Abstract.–In 1996 we surveyed the fishes living on and around seven offshore oil platforms in the Santa Barbara Channel area. We conducted belt transects at various depths in the midwater and around the bottoms of each platform using the research submersible *Delta*. The bottom depths of these platforms ranged from 49 to 224 m and the midwater beams ranged from 21 to 196 m. We found that there were several distinct differences in the fish assemblages living in the midwater and bottom habitats around all of the platforms. Both midwater and bottom assemblages were dominated by rockfishes. Platform midwaters were dominated by young-of-the-year (YOY) or juveniles up to two years old. Rockfishes larger than about 18 cm total length were rarely seen in the midwater. The fish assemblages around the bottoms of the platforms were dominated by larger individuals, primarily subadults or adults. Density of all fishes was similar between the bottoms and midwater of any given platform. However, the total biomass was much greater on the bottoms, owing to larger fish living there. There was a consistently greater number of species on the bottom than in the midwater of each platform, likely because of a larger variety of habitat types on the bottom. The fish assemblages also differed among platforms. We found significantly higher densities of young-of-the-year rockfishes around platforms north of Pt. Conception compared with those in the Santa Barbara Channel, probably because the more northerly platforms are located in the more productive waters of the California Current.

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Fish assemblages around seven oil platforms in the Santa Barbara Channel area

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Petroleum production has been a part of the southern California economy since the nineteenth century. The earliest drilling took place on land, but by the early twentieth century a large number of piers lined the coast, tapping into offshore oil deposits. Hazel, the first offshore oil platform, was constructed off Summerland in 1958 (Carlisle et al., 1964). At the peak of oil drilling in the early 1980s, there were 30 platforms operating in southern and central California. Currently, there are 19 platforms in operation in the Santa Barbara Channel and off Point Conception (Fig. 1).

Oil platforms provide considerable habitat for marine organisms. The earliest structures were relatively small (23 m long at the surface), newer platforms, however, are over 100 m long (MBC[1]). Sessile invertebrates (primarily mussels, barnacles and anemones) encrust the pilings and well pipes and cover the bottom to form additional habitat.

Oil platforms have a finite economic lifespan and a number of them are becoming uneconomical to operate. In 1996, four platforms were removed from the Santa Barbara Channel, although not without controversy. There is considerable debate regarding the fate of these structures. Some interest groups would like to leave part or all of them in place, claiming protection of fish habitat; others favor complete removal. Understanding the biological communities on the platforms is crucial to making rational decisions regarding the fates of these structures. In addition, research on these platforms could also address questions regarding the role that artificial reefs might play in coastal fish communities. Ultimately, this research will allow us to contrast the fish assemblages on platforms with those of nearby reefs.

Currently, very little is known about the fish fauna around these platforms. One relatively comprehensive SCUBA survey examined fish populations around two shallow inshore platforms, Hazel and Hilda, during Hazel's first three years and Hilda's first year of operation (Carlisle et al., 1964). Additional cursory surveys were conducted around these two platforms in 1970 and 1975; Bascom et al., 1976; Allen and Moore[2]). With the exception of a short-term study of fishes around platform Hidalgo using a remotely operated vehicle (ROV) (Love et al., 1994) and a survey of recreational fishing around Santa Bar-

[1] MBC (Marine Biology Consultants). 1987. Ecology of oil/gas platforms offshore California. Outer Continental Shelf (OCS) Study Minerals Management Service (MMS) 86-0094.

[2] Allen, M. J., and M. D. Moore. 1976. Fauna of offshore structures. South. Calif. Coast. Water. Res. Proj. Annu. Rep., Long Beach, CA, p. 179–186.

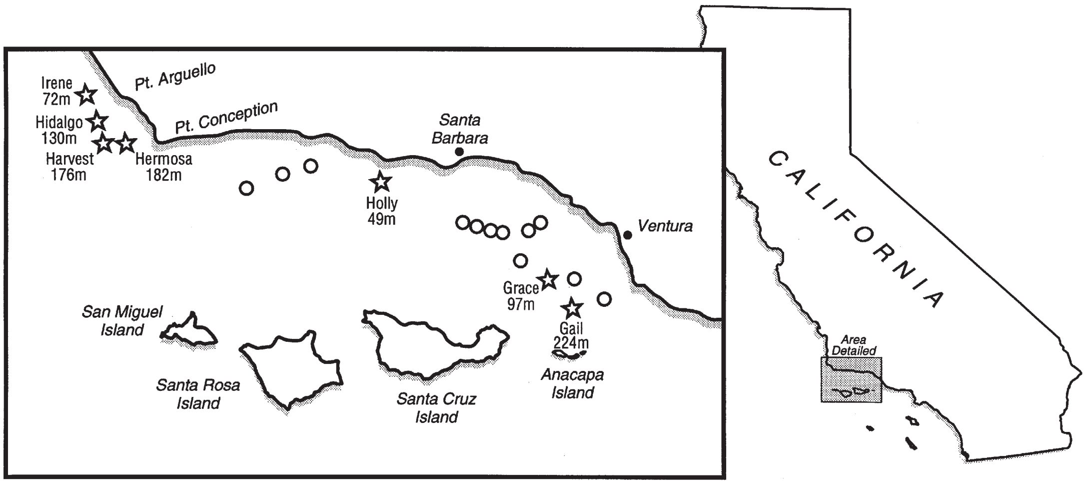

Figure 1

Locations of 19 oil platforms in the Santa Barbara Channel and off Pt. Conception. The seven platforms surveyed in this paper are denoted with stars and labeled.

bara Channel platforms (Love and Westphal, 1990), no other research has been published on the fishes of any California oil platform.

In 1995, we began a survey of the fishes living on and around several platforms in the Santa Barbara Channel area. The surveys were of two types: a scuba-based study in the surface waters (to 30 m) of the platforms and a submersible survey that examined the deeper sections of these structures. However, in 1995, we could not survey any platform bottoms because of inclement weather. This paper discusses the results of the 1996 deep survey.

Materials and methods

Study sites

We surveyed fish assemblages around oil platforms situated in and just northwest of the Santa Barbara Channel. Surveys were conducted around the bottom of six platforms and in the midwater of seven platforms in 1996 (Fig. 1; Table 1). The bottom depth of these platforms ranged from 49 to 224 m. The midwater depths ranged from 21 to 196 m.

The platforms are situated in an area with a complex oceanographic regime. The Santa Barbara Channel is semi-enclosed, faces east-west, and is bordered by the Northern Channel Islands on the south and the mainland on the west. It is embedded within the much larger California-Baja California coastal current regime (Brink and Muench, 1986; Hickey, 1992). Surface waters to the north and west of the Channel are typically cool because the California Current flows equatorward from high latitudes year-round and upwells in the Point Conception and Point Arguello areas during spring and summer. At the same time, the cyclonic circulation pattern in the southern California bight brings warm water flowing poleward along the coast from the east and south of the Santa Barbara Channel. In general, water is cooler and more productive in the area of Points Arguello and Conception than in the Santa Barbara Channel, particularly compared with the more eastern end of the channel.

Surveys

Using the submersible *Delta*, we conducted belt transects around each platform. The submersible maintained a speed of approximately 0.5 knots and stayed approximately 2 m from the structure. Transects were made around the bottom of the platform (from the substrata to approximately 2 m above the substrata) and around each set of cross beams to a minimum depth of about 20 m below the surface. Dives were conducted during daylight hours, between one hour after sunrise and two hours before sunset.

During the transects, researchers made their observations from the central starboard-side viewing port. An externally mounted Hi 8-mm video camera with associated lights filmed the same viewing field as seen by the observers. Observers identified and counted all fishes and verbally recorded those data on the video. All fishes within 2 m of the submarine were counted. Fish lengths were estimated by using

Table 1

Latitude, longitude, bottom and midwater depths, and date of sampling of the seven oil platforms. Platforms listed from northwest to southeast.

Platform	Location	Bottom depth (m)	Midwater depths (m)	Date surveyed
Irene	34°36.62'N, 120°43.77'W	72	29, 50	2 Nov 1996
Hidalgo	34°29.70'N, 120°42.13'W	130	36, 59, 83, 107	28 Oct 1996
Harvest[1]	34°28.15'N, 120°40.85'W	176	38, 61, 84, 113, 141	28 Oct 1996
Hermosa	34°27.33'N, 120°38.78'W	182	63, 84, 106, 131, 156	28 Oct 1996
Holly	34°23.38'N, 120°54.33'W	49	21, 35, 50	29 Oct 1996
Grace	34°10.77'N, 120°28.12'W	97	45, 69, 82	30 Oct 1996
Gail	34°07.50'N, 120°24.02'W	224	71, 95, 115, 141, 166, 196	30 Oct 1996

[1] Midwater survey only.

a pair of lasers mounted on either side of the external video camera. The projected reference spots were 20 cm apart and were visible to the observer. An environmental monitoring system aboard the submarine continuously recorded date and time, depth, and altitude of the vessel above the sea floor. After the dive, these data were overlaid on the original videotape.

Transect videos were reviewed either aboard the research vessel or in the laboratory. For each fish, we recorded 1) its species, to lowest identifiable taxa; 2) its estimated total length to the nearest cm; and 3) the microhabitat it occupied (e.g. pipe, sand, mussel shell mounds, mud). We defined young-of-year fishes (YOYs) from published estimates of size at age. Subadults are defined as juveniles in their second year up to, but not including, maturity.

During the survey at platform Gail, all greenspotted (*Sebastes chlorostictus*) and greenblotched rockfishes (*S. rosenblatti*) were inadvertently identified as greenspotted rockfish. In reviewing the videotape, it was clear that some of the individuals that were recorded as greenspotted rockfish were in fact greenblotched rockfish. In order to correct for this potential misidentification, the total number of both species was adjusted by using the proportion of greenblotched to greenspotted rockfishes (ratio=2.2) observed at platform Gail during the following year's survey (Love, unpub. data). Similar numbers of the two species combined were observed during the two years (1996: n=186,1997: n=209).

Analyses

We estimated length of those transects conducted on the bottom by first determining the submersible speed. This was done by evaluating a ten-second segment for every one minute of transect. The video was manually forwarded frame by frame and the number of 20-cm segments passing the lasers in a ten-second section was counted. The number of 20 cm segments per 10 seconds was divided by 2 to obtain speed in centimeters per second. All subsamples were then averaged to obtain mean transect speed (cm/s). The mean speed was then multiplied by the number of seconds in the transect and divided by 100 to obtain transect length in meters. The length was then multiplied by 2 m (the transect width) to obtain transect area, allowing us to present both densities (fish/m^2) and biomass (kg/m^2). Biomass was estimated for all species by using length-weight relationships derived empirically or obtained from the literature. No biomass estimates were made for species that could not be identified to the family level.

In the midwater, we could not see the lasers pass before fixed points; therefore, we could not directly measure the length of the midwater transects. Without knowledge of the length of the midwater transects, we could not calculate density or biomass per unit area as done on the bottom transects. However, we were able to estimate the length of midwater transects for use in estimating both fish density and biomass. We did this by converting density and biomass on the midwater transects from number and kilogram per minute to number and kilogram per m^2, respectively. This conversion was accomplished by calculating the equation for the regression of density in terms of number per m^2 on density in terms of number per minute for the bottom transects where both values were known (Fig. 2A). The same relationship was calculated for biomass (Fig. 2B). Given the regression equations, density per m^2 and biomass per m^2 could be calculated from number per minute and kilograms per minute. We called these calculations "estimated density" (number/m^2) and "estimated biomass "(kg/m^2).

This method of estimating transect length and hence fish density and biomass relies on the assumption that the submersible travels at the same speed in both habitats. Although we did not have data on submersible speed, every attempt was made to maintain the submersible at the same speed on all transects during the survey. However, because of debris on the bottom and water currents in the midwater, if there were differences in speed, the submersible was likely to travel slightly faster in the midwater habitats than on the bottoms. In this case, the submersible would cover more area per unit time and the true fish density in the midwater may actually be slightly lower than our estimated density. We consider the potential bias introduced by differences in submersible speed to be minor in relation to the magnitude of the observed differences in fish densities between the midwater and bottom transects (see "Results" section).

We calculated both species richness (number of species) and species diversity. We used the Shannon-Weiner diversity index (H′) for all species diversity comparisons (Shannon and Weaver, 1949). We also calculated a percent similarity index (PSI) that quantifies how similar two assemblages are in terms of their species composition (i.e. the relative abundance of those species). The index ranges from 0 (no species shared) to 100% (identical composition and relative abundances). The formula for PSI is

$$PSI = \left\{ \sum \min(p_{xi}, p_{yi}) \right\} \times 100,$$

where, p_{xi} and p_{yi} are the proportion of the ith species in habitat x and habitat y. PSI was calculated for each pair of platform bottom assemblages.

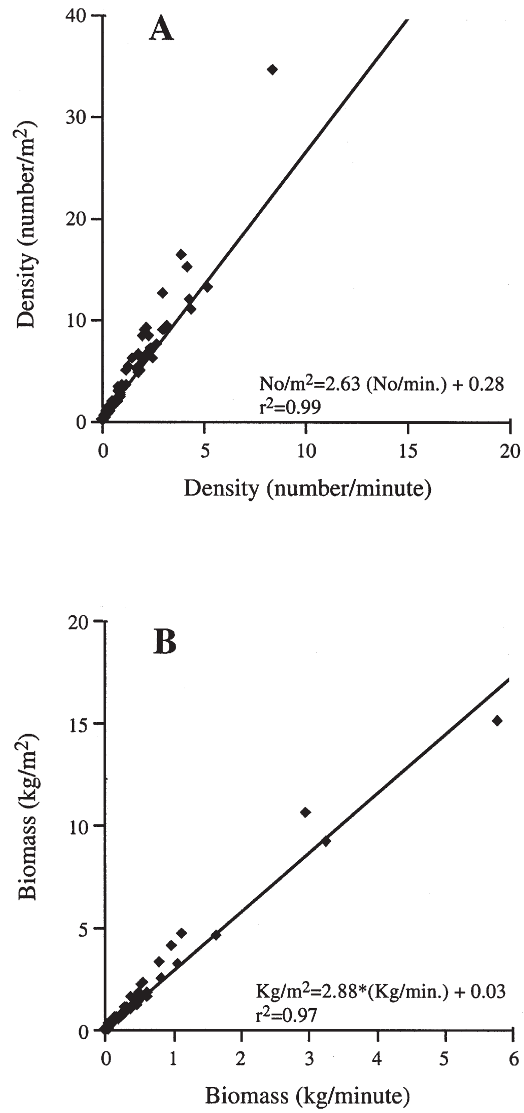

Figure 2

Regressions of (**A**) density in terms of number per minute on density in terms of number per m^2 and (**B**) biomass in terms of kilograms per minute on biomass in terms of kilogram per m^2 for bottom transects on all platforms. The regression equations were used to calculate density and biomass from number and kilogram per minute into number and kilogram per m^2 on the midwater transects. See "Methods" section for explanation of the conversion.

Results

Bottom versus midwater transects

We found that there were several distinct differences in the fish assemblages living in the midwater and bottom habitats around all of the platforms. We calculated percent similarity indices (PSI) between the bottom and midwater assemblages for each platform. These PSIs ranged from 1% to 34% (mean 13.3%). Although both midwater and bottom assemblages were dominated by rockfishes, platform midwaters were dominated by young-of-the-year (YOY) or slightly older juveniles (<10 cm). Rockfishes larger than about 20 cm were rarely seen in the midwater (Fig. 3). The fish assemblages around the bottoms of the platforms were dominated by subadults or adults (11–20 cm) and occasionally harbored very large individuals (up to 48 cm) (Fig. 3).

Average density per platform of all fishes combined was not significantly different on the bottom versus the midwater transects (bottom mean density

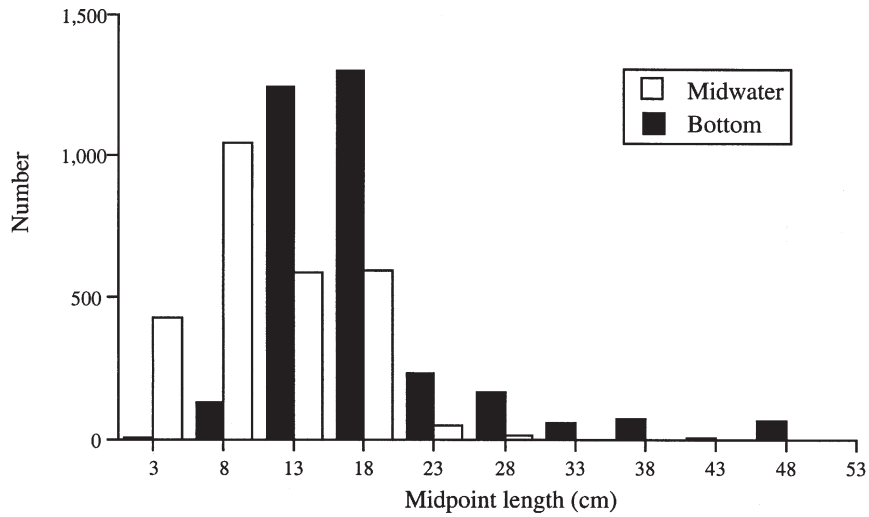

Figure 3
Length-frequency distribution for all rockfish species and all platforms combined. Midpoint length is the midpoint of 5-cm length bins.

(SE)=141.4 fish/100m^2 (49.0), n=6 platforms; midwater mean density (SE)=115.8 fish/100m^2 (32.2), n=7 platforms; t-test, t=0.44, P=0.66). On three platforms, density was higher on the bottom than in midwater and on three other platforms the reverse was true. However, there was a much larger and consistent difference in biomass between bottom and midwater transects. For most families and all platforms, total biomass was higher on bottom than midwater transects (Table 2). Average biomass per platform (SE) for all species combined was 19.06 kg/m^2 (2.5) on the bottom and 6.47 kg/m^2 (2.3) in the midwater (t-test, t=3.75, P=0.003). This consistent difference was due to the lack of adult fishes in the midwater.

Fewer species lived on the midwater structures than on the bottom. Species richness for all rigs combined was 24 in the midwater versus 40 on the bottom. Average species richness per platform was significantly higher on the bottom than in the midwater (bottom mean richness (SE)=14.7 species (1.5); midwater mean richness (SE)=8.2 species (1.4); t-test, t=3.26, P=0.008). Average species diversity (H′) across platforms was identical between bottoms and midwaters (bottom mean H′ (SE)=1.2 (0.2); midwater mean H′ (SE)=1.2 (0.2); t-test, t=0.09, P=0.99). We present the remaining results for bottom and midwater habitats separately.

Bottom habitat

All platforms We identified at least 40 fish species around the platform bottoms (Table 2). Twenty-seven species were rockfishes; they were by far the most speciose group. Rockfishes made up 92.7% of all fishes on the bottom (Table 3) and represented 96.7% of the biomass (Table 2).

Halfbanded, greenspotted, copper, vermilion, widow, and flag rockfishes, and bocaccio were among the most commonly observed rockfishes (Table 3). Our observations indicated that vermilion rockfish, flag rockfish, and bocaccio of all sizes were always closely associated with the platform structure (Fig. 4A). Larger copper and greenspotted rockfishes also were more likely to be very close to the platform. In particular, flag rockfish were most often seen tucked well into the space formed by the bottom of the lowest crossbeam and the bottom (Fig. 4B). Flag and greenspotted rockfishes were almost always seen on or very close to the bottom. Halfbanded rockfish, as well as smaller greenspotted and copper rockfishes, were less bound to the platform and were often seen well away from the structure. Juvenile greenspotted and copper rockfishes were usually nestled within or just above the mussel, shell-covered substrata. Vermilion rockfish, and to a certain extent copper rockfish and bocaccio, would occasionally ascend up platform legs as much as 5 m.

Flag rockfish, as well as larger bocaccio and vermilion rockfish, often were solitary or found in small groups. The exception occurred at platform Gail, where one school of bocaccio comprised at least 100 individuals. Smaller adult or subadult vermilion and copper rockfishes tended to aggregate, often in mixed groups containing 50 or more individuals. The few

Table 2

Biomasses of fishes observed, by species, around all platforms in October–November of 1996. Biomasses are given for bottoms of platforms and midwater, with percent of totals for those parts of the platforms. Biomass is kilograms/m^2. Family totals are given in boldface. YOY means "young-of-year."

			Bottom		Midwater	
Family	Common name	Scientific name	Biomass	% Total	Biomass	% Total
Scorpaenidae	Rockfishes		**96.83**	**84.66**	**38.81**	**85.90**
	Kelp rockfish	*Sebastes atrovirens*	0	0	0.34	0.75
	Brown rockfish	*S. auriculatus*	0.82	0.71	0	0
	Gopher rockfish	*S. carnatus*	0.01	<0.1	0.23	0.51
	Copper rockfish	*S. caurinus*	12.12	10.59	0.47	1.04
	Greenspotted rockfish	*S. chlorostictus*	8.80	10.94	0.56	1.23
	Starry rockfish	*S. constellatus*	0.02	<0.1	0	0
	Darkblotched rockfish	*S. crameri*	0.07	<0.1	0	0
	Calico rockfish	*S. dalli*	1.40	1.22	0.08	0.18
	Greenstriped rockfish	*S. elongatus*	0.32	0.28	0	0
	Swordspine rockfish	*S. ensifer*	0.03	<0.1	0.08	0.17
	Widow rockfish	*S. entomelas*	1.86	1.62	24.08	53.15
	Yellowtail rockfish	*S. flavidus*	0.08	<0.1	0	0
	Chilipepper	*S. goodei*	0	0	0.82	1.82
	Squarespot rockfish	*S. hopkinsi*	0.46	0.40	0.51	1.12
	Vermilion rockfish	*S. miniatus*	20.84	18.22	0	0
	Blue rockfish	*S. mystinus*	0.74	0.65	0.29	0.64
	Bocaccio rockfish	*S. paucispinis*	14.35	12.55	3.68	8.12
	Canary rockfish	*S. pinniger*	1.18	1.03	0	0
	Rosy rockfish	*S. rosaceus*	0.46	0.40	0.07	0.15
	Greenblotched rockfish	*S. rosenblatti*	3.89	0.15	0	0
	Yelloweye rockfish	*S. ruberrimus*	0.06	<0.1	0	0
	Flag rockfish	*S. rubrivinctus*	1.44	1.26	0.55	1.21
	Bank rockfish	*S. rufus*	0.29	0.25	0	0
	Halfbanded rockfish	*S. semicinctus*	26.21	22.91	0.04	<0.1
	Olive rockfish	*S. serranoides*	0.03	<0.1	0	0
	Treefish	*S. serriceps*	0.19	0.17	0.04	<0.1
	Pygmy rockfish	*S. wilsoni*	0.04	<0.1	0	0
	Sharpchin rockfish	*S. zacentrus*	0.10	<0.1	0.04	<0.1
	Shortspine thornyhead	*Sebastolobus alascanus*	<0.1	<0.1	0	0
	Sebastomus group[1]		0.31	0.27	0.37	0.82
	Rockfish YOY	*Sebastes* spp.	0.72	0.63	6.56	14.47
Hexagrammidae	Greenlings		**12.88**	**11.25**	**2.72**	**6.01**
	Kelp greenling	*Hexagrammos decagrammus*	0	0	<0.1	<0.1
	Lingcod	*Ophiodon elongatus*	12.35	10.80	0	0
	Painted greenling	*Oxylebius pictus*	0.51	0.44	2.72	6.01
	Shortspine combfish	*Zaniolepis frenata*	0.01	<0.1	0	0
	Combfish sp.	*Zaniolepis* sp.	0.01	<0.1	0	0
Pomacentridae	Damselfishes		**0**	**0**	**0.54**	**1.20**
	Blacksmith	*Chromis punctipinnis*	0	0	0.54	1.20
Embiotocidae	Seaperches		**4.57**	**3.99**	**3.02**	**6.65**
	Pile perch	*Damalichthys vacca*	3.71	3.24	1.18	2.60
	Sharpnose surfperch	*Phanerodon atripes*	0.49	0.43	1.84	4.05
	Unident. sea perches		0.20	0.17	0	0
	Pink surfperch	*Zalembius rosaceus*	0.17	0.15	0	0
Gadidae	Cods		**0**	**0**	**0.20**	**0.44**
	Pacific hake	*Merluccius productus*	0	0	0.20	0.44

continued

Table 2 (continued)

Family	Common name	Scientific name	Bottom Biomass	Bottom % Total	Midwater Biomass	Midwater % Total
Cottidae	Sculpins		**0**	**0**	**0.03**	**0.07**
	Unidentifed sculpin		0	0	0.03	0.07
Bathymasteridae	Ronquils		**0.03**	**0.03**	**0**	**0**
	Unidentified ronquil		0.03	0.03	0	0
Agonidae	Poachers		**0.01**	**0.01**	**0**	**0**
	Unidentified poacher		0.01	0.01	0	0
Flatfish	Flatfish		**0.06**	**0.06**	**0**	**0**
	Sanddabs	*Citharichthys* sp.	0.01	0.01	0	0
	Unident. flatfish		0.05	0.05	0	0

[1] *Sebastomus* group may include greenblotched, greenspotted, pinkrose, rosethorn, rosy, starry, or swordspine rockfishes.

canary rockfish we noted tended to associate with vermilion rockfish. Halfbanded rockfish were almost always seen in schools, sometimes containing hundreds of individuals (Fig. 4C).

In the greenling family, Hexagrammidae, both lingcod and painted greenling, were common; together they represented about 5.3% of all fishes seen. Larger lingcod were solitary and tended to remain near the bottom of the platform (Fig. 4D). They were usually seen sitting motionless on the bottom or slowly swimming just above it. Juvenile lingcod rarely came within a meter of the platform, they were usually seen lying among the mussel shells away from the structure (Fig. 4E). Painted greenling sat on the crossbeams, along the pilings and on the mussel shells, always found as solitary individuals.

Among platform comparisons The bottom fish assemblages around each platform were all different (Tables 4 and 5). Pairwise percent similarity indices (PSI) for each combination of platforms ranged from 0% (platforms Gail and Holly) to 70.1% (platforms Grace and Hidalgo) (Table 4). The average percent similarity was 20.0%. Despite a low average similarity value, rockfishes, as measured by number, density and biomass, dominated the bottom assemblages around all of the platforms (Table 5). Lingcod were the only nonrockfish species among the top four most common species at any platform.

Around platform Irene, subadult and adult copper and vermilion rockfishes were most abundant. Irene also was unique among the platforms in having large numbers of juvenile lingcod. Halfbanded rockfish, painted greenling, and pile perch were also commonly seen. Halfbanded and greenspotted rockfish were most common at platform Hidalgo, along with flag rockfish, lingcod, bocaccio, and vermilion rockfish. Similar to that around Hidalgo (PSI=60%), the bottom fish assemblage around platform Hermosa was characterized by greenspotted and halfbanded rockfish, with lesser numbers of flag rockfish and lingcod (Table 4). Vermilion, calico, widow, copper, and squarespot rockfishes were most often seen at Holly, along with lesser numbers of halfbanded rockfish, pile perch, rosy rockfish, and painted greenling. Very large schools of halfbanded rockfish were observed at Grace, along with some flag, greenspotted, and vermilion rockfishes. The dominance of halfbanded rockfish at Hidalgo and Grace resulted in the highest PSI among platform pairs (70.1%). Members of the rockfish subgenus *Sebastomus*, primarily greenblotched and greenspotted rockfishes and bocaccio were most abundant at platform Gail. Gail had by far the highest number and density of bocaccio of any of the platforms.

We observed between 8 and 21 species around the bottom of the platforms (Fig. 5A). We found no significant relationship between species number or diversity (H′) and platform bottom depth (linear regression: species richness vs. depth, r^2=0.58, P=0.07, diversity (H′) vs. depth, r^2=0.19, P=0.37, Fig. 5A). Although neither relationship was significant, there was a tendency for platforms in shallower water to have both higher species richness and species diversity. Location of the platforms within the Santa Barbara Channel and Santa Maria Basin also did not explain the differences among platforms. There was no correlation between northwest to southeast orientation and either species richness or diversity (Spearman rank correlation: species richness vs. orientation, r_s=–0.26, P=0.6, diversity (H′) vs. orientation, r_s=–0.6, P=0.2). In fact, the two most

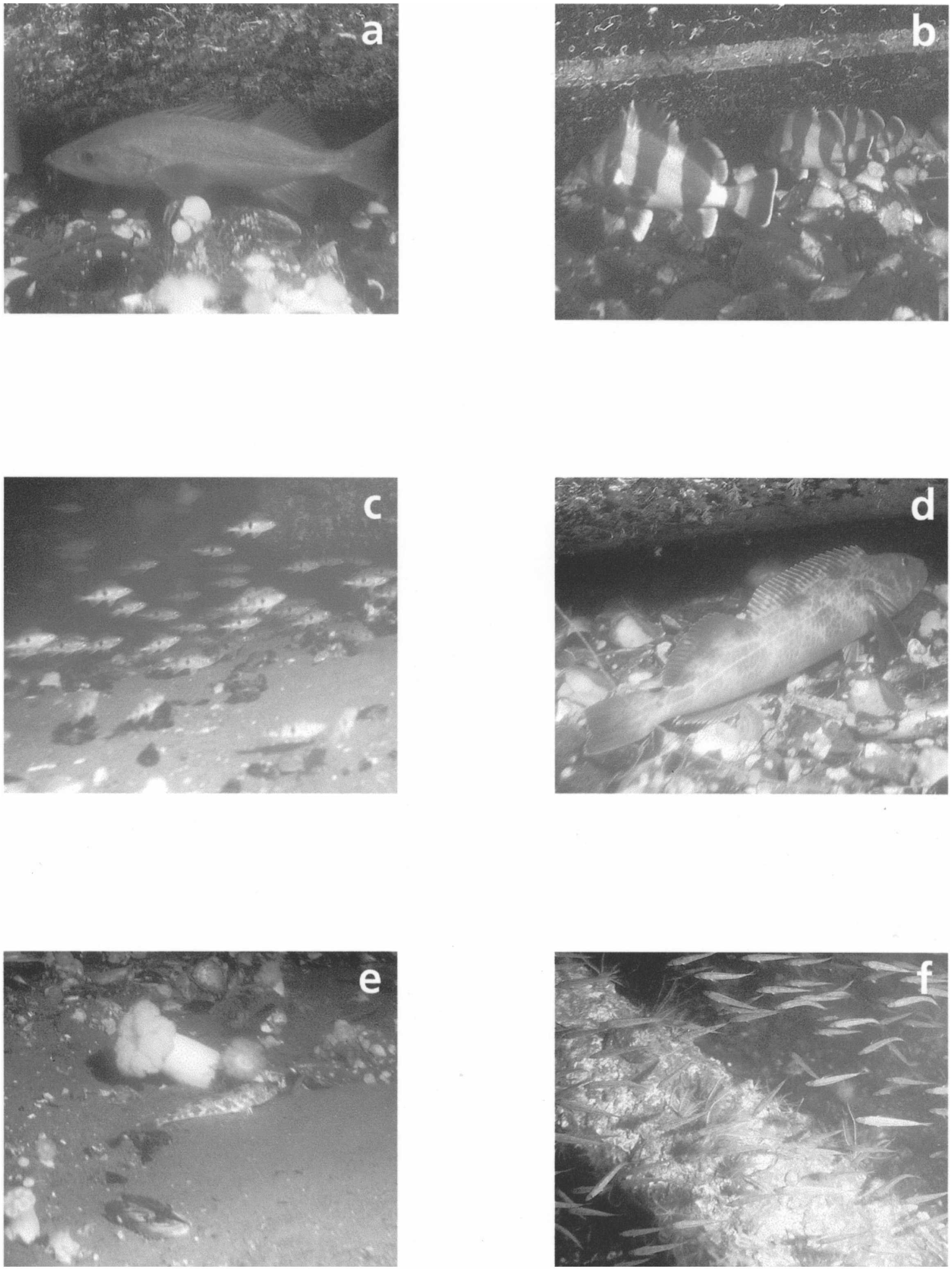

Figure 4

Fishes typical of offshore oil platforms in the Santa Barbara Channel and Santa Maria Basin: (**A**) bocaccio, *Sebastes paucispinis*, (**B**) flag rockfish, *S. rubrivinctus*, (**C**) halfbanded rockfish, *S. semicinctus*, (**D**) adult lingcod, *Ophiodon elongatus*, (**E**) juvenile lingcod, A–E all on bottom transects, and (**F**) young-of-the-year rockfish, *Sebastes* spp,. on midwater crossbeam.

Table 3

Numbers of fishes observed, by species, around all platforms in October–November of 1996. Numbers are given for bottoms of platforms and midwater, with percent of totals for those parts of the platforms. Family totals are given in boldface. YOY means "young-of-year."

			Bottom		Midwater	
Family	Common name	Scientific name	Biomass	% Total	Biomass	% Total
Scorpaenidae	Rockfishes		**4212**	**92.7**	**2753**	**91.4**
	Kelp rockfish	*Sebastes atrovirens*	0	0	1	<0.1
	Brown rockfish	*S. auriculatus*	7	0.2	0	0
	Gopher rockfish	*S. carnatus*	2	<0.1	4	0.1
	Copper rockfish	*S. caurinus*	347	7.6	11	0.4
	Greenspotted rockfish	*S. chlorostictus*	365	8.0	18	0.6
	Starry rockfish	*S. constellatus*	1	<0.1	0	0
	Darkblotched rockfish	*S. crameri*	1	<0.1	0	0
	Calico rockfish	*S. dalli*	68	1.5	2	<0.1
	Greenstriped rockfish	*S. elongatus*	12	0.3	0	0
	Swordspine rockfish	*S. ensifer*	2	<0.1	2	<0.1
	Widow rockfish	*S. entomelas*	115	2.5	1054	35.0
	Yellowtail rockfish	*S. flavidus*	1	<0.1	0	0
	Chilipepper	*S. goodei*	0	0.00	68	2.3
	Squarespot rockfish	*S. hopkinsi*	47	1.0	22	0.7
	Vermilion rockfish	*S. miniatus*	307	6.8	0	0
	Blue rockfish	*S. mystinus*	7	0.2	6	0.2
	Bocaccio rockfish	*S. paucispinis*	85	1.9	264	8.8
	Canary rockfish	*S. pinniger*	10	0.2	0	0
	Rosy rockfish	*S. rosaceus*	31	0.7	1	<0.1
	Greenblotched rockfish	*S. rosenblatti*	129	2.8	0	0
	Yelloweye rockfish	*S. ruberrimus*	2	<0.1	0	0
	Flag rockfish	*S. rubrivinctus*	113	2.5	15	0.5
	Bank rockfish	*S. rufus*	2	<0.1	0	0
	Halfbanded rockfish	*S. semicinctus*	2491	54.8	1	<0.1
	Olive rockfish	*S. serranoides*	1	<0.1	0	0
	Treefish	*S. serriceps*	5	0.1	1	<0.1
	Pygmy rockfish	*S. wilsoni*	4	<0.1	0	0
	Sharpchin rockfish	*S. zacentrus*	11	0.2	1	<0.1
	Shortspine thornyhead	*Sebastolobus alascanus*	1	<0.1	0	0
	Sebastomus group[1]		19	0.4	13	0.4
	Rockfish YOY	*Sebastes* spp.	26	0.6	1269	42.1
Hexagrammidae	Greenlings		**244**	**5.4**	**187**	**6.2**
	Kelp greenling	*Hexagrammos decagrammus*	0	0	1	<0.1
	Lingcod	*Ophiodon elongatus*	193	4.3	0	0
	Painted greenling	*Oxylebius pictus*	46	1.0	186	6.2
	Shortspine combfish	*Zaniolepis frenata*	2	<0.1	0	0
	Combfish sp.	*Zaniolepis* sp.	3	<0.1	0	0
Pomacentridae	Damselfishes		**0**	**0**	**12**	**0.4**
	Blacksmith	*Chromis punctipinnis*	0	0	12	0.4
Embiotocidae	Seaperches		**65**	**1.4**	**20**	**0.7**
	Pile perch	*Damalichthys vacca*	46	1.0	6	0.2
	Sharpnose surfperch	*Phanerodon atripes*	9	0.2	14	0.5
	Unident. sea perches		1	<0.1	0	0
	Pink surfperch	*Zalembius rosaceus*	9	0.2	0	0
Gadidae	Cods		**2**	**<0.1**	**18**	**0.6**
	Pacific hake	*Merluccius productus*	2	<0.1	18	0.6

continued

Table 3 (continued)

Family	Common name	Scientific name	Bottom Biomass	Bottom % Total	Midwater Biomass	Midwater % Total
Cottidae	Sculpins		**0**	**0**	**1**	**<0.1**
	Unidentifed sculpin		0	0	1	<0.1
Bathymasteridae	Ronquils		**2**	**<0.1**	**0**	**0**
	Unidentified ronquil		2	<0.1	0	0
Agonidae	Poachers		**2**	**<0.1**	**0**	**0**
	Unidentified poacher		2	<0.1	0	0
Flatfish	Flatfish		**13**	**0.3**	**0**	**0**
	Sanddabs	*Citharichthys* sp.	1	<0.1	0	0
	Unident. flatfish		12	0.3	0	0

[1] *Sebastomus* group may include greenblotched, greenspotted, pinkrose, rosethorn, rosy, starry, or swordspine rockfishes.

similar assemblages were on platforms near the geographic extremes (Hidalgo and Grace).

Density and biomass of all species combined also varied among rigs but in a pattern different from species richness and diversity (Fig. 5B). However, similar to richness and diversity, density and biomass differences could not be explained by bottom depth or by geography (linear regression: density vs. depth, r^2=0.22, P=0.35, biomass vs. depth, r^2=0.06, P=0.64; Spearman rank correlation: density vs. orientation, r_s=-0.31, P=0.54, biomass vs. orientation, r_s=-0.37, P=0.46).

Although bottom depth did not explain the patterns of abundance of all species combined, the abundance patterns of individual species did relate more strongly to bottom depth. Among the more commonly observed species, eight showed depth-related patterns of abundance (Fig. 6). Copper and vermilion rockfishes, lingcod, and painted greenling were most dense around the bottoms of some of the shallower platforms (especially platform Irene). Halfbanded and flag rockfishes were most dense on the bottoms of the middepth structures and bocaccio and greenspotted rockfish were most common at the bottom of the deeper platforms.

Table 4

Percent similarity indices for each pair of platforms for the bottom only in 1996. No bottom surveys were done on platform Harvest.

Platform	Gail	Grace	Holly	Hermosa	Hidalgo
Grace	2.3				
Holly	0	8.5			
Hermosa	24.7	34.5	8.5		
Hidalgo	17.9	70.1	11.8	60.0	
Irene	1.4	4.7	41.5	3.8	10.0

Midwater habitat

All platforms Rockfishes also dominated the midwater portions of the platforms, but were primarily YOYs and slightly older juveniles. Rockfishes represented 91.4% of the individuals (Table 3) and 85.9% of the biomass (Table 2) in the midwater. Although it was difficult to identify many of the smaller individuals, widow rockfish were by far the most common species, representing 35.0% of all fishes seen. It is likely that many of the small, unidentifiable YOYs also were widow rockfish. YOY bocaccio also were fairly abundant around some of the platforms and occasionally schooled with widow rockfish. Both species formed relatively tight, polarized schools, loosely associated with the pilings and crossbeams (Fig. 4F). When disturbed, the schools immediately swam inward underneath the platform structure. We also saw small numbers of what we tentatively identified as YOYs of the complex of kelp, copper, gopher and black-and-yellow rockfishes (*S. chrysomelas*). These were found in smaller, much less coherent aggregations and were more likely to move in closer to the substrata when disturbed.

Painted greenling, primarily small individuals, were the most commonly seen nonrockfish species. We often saw solitary individuals resting on the crossbeams. Other species occasionally seen near or

Table 5

Number, densities, and biomasses of fishes observed around the bottoms of six oil platforms off central and southern California. Platforms are listed geographically, from northwest to southeast. Species are ranked by number observed. YOY means "young-of-year." We computed minimum number of species by assuming that each unidentified taxa (flatfish, poacher, ronquil and seaperch) represented one species.

Platform	Species	Number	Density (fish/100m^2)	Biomass (kg/m^2)
Irene	Copper rockfish	297	55.99	10.01
	Vermilion rockfish	198	37.33	11.81
	Lingcod	152	28.65	1.23
	Halfbanded rockfish	25	4.71	0.16
	Painted greenling	20	3.77	0.24
	Pile perch	20	3.77	0.83
	Rosy rockfish	4	0.75	0.02
	Sebastomus group[1]	2	0.38	0.01
	Brown rockfish	2	0.38	0.05
	Bocaccio	1	0.19	0.24
	Flag rockfish	1	0.19	0.01
	Gopher rockfish	1	0.19	0.00
	Rockfish YOY	1	0.19	0.01
	Widow rockfish	1	0.19	0.02
	Yellowtail rockfish	1	0.19	0.08
	Total	**726**	**136.86**	**24.73**
	Minimum number of species	13		
Hidalgo	Halfbanded rockfish	552	94.62	9.35
	Greenspotted rockfish	109	18.68	3.48
	Flag rockfish	58	9.94	1.00
	Lingcod	29	4.97	6.52
	Bocaccio	17	2.91	2.10
	Vermilion rockfish	13	2.23	2.83
	Rosy rockfish	10	1.71	0.27
	Sharpchin rockfish	10	1.71	0.09
	Canary rockfish	7	1.20	1.03
	Greenstriped rockfish	7	1.20	0.11
	Painted greenling	5	0.86	0.07
	Pygmy rockfish	4	0.69	0.04
	Widow rockfish	4	0.69	0.64
	Squarespot rockfish	3	0.51	0.03
	Rockfish YOY	2	0.34	0.06
	Shortspine combfish	2	0.34	0.01
	Yelloweye rockfish	2	0.34	0.06
	Sebastomus group [1]	1	0.17	0.01
	Bank rockfish	1	0.17	0.02
	Unidentified poacher	1	0.17	0.01
	Total	**837**	**143.47**	**27.73**
	Minimum number of species	18		
Hermosa	Greenspotted rockfish	179	25.72	3.24
	Halfbanded rockfish	98	14.08	0.71
	Flag rockfish	16	2.30	0.20
	Lingcod	7	1.01	2.60
	Rockfish YOY	5	0.72	0.10
	Copper rockfish	4	0.57	0.03
	Pacific hake	2	0.29	0.00
	Sebastomus group[1]	1	0.14	0.04
	Greenblotched rockfish	1	0.14	0.15

continued

Table 5 (continued)

Platform	Species	Number	Density (fish/100m²)	Biomass (kg/m²)
Hermosa continued	Greenstriped rockfish	1	0.14	0.01
	Unidentified poacher	1	0.14	0.00
	Sharpchin rockfish	1	0.14	0.01
	Starry rockfish	1	0.14	0.02
	Widow rockfish	1	0.14	0.02
	Total	**318**	**45.70**	**7.13**
	Minimum number of species	12		
Holly	Vermilion rockfish	87	21.98	5.87
	Calico rockfish	68	17.18	1.40
	Widow rockfish	47	11.88	1.14
	Copper rockfish	45	11.37	2.05
	Squarespot rockfish	43	10.87	0.41
	Halfbanded rockfish	29	7.33	0.12
	Pile perch	26	6.57	2.88
	Rosy rockfish	16	4.04	0.11
	Painted greenling	15	3.79	0.17
	Sharpnose surfperch	9	2.27	0.49
	Blue rockfish	7	1.77	0.74
	Pink surfperch	7	1.77	0.15
	Unident. flatfish	6	1.52	0.02
	Brown rockfish	5	1.26	0.77
	Sebastomus group [1]	4	1.01	0.08
	Canary rockfish	3	0.76	0.15
	Rockfish YOY	3	0.76	0.15
	Treefish	2	0.51	0.10
	Ronquils	1	0.25	0.00
	Unident. sea perches	1	0.25	0.20
	Combfish sp.	1	0.25	0.00
	Gopher rockfish	1	0.25	0.01
	Olive rockfish	1	0.25	0.03
	Shortspine thornyhead	1	0.25	0.00
	Unidentified fish	1	0.25	•
	Total	**429**	**108.40**	**17.04**
	Minimum number of species	21		
Grace	Halfbanded rockfish	1787	351.16	15.87
	Flag rockfish	30	5.90	0.18
	Greenspotted rockfish	18	3.54	0.38
	Vermilion rockfish	9	1.77	0.33
	Rockfish YOY	7	1.38	0.05
	Unident. flatfish	6	1.18	0.03
	Painted greenling	6	1.18	0.03
	Widow rockfish	5	0.98	0.05
	Treefish	3	0.59	0.09
	Combfish sp.	2	0.39	0.01
	Lingcod	2	0.39	0.03
	Pink surfperch	2	0.39	0.01
	Ronquils	1	0.20	0.03
	Copper rockfish	1	0.20	0.03
	Greenblotched rockfish	1	0.20	0.02
	Rosy rockfish	1	0.20	0.06
	Sanddabs	1	0.20	0.01
	Squarespot rockfish	1	0.20	0.01

continued

Table 5 (continued)

Platform	Species	Number	Density (fish/100m²)	Biomass (kg/m²)
Grace	Unidentified fish	1	0.20	•
continued	Total	**1884**	**370.22**	**17.21**
	Minimum number of species	16		
Gail	Greenblotched rockfish	127	19.8	3.71
	Bocaccio	67	10.46	12.01
	Greenspotted rockfish	59	9.2	1.70
	Sebastomus group †	10	1.9	0.18
	Rockfish YOY	5	0.78	0.35
	Greenstriped rockfish	4	0.62	0.20
	Lingcod	3	0.47	1.96
	Flag rockfish	2	0.31	0.03
	Swordspine rockfish	2	0.31	0.03
	Bank rockfish	1	0.16	0.27
	Darkblotched rockfish	1	0.16	0.07
	Total	**281**	**44.17**	**20.51**
	Minimum number of species	9		

[1] *Sebastomus* group may include greenblotched, greenspotted, pinkrose, rosethorn, rosy, starry, or swordspine rockfishes.

on midwater structure included juvenile greenspotted and flag rockfishes, as well as sharpnose seaperch, pile perch, and blacksmith.

Among platform comparisons The midwater assemblages also differed among rigs, although the variability was less than among the bottom assemblages. Species richness ranged from 6 to 11 species per platform (Fig. 7A). Species diversity also showed less variability among platform midwaters than platform bottoms (midwater H′ range: 0.7 to 1.8, Fig. 7A).

The midwater around platform Irene was dominated by widow rockfishes (primarily YOYs, but also one-year-old fishes), unidentified YOY rockfishes (probably primarily widow rockfish) and YOY bocaccio. Almost no other fishes were noted (Table 6). The species composition at platforms Hidalgo and Harvest was similar to that at platfrom Irene, although painted greenling were also occasionally seen. Far fewer fishes were noted at platform Hermosa, although the species composition was similar, with the addition of small numbers of Pacific hake. Fewer fishes were seen at platform Holly. Here, YOY rockfish (probably widow rockfish), painted greenling, sharpnose seaperch and squarespot rockfish were the most common species. Smaller numbers of juvenile widow rockfish, YOY rockfish, and juvenile chilipepper characterized platform Grace. We saw fewest fishes in the midwaters around platform Gail where YOY rockfish (again probably widow rockfish) were the most common.

In general, the platforms at the western end of the Santa Barbara Channel harbored a higher density of fishes in the midwater than did those towards the east (Fig. 7B). There was a significant relationship between density and northwest-southeast rank (Spearmans r_s=0.89, P=0.006). This pattern was due to higher density of YOY rockfishes, especially widow rockfish and bocaccio, at platforms Irene and Hidalgo. YOY rockfishes were abundant only at Irene and Hidalgo, they were much less common at the platforms farther east. There was not a significant relationship between biomass and northwest-southeast rank (Spearmans r_s=0.64, P=0.11).

Length-frequency comparisons

Relatively few species were abundant in both the midwater and bottom assemblages. For those species that were found in both environments, such as copper, flag, and greenspotted rockfishes, there was a tendency for juveniles to be found in the midwater and older individuals on the bottom. Bocaccio were the extreme example, with smaller juveniles occurring only in midwater and larger individuals only on the bottom (Fig. 8). The painted greenling was one of the few species that occurred in virtually all size classes in both the midwater and on the bottom (Fig. 8).

There were considerable differences in the size frequencies of the major species around the platforms (Fig. 8). Some species, such as copper rockfish and vermilion rockfish, were found primarily as juveniles and subadults. At the extreme, we did not identify any mature widow rockfish. Numerous other species (i.e. painted greenling, bocaccio, greenspotted rockfish,

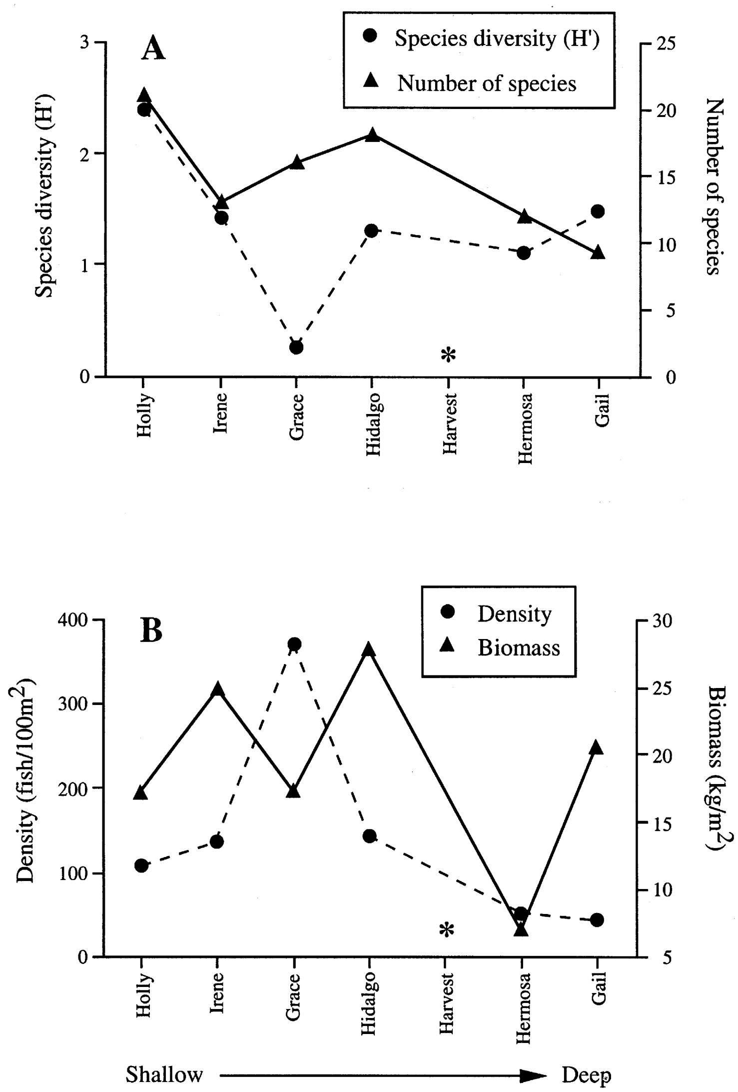

Figure 5

(**A**) Species richness (number of species) and species diversity (Shannon-Weaver diversity index, H′) and (**B**) density (fish/100 m²) and biomass (kilograms/m²) on the bottoms of seven platforms in the Santa Barbara Channel area. Platforms are ordered by bottom depth from shallow (Holly) to deep (Gail). * = no bottom transects done.

flag rockfish, and halfbanded rockfish) were found over a wide size range, encompassing most life stages. Although a wide size range of lingcod was observed, it is noteworthy that most of the small fish were found around platform Irene; relatively few of these young individuals inhabited the other platforms.

Discussion

Although we found large variability in many of the attributes of the fish assemblages living around these seven oil platforms, several consistent patterns were evident. Around all of these structures, the midwater fish assemblage was quite different from that inhabiting the platform bottoms. Juvenile rockfishes were by far the dominant group occupying the midwater. Although the density of all species combined was similar between the bottom and midwater of any given platform, the biomass was much greater on the bottom, owing to larger fish living around the bottom. In addition, there was a consistently greater number of species on the bottom than in the midwater around each platform. The bottom of the

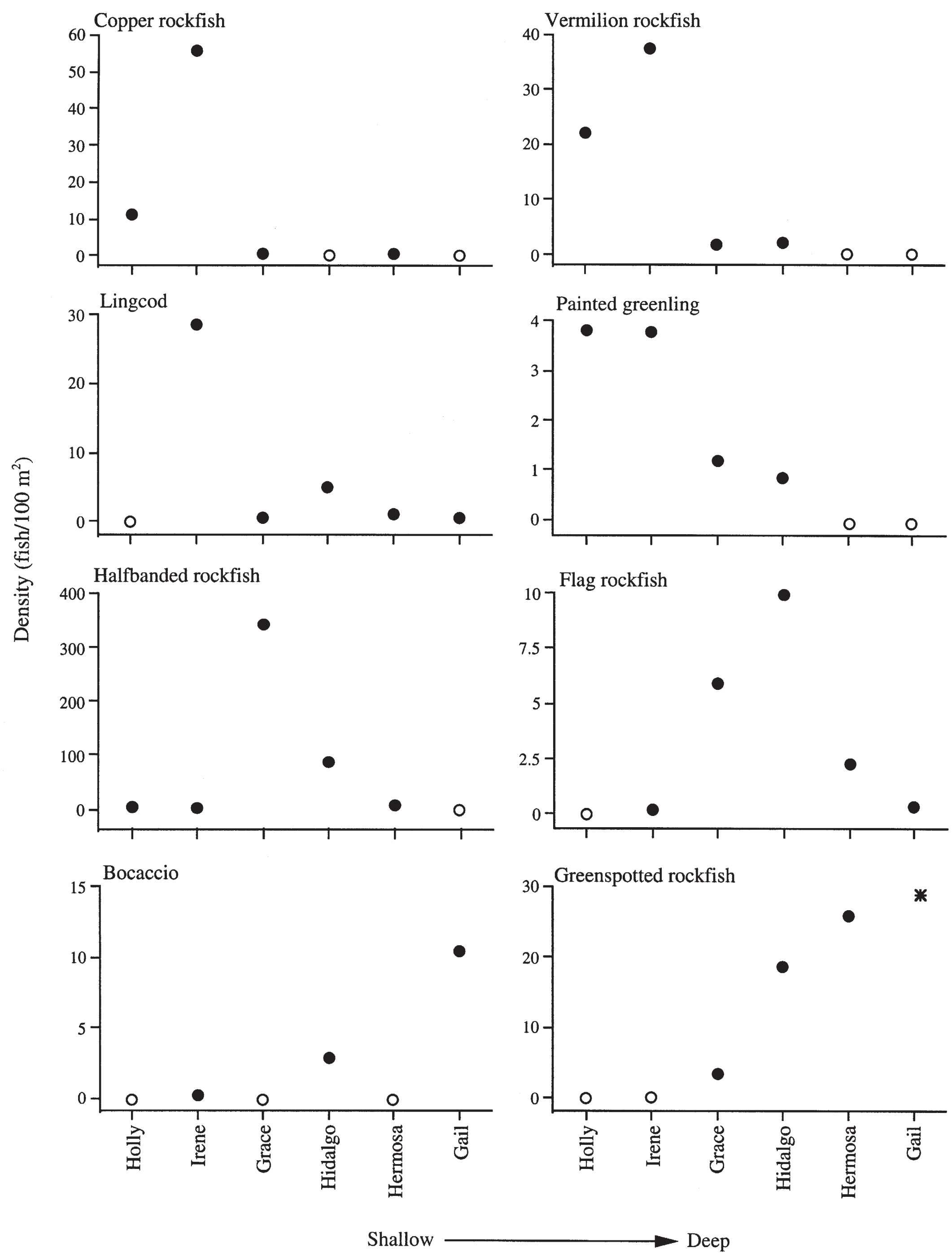

Figure 6

Densities (fish/100m^2) of eight common species on the bottoms of seven platforms in the Santa Barbara Channel area. Platforms are ordered by bottom depth from shallow (Holly) to deep (Gail). Data for greenspotted rockfish around platform Gail (noted by *), may include observation of greenblotched rockfish. Empty symbols represent zero values.

platforms provided a larger variety of habitat types than did the midwater. Bottoms are often largely composed of shell mounds that have fallen from the upper parts of the platforms. These mounds, in com-

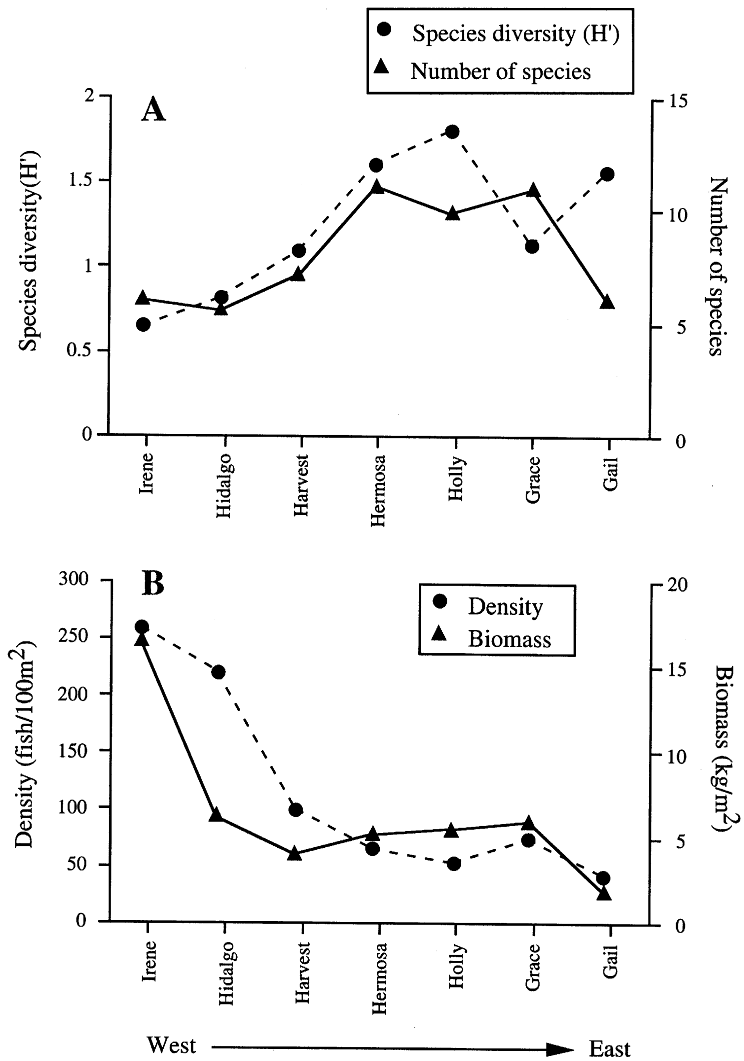

Figure 7

(**A**) Species richness (number of species) and species diversity (Shannon-Weaver diversity index, H′) and (**B**) density (fish/100 m^2) and biomass (kilograms/m^2) on the midwater transects of seven platforms in the Santa Barbara Channel area. Platforms are ordered by geography from northwest (Irene) to southeast (Gail).

bination with the wells, crossbeams, and pilings provide a greater degree of habitat complexity and thus, may allow a greater number of species to coexist.

Platforms north of Pt. Conception in the Santa Maria Basin contain far more YOY rockfishes than those in the Santa Barbara Channel to the south. This geographic difference is almost certainly due to the difference in water masses of the two areas. Platforms north of Pt. Conception are more exposed to the California Current; those south of the Point are more influenced by Southern California Bight water (Brink and Muench, 1986; Hickey, 1992). There is considerable evidence that, within much of the Southern California Bight, juvenile rockfish recruitment has been poor for a number of years (Stephens et al., 1984, 1994; Love et al., 1998), probably due to decadal-long changes in oceanographic conditions. Since the late 1970s, waters off Southern California have warmed significantly and upwelling has declined. This situation has led to reduced zooplankton production (Roemmich and McGowan, 1995) and a reduction in the survival of many marine fish species in early life stages (Holbrook and Schmitt, 1996). The present regime is probably part of a long-term

Table 6

Number, densities, and biomasses of fishes observed on the midwater transects of seven oil platforms off central and southern California. Platforms are listed geographically, from northwest to southeast. YOY means "young-of-year." We computed minimum number of species by assuming that each unidentified taxa (flatfish, poacher, ronquil, and seaperch) represented one species. Both density and biomass on midwater transects are estimates calculated from transect minutes (see text for explanation of the conversion).

Platform	Species	Number	Estimated density (fish/100m²)	Estimated biomass (kg/m²)
Irene	Widow rockfish	447	127.25	12.47
	Rockfish YOY	271	78.22	1.36
	Bocaccio	162	46.56	2.73
	Blue rockfish	2	0.85	0.07
	Copper rockfish	2	0.85	0.11
	Pile perch	2	1.14	0.19
	Painted greenling	1	0.57	0.04
	Total	**887**	**255.44**	**16.97**
	Minimum number of species	6		
Hidalgo	Rockfish YOY	647	137.88	1.80
	Widow rockfish	286	50.57	3.62
	Bocaccio	78	19.70	0.29
	Painted greenling	29	8.60	0.28
	Greenspotted rockfish	2	0.71	0.04
	Unident. sculpin	1	0.53	0.03
	Flag rockfish	1	0.46	0.04
	Total	**1044**	**218.46**	**6.10**
	Minimum number of species	6		
Harvest	Widow rockfish	171	39.45	2.51
	Rockfish YOY	102	24.80	0.42
	Bocaccio	43	11.53	0.18
	Painted greenling	36	11.78	0.51
	Unidentified fish	17	5.09	•
	Blacksmith	8	2.27	0.05
	Greenspotted rockfish	5	1.80	0.11
	Calico rockfish	1	0.55	0.05
	Flag rockfish	1	0.45	0.03
	Total	**384**	**97.72**	**3.87**
	Minimum number of species	7		
Hermosa	Painted greenling	77	21.24	1.06
	Rockfish YOY	63	17.70	1.41
	Widow rockfish	36	11.01	0.99
	Pacific hake	18	3.76	0.20
	Bocaccio	16	4.60	0.38
	Greenspotted rockfish	6	1.94	0.17
	Squarespot rockfish	6	2.67	0.20
	Sebastomus group [1]	4	1.56	0.12
	Blue rockfish	3	1.46	0.16
	Unidentified fish	3	1.45	•
	Copper rockfish	1	0.46	0.08
	Flag rockfish	1	0.46	0.04
	Halfbanded rockfish	1	0.45	0.04
	Sharpchin rockfish	1	0.46	0.04
	Total	**236**	**69.20**	**4.90**
	Minimum number of species	11		
Holly	Rockfish YOY	62	20.22	0.54
	Painted greenling	33	13.75	0.53

continued

Table 6 (continued)

Platform	Species	Number	Estimated density (fish/100m²)	Estimated biomass (kg/m²)
Holly	Sharpnose seaperch	14	6.22	1.84
continued	Squarespot rockfish	11	4.02	0.12
	Copper rockfish	8	3.77	0.28
	Blacksmith	4	1.82	0.49
	Gopher rockfish	4	2.13	0.23
	Pile perch	4	2.23	0.99
	Widow rockfish	3	1.80	0.31
	Bocaccio	1	0.57	0.04
	Kelp rockfish	1	0.67	0.34
	Total	**145**	**57.21**	**5.70**
	Minimum number of species	10		
Grace	Widow rockfish	103	28.92	3.90
	Rockfish YOY	76	25.18	0.32
	Chilipepper	25	6.73	0.64
	Sebastomus group[1]	9	4.67	0.25
	Painted greenling	8	3.37	0.16
	Squarespot rockfish	5	1.58	0.18
	Flag rockfish	2	0.88	0.03
	Greenspotted rockfish	2	0.80	0.06
	Swordspine rockfish	2	1.09	0.08
	Calico rockfish	1	0.62	0.04
	Kelp greenling	1	0.54	0.05
	Rosy rockfish	1	0.54	0.07
	Treefish	1	0.54	0.04
	Total	**236**	**75.47**	**5.76**
	Minimum number of species	11		
Gail	Rockfish YOY	48	21.49	0.72
	Flag rockfish	10	4.92	0.40
	Widow rockfish	8	3.77	0.27
	Bocaccio	7	3.07	0.25
	Greenspotted rockfish	3	1.42	0.18
	Painted greenling	2	1.29	0.14
	Unidentified fish	2	1.10	•
	Blue rockfish	1	0.63	0.06
	Total	**81**	**37.69**	**2.00**
	Minimum number of species	6		

[1] *Sebastomus* group may include greenblotched, greenspotted, pinkrose, rosethorn, rosy, starry, or swordspine rockfishes.

alternation of warm- and cold-water conditions that have occurred over millennia (MacCall, 1996).

Previous surveys of rockfishes at the two most inshore platforms of the Santa Barbara Channel, Hilda and Hazel, provide some evidence for the plasticity of rockfish populations in the Santa Barbara Channel. In the late 1950s, Carlisle et al. (1964) found large numbers of bocaccio and olive, copper, and brown rockfishes. Most of these fishes were either YOYs or older juveniles. By 1975, olive and brown rockfishes were still abundant, but bocaccio and copper rockfishes were uncommon (Bascom et al., 1976). In this latter survey, blue rockfish, not reported by Carlisle et al. (1964), were abundant.

Thus, we believe that the relative dearth of juvenile rockfishes around Southern California Bight platforms is not a permanent condition but represents a fluctuating system. It is likely that as oceanographic conditions in the Southern California Bight become more favorable to rockfish recruitment, offshore platforms in the Santa Barbara Channel may well harbor far greater numbers of juvenile rockfishes than at present. In fact, indirect evidence implies that juvenile rockfishes were at one time far more abundant around southern California platforms. This conclusion comes from observations we made in the mid-1970s, a period of relatively strong juvenile rockfish recruitment off California (Love and Westphal, 1990). During that period, we observed a significant recreational fishery directed at juvenile widow rockfish and bocaccio (and to a certain extent olive and blue rockfishes) at platform Holly, as well as at a number of other Santa Barbara Channel platforms. We estimate that tens of thousands of these YOY and 1- and 2-yr-old fishes were caught over the course of about three years.

The absence or relative rarity of such common nearshore species as kelp bass (*Paralabrax clathratus*), opaleye (*Girella nigricans*), black seaperch (*Embiotoca jacksoni*), and white seaperch (*Phanerodon furcatus*) from the upper waters was particularly striking. This is in contrast to the inshore platforms and reefs of this area that harbor many of these species (Carlisle et al., 1964; Ebeling et al., 1980; Schroeder[3]). A most important cause for the absence of nearshore species is the isolation of these offshore structures; relatively deep water separates them from the mainland. This distance may effectively cut these species off from source populations of many shallow-water species. Thus, it may be difficult for the young of many species to either reach these platforms or become established there. Seaperches are viviparous and produce fully developed

[3] Schroeder, D. 1997. Marine Science Institute, University of California, Santa Barbara, CA 93106. Personal commun.

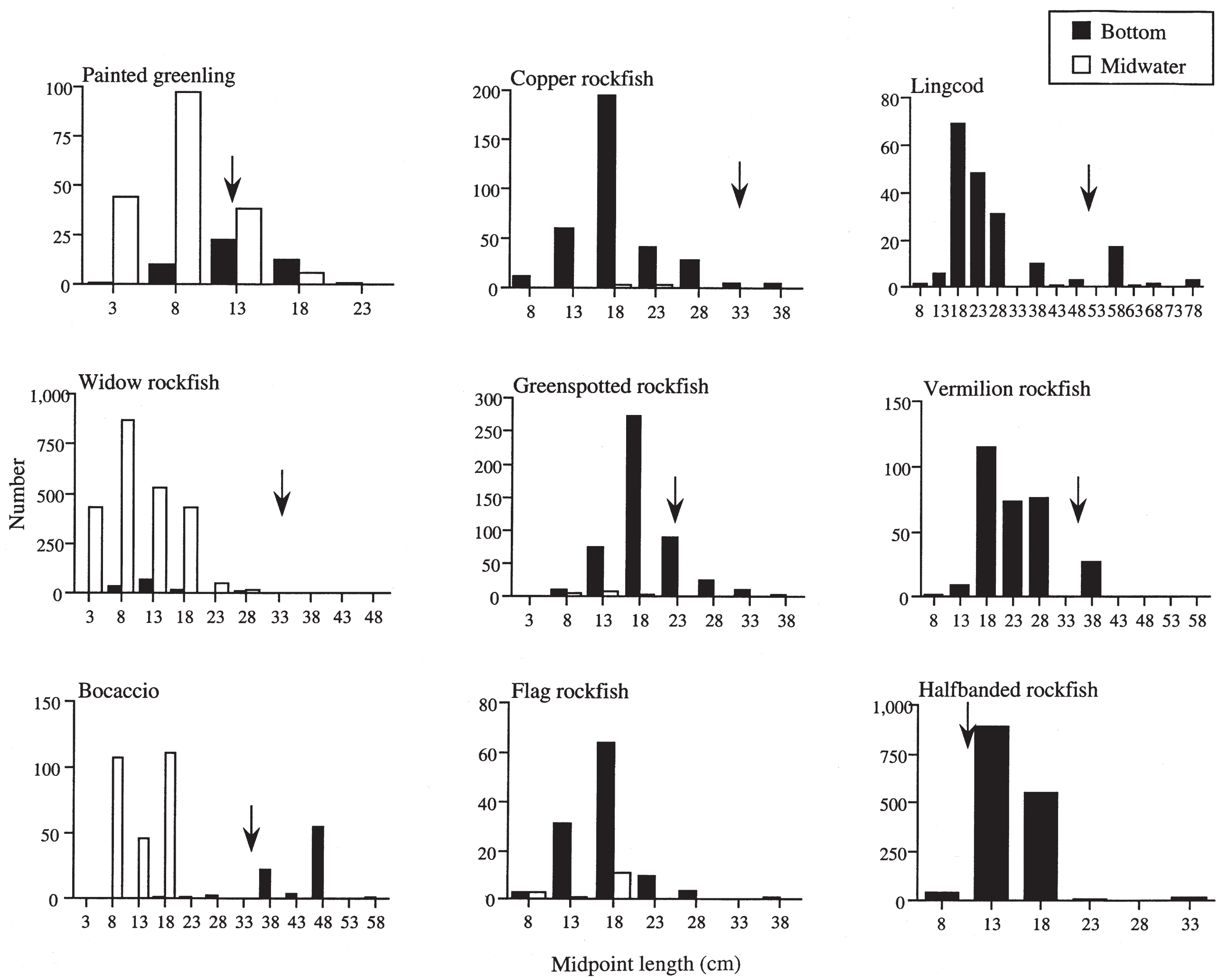

Figure 8

Length-frequency distributions of nine common species on midwater and bottom transects on all platforms combined. Midpoint length is the midpoint of 5-cm length bins.

young that do not disperse widely, making it unlikely that they commonly find their way to platforms. Kelp bass and opaleye produce pelagic larvae and although it is likely that some may settle to the platforms, conditions at these structures may preclude their survival after settlement. Young opaleye seem to require quiet intertidal waters and kelp bass YOY may need algae or thick benthic turf to avoid predation (Carr, 1994; Stephens[4]). Both of these conditions are lacking at platforms. Moreover, in the study area kelp bass recruitment is only sporadic and may not have occurred in the recent past. Thus, strong currents and lack of suitable habitat around platforms may reduce the amount of successful recruitment of these and other nearshore species.

A few species, notably painted greenling, do seem to be well adapted to a substrate-associated life in the midwaters. Judging from the very small individuals we observed, it is likely that larvae of this species recruit directly to the platform and settle out in the shallower portions. We saw a wide range of sizes, from newly settled individuals to adults, sitting on the crossbeams and hanging vertically on the pilings. Other than painted greenling, only a few juvenile flag, greenspotted, copper, swordspine, gopher, and rosy rockfishes were seen sitting on the platform in midwater.

Although juvenile rockfishes dominated the platform midwater, for some species platform bottoms tended to harbor a wider range of life stages. For some rockfishes (such as copper and greenspotted rockfishes), the entire range of stages from YOY to adults were present. In these species, the smaller individuals tended to live somewhat away from the legs and crossbeams and more among those parts of the mussel shell mounds a few meters from the platform. Although juvenile vermilion rockfish were common on several of the shallower platforms, we saw no YOYs around any of these structures. Vermilion rockfish tend to settle out in the nearshore, relatively shallow waters, and it is likely that even the shallowest of the surveyed platforms were situated in waters too deep for successful recruitment. This supposition was born out in our SCUBA diver surveys of platform Gina, located off Port Hueneme, southern California. Platform Gina is located in waters about 33 m deep. Divers have surveyed the entire structure and on several occasions have noted YOY vermilion rockfish at the bottom of the platform.

The situation with lingcod is particularly interesting. Including observations from all platforms, we observed all life stages from YOYs to large adults. However, almost all the young fish lived around platform Irene, in relatively high densities. From the lengths of these animals (Miller and Geibel, 1973), we determined that these fish were either YOYs or one-year-olds. We noted that most were sitting in the mussel shells on the bottom slightly away from the structure. In an underwater survey that encompasses seven platforms and 61 natural reefs in central and southern California, we have never encountered juvenile lingcod densities approaching the levels noted around platform Irene. Similar submersible research farther north, off Big Sur-Monterey (Yoklavich[5]) and Alaska (O'Connell[6]) also implies that such aggregations are very rare. The aggregation around Irene may also be relatively stable because we saw similar high densities in the subsequent 1997 survey. It is unclear what attracts young lingcod to this location. A large juvenile aggregation was noted off Big Sur on a sandy bottom covered with ripple marks (Yoklavich[4]). Perhaps young lingcod seek out substrate with at least some vertical relief and, at Irene, mussel shell mounds provide this type of relief.

Many bottom fishes tended to be patchily distributed around individual platforms. This is particularly true of the aggregating species, such as bocaccio and vermilion and halfbanded rockfishes. Whether this is in response to current pattern, variations in platform structure, or to other parameters is not clear at this point. We have also observed a tendency for small individuals, such as halfbanded rockfish or juvenile greenspotted rockfish, to be found away from larger, presumably predacious, individuals. Smaller fishes also tend to be found farther away from the platform, again probably to avoid the larger fishes nestled in the structure.

Fishing pressure is intense over most of the natural reefs in southern California and platforms may act as refuges for rockfishes and lingcod. An example is the relatively high numbers of bocaccio living around platform Gail. Historically, bocaccio were very important recreational and commercial fish along all of California and owing to a combination of over-fishing and poor juvenile recruitment, their populations have drastically decreased (Ralston et al., 1996). Our survey of the fish assemblages of 61 natural reefs off southern and central California shows that platform Gail has by far the highest density of adult bocaccio of all of these sites (10.5 fish/100 m^2 on platform Gail

[4] Stephens, J. 1997. Department of Biology, Occidental College, 1600 Campus Rd., Los Angeles, CA 90041. Personal commun.

[5] Yoklavich, M. 1997. Pacific Fisheries Environmental Laboratory, National Marine Fisheries Service, 1352 Lighthouse Ave., Pacific Grove, CA, 93950. Personal commun.

[6] O'Connell, T. 1998. Alaska Department of Fish and Game, 304 Lake St., Rm. 103, Sitka, AK, 99835. Personal commun.

compared with 4.4 fish/100 m^2 on the highest density natural reef). The reef was located on the northern side of the passage between San Miguel and Santa Rosa islands. The average density of bocaccio across all natural reefs surveyed in 1996 was only 1.26 fish/ 100 m^2. The large numbers of bocaccio around Gail may reflect the minimal fishing pressure around this platform. Fishing by recreational or commercial vessels near platforms is generally discouraged by platform operators. In addition, because larger fishes tend to live close to or inside the platforms, they are difficult to catch because the habitat close to or inside the platforms eludes most fishing gear.

We realize that the data presented in this paper represent a "snapshot" in time and thus issues of seasonality or interannual variation in assemblage structure remain to be addressed. Longer-term surveys of the fish fauna on two platforms in the Gulf of Mexico as well as one in the Santa Barbara Channel showed considerable diel and seasonal variation in the number of species present (Carlisle et. al 1964; Hastings et. al. 1975). In addition, monthly SCUBA observations on one shallow-water platform indicate that there may be large temporal changes in assemblage structure (Schroeder[2]). Despite this, the differences we observed in fish assemblages among and within platforms suggest that each platform may have unique characteristics.

There has been considerable discussion regarding the role of artificial structures in aggregation or enhanced production of marine species (or both) (Carr and Hixon, 1997). Based on this study, it appears that oil platforms may serve to do both. First, large adult fishes of several species were present on several platforms where no juveniles of those species had previously been observed, e.g. vermilion rockfish. It appears that those adults may have settled away from the platforms and migrated to them at some life stage. On the other hand, several platforms had very large numbers of very young fish that presumably settled to the platforms directly from the plankton, e.g. widow rockfish. If we assume that some of these young fishes would not have found appropriate settling habitat, then platforms, at least in the short term, do play some role in enhancing production. To ultimately assess the role of platforms in production of reef fishes, it will be necessary to understand the fate of the young fish settling to them.

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