ROCKFISH RESOURCES OF THE SOUTH CENTRAL CALIFORNIA COAST: ANALYSIS OF THE RESOURCE FROM PARTYBOAT DATA, 1980–2005

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ABSTRACT

Rockfishes (*Sebastes* spp.) have historically comprised a large proportion of catches in the nearshore recreational fishery in California, but declining populations of some species have led to increasingly restrictive management of the resource. This report summarizes new and existing data on rockfishes of the south central coast of California. In 2003, the California State Polytechnic University, San Luis Obispo placed observers on commercial passenger fishing vessels (partyboats) from the region. By the end of 2005, we had observed catches from 258 trips (8,839 fisher hours). We appended these data to partyboat catch statistics collected by the California Department of Fish and Game from 1988 to 1998 and calculated annual catch per unit effort (CPUE) and mean sizes by species and year. The CPUE data by species fluctuate annually but rarely show consistent trends. The overall CPUE for 2004 and 2005 ranks in the top five of the twenty sampled years. Mean sizes have been consistent by species, generally just above the size of 50% maturity. Comparing these sizes to historical data shows decreases in some species but not in others. A review of NOAA/NMFS triennial trawl data for the Point Conception area in the southern part of the study region suggests that the deeper shelf and slope species, with a few exceptions, show little evidence of long-term declines. In general, the south central coast rockfish resources, with the exception of bocaccio (*S. paucispinis*), have not shown strong evidence of a declining trend over the past 25 years.

INTRODUCTION

Elements of the rockfish (*Sebastes* spp.) resource of California have been depleted for many years. Fishery-related problems have been diagnosed by many researchers including Lenarz (1987), Ralston (1998), Gunderson (1998), and Love et al. (1998, 2002). Rockfish are long-lived, slow to mature (iteroparous), and therefore subject to pre-spawning mortality (Leaman 1991). Two factors, overfishing and climate change, are considered primarily responsible for the declining marine fish populations in much of California. Climate change, including El Niño Southern Oscillation (ENSO) events and Pacific Decadal Oscillation (PDO) reversals (Chavez et al. 2003), has been emphasized by many, including Beamish (1995), Brooks et al. (2002), Francis and Hare (1994), and Holbrook et al. (1997). Fishing pressure has also been implicated as a major factor in scientific publications (Mason 1995; Jackson et al. 2001; Myers and Worm 2003) and by the media. Recently, the interrelationship between these two forcing functions on California partyboat catches has been analyzed by Bennett et al. (2004) while Tolimieri and Levin (2005) have looked at their effects on bocaccio (*S. paucispinis*). Possible detrimental effects of warmer climatic conditions on rockfish include reduced adult condition factors or gonadal growth (Ventresca et al. 1995; Harvey 2005), and increased mortality in larvae and young-of-the-year (YOY) (Boehlert et al. 1985; Ross and Larson 2003). Besides density-related decreases in catch per unit effort (CPUE), there has been an indication that relative sizes of species have also declined over the years (Mason 1998) and that the lack of large females in the population could lead to reduced recruitment through loss of fecundity or the loss of highly competent larvae produced by such females (Berkeley et al. 2004).

This paper examines changes in CPUE and mean sizes of the rockfish species taken in the nearshore environment of the south central coast (SCC) of California (fig. 1), an area not specifically examined in previous

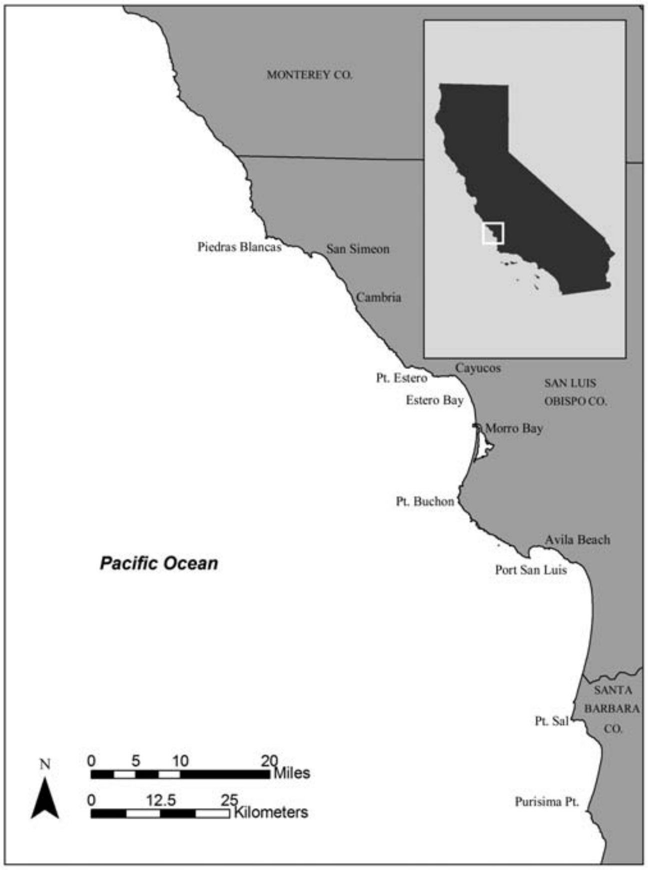

Figure 1. Coastal California and the south Central Coast Region. Map provided by Jim Stramp, Tenera Environmental.

studies and an area that marks the transition between the warm-temperate southern California bight to the south, and the cool-temperate "Oregonian" oceanic province to the north. The latter is the center of distribution for the majority of eastern Pacific rockfish species (Love et al. 2002).

The earliest published data on fishes of the SCC was Heimann and Miller's (1960) comparison of trawlers and partyboat fisheries from 1957 to 1958 while Miller and Gotshall (1965) included the area in their partyboat survey of 1957–61. Miller et al. (1967) reported on blue rockfish while Miller and Geibel (1973) reported on blue rockfish and lingcod. Love et al. (1991) discussed aspects of the biology of nearshore rockfish of the central coast. The present report is based upon the partyboat monitoring program of the California State Polytechnic University, San Luis Obispo (Cal Poly, 2003–05) and makes use of these published records as well as unpublished data for the region for 1988–98, which are partially available in administrative reports through the California Department of Fish and Game (CDFG) (Wilson et al. 1996; Wilson-Vandenberg et al. 1995, 1996; Reilly et al.1998), and unpublished partyboat studies by the Pacific Gas and Electric Company (PG&E) Diablo Canyon (1980–86), in situ young-of-the-year (YOY) recruitment observations (PG&E/Tenera Environmental [1976–2004]), and recruitment module studies (Cal Poly [2004–05]). These data are discussed along with the available results of the NOAA/NMFS Triennial Trawl Surveys (1977–2004) for the Conception region.

METHODS

The Cal Poly partyboat observer program, which began July 2003 and is ongoing, follows the methods developed by the CDFG (Reilly et al. 1998) with some exceptions. In both protocols the observer selects a sample of between six and 15 anglers to observe at the start of the trip. The observer records the number of the sampled anglers fishing at each drop along with the fishing time for that drop, its maximum/minimum depth, and the number of fish caught by species. Localities are recorded for each site. We measured the total length of all fish as they were landed and then recorded their fate, whether they were retained or returned to the ocean. CDFG observers recorded the species as they were landed as well as their fate but measured them from the fishers' bags at the end of the fishing day (kept fish only). They may also measure fish not included in the observer's sample. The CDFG protocol does not allow accurate determination of the relationship of size to depth. The Cal Poly data were limited to rockfishes (*Sebastes* spp.), hexagrammids (greenlings and lingcod), and cabezon (*Scorpaenichthys marmoratus*), though other species were noted. The CDFG recorded all fish. The catch-per-unit-effort (CPUE) statistic is the total number of fish caught by the observed sample divided by the effort. The effort variable (man hours) is developed from actual fishing time in minutes for each drop multiplied by the number of anglers in the observed sample. Data from the field sheets were checked by each observer and entered into a Microsoft Access® database, with subsequent quality control. Comparative data were made available on Microsoft Access® by the CDFG from their 1988–98 partyboat surveys for the same sites. Similar data for 1980–86 were available from PG&E's Diablo Canyon surveys.

Recruitment data (1976–2004) from diver transects at a PG&E control station for Diablo Canyon (Patton Cove), which is outside the influence of the power plant's thermal discharge plume, was supplied by Tenera Environmental.

We imitated SMURF collections of settling larvae (Ammann 2004) in 2004. SMURFs are 1.0 m by 0.35 m mesh plastic cylinders filled with larger mesh plastic grids that act as settlement "traps" for many nearshore fish species. Ours were attached to buoys just below the surface and sampled bi-weekly at three stations, three SMURFs per station.

TABLE 1
2003–05 Observed Catch of Rockfish, Greenlings, and Cabezon.
Numbers of fish caught and numbers retained; mean length (cm) of fish caught and retained; catch per unit effort.

Species/Sebastes	Number Caught	Number Kept	length (st dev.) Caught	Kept	CPUE
2003					
S. atrovirens (kelp)	8	7	31.7 (2.2)	31.6 (2.3)	0.003
S. auriculatus (brown)	1151	1099	34.4 (4.7)	34.7 (4.3)	0.51
S. carnatis (gopher)	2268	1074	26.4 (2.5)	27 (2.2)	1
S. caurinus (copper)	83	76	33 (7.2)	34 (6.7)	0.03
S. chlorostichus (greenspotted)	2	2	20 (2.1)	20 (2.1)	<.001
S. chrysomelas (black & yellow)	33	23	26.8 (1.7)	27.5 (1.4)	0.01
S. constellatus (starry)	50	45	31.3 (4.0)	31.8 (3.5)	0.02
S. dalli (calico)	72	17	15.6 (1.5)	17 (1.8)	0.03
S. entomelas (widow)	0		0		
S. flavidus (yellowtail)	239	75	22.8 (6.7)	29.3 (6.5)	0.11
S. hopkinsi (squarespot)	0		0		
S. melanops (black)	152	140	30.3 (2.6)	30.5 (2.5)	0.07
S. mineatus (vermillion)	859	813	33.8 (7.1)	344.4 (6.9)	0.38
S. mystinus (blue)	3984	2659	27 (5.1)	28.8 (4.1)	1.75
S. nebulosus (china)	36	28	28.8 (2.9)	29.3 (2.3)	0.01
S. paucispinnis (bocaccio)	9	0	45.4 (8.1)	0.003	
S. pinniger (canary)	72	0	29.8 (3.4)	0.03	
S. rosaceous (rosy)	183	53	20.7 (3.0)	21.8 (2.8)	0.07
S. rosenblatti (greenblotched)	0	0			
S. ruberrimus (yelloweye)	0	0			
S. rubrivinctus (flag)	0	0			
S. serranoides (olive)	360	224	30.1 (7.6)	33.6 (5.7)	0.16
S. serriceps (treefish)	61	60	29.5 (2.7)	29.5 (2.7)	0.02
Scorpanichthys marmoratus (cabezon)	13	6	40.9 (5.6)	43.9 (4.7)	0.005
H. decagrammos (kelp greenling)	95	26	31.1 (2.9)	32.4 (2.7)	0.04
H. lagocephalus (rock greenling)	2	2	32.5 (2.1)	32.5 (2.1)	<.001
O. elongatus (lingcod)	1025	231	56 (8.8)	66.2 (6.2)	0.45
Total Fish	10,757	6,647			
Overall CPUE					4.70
2004					
S. atrovirens (kelp)	27	26	30.9 (2.1)	31.2 (1.7)	0.008
S. auriculatus (brown)	1029	986	36.7 (4.0)	36.9 (3.8)	0.32
S. carnatis (gopher)	2406	1359	26.4 (2.2)	27 (2.0)	0.75
S. caurinus (copper)	304	282	35.6 (5.8)	36.3 (5.3)	0.1
S. chlorostichus (greenspotted)	0				0
S. chrysomelas (black & yellow)	11	1	31.2 (2.0)	25.5 (0)	0.003
S. constellatus (starry)	219	201	30.8 (3.6)	31.3 (3.3)	0.07
S. dalli (calico)	61	2	15 (1.4)	15.5 (0.7)	0.02
S. entomelas (widow)	2	0	18.5 (2.1)		<.001
S. flavidus (yellowtail)	631	150	22.5 (5.3)	28.9 (4.5)	0.19
S. hopkinsi (squarespot)	3	0	17.3 (4.6)		<.001
S. melanops (black)	31	25	30.9 (2.3)	31.4 (2.1)	0.01
S. mineatus (vermillion)	2017	1927	35.2 (7.2)	35.6 (7.1)	0.63
S. mystinus (blue)	9059	4927	27.6 (4.4)	30.1 (2.9)	2.8
S. nebulosus (china)	58	49	29.6 (3.2)	30 (2.9)	0.02
S. paucispinnis (bocaccio)	57	55	52.1 (5.8)	52.7 (4.5)	0.02
S. pinniger (canary)	214	0	29.6 (4.0)		0.07
S. rosaceous (rosy)	424	51	20.5 (2.5)	22.2 (3.7)	0.13
S. rosenblatti (greenblotched)	0				0
S. ruberrimus (yelloweye)	2	0	51.5 (7.8)		<.001
S. rubrivinctus (flag)	15	15	31.2 (2.0)	31.2 (2.0)	0.005
S. serranoides (olive)	499	389	34.7 (7.2)	36.9 (6.1)	0.15
S. serriceps (treefish)	27	25	29.5 (3.3)	29.8 (3.0)	0.008
Scorpanichthys marmoratus (cabezon)	24	18	45.3 (6.7)	47.5 (4.6)	0.007
H. decagrammos (kelp greenling)	98	8	29.9 (2.0)	32.8 (1.6)	0.03
H. lagocephalus (rock greenling)	0				0
O. elongatus (lingcod)	1385	106	55.8 (9.1)	69 (7.6)	0.43
Total Fish	18,603	10,602			
Overall CPUE					5.77

TABLE 1, continued
2003–05 Observed Catch of Rockfish, Greenlings, and Cabezon.
Numbers of fish caught and numbers retained; mean length (cm) of fish caught and retained; catch per unit effort.

Species/Sebastes	Number Caught	Number Kept	length (st dev.) Caught	length (st dev.) Kept	CPUE
2005					
S. atrovirens (kelp)	0				0
S. auriculatus (brown)	504	453	37.5 (3.8)	37.9 (3.6)	0.35
S. carnatis (gopher)	591	343	26.3 (2.3)	26.8 (2.2)	0.41
S. caurinus (copper)	371	347	36.6 (5.6)	37.3 (5.0)	0.26
S. chlorostichus (greenspotted)	0				0
S. chrysomelas (black & yellow)	2	0	29.5 (2.1)		0.001
S. constellatus (starry)	329	279	29.4 (4.2)	30.3 (3.5)	0.23
S. dalli (calico)	43	0	14.7 (1.6)		0.03
S. entomelas (widow)	70	11	21.2 (4.6)	28.3 (5.7)	0.05
S. flavidus (yellowtail)	1092	404	26.1 (5.5)	31.0 (4.2)	0.76
S. hopkinsi (squarespot)	0				0
S. melanops (black)	4	2	31.3 (1.8)	31.3 (2.5)	0.001
S. mineatus (vermillion)	1218	1143	36.7 (7.1)	37.2 (6.9)	0.84
S. mystinus (blue)	2751	1674	28.1 (4.7)	30.8 (3.1)	1.9
S. nebulosus (china)	27	23	29.3 (3.1)	29.6 (3.0)	0.02
S. paucispinnis (bocaccio)	85	84	46.9 (8.0)	47.2 (7.7)	0.06
S. pinniger (canary)	153	1	30.8 (4.7)	33.5	0.11
S. rosaceous (rosy)	436	58	20.6 (2.2)	22.1 (2.7)	0.3
S. rosenblatti (greenblotched)	2	2	34.8 (.4)	34.8 (.4)	0.001
S. ruberrimus (yelloweye)	4	0	50.4 (11.3)		0.003
S. rubrivinctus (flag)	17	16	31.1 (2.5)	30.9 (2.5)	0.01
S. serranoides (olive)	188	176	39.6 (5.7)	40.1 (4.9)	0.13
S. serriceps (treefish)	15	9	27.6 (2.7)	27.9 (3.0)	0.01
Scorpanichthys marmoratus (cabezon)	8	7	53.9 (5.3)	53.9 (5.3)	0.006
H. decagrammos (kelp greenling)	18	2	30.1 (1.6)	32.8 (1.8)	0.012
H. lagocephalus (rock greenling)	0				
O. elongatus (lingcod)	414	130	56 (10.7)	67.5 (6.4)	0.29
Total Fish	8,353	5,166			
Overall CPUE					5.78

Further data for the region were available from the NOAA/NMFS Triennial Trawl publications (1977, 1995, 1998, and 2001) and we received data from 2004 from the NOAA Northwest Fisheries Science Center and the NOAA Alaska Fisheries Science Center's Racebase database (Beth Horness, NOAA/NMFS, pers. comm.).

RESULTS AND DISCUSSION

For 2003, 2004, and 2005 we observed partyboat catches from Patriot Sportfishing and Virg's Sportfishing operating out of Port San Luis and Morro Bay, respectively. A total of 258 trips were observed: 68 in 2003, 126 in 2004, and 62 in 2005. The number of trips was evenly dispersed between the two ports. In 2005, fishing was allowed only at depths of 20 fm (36.6 m) or shallower and the season lasted from 1 July until the middle of December (five+ months). For 2004, the season opened 1 January, closed for the months of March, April, and July, and was open for the remainder of the year (nine months). That year, fishing as deep as 30 fm (54.7 m) was permitted for about one-third of the period, and fishing was restricted to 20 fm the remainder of the time. For 2005, the season opened on 1 May and ended 30 September (five months). Fishing was permitted to 40 fm (80m) or less for the entire season.

The Cal Poly partyboat data (tab. 1) includes the total catch and retention of species of interest for each year with mean size and standard deviation for each category. There were 23 species of rockfishes, three hexagrammids, and one cottid for a total of 27 species of interest taken in our samples for these three years. Of these, 11 rockfishes and the two hexagrammid greenlings represent elements of the 19 species complex included in the California Resources Agency Nearshore Fishery Management Plan. Catch per unit effort is considered to be a reliable measure of fish density in the habitat. The overall partyboat CPUE (fig. 2) has remained relatively constant over the years even though recreational regulations have reduced the overall bag limit, number of hooks per line, and the take, while increasing size limits on some species and excluding others from take altogether. A number of factors could reduce the effects of these changes, including improved fish finding (sonar) and new technology in artificial lures. The recent Cal Poly data do not show evidence of decline and the CPUE (2003–05) ranks in the top five in the 20 years sampled.

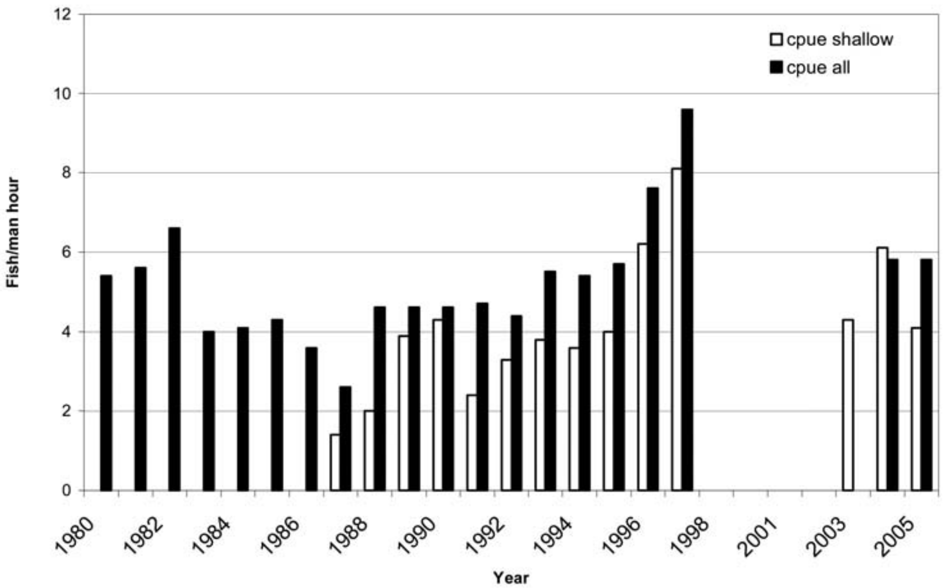

Figure 2. Partyboat CPUE for all species of interest in the South Central Coast, 1980-2005.

Data on species-specific CPUEs are much more informative than generic ones. Because partyboats fish deeper than where the majority of several of our species of interest (grass, black and yellow rockfish, treefish, kelp greenling, and cabezon) are distributed, these species are therefore not sampled well by this methodology and we will not discuss them further. Most of the other species that were taken are available to fishers at shallow depths, but many are more numerous and are larger in size at greater depths. Thirteen species made up more than 1% of the catch in at least one year of sampling. In order of decreasing total abundance they were: blue, gopher, and vermillion rockfish, lingcod, brown, yellowtail, olive, rosy, copper, starry, canary, and black rockfish, and bocaccio. The assemblage rank order did not differ significantly over these three years (pair-wise Kendall's tau, p =.05, uncorrected for multiple testing) even though different depths were fished over different years. During 2005, because fishing was allowed to depths of 40 fm (80 m), we were able to test the effect of this depth range on species distributions. Five of the thirteen rockfish species increased regularly in CPUE with greater depth (canary, copper, olive, rosy, and yellowtail), while two species, brown and gopher rockfish, decreased in density with depth. Changes in CPUE and size are shown (fig. 3) for relevant species. The CPUE of two species, blue and starry rockfish, decreased in depths below 20 fm but decreased or stayed constant in depths greater than 30 fm, while the CPUE of vermillion rockfish and bocaccio increased in the deepest fishable strata of 30–40 fm. Five species increased in size (mean length) in deeper water: blue, canary, copper, olive, and yellowtail rockfish. These data suggest that it is important to consider depth when describing changes in abundance and size of rockfishes through time.

CPUEs and size data measured outside the preferred habitat of a species may not be typical for that species (MacCall 1990), therefore we compare species that occupy similar depth strata and depict CPUE from all depths as well as data from 20 fm or less (figs. 4 and 5). Species that seem to center their distribution around 20 fm (black, blue, brown, china, gopher, and olive rockfish and lingcod) are compared (fig. 4). Here, CPUE is generally higher for the shallow (<21 fm) data which more accurately reflect the preferred habitat. For a number of species (black, brown, china, and olive rockfish) the highest CPUE of the 14-year sampling period occurred in 1990–91, which were "normal" years for oceanographic conditions between the ENSO events of 1983–84 and 1992–93. Black and china rockfish have been in low abundance recently which may reflect a northern displacement of these species from their southern limits in response to the warm PDO (1977–98). Olive rockfish have not been abundant the last three years but apparently were very abundant between 1998 and 2002 (Steve Moore, Patriot Sportfishing, pers. comm.) when sampling did not occur. CPUE for these shallow species appears to decrease during 2005 but this may be the result of decreased fishing in shallow water and expanded fishing outside their depth range. Only 21% of the fishing drops in 2005 were in shallow water. Blue, brown, gopher, and olive rockfish, and lingcod appear to have strong populations. CPUEs for blue rockfish peak coinciding with El Niño events. It has been shown that the conditional factor of blue rockfish declines during El Niños because of reduced food resources (Ventresca et al. 1995). The

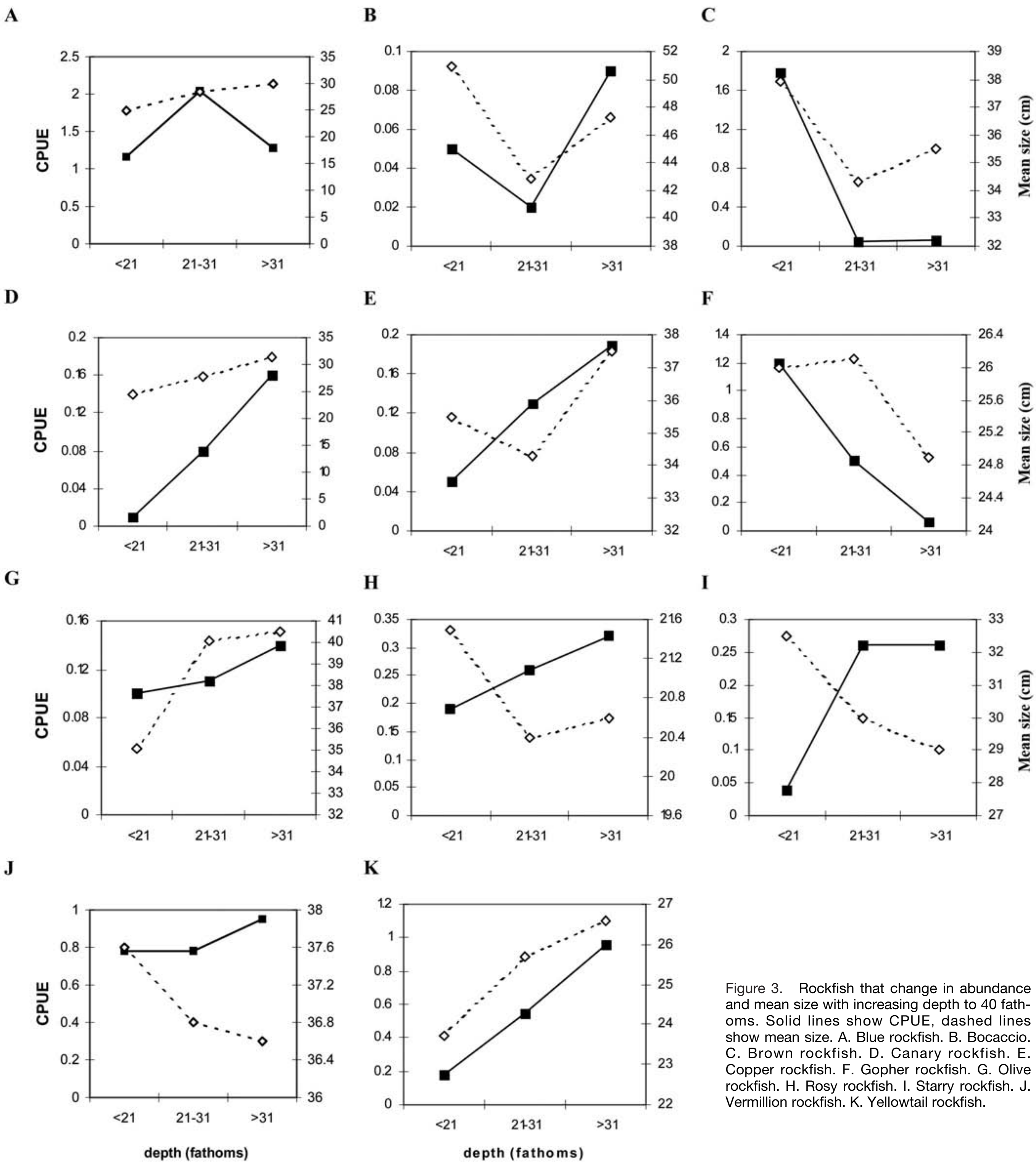

Figure 3. Rockfish that change in abundance and mean size with increasing depth to 40 fathoms. Solid lines show CPUE, dashed lines show mean size. A. Blue rockfish. B. Bocaccio. C. Brown rockfish. D. Canary rockfish. E. Copper rockfish. F. Gopher rockfish. G. Olive rockfish. H. Rosy rockfish. I. Starry rockfish. J. Vermillion rockfish. K. Yellowtail rockfish.

increased catchability observed here may be related.

As cited earlier, seven species (bocaccio and canary, copper, rosy, starry, vermillion, and yellowtail rockfish) though often common in depths less than 20 fm, increase in density in deeper water (fig. 5). The 2005 CPUE for copper and vermillion rockfish is the highest of the time series, while that for rosy and starry rockfish ranks in the top five. Bocaccio have been in decline since at least 1989 (Ralston et al. 1996; MacCall et al. 1998), and are still depleted as evidenced by their low

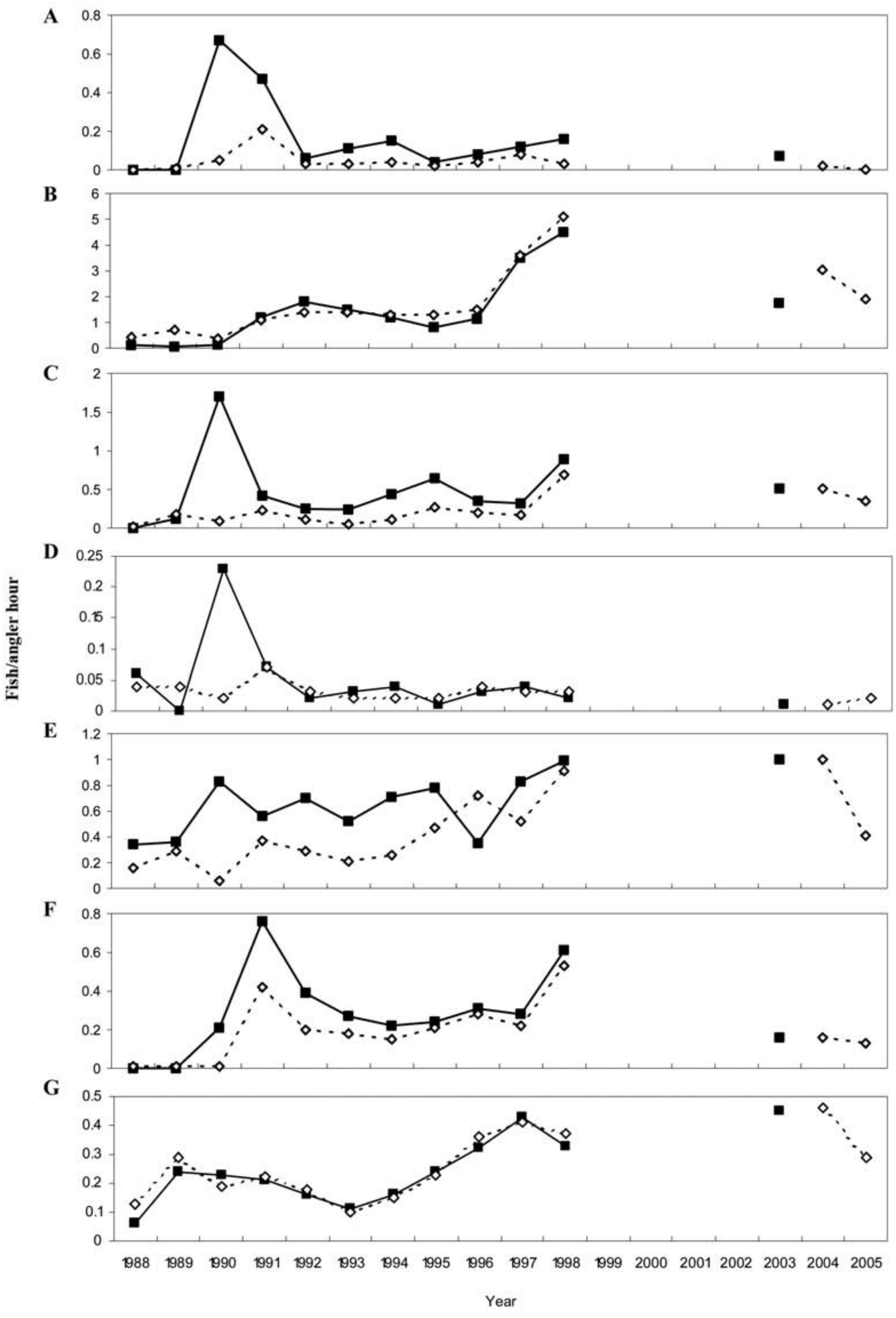

Figure 4. Changes in CPUE by year (partyboat data, SCC) for fish abundant in waters shallower or equal to 20 fathoms. Solid lines show fish caught in 20 fathoms or less, dashed lines show fish caught at all depths. A. Black rockfish. B. Blue rockfish. C. Brown rockfish. D. China rockfish. E. Gopher rockfish. F. Olive rockfish. G. Lingcod.

CPUE. Their density increased slightly in our 40 fm data but it appears that their density has not changed much in the last 12 years since their major collapse (1989–92). Recent work by Tolimieri and Levin (2005) suggests that the balance between reproductive success (recruitment) and population growth in the bocaccio is tenuous at best and that any fishing pressure could push the population towards extinction. The present bag limit for bocaccio is two fish per angler, an increase over the no-take regulation in 2003, but still conservative.

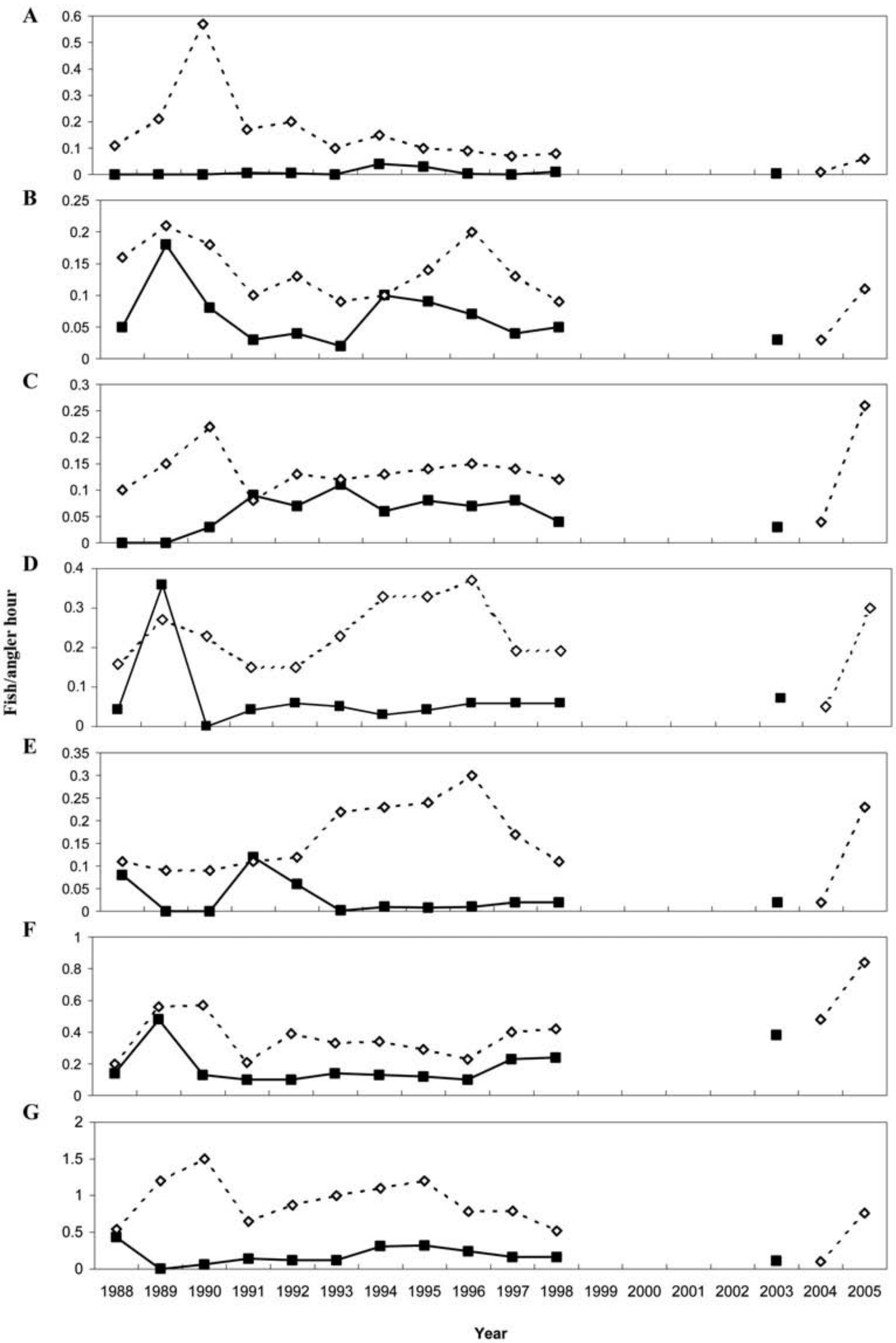

Figure 5. Changes in CPUE by year (partyboat data, SCC) for fish common in shallow water and deeper than 30 fm. Solid lines show fish caught in 20 fm or less, dashed lines show fish caught at all depths. A. Bocaccio. B. Canary rockfish. C. Copper rockfish. D. Rosy rockfish. E. Starry rockfish. F. Vermillion rockfish. G. Yellowtail rockfish.

Densities of most species do not appear to change dramatically or consistently with El Niño years. This may reflect the relatively low fishing intensity in the SCC as well as the relatively cool water habitat. Bennett et al. (2004) discussed the interaction of ocean climate and fishing pressure on rockfish. During El Niño events in the warm, heavily fished southern California bight, CPUE decreased, while in the cool-water low fishing intensity sites north of San Francisco, CPUE increased. A similar interaction could apply here.

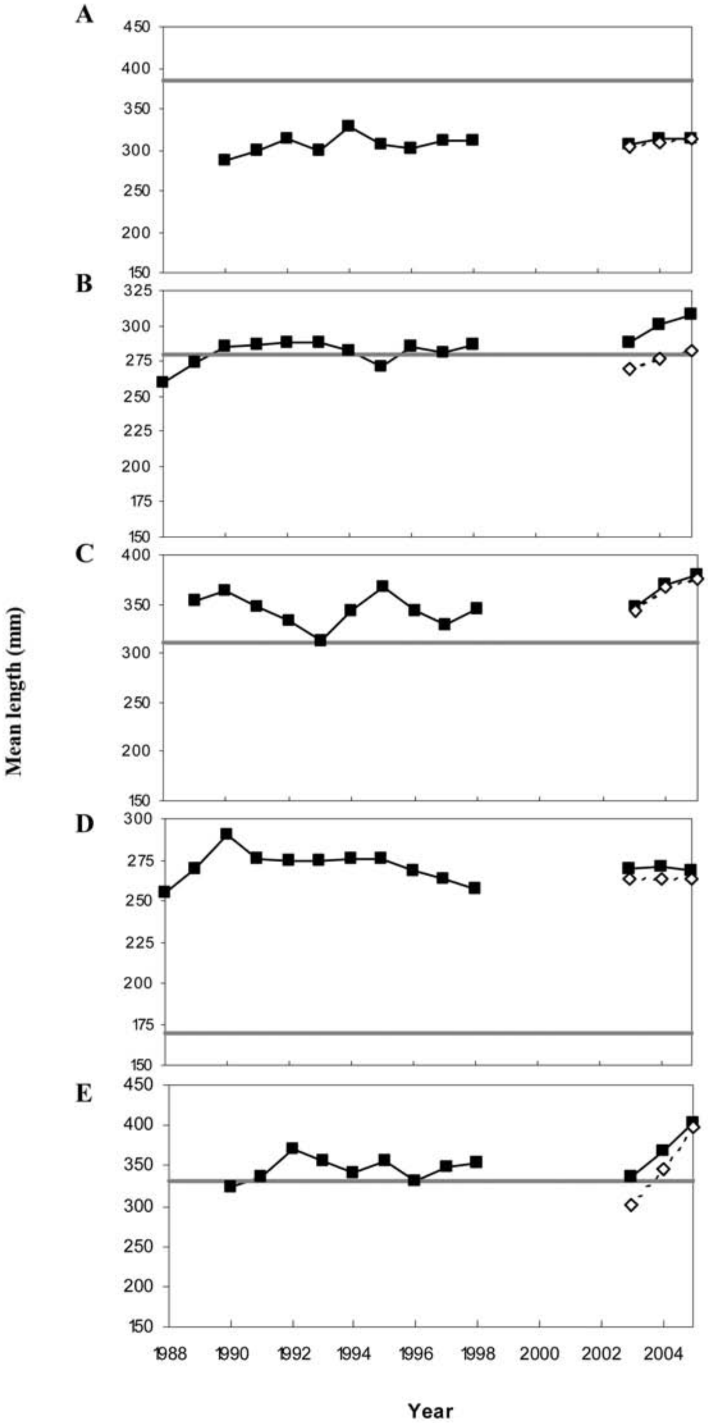

Figure 6. Changes in mean length by year of nine species caught at all depths by partyboats in SCC. Solid lines show kept fish, dashed lines show all fish caught. Horizontal line denotes 50% maturity. A. Black rockfish. B. Blue rockfish. C. Brown rockfish. D. Gopher rockfish. E. Olive rockfish. F. Rosy rockfish. G. Vermillion rockfish. H. Yellowtail rockfish. I. Lingcod.

Reduction of fish size, as well as in CPUE (density), is an important indicator of possible population problems. Reduction in fish size may be due to fishing pressure which reduces the number of large mature individuals in the population (Cushing 1975). Long-lived and slow-growing species are especially vulnerable to this effect. The loss of large females from the population can have an especially strong effect on larval production and survival (Berkeley et al. 2004). Thus, growth and recruitment overfishing can be closely related. The annual change in mean length as a measure of size since 1988 (fig. 6) does not indicate a major trend by species in the SCC. Most species have mean lengths above the 50% maturity size, though yellowtail and black rockfish do not. Yellowtail caught in deeper waters (2005) did exceed this mean length, and the smaller size of the shallow-water

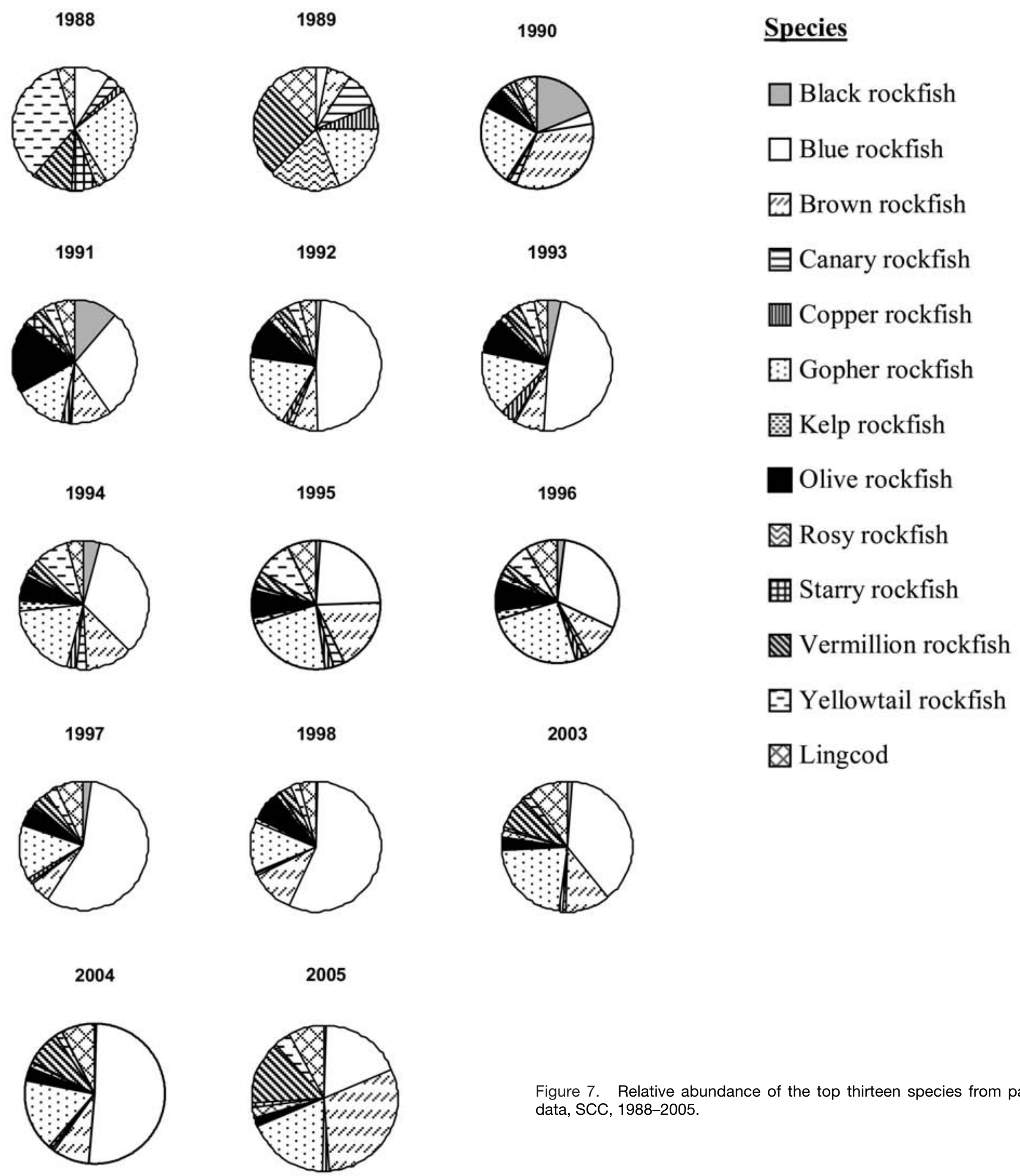

Figure 7. Relative abundance of the top thirteen species from partyboat data, SCC, 1988–2005.

catch may reflect ontogenetic movements in this species. Black rockfish generally have not done well on the SCC since the change to a warm phase of the PDO, and were small for the species even in 1980–86 (Karpov et al. 1995). The SCC is the southern limit of their range.

The CDFG collected size data (1988–98) from fish retained by the partyboat fishery, and the depths from which they were taken were uncertain. Our data (2003–05) include both caught and kept fish as well as depth of capture. We have used kept fish size to make our data comparable to previous studies, but the use of size from only kept fish biases (increases) the fish size estimate of the fished population because fishers sometimes released smaller fish. The difference between mean sizes of all captured fish and the size of those retained are presented in Table 1. Certain species (e.g., brown, gopher, and vermillion rockfish) are rarely discarded regardless of size, and the kept/catch ratio is close to unity.

The lingcod data demonstrate the effect of minimum size regulations on the kept/catch ratio. Rockfish regulations rarely specify minimum size limits because survival of released fish is estimated to be very low due to swim bladder distension. Lingcod, however, lack swim bladders and show little effect from being brought to the surface so that releasing smaller fish is a viable option. In 2003, the minimum size was 60 cm total length and only about 25% of landed fish were kept. In 2004, the minimum size was raised to 76 cm and only 10% were retained, while in 2005, the minimum size was reduced to 60 cm and more than 30% were kept. Certainly, in this case, the number of fish retained is not a reflection of the fish size in the population.

The relationship of size to depth of capture for 2005, the year when regulations allowed fishing to depths of 40 fm (fig. 3), suggests that changing the allowable depth of the fishery can lead to increases in size. The mean lengths for fish from 2005 were higher for species that inhabit deeper strata. The closure of partyboat fishing in 2003 to waters deeper than 20 fm would not account for size differences observed in 2005. It is therefore not possible to accurately relate historical size differences to today's catch without depth data from each source.

Karpov et al. (1995) discussed decreases in rockfish size comparing Miller and Gotshall's partyboat survey data of 1957–61 to the Marine Recreational Fishery Statistics Survey (National Marine Fisheries Service) data from the 1980s. Mason (1998) described a decremental trend in rockfish size from partyboat catches, 1959–94, in the Monterey region. She used logbook data to estimate total catch and catch per angler day, and CDFG sampling surveys to estimate species composition and lengths. Neither estimates are without question but her general description of trends seems reasonable. She used data with depth limits for species groups, and her ten most abundant species included bocaccio, chilipepper, greenspotted and greenstriped rockfish from the deep group, canary, widow, and yellowtail rockfish from the mixed-depth group, and blue and olive rockfish from our shallow group. We can compare our length data for 2005 to Mason's last data point (1994) for blue, yellowtail, olive, rosy, and canary rockfish and bocaccio, and with the exception of the canary rockfish, our mean lengths (tab. 1) are equal to or higher than hers. It is probable that there is a latitudinal trend in size for rockfishes (but see Laidig et al. 2003) and that growth patterns as well as fishing intensity are not the same between sites. The PG&E Diablo Canyon partyboat sampling data from 1980 to 1986 (Gibbs and Sommerville 1987) include size-frequency histograms for seven species. If we compare their 1982 data to ours from 2005, four species (gopher, blue, canary, and copper rockfish) have higher mean lengths in 1982 while three species (olive and yellowtail rockfish and bocaccio) were smaller. Blue rockfish data from the early 1960s (Miller et al. 1967) for Avila samples have means that fluctuate between 33.6 cm (1960) and 28.0 cm (1964). The years 1959, 1960, and 1963 had higher means than 2005 while the means for 1962 and 1964 were lower. There is considerable annual fluctuation in catch size of rockfishes that must be related to site specific and historical factors such as recruitment success and fishing intensity. Continual fishing pressure is certain to decrease the abundance of older, larger reproductive individuals in populations of slow-growing fish like rockfish.

An additional effect of fishing pressure might be a change in the dominance of one or more species within the assemblage. Using only the shallow data (20 fm or less) to eliminate depth effects, we created pie charts for 13 species that rank in the top 10 for any single sampled year for the 14 years of sampling (fig. 7). After 1992, blue, brown, and gopher rockfish make up about 75% of the catch. Yellowtail and gopher rockfish were important in 1988; vermillion, gopher, and rosy rockfish in 1989; and black, brown, and gopher rockfish in 1990. The dominance of brown rockfish in 2005 results from the fact that the majority of the shallow fishing that year occurred at Point Purisima which is an exceptional habitat for browns.

We tested the rank order of abundance of species in the shallow water assemblage (1979–2004) using Kendall's tau statistic (p = .05, uncorrected for multiple testing) between all possible pairs of years. Over 80% of the 190 comparisons were significantly correlated (tab. 2). There was a slow, modest transformation of the assemblage over the 20 sampling years. For example, the 1979 rank order was significantly correlated to most years prior to 1992, and not to later years. The 1980 rank order was generally correlated until 1996 but not thereafter. Some years (1985, 1990, and 1991) did not significantly correlate to a number of years and these instances are not easily interpreted.

Information on recruitment to the fishery can be obtained from annual changes in size frequency (Mason 1998). Recently, vermillion rockfish have had strong recruitment to the habitat (Dan Pondella, Vantuna Research Group, pers. comm.) and to the fishery of the SCC, and have shown an increasing CPUE since 1996 with decreasing mean length. Since 1998, the mean size has stabilized or increased reflecting growth in the recruitment class. The best record of shallow water recruitment to the nearshore habitat in the SCC region is available from PG&E's unpublished diver transect studies of rockfish at Patton Cove near Diablo Canyon (fig. 8). Pulses of rockfish recruitment have occurred since the study began in 1976 though pelagic species (bocaccio, and olive, yellowtail, and blue rockfish) have not recruited strongly since the mid 1980s. The last five years have shown very limited successful recruitment at the study site. In 2004,

TABLE 2
Composition of total catch by partyboats, 1979–2004

A. Rank order of abundance of the total catch of rockfish and lingcod based upon surveys by PG&E (1979–86), CDFG (1988–98), and Cal Poly (2003, 2004)
B. Year to year comparison, Kendall's nonparametric correlation (tau, uncorrected for multiple testing); n.s. correlation below traditional confidence level, p =.05

A

species	1979	1980	1981	1982	1983	1985	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	2003	2004
yellowtail	3	3	2	2	2	1	1	1	1	1	2	2	2	2	2	2	2	2	7	6
blue	1	1	1	1	1	2	2	2	2	4	1	1	1	1	1	1	1	1	1	1
vermillion	11	12	9	9	7	7	9	3	3	2	6	3	3	3	5	8	5	6	5	3
rosy	5	4	3	3	4	3	5	4	6	6	11	9	4	4	4	4	8	8	8	7
gopher	14	10.5	8	6	3	10	3	5	5	13	4	5	6	6	3	3	3	2	2	2
widow	7	6	11.5	12	12	9	7.5	6	13	5	9	4	9	5	10	13	7	13	16.5	16
canary	4	5	5	7	9	4	4	7	7	9	13	10	12	13	12	9	12	11	11	11
lingcod	8	9	16	14	15	14	11	8	4	8	6	8	10	9	8	5	4	7	4	8
starry	10	7	4	4	6	5	6	9	12	10	12	13	5	7	7	6	10	10	12	10
bocaccio	2	2	10	11	17	8	10	10	8	3	10	7	11	10	13	12	14	12	14	13
copper	9	10.5	6	8	8	6	7.5	11	10	7	14	11	8	11	11	11	11	9	10	9
china	15	14	15	13	10	16	15	12	15	15	15	16	17	16	15	14	17	15	13	12
greenspot	6	13	11.5	10	11	11	12	13	14	12	17	14	14	15	14	16	16	16	15	16
olive	12	8	7	5	5	15	14	14	16	16.5	3	6	7	8	9	7	6	4	6	7
brown	16	17	16	15.5	14	13	13	15	9	16.5	5	12	13	12	6	10	9	3	3	5
chilipepper	13	16	17	17	16	17	16	16	11	17	16	17	15	17	17	17	15	17	16.5	16
black	17	15	18	15.5	13	12	17	17	17	14	7	15	16	14	15	15	13	14	9	14

B

	1980	1981	1982	1983	1985	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	2003	2004
1979	0.73	0.52	0.44	ns	0.51	0.51	0.49	0.35	0.54	ns	0.38	ns	ns	ns	ns	ns	ns	ns	ns
1980		0.65	0.64	0.39	0.60	0.58	0.52	ns	0.56	ns	0.51	0.45	0.52	0.38	0.47	ns	ns	ns	ns
1981			0.90	0.65	0.71	0.71	0.58	0.39	0.42	ns	0.41	0.65	0.52	0.53	0.61	0.37	0.44	ns	0.38
1982				0.75	0.64	0.67	0.54	ns	0.37	ns	0.47	0.67	0.57	0.57	0.66	0.42	0.47	ns	0.43
1983					0.49	0.52	0.49	ns	ns	0.36	0.41	0.59	0.51	0.60	0.63	0.49	0.54	0.41	0.55
1985						0.75	0.59	0.46	0.63	ns	0.43	0.54	0.50	0.47	0.47	ns	ns	ns	ns
1986							0.73	0.58	0.47	ns	0.51	0.61	0.55	0.61	0.60	0.44	0.41	ns	0.38
1988								0.66	0.64	0.38	0.63	0.66	0.71	0.59	0.59	0.53	0.44	ns	0.40
1989									0.49	0.36	0.56	0.53	0.48	0.57	0.57	0.51	0.54	0.39	0.51
1990										ns	0.60	0.51	0.55	0.36	ns	ns	ns	ns	ns
1991											0.63	0.45	0.55	0.58	0.57	0.72	0.70	0.61	0.58
1992												0.68	0.78	0.60	0.54	0.69	0.60	0.41	0.49
1993													0.84	0.72	0.66	0.66	0.60	0.38	0.54
1994														0.74	0.65	0.71	0.61	0.39	0.55
1995															0.79	0.76	0.76	0.57	0.73
1996																0.71	0.76	0.57	0.70
1997																	0.73	0.60	0.64
1998																		0.76	0.85
2003																			0.81

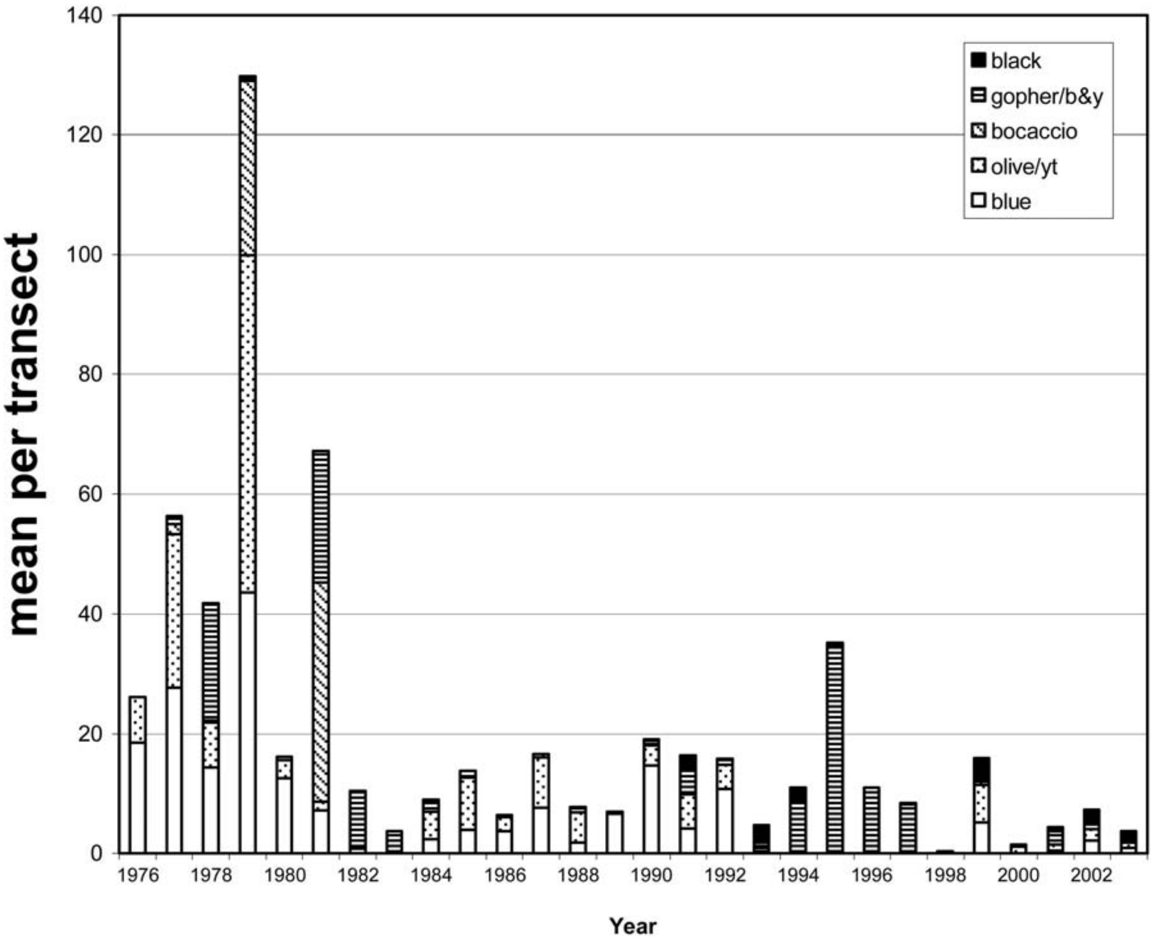

Figure 8. Recruitment of young-of-the-year/juvenile rockfish at Patton Cove, 1976–2003.

this site became a portion of the Cooperative Research and Assessment of Nearshore Ecosystems sampling system (CDFG) for the SCC and several additional sampling sites were added. It will be interesting to compare these more diverse data to those from the Patton Cove site alone.

In 2004–05, we initiated a study of larval settlement using SMURF settlement modules which have been employed for some years at contiguous sites in the Santa Barbara area (J. Caselle, UCSB, pers. comm.) and in the Santa Cruz area (M. Carr, UCSC, pers. comm.). Recruitment success depends not only on larval supply but within-site predation (Hobson et al. 2001; Adams and Howard 1996), and with SMURFs we examine the settlement of recently transformed larvae and reduce the effects of subsequent predation. The two-year pattern of settlement (fig. 9) shows a similar pattern for cabezon and the complex of copper, gopher, and black and yellow rockfish. The black, yellowtail, and olive rockfish complex failed to recruit in 2005. A similar pattern occurred in the Santa Cruz area (M. Carr, UCSC, pers. comm.), though not in the southern California bight. In this case, the lack of recruits reflects absence of larvae rather than post-settlement predation.

The NOAA/NMFS triennial trawl data are available and provide estimates of CPUE, biomass, and abundances in the SCC (tab. 3). The original survey in 1977 (Gunderson and Sample 1980) sampled deeper strata (depths below 91 m) than those between 1995 and the present, which sampled below 55 m. The NOAA/NMFS surveys did not calculate population estimates and CPUE was measured as kg/km trawled, while later publications used kg/ha. The area sampled later can be about 30% smaller than the former estimate (trawl width is estimated to be between 12 m and 14 m). Further, there was a hiatus of 18 years between 1977 and 1995 when no data were collected as far south as the SCC. However, the existing data can still be used as an indicator of change for shelf and slope species in the SCC. The triennial trawl surveys sample depths between 55 m and 500 m (30–275 fm). At the shallower depths they overlap partyboat strata. Depths from 50–150 fm have been closed since 2003 to all bottom fishing including commercial and recreational. The triennial trawl data since 1980 have

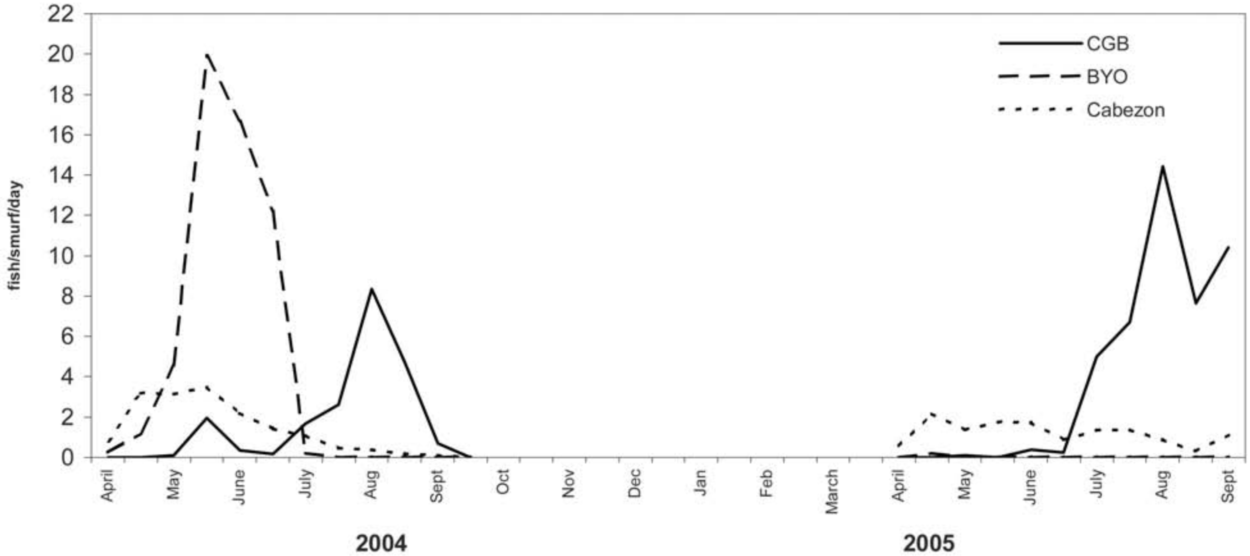

Figure 9. Larval settlement to SMURFs on the SCC, 2004–2005. Solid line represents CGB (copper, gopher, black & yellow) complex, dashed line shows BYO (black, yellowtail, and olive) complex and dotted line, cabezon.

TABLE 3
NOAA/NMFS Triennial Bottom Trawl Survey Data, Conception Region

	A. CPUE Estimated (kg/ha) (data for 2004 not available)				B. Biomass Estimates (tons)					C. Abundance estimates (# fish/1000) (data for 1977 not available)			
species	**1977**	**1995**	**1998**	**2001**	**1977**	**1995**	**1998**	**2001**	**2004**	**1995**	**1998**	**2001**	**2004**
aurora rockfish		1.82	1.59	1.93					610				2455
bank rockfish		0.1	0.003						17				39
blackgill rockfish		0.4	0.67	1.05					208				339
bocaccio	2.3	0.15	0.02		830	58	11	52	214	189	24	87	239
canary rockfish	0.1	0.41	0.01			T	2	8	T	2	2	5	2
chilipepper	0.6	4.45	2.2	30.36	200	1467	702	13568	2201	5440	2903	96454	11487
copper rockfish			0.001										
cowcod			0.003										
darkblotched rockfish	0.1		0.003			3	1	3	52	6	3	18	196
greenblotched rockfish			0.003										
greenspotted rockfish			0.003										
greenstriped rockfish			0.06			3	3	1	9	49	48	25	30
halfbanded rockfish		0.81	0.28	0.23		0	0	0	332	0	0	0	7160
redbanded rockfish			0.003										
rosethorn rockfish			0.003										
sharpchin rockfish			0.003			T	T	2	T	1	5	20	1
shortbelly rockfish	1.7	3.13	17.36	3.73	610	1643	8510	4104	1286	22927	180842	40560	53199
shortraker rockfish				0.06									
splitnose rockfish	11.2	17.99	14.6	6.16	3610	8521	4781	2663	15861	59487	39242	21752	156082
stripetail rockfish	6.2	10.1	6.24	4.42	2170	4080	1788	1685	2190	43047	21351	15363	46828
widow rockfish	0.3					10	T	10	16	56	1	67	13
yellowtail rockfish						29	0	17	0	186	0	20	0
shortspine thornyhead	0.3	0.88	0.25	1.23	80	249	90	407	442	1079	508	1501	1261
longspine thornyhead		0.47	0.76	0.78					96				418
Total Biomass					7500	16063	15888	22520	22924				

been published in NOAA Technical Memoranda (1995 [Wilkens et al. 1998]; 1998 [Shaw et al. 2000]; and 2001 [Weinberg et al. 2002]). The 2004 data were collected but are not yet published; however, we have been given access to some of the unpublished SCC data. The SCC is represented by the Conception site which extends from 34°30'N to 36°00'N. This is not the same Conception site used by Ware and Thomson (2005). Their Conception extends from 36°N to the Mexican border, crossing major faunal lines, changed environmental conditions, and decreasing estimates of productivity. The estimated rockfish total biomass (tons) for the Conception region (1995–2004) is 17,318, 17,092, 22,810, and 23,726 by year. The 2001 estimate in the report (12,898) is obviously an error and we recalculated this figure as a total of reported data. These biomass totals are small compared to the estimates for most other regions. The Conception region, however, is the smallest of the regions. If we standardize by unit area, the standardized biomass of Conception ranks first or second by year among the five U.S. sites.

The CPUE estimates for selected species in the Conception region (tab. 3A) includes limited data on 23 species (1977, 1995, 1998, and 2001 [2004 not as yet available]). Estimated total biomass (tab. 3B) has increased since 1977, even if only species reported in 1977 are included. Similarly, the estimated species abundance (tab. 3C) has increased, though not in a linear fashion. Extremely large catches of one species have large effects on these data: shortbelly rockfish in 1998, chilipepper in 2001, and splitnose rockfish in 2004. The coefficients of variation are large for these data though the trends, or lack of trends, shown may be valid. There has been no significant change in rank order of important species based on yearly CPUE or estimated abundance between 1995 and 2004 (Kendall's tau, $p = .05$, uncorrected for multiple testing). The 1977 data were not significantly correlated to the other years, but the species list was probably incomplete. These data suggest that the rockfish assemblage in the triennial trawl depth range has been stable at least since 1995. We have not as yet been granted permission to sample these depths experimentally with partyboats, although the data could potentially corroborate such trends.

In conclusion, it does not appear that the major decline in rockfish abundance or biomass which has been observed for some species in the northeast Pacific since the late 1970s can be documented for fish from the south central coast of California, with the exception of bocaccio. Existing trends may be masked by sampling error as well as by technological improvements in the sportfishing boats' ability to locate and capture fish. Nevertheless, this site is the southernmost area of the cool temperate zone (Oregonian) and is isolated from large human population centers (Monterey and San Francisco to the north, and Santa Barbara, Los Angeles, and San Diego to the south). This combination of nutrient-rich upwelling, cool temperatures, and lower levels of exploitation, coupled with vigorous fishery regulations (CDFG, PFMC), is likely responsible for the persistence of this rockfish assemblage.

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