFV's for 1977–86 for Santa Cruz and Monterey and for 1979–81 for Moss Landing (all Moss Landing CPFV's had moved to Monterey by 1982). The creel census portion of the Marine Recreational Fishery Statistics Survey collected data on species composition and length for 1979–86 for Santa Cruz County and Monterey County ports and overlaps with the previous survey (Holliday, 1984). These data augment reduced sampling by the California Cooperative Rockfish Survey during these years. Data sources through 1986 and numbers of fish sampled are further described by Mason (1995). The Central California

Marine Sport Fish Project again collected samples from 1987 to 1994, and their sampling techniques are described by Reilly et al.[1] In 1990, samples were taken only from January to June, and in 1991 from August to December so these 2 partial years were combined to remove the seasonal differences in species composition.

All sampling programs measured total length of rockfish in millimeters. Frequency distributions were calculated in 0.5 cm length intervals (e.g. 10.0 to 10.4 cm) and grouped to 2 cm for display and labeled by lower limit of interval. Mean lengths for species were calculated from the total lengths for years with at least 20 measured fish of a species. The 10 leading species were used for analysis of mean length because they had nearly complete series. Boundaries for the 10th and 90th percentiles were calculated from 0.5 cm length-frequency categories and used to indicate the size range. Mean lengths were compared to the sizes at which 50% of the females and 50% of the males reach sexual maturity, as described by Wyllie Echeverria (1987) for northern California rockfish.

Length frequencies were expanded by catch by multiplying the total catch of rockfish reported in the CPFV logbooks times that species' proportion in the sampled catch times the proportion in each 2 cm size class. Length frequencies for four species with at least 50 fish per year were used to produce the length-frequency time series.

Only the California Cooperative Rockfish Survey (1977–86) identified the sex of rockfish when collecting lengths from the CPFV's. These lengths were used to examine sexual dimorphism in length frequency for each sex for each of the ten leading species.

Estimated weights of rockfish landed by CPFV's were derived from the estimated annual catch by species to compare CPFV and commercial landings. I calculated weights from the length frequencies by using length-weight parameters calculated from studies in southern California (Love et al., 1990), except for blue rockfish which Miller and Geibel (1973) studied in the Monterey Bay area. I divided the estimated CPFV species landings by the sum of CPFV landings and expanded commercial landings from the California port sampling program data (Pearson and Ralston, 1990; Pearson and Almany, 1995) to get the percent caught by CPFV's. Logbooks may underestimate the CPFV catch by the proportion of fishing trips that are not reported, so percentages are adjusted to include unreported catch. I also calculated mean lengths of species by commercial gear type from this sampling program for principal species occurring in both the CPFV and commercial fisheries. Total commercial rockfish landings were obtained from the series of annual commercial landings published by the California Department of Fish and Game (1980–95).

Results

Many aspects of the CPFV fishery have changed during the 35 years covered by this report. There have been increases and decreases in effort and in total catch, as well as changes in the species caught and the depths fished. Declines in the proportion of certain species in the catch may reflect reduced availability of these species or increased availability of alternate species. The catch of smaller fish indicates a scarcity of large fish of particular species available to this fishery. All of these changes must be examined in relation to each other to evaluate the condition of the fishery.

Catch and Effort

Total catch by CPFV's increased threefold from 1964 to 1982 (Fig. 3a). Rockfish ranged from 81% to 95% of the catch and averaged 91% from 1959 to 1994. The rise in catch closely reflects the increased fishing effort through 1982 (Fig. 3b). Effort dropped sharply from 1983 to 1985 and catch dropped in 1984–85. As effort dropped in 1983, CPAD peaked (Fig. 3c) but decreased the next year as catch also dropped. Total effort climbed to a second peak in 1988, but total catch did not increase proportionately (Fig. 3a), probably because more effort was directed toward Pacific salmon which became more available after 1985.

When salmon become available, many boats troll for them instead of bottom fishing for rockfish. Salmon availability increased in the local area, and their catch rose from 2,500 (1.0% of CPFV catch) in 1985 to about 10,000 salmon (2.8% of CPFV catch) in 1986 (shown at 10 times actual catch in Fig. 3a). From 1987 to 1994, salmon fishing accounted for an average of 26% of the CPFV effort and a maximum of 34% in the combined 1990–91 seasons.

Catch per angler day differs for trips bottom fishing for rockfish and trips trolling for salmon. Marine anglers in California may keep 20 fish per day, 15 may be one or more species of rockfish, but only two may be salmon. The average catch of rockfish has varied from 8 to 13 fish per angler day (Fig. 3c). Catch per angler day for salmon trips averaged less than 4 fish per angler day. What appears to be a declining trend in catch per angler day after 1982 (Mason, 1995) was calculated from total fish divided by total anglers. When salmon fishing trips are removed after 1986, CPAD for rockfish trips stays at 10–12 fish per day. Salmon effort was negligible in earlier years, except for 1959–62, 1964, 1967, and 1986 when salmon totaled 1% or more of the CPFV catch. The low rockfish CPAD in 1985 reflects both a slight increase in salmon effort and low availability of rockfish.

Total catch and effort for the Monterey Bay area may have declined less than the logbooks indicate. Although skippers are required to report the number of trips along with the number of passengers and the number of fish caught, not all trips are actually reported. Skippers reported 73% of both the actual number of anglers and the fish caught on trips observed by CDFG in the area from 1987 to 1991 (Table 76 in Reilly et al.[1]) and only 58% of the number of anglers and 56% of the catch for 1992–94. The percentage of trips reported dropped from a peak of 87% in 1988 to a low of 48% in 1994. The catch reported has also dropped for those years (from 73% to 84%: Wilson-Vandenberg et al.[2,3]; Wilson et al.[4]). Adjusted total catch and rockfish effort are indicated only after 1986 (Fig. 3, a

and b), since we do not have compliance data for earlier years. Thus the decline in total catch and effort in 1993–94 may be slightly exaggerated by under reporting.

Species Composition

Catch composition has changed over time with changes in the depth and habitat fished. Blue rockfish was the leading species taken in the late 1950's. From 1959 through 1972 blue rockfish and yellowtail rockfish dominated, averaging 35% and 21% of the catch, respectively (Fig. 4). Olive rockfish averaged 6% of the catch and other shallow-water species together averaged only 3% through 1972. Since 1977, four species caught in deeper water (below 75 m) have become very important to the fishery averaging 32% of the catch in 1977–94 as compared to 7% in 1959–72. Most important in this group is chilipepper, which increased from 2% of the catch in 1959–72, to 15% in 1977–85, and 21% in 1986–94. The three other members of the deepwater group (bocaccio, greenspotted rockfish, and greenstriped rockfish) also increased in relative importance after 1977, although from 1991 to 1994 they declined sharply from 38% to 17% of the catch. Species compositions for 1990–91 are averaged from two incomplete sampling years (see Methods).

The relative importance of the different species groups varied more after the expansion into deeper water in 1977 than in earlier years. The fleet did not shift completely away from shallow water, but moved among different fishing areas at different depths, thus targeting a greater variety of species. The most blue rockfish were landed by CPFV's (estimated at 290,000) in 1981 after the fishery diversified into deep water. High fishing effort and good availability of species from all depth ranges contributed to the record total landings in 1981–82 (Fig. 3a). The catch included chilipepper, bocaccio, and widow rockfish from deep water, yellowtail rockfish from intermediate depths, and blue rockfish from shallow water. After 1978, total catch peaked only in years when blue rockfish were available, such as in 1988 and 1993. The proportion of the catch comprising the four deepwater species has steadily declined since 1986 (Fig. 4) despite increased deepwater trips in 1989–92 (Table 1). The proportion of trips to deep water did not decline appreciably until 1993–94. The ten leading rockfish species are listed by order of abundance in the annual landings for the entire time period in Table 2.

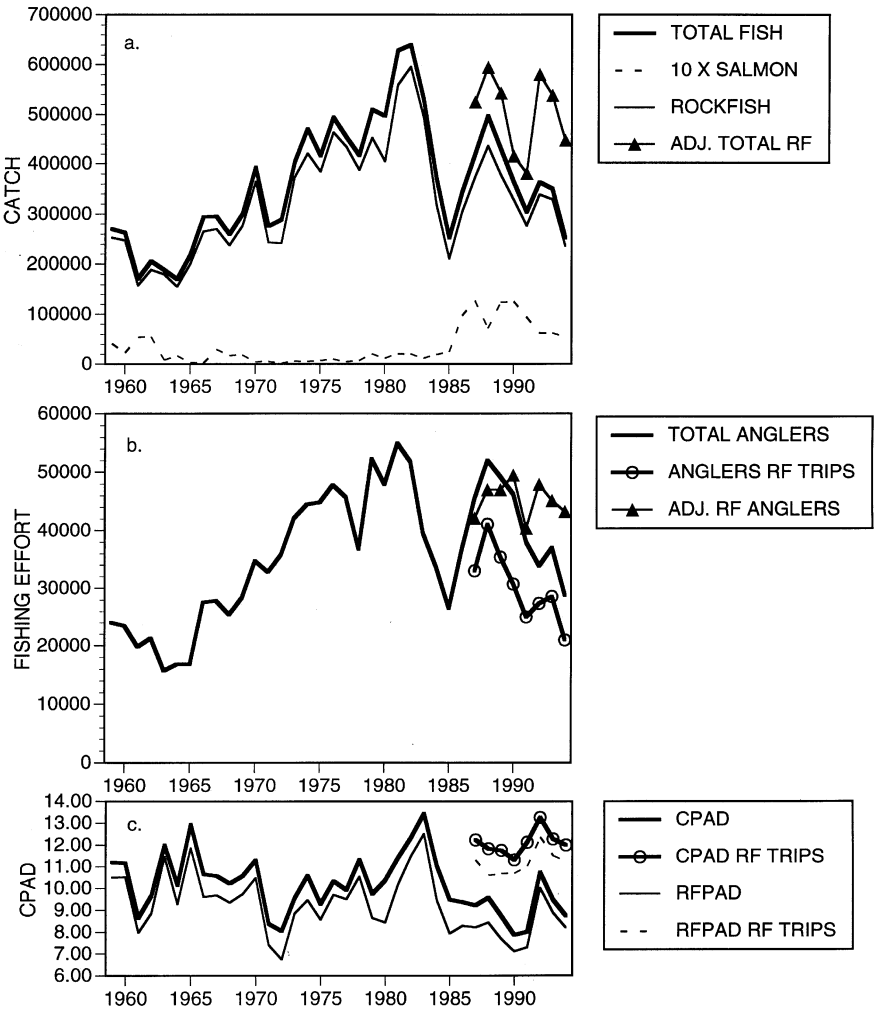

Figure 3a.—Catch from Monterey Bay area CPFV's: TOTAL FISH =Total fish reported; 10 X SALMON = salmon plotted at 10 times reported numbers; ROCKFISH = total rockfish reported; ADJ. TOTAL RF = total rockfish adjusted upwards for percentage not reported in logbooks. 3b.—CPFV effort in Monterey Bay area: TOTAL ANGLERS = total anglers reported; ANGLERS RF TRIPS = anglers from trips targeting rockfish (not salmon trips); ADJ. RF ANGLERS = anglers from rockfish trips adjusted upwards for percentage not reported in logbooks. 3c.—CPFV catch per angler day: CPAD = all fish from all trips; CPAD RF TRIPS = all fish from trips targeting rockfish; RFPAD = rockfish per angler day, all trips; RFPAD RF TRIPS = rockfish per angler day from trips targeting rockfish.

Sexual Dimorphism

Sexual dimorphism in total body length was present in some but not all species of rockfish sampled from 1977 to 1984 (Fig. 5). Sexual dimorphism was pronounced in blue rockfish: only 7% of the males were larger than the mean length of females. Only 4% of chilipepper males were 40 cm or larger

Table 1.—Percentage of CPFV trips to two depth ranges. Trips classified as mixed depth could not be separated into just one depth range.

Year	Trips (%)		
	Shallow (<80 m)	Deep (>80 m)	Mixed depths
1987	17	56	27
1988	22	56	21
1989	19	63	17
1990–91	19	72	9
1992	20	64	16
1993	7	40	53
1994	31	33	36

Table 2.—Rating and percentage contribution of the ten most abundant species in the CPFV catch from 1959–94.

Rank	Common name	Scientific name	Percent contributed
1.	Blue rockfish	*S. mystinus*	27
2.	Yellowtail rockfish	*S. flavidus*	16
3.	Chilipepper	*S. goodei*	11
4.	Bocaccio	*S. paucispinis*	7
5.	Widow rockfish	*S. entomelas*	5
6.	Olive rockfish	*S. serranoides*	5
7.	Rosy rockfish	*S. rosaceus*	3
8.	Greenspotted rockfish	*S. chlorostictus*	3
9.	Canary rockfish	*S. pinniger*	3
10.	Greenstriped rockfish	*S. elongatus*	2
Total contribution of top ten species			82

compared to 52% of females. Only 8% of male olive rockfish were larger than the mean length of females. Only 4% of male greenstriped rockfish were larger than the mean length of females. In all four of these species, the females attained a larger maximum length and a larger mean length than the males.

Some species (bocaccio, widow rockfish, and yellowtail rockfish: Pearson and Ralston, 1990) that are sexually dimorphic at larger sizes were less clearly dimorphic in the sizes taken by the CPFV fishery. The mean length of females was only slightly larger than that of males, but in each of these species females predominated in the largest size classes. Yellowtail rockfish males appeared to have a narrower size distribution than females, but since some sampled fish, especially immature ones, were not categorized by sex, the apparent lack of smaller males may result from a difficulty in identifying immature males. Canary rockfish and rosy rockfish did not display sexual dimorphism in the lengths taken from CPFV's, although Boehlert and Kappenmann (1980) found that canary rockfish females caught by research trawls had a larger mean length, and Pearson and Ralston (1990) found that canary rockfish females were more abundant than males in the larger size range from commercial trawls (>56 cm, a size not occurring in the CPFV samples). The mean length of greenspotted rockfish males was slightly larger than the mean length of females, and this is the only species in which males averaged larger than females. Greenspotted rockfish and rosy rockfish are not dimorphic in length, according to Lenarz and Wyllie Echeverria (1991).

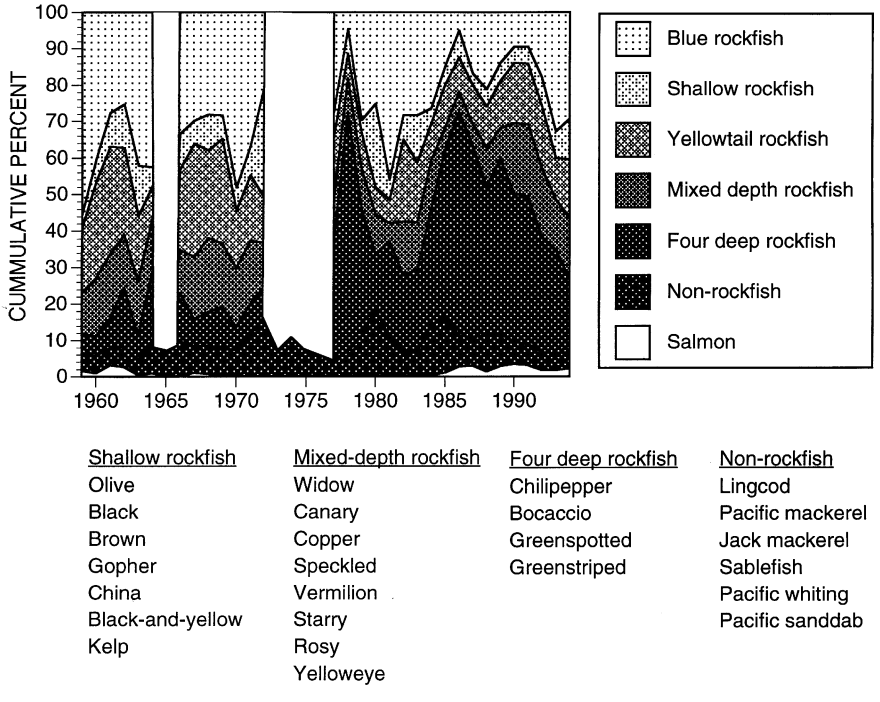

Figure 4.—Cumulative percentage of CPFV-caught rockfish by dominant single species (blue rockfish and yellowtail rockfish) and species groups based on depth. Blank areas are years without sampling of rockfish species.

Lengths

The mean lengths of the ten most abundant rockfish species caught on CPFV's in Monterey Bay between 1960 and 1994 are presented in Fig. 6. The spread between the 10th and 90th percentiles of lengths represents the size range of 80% of the catch. Plots of length frequencies (Fig. 7) display changes in lengths for four species.

The time series of blue rockfish lengths is the most complete because only blue rockfish were sampled throughout the 1960's (Fig. 6). The sharp drops in mean length and the 10th percentile of length in 1962, 1964, and 1968 reflect small fish recruiting to the fishery. Increasing mean length from 1970 to 1972 can be attributed to the growth of the new recruits observed in 1968 (Fig. 7). Mean length was greatest during the period of highest catches (1977–84). Length frequencies indicate a mode of larger fish at about 34 cm as well as a mode of smaller fish at 26–28 cm visible in 1981; this bimodality could be produced by two or more rela-

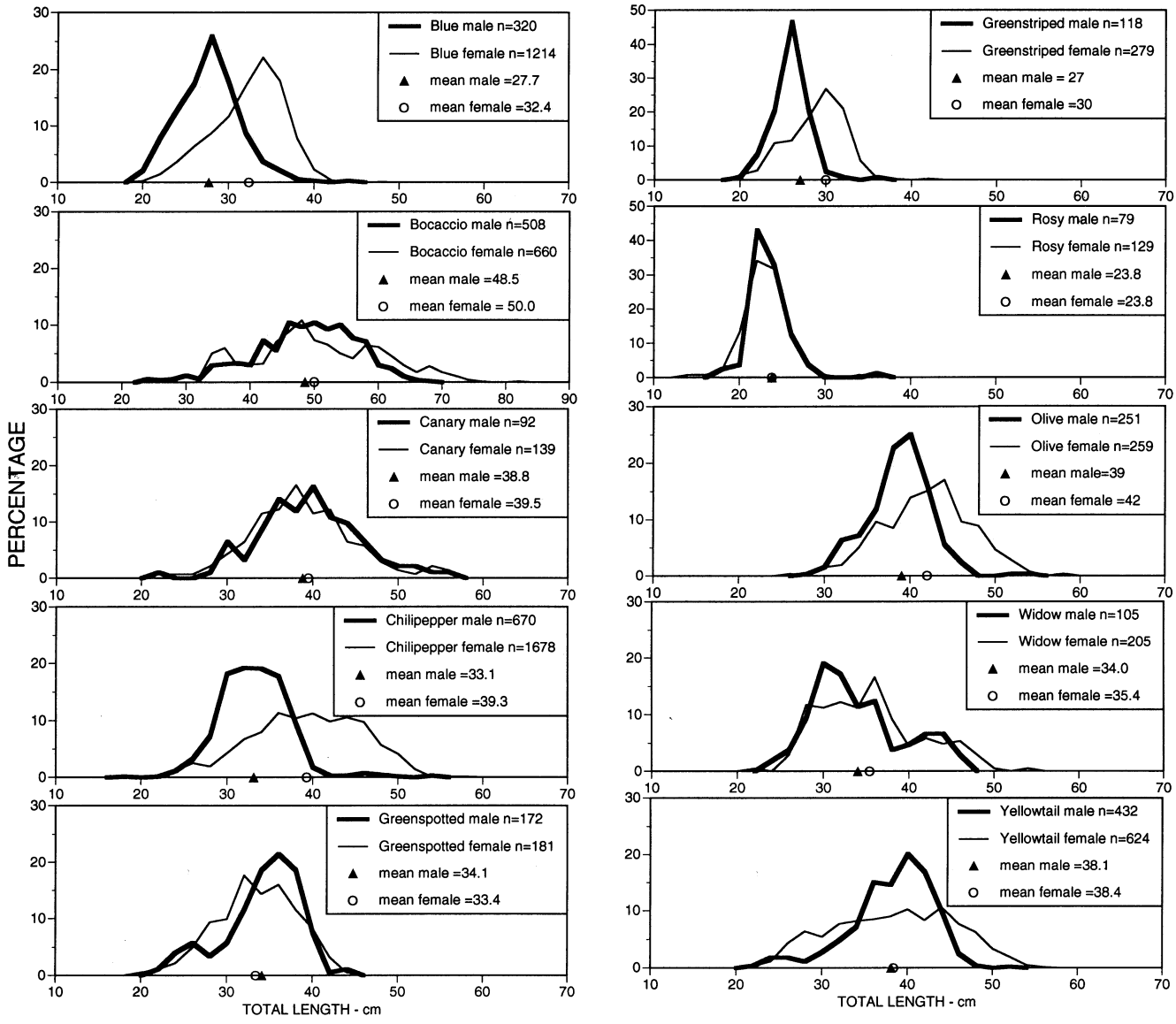

Figure 5.—Sexual dimorphism in length distributions of ten leading rockfish species caught by CPFV's in Monterey Bay in 1977–86 (California Cooperative Rockfish Survey data); each 2 cm group is shown as a fraction of total males or total females (n = number sampled per sex).

tively strong year classes separated by less strong year classes, but also reflects the pronounced sexual dimorphism of this species. Mean length dropped in 1984 as larger fish became less abundant in the catch; after that only 42% of the catch was larger than the size (29 cm) at which half of blue rockfish females mature (Wyllie Echeverria, 1987). In 1977–84, 79% of the fish sampled were female. It is not known if the smaller mean length after that reflects more males in the catch or smaller females, but few fish have reached the large sizes present in 1977–83.

Yellowtail rockfish were largest in 1977, 1983, and 1991 (Fig. 6). New recruitment to the fishery appeared as a drop in the length of the 10th percentile in 1978, 1984, and 1987. Growth of these recruits can be tracked in the mean length and in the length frequencies of the catch for the next four years (Fig. 7). Since 1985, large fish have been scarce and only 32% of the yellowtail rockfish have been above the length (36 cm) at which half of the females reach maturity, compared to 54% from 1977–84. The drop in 1994 to the lowest size for both the mean length and length of the 10th percentile may indicate new recruitment to the fishery, especially since yellowtail rockfish contributed a significant proportion (15%) of the CPFV catch in that year, but also reflects the smaller size of fish caught in

shallow water. Half of the yellowtail rockfish were caught in shallow water in 1994 as compared to 10% in earlier years (Reilly et al.[1]; Wilson-Vandenberg et al.[3]).

Chilipepper had the most dramatic and sustained decline in mean length of the catch, 14 cm from 1960 to 1994 (Fig. 6). The increasing mean length during 1980–82 resembled growth of recruits but was faster than the growth rates of either males or females described by Wilkins (1980) or Rogers and Bence.[5] This increase in mean length may indicate several older year classes exploited by an expanding fishery rather than growth of a single year class. The drops in the 10th percentile of length in 1986 and in mean length and 90th percentile in 1987 indicate a surge of new recruits, which can easily be seen in the length frequencies (Fig. 7). Catches of chilipepper soared in 1987 with a strong single mode of fish that remained dominant for the next 2 years. The growth rate in this period is consistent with growth rates for females described by Wilkins (1980) and Rogers and Bence.[5] By 1989, the peak broadened as male growth slowed, but by 1990 this mode's contribution had greatly declined and catches of chilipepper decreased. After 1984 there was a noticeable lack of larger fish; only 48% were 34 cm or larger (the size of maturity for half of the females) when compared to 74% during 1977–84. The proportion of females in the catch after 1986 is not known, but during 1977–86, 71% of the identified fish were female. Since 1992, the mean length has been below the length at maturity (34 cm) for 50% of females (Fig. 6). Although this drop may be caused by recruitment, the number of chilipepper in the catch has continued to decline, indicating that recruitment was only moderate.

Bocaccio had the largest mean length and 90th percentile of the ten leading species and also the greatest fluctuation in mean length in the catch. The mean length of bocaccio dropped dramatically from its largest mean in 1983 to its smallest just 2 years later. This drop in mean length and in the 10th percentile in 1985 reflected new recruitment to the fishery, and these new recruits dominated the bocaccio catch for the next 4 years (Fig. 7). Noticeable recruitment to the fishery also occurred in 1979, 1981, and 1990. Fish larger than the size of maturity of 50% of females (48 cm) have constituted 41% of the bocaccio catch since 1984, but before that they contributed 65%. Mean length has been below the size of maturity of 50% of females but above the length at

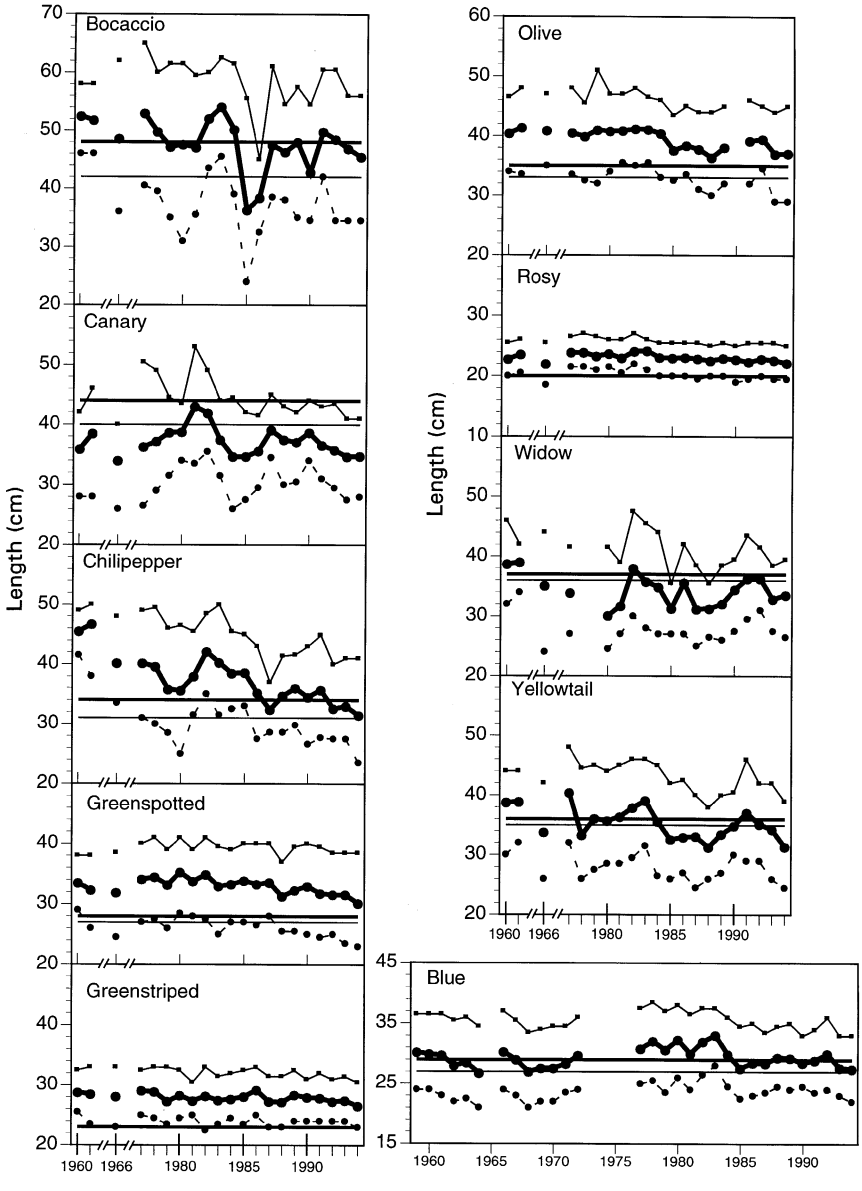

Figure 6.—Changes in length over time for ten leading species of rockfish: mean length, heavy line; 10th percentile, dashes; 90th percentile, light line. Breaks in lines indicate missing or insufficient data. Data are discontinuous for all species except blue rockfish in 1962–65 and 1967–76. Size at maturity for 50% of species is indicated by horizontal lines: female = heavy line; male (if different from female) = light line.

[5]Rogers, J. B., and J. R. Bence. 1992. Review of the fishery and auxiliary data for chilipepper rockfish in the Conception/Monterey/Eureka INPFC areas: a qualitative assessment of the status of the stock in 1992. *In* Appendices to the status of Pacific groundfish fishery through 1992 and recommended acceptable biological catches for 1993: Stock assessment and fishery evaluation. Pac. Fish. Manage. Counc., Portland, Oreg. 18 p.

maturity of 50% of males in all but 2 years since 1987 (Fig. 6).

The longest mean lengths for widow rockfish were recorded in 1960–61 and 1982 (Fig. 6). In 1982 an increased catch of large widow rockfish raised the length of the 90th percentile and contributed more to the increase in mean length than did the growth of smaller fish. Fewer than 20 widow rockfish were measured per year in 1978–79, so these years (when widow rockfish constituted less than 1% of the catch) are not included in the graph. The drop in the mean length and in the 10th percentile in 1987, followed by increasing mean length through 1992, indicate a pulse of recruitment to the fishery. Widow rockfish reached their highest percentage in the catch in 1988, as these new recruits were targeted. The return to smaller fish in 1993–94 may indicate new recruitment. More than half of the widow rockfish caught by CPFV's are juveniles; the mean length has been at or below the length at maturity for 50% of females (37 cm) and males (36 cm) since 1983.

The mean length of olive rockfish remained constant at about 40 cm from 1977 to 1984, but then it declined (Fig. 6). New recruitment to the fishery was apparent in 1988, followed by an increase in mean length to 1992. The drop in the 10th percentile of length in 1993–94 reflects recruitment of small fish. The percentage of olive rockfish in the catch is generally less than 5%, but it jumped to 18% in 1980 and to 9% in 1983. These increases in catch did not coincide with pulses of new recruitment as they did for bocaccio and chilipepper. The mean length has remained above the length of maturity (35 cm) for 50% of females throughout the period examined.

Rosy rockfish had the smallest mean length of the ten most abundant species (Fig. 6). Mean length of rosy rockfish varied little, but it dropped 1 cm from 1982 to 1983 and then gradually declined to 1994. The 10th percentile of length also declined by 2 cm and may have been affected by the discard of small fish. Rosy rockfish are not targeted by the fishery but are a smaller species caught incidentally to other species. Small fish are sometimes thrown back as "too small" even though expansion of their air bladder from rapid decompression causes them to float and die. The percentage of rosy rockfish retained (not discarded) in 1987–91 does not have an obvious trend but has varied between 84% and 93% in the Monterey Bay area (Reilly et al.[1]; Wilson-Vandenberg et al.[2,3]; Wilson et al.[4]). Earlier discard rates might have been higher. Almost all of the rosy rockfish sampled were above the length at maturity (20 cm) for 50% of the females throughout the time series.

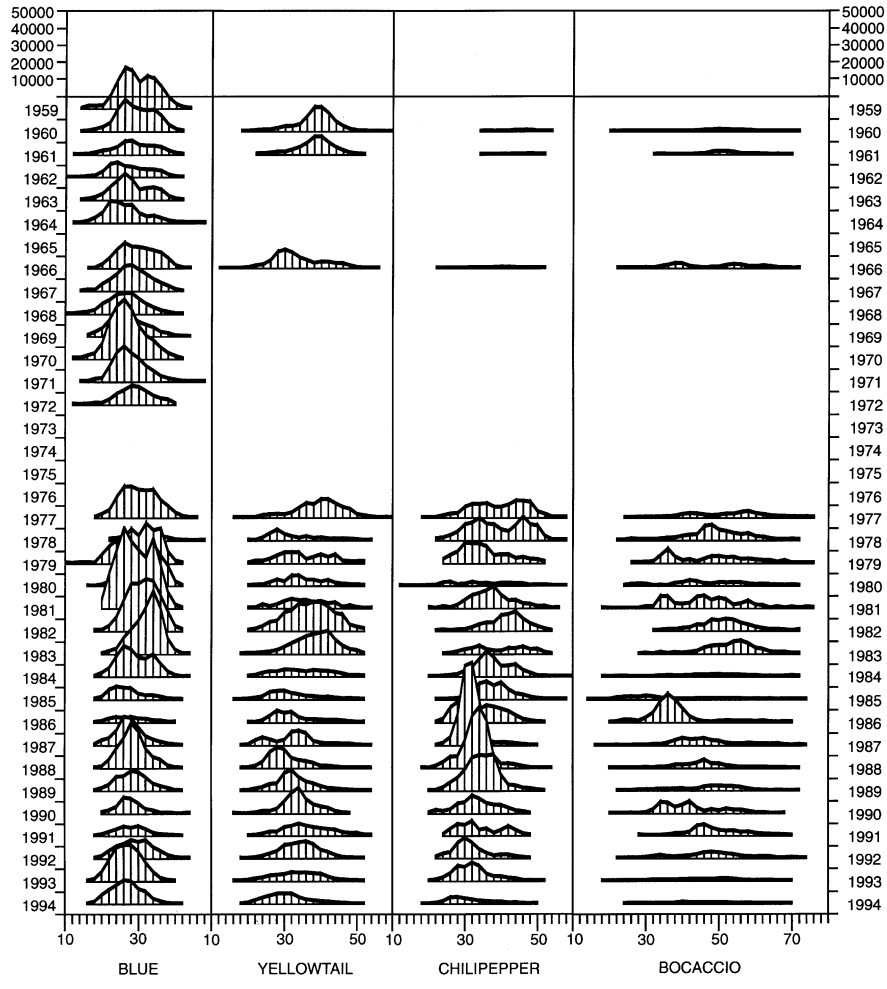

Figure 7.—Estimated annual CPFV catch for four leading species of rockfish by 2 cm length-frequency categories, 1959 at top to 1994 at bottom. The vertical scale at top displays the number of fish indicated by the height within each curve.

Greenspotted rockfish mean length was larger in 1977–83 than in 1960, and it declined after 1987 to its lowest size in 1994. There are no apparent periods of recruitment and growth. The 10th percentile of length has declined despite the high retention rate of this species (97–99% in 1987–94). In all years, the mean length was above the length at maturity (28 cm) for 50% of the females.

Canary rockfish mean length varied over the study period and was largest in 1981–82. Periods of recruitment to the fishery in 1977 and 1984 are indicated by sharp 1-year declines followed by sustained increases in the 10th percentile and mean length. The most recent drop in mean length has been continuous since 1990. Canary rockfish mean length has been below the length at maturity of 50% of females throughout the study, and since 1983, 90% of the canary rockfish caught in the CPFV

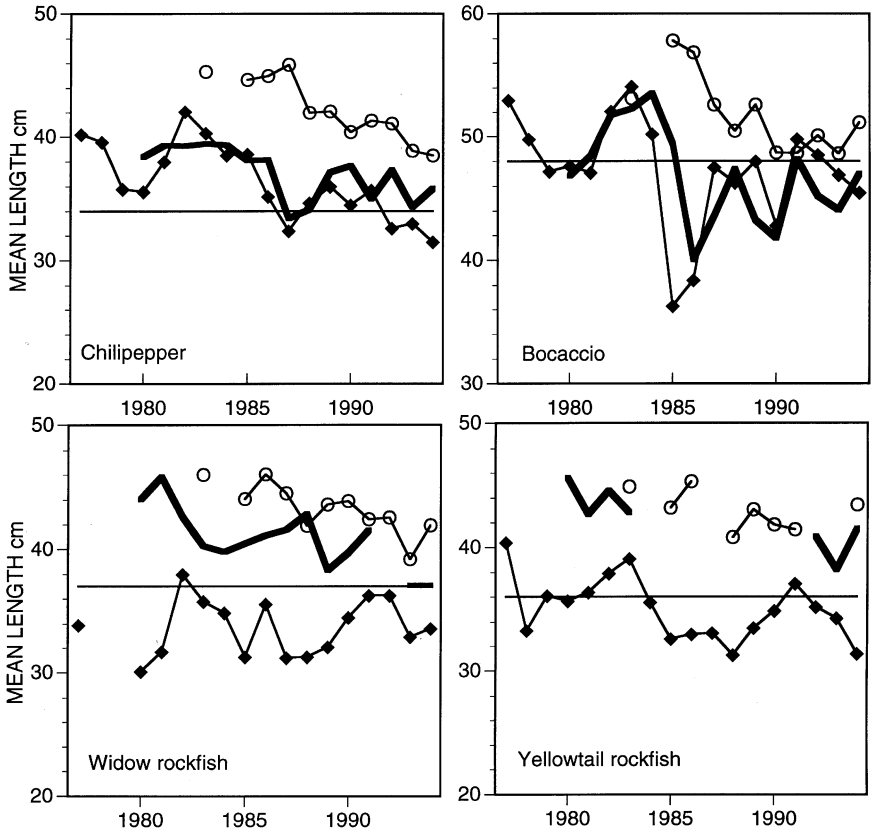

Figure 8.—Mean lengths of four rockfish species from two commercial fishing gears compared to means from CPFV. Heavy line represents mean from bottom trawls; circles represent mean from gillnets; diamonds represent means from CPFV's. Horizontal lines are as described in Figure 6.

Table 3.—Percentage of change in total length for top ten rockfish species from CPFV's over two time periods. Negative numbers indicate declining size.

	Percent change	
Species	1960–77	1960–94
Blue rockfish	3.01	–6.84
Yellowtail rockfish	4.12	–12.07
Chilipepper	–11.65	–27.31
Bocaccio	0.95	–12.28
Widow rockfish	–12.40	–11.35
Olive rockfish	0.25	–8.91
Rosy rockfish	4.82	–1.93
Greenspotted rockfish	1.79	–4.12
Canary rockfish	1.11	–1.35
Greenstriped rockfish	1.04	–4.28

fishery have been juveniles, below the length at maturity of 50% of females (44 cm) and 50% of males (40 cm).

The mean length of greenstriped rockfish fluctuated only slightly over the study period. The species is caught incidentally to targeted deepwater species such as chilipepper and bocaccio, and the mean length was the second smallest of the ten most abundant species in the catch. The mean length has declined steadily from 1989 to 1994. Despite their relatively small size, most of the greenstriped rockfish were retained: 96% in 1987–91(Reilly et al.[1]) and 93% in 1994 (Wilson-Vandenberg et al.[3]). Over 90% of them were larger than the length at maturity for 50% of females and males (both 23 cm).

There has been a net decline in the mean length of all ten dominant species between 1960 and 1994 (Table 3). The decline occurred after 1977 for all but two of the species. Eight of the ten species dropped at least 4% in mean length during this period. Chilipepper, bocaccio, widow rockfish, and yellowtail rockfish declined the most, dropping more than 10% in mean length from 1960 to 1994.

Mean Lengths From Commercial Fisheries

The declining mean length trends of chilipepper and bocaccio from the CPFV fishery were also present in the catch from the commercial trawl and gillnet fisheries (Fig. 8). The new recruitment evident in the CPFV fishery in 1985–87 can also be identified by a drop in mean length in the trawl and the gillnet fisheries. Gillnet mesh size selects larger fish which explains the larger mean length caught by this fishery and the delay in recruitment until fish reach gear-selected size. The decline in mean length of chilipepper rockfish was more gradual in the trawl fishery, where escapement related to mesh size or processor preference may limit the minimum size, than in the CPFV or gillnet fisheries.

The mean lengths of widow and yellowtail rockfish from CPFV's were noticeably smaller than the means from trawls and gillnets and may reflect escapement of smaller fish and the ontogenetic movement of older fish to deeper water (Love et al., 1990). Yellowtail rockfish are not targeted by trawlers in Monterey Bay and contribute only 5%, on average, of the commercial rockfish catch, so data are less complete. Mean lengths for commercially caught widow and yellowtail rockfish declined over time, coming closer to the mean lengths from CPFV's.

Grouped Species Lengths

Grouping rockfish species together in different ways can reveal the larger trends in the fishery. The mean length of all rockfish caught on CPFV's was 3 cm (8%) larger in 1977 than in 1960–61, but varied before dropping sharply in 1994 to 10% below the 1960–61 mean (Fig. 9).

Comparing the relative contribution of larger and smaller species to the fishery reveals periods in which shifting proportions of these two groups affected mean length. Two size categories of species were created based on average mean length from 1960–94. As expected, the five species with average mean lengths of 35 cm or larger (bocaccio, chilipepper, canary rockfish, olive rockfish, and yellowtail rockfish) in-

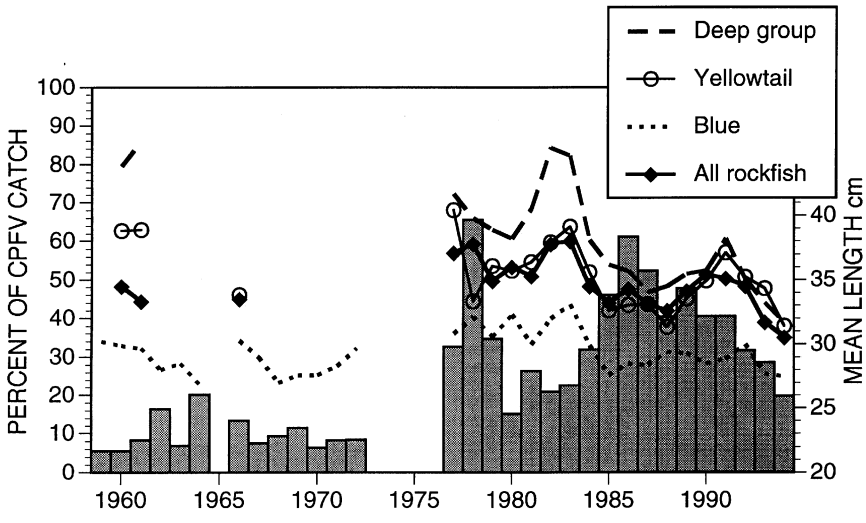

Figure 9.—Proportion of the four deep-water rockfish species (bocaccio, chilipepper, greenspotted rockfish, and greenstriped rockfish) in the total CPFV catch indicated by columns, scale on left. Mean length indicated by scale on right: dashes = group of four deep-water rockfish species, circles = yellowtail rockfish, dotted line =blue rockfish, and line with diamonds = total rockfish.

creased in the catch from 41% in 1959–72 to 48% in 1977–85, when mean length of total rockfish was high. As large species continued to increase in importance (to 53% of the catch in the 1985–94 period), however, the mean length of total rockfish dropped. The proportion of large species remained high until the proportion of blue rockfish increased (in 1993–94), at which point the mean length dropped even more. The mean length decreased from 1983 to 1992 despite an increased proportion of large species.

Grouping the species together by fishing depths reveals the influence of deepwater species on the overall mean length (Fig. 9). In 1960, when blue rockfish and yellowtail rockfish contributed about 60% of the catch, the mean length fell between the means of these two species. As the catch shifted to deepwater species by 1977, the mean length increased. Four key species (bocaccio, chilipepper, greenstriped rockfish, and greenspotted rockfish) caught in deeper water increased from 7% to 32% of the catch between 1972 and 1977. The mean length of the deepwater group was over 40 cm (11 cm larger than the mean length of blue rockfish in 1977).

The mean length for all combined rockfish was bounded by the means of the deepwater group and blue rockfish from 1977 to 1987 (Fig. 9). Deepwater species decreased in mean length from 1977 to 1980, as young bocaccio and chilipepper recruited to the fishery, but then increased in length to a maximum in 1982–83. Bocaccio contributed significantly from 1981 to 1983 and their larger size during this period is reflected in the longest mean length for total rockfish. Blue rockfish were also at their largest size from 1977 to 1983 and contributed to higher total means. The mean lengths of all the important groups decreased in 1984–85 with a scarcity of large fish, and remained low through 1987. Despite the increased proportion of deepwater species (columns in Fig. 9), the overall mean length was reduced in this period by the smaller size of the dominant species.

Both yellowtail rockfish and the deepwater species group increased in size in 1989–91 with the growth of young fish, and their high proportion in the catch kept the mean length of all combined rockfish close to that of the deepwater group. The length of the deepwater species group declined after 1991 with the reduced proportion of bocaccio and declining size of chilipepper, greenspotted rockfish, and greenstriped rockfish; yellowtail rockfish size also declined. The difference in size between the deepwater group and blue rockfish shrank from 10 cm in 1991 to only 5 cm by 1994. The mean length for all combined rockfish reached its lowest recorded level in 1994 as smaller blue rockfish contributed more to the catch. The smaller size of the deepwater species has noticeably affected the overall mean length.

Discussion

Reduction of the mean length of fish caught by a fishery is often used as an indicator of increased mortality rate. In the Monterey Bay area CPFV fishery, the mean length of rockfish has declined; however, the interpretation of this trend is complicated by the changes in species composition of the fishery. The decline in size results from a decline in the mean length of the dominant species as well as from shifts in the relative contribution of various species to the catch. Several factors which vary over time contribute to the declining overall size of rockfish caught by CPFV's: 1) changes in target species, 2) removal of larger fish by both CPFV's and commercial fisheries, 3) environmental effects on mortality and recruitment, and 4) declining proportion of spawning adults.

The change in target species from shallow-water species to deepwater species in 1977–78 increased the mean length of combined rockfish in the catch. Large chilipepper and bocaccio were available in these deeper areas through 1983, but a shift back to shallow-water fishing for blue rockfish in 1979–84 moderated the mean length (Fig. 9). The return to deepwater fishing in 1985–89 did not increase the overall mean length, because the size of fish in the deepwater group had dropped. Although the mean length of the group of deepwater species was larger than that of the shallow-water species (blue rockfish), the periods after 1977 with higher proportions of deepwater species did not correspond with the largest mean lengths for total rockfish. Changes in target species explain only the 1977–81 changes in total mean length.

Variability in the size of dominant species affected the overall mean length

more than species composition after 1981. One component of that mean length is the proportion of large fish in the catch. The mean length of several important species (bocaccio, chilipepper, blue rockfish, widow rockfish, and yellowtail rockfish) reached a maximum in 1982–83 from both growth of young fish and accumulation of larger fish from abundant year classes produced in the mid-1970's or earlier (Beamish, 1993; Rogers and Bence[5]; Ralston et al.[6]). For example, large chilipeppers (40–50 cm) composed half of the chilipepper catch in 1977–78. Chilipeppers of this size, estimated at 7–15 years old by von Bertalanffy age-at-length equations (Rogers and Bence[5]), were produced before 1971, when both recreational and commercial fishing was less intense. In the first few years that CPFV's fished in deep water, many locations had accumulations of large fish. Fishing pressure, as indicated by landings of rockfish, peaked in 1982 in the Monterey Bay area for both CPFV (Fig. 3a) and commercial fisheries. As fishing pressure increased, large fish were caught and removed more rapidly than they were replaced, and smaller fish dominated the catch. CPFV's could no longer find locations with unexploited populations of large fish. The proportion of large fish in the catch dropped from 1983 to 1985 as indicated by the reduced size of the 90th percentile of bocaccio, chilipepper, yellowtail rockfish, canary rockfish, and widow rockfish. Declining mean lengths for bocaccio and chilipepper in the trawl and gillnet fisheries indicated fewer large fish in commercial fisheries as well (Fig. 8).

Although both CPFV's and commercial fisheries remove large rockfish, their relative impact differs among species. Bocaccio are heavily exploited by commercial fisheries; their annual take for 1982–94 has been estimated at 20–30% of the biomass, and by 1994 the estimated biomass had dropped to about 17% of its 1980 level (Ralston et al.[6]). Bocaccio has experienced the most dramatic decline in biomass of the commercial rockfish species in the Monterey Bay area, but sustained fishing pressure has also resulted in decreased mean lengths of commercially caught chilipepper and widow rockfish (Fig. 8) and reduced the availability of large fish to CPFV's.

The larger deepwater species (bocaccio and chilipepper) are harvested mostly by the commercial fisheries. Average estimated percent landed by CPFV's of the combined CPFV and commercial landings for 1980–94 are displayed in Table 4. CPFV's took no more than 18% of chilipepper and 27% of bocaccio in any year. CPFV's also took less widow rockfish than were taken by commercial fisheries.

Shallower species such as blue rockfish have been taken primarily by the recreational fishery. CPFV's also took a high percentage of mid-depth yellowtail rockfish and canary rockfish; these species are commonly caught by commercial trawlers at ports farther north, but yellowtail rockfish averaged only 5% and canary rockfish only 0.5% of the commercial rockfish catch in the Monterey Bay area from 1980 to 1994. Thus, CPFV landings have a large local impact on blue, yellowtail, and canary rockfish, but commercial fisheries have a greater effect on bocaccio, chilipepper, and widow rockfish.

Increased natural mortality as well as increased fishing mortality during the northern El Niño of 1982–83 may have reduced the proportion of large rockfish. Yellowtail rockfish and widow rockfish grew more slowly, and yellowtail rockfish, chilipepper, and blue rockfish weighed less relative to their length during strong El Niño events (Lenarz et al., 1995; VenTresca et al., 1995). These species appear to be stressed when changes in ocean circulation reduced the nutrient levels and available food. Zooplankton volumes were reduced in 1982–83 (McGowan, 1985), and primary productivity and euphausid abundance were below normal during the 1992 El Niño (Lenarz et al., 1995). The pattern of strong upwelling alternating with periods of onshore advection, important to the production of macrozooplankton prey for blue rockfish (Hobson and Chess, 1988), was disrupted during the 1982–83 El Niño (Norton et al., 1985). These factors indicate reduced prey for rockfish, which increased feeding stress, decreased their fitness, and may have increased mortality. The lack of food may have also made rockfish of all sizes more vulnerable to CPFV hook and line fishing; overall catch per unit of effort was highest in 1982–83.

In addition to increased natural mortality of adults, El Niño environmental conditions also reduced first-year recruitment of most rockfish species (Lenarz et al., 1995). Wide variations in abundance of young-of-the-year recruits have been observed over 10 years from both midwater juvenile trawls and from *in situ* counts of settled juveniles (Ralston and Howard, 1995). Years such as 1983 with high sea surface temperatures produce particularly poor year classes for most rockfish species studied. Recruitment for many of these species improved after the El Niño; average oceanic conditions returned producing a surge of young-of-the-year in 1984 and 1985. These year classes first appeared in the fishery as drops in the 10th percentile and mean length. Bocaccio, the fastest growing species, was the first to appear in the fishery with a few small fish in 1985 and more in 1986. Chilipepper appeared in 1986–87, and yellowtail rockfish in 1987–88. The growth of these new recruits was the dominant

Table 4.—Estimated percentage of weight taken by CPFV's from combined commercial and CPFV landings 1980–94. Values adjusted for under-reporting of catch in CPFV logbooks.

Common name	Scientific name	Weight taken (%)
Blue rockfish	*S. mystinus*	83
Yellowtail rockfish	*S. flavidus*	40
Chilipepper	*S. goodei*	9
Bocaccio	*S. paucispinis*	9
Widow rockfish	*S. entomelas*	11
Greenspotted rockfish	*S. chlorostictus*	65
Canary rockfish	*S. pinniger*	63

[6] Ralston, S., J. N. Ianelli, R. A. Miller, D. E. Pearson, D. Thomas, and M. E. Wilkins. 1996. Status of bocaccio in the Conception /Monterey/ Eureka INPFC areas in 1996 and recommendations for management in 1997. *In* J. Glock and S. K. Krause (Editors), Appendix Volume 1: Status of Pacific groundfish fishery through 1996 and recommended acceptable biological catches for 1997: Stock assessment and fishery evaluation, p. B1–B48. Pac. Fish. Manage. Counc., Portland, Oreg.

cause of increasing mean lengths until 1991.

Variable success of year classes is a significant characteristic of rockfish populations (Leaman and Beamish, 1984). Several dominant rockfish species in the CPFV catch, especially chilipepper, bocaccio, yellowtail rockfish, and widow rockfish, recruited strongly to the fishery in 1977–80 from year classes produced in the mid-1970's, and in 1985–87 from 1984–85 year classes. The fishery appears to have depended on these strong recruitment events for most of the catch after 1984 (Fig. 7). Strong recruitment pulses are not apparent in the less heavily targeted rockfish species such as olive, greenstriped, greenspotted, and rosy rockfish, because they have a reserve of older year classes to buffer the effect of new recruitment. Without the reserve of older fish, the targeted species are highly vulnerable to recruitment variability.

Recruitment success may vary with environmental conditions between decades as well as between years. Ocean surface temperature off California changed from below average to above average around 1976 (Smith, 1995). This change produced more than a decade of warm conditions that may have limited recruitment of colder-water species to central California, similar to the reduced recruitment of blue rockfish and olive rockfish at the edge of their range in southern California during 1978–81 (Stephens et al., 1984). So instead of a few years between successful recruitment, some species may have experienced longer periods with little recruitment (Hollowed and Wooster, 1995). The accumulated larger bocaccio, chilipepper, yellowtail rockfish, and blue rockfish in 1977–83 may have been the product of several years of successful recruitment during the colder years before 1976. Relatively large year classes appear to be less frequent after 1985.

Rockfish are generally long lived, with over half of the species reaching maximum ages of 60 years or more (Love et al., 1990). They take an average of 5 years to reach sexual maturity (Wyllie Echeverria, 1987). The prolonged reproductive phase for unexploited populations (from about age 5 to 60) serves as a buffer against periods of recruitment failure due to environmental variations (Leaman and Beamish, 1984). In the CPFV fishery, half of the catch of the large rockfish species (bocaccio, chilipepper, yellowtail rockfish, and widow rockfish) and 90% of canary rockfish are now taken before sexual maturity. Only smaller species such as rosy and greenstriped rockfish usually reach sexual maturity before they are caught. Fishing down the reservoir of older, sexually mature fish removes the buffer and increases the risk of prolonged recruitment failure.

A similar decline in the availability of large rockfish was noted by Love et al. (1998) in the Southern California CPFV catch. They noted a dramatic decline in the catch from 3.0 to 0.4 rockfish per hour for 21 target species from 1980 to 1996, and they noted a shift from predominantly larger species to smaller species. The catch rate declined for most large species including bocaccio and chilipepper, and the mean size declined for several large species including chilipepper, vermilion rockfish, copper rockfish, and greenspotted rockfish. They noted a lack of adult fish in the catch of several species. These changes in Southern California indicate the declining size and availability of rockfish in California is widespread and not localized to the Monterey Bay area.

Fishery managers should be concerned for the health and sustainability of species with mean length at or below that of maturity. Bocaccio, chilipepper, yellowtail rockfish, and canary rockfish all fall into this category in the Monterey Bay area. If significant new recruitment is the cause of the recent declines in mean size, it should be traceable in the length frequency modes of fish from 1994 onward. If there is no strong mode of young fish, we must assume that recruitment is not keeping up with removals by the combined recreational and commercial fisheries.

Summary

The mean length of rockfish caught in the late 1970's increased as CPFV's moved into deeper water. The mean length was generally larger for deepwater species than for shallow-water species, and large individuals were caught from 1977 through 1983. A surge of new recruitment after the 1982–83 El Niño produced a sharp drop in mean length of several important species and a decline in combined rockfish mean length. Mean lengths did not recover to the high levels of 1982–83 despite the growth of these recruits and the continued emphasis on deepwater species through 1991.

Fish were harvested by both the CPFV and commercial fisheries at smaller sizes after 1982, and mean length and total landings have dropped in both fisheries. CPFV's shifted back toward shallow water as the difference in size between the deepwater and shallow-water species decreased in 1992–94. The mean length of bocaccio, chilipepper, and yellowtail, canary, and blue rockfish caught on CPFV's has dropped below the size at which 50% of the females mature.

Since 1984, the period between highly successful recruitment events seems to have been longer for the dominant species in the catch, and recruits have been harvested by CPFV's and commercial fisheries (depending on species) at smaller sizes than in the past, within a few years of entering the fishery. Since new recruits often appear in the CPFV catch at least 1 year ahead of the commercial catch, the CPFV fishery could serve as an indicator of the relative strength of new recruitment.

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