



## CHAPTER 3

# A REVIEW OF BIOLOGICAL AND OCEANOGRAPHIC SURVEYS: RESULTS AND ANALYSES

Milton S. Love, Donna M. Schroeder, and Mary M. Nishimoto

There was no single characteristic fish assemblage that could be described for the oil platforms and natural outcrops of central and southern California. However, we identified a number of patterns in fish diversity and abundance that corresponded to bottom depth, geographic area, and year. Depth played an important role because, in general, rockfishes numerically dominated fish assemblages around platforms and deep natural reefs, and rockfish species segregate themselves according to habitat depth. We also observed biogeographic partitioning in species composition, where northerly platforms show the influence of the Oregonian province and southerly platforms show the influence of the San Diegan province. These zoogeographic patterns were more conspicuous in shallow water fish assemblages. The large inter-annual fluctuations in juvenile fish recruitment observed during the studies may have been generated by the large inter-annual variability in oceanographic conditions (e.g., upwelling, El Niño-Southern Oscillation events). Since juveniles of many species inhabited shallow and midwater portions of oil platforms, the greatest temporal variability in fish abundance occurred at these depths.

We present more detailed summaries of fish assemblages identified by the two different survey methods (scuba and submersible) in the sections below. The common and scientific names of fishes observed in these studies are listed in Table 1.

### 1. Shallow Water Fish Assemblages: 0–36 m (119 ft.)

#### Findings at a Glance

**A combination of regional and local processes influenced patterns of reef fish assemblages in shallow water. At regional scales, composition and relative abundance of reef fishes often shifted abruptly as oceanography changed. This shift delineated a cool-temperate assemblage in the western Santa Barbara Channel, and a warm-temperate assemblage in the eastern Santa Barbara Channel. This distinct spatial pattern was reflected in both platform and natural reef habitats. There was greater variability in platform species assemblages and population dynamics compared to natural outcrop assemblages and dynamics, and this was most likely caused by the offshore position**

**and greater sensitivity of platform habitats to changing oceanographic conditions. Local processes which affected fish distribution and abundance were related to habitat features, where depth, relief height, and presence of giant kelp all played important roles. We found that the majority of juvenile rockfish recruits resided at depths greater than 26 m (86 ft.), although there were differences among species.**

**Except where noted, the following synopsis encompasses platforms Irene, Hidalgo, Harvest, Hermosa, Holly, Grace, Gilda, Gail, and Gina and are based on diver surveys conducted between 1995 and 2000.**

#### 1a. General Patterns

The two primary research objectives were to (1) describe the spatial and temporal variability of shallow water (less than 36 m, 119 ft.) fish assemblages residing on oil/gas production platforms and natural outcrops, and (2) describe the relative importance of regional processes (e.g., oceanographic patterns) compared to local processes (e.g., habitat features) in generating observed patterns of reef fish assemblages. An understanding of mechanisms which structure marine populations is necessary to predict the outcome of resource management decisions related to marine fisheries, platform decommissioning, and marine protected areas on fish assemblages within the Santa Barbara Channel region (including the Santa Maria Basin). A list of species observed at each platform is given in Appendix 2.

We find that a combination of regional and local processes influenced patterns of reef fish assemblages in shallow water. At regional scales, composition and relative abundance of reef fishes often shifted abruptly as oceanography changed. This shift delineated a cool-temperate assemblage in the western Santa Barbara Channel, and a warm-temperate assemblage in the eastern Santa Barbara Channel. Rockfishes and surfperches dominated the cool-temperate assemblage, and damselfishes, wrasses, and sea chubs dominated the warm-temperate assemblage. This distinct spatial pattern was reflected in both platform and natural outcrop habitats.

Within each of the cool- and warm-temperate assemblages, local habitat features modified patterns of

species abundance and distribution. For example, kelp surfperch and giant kelpfish were only observed on rocky outcrops that possessed stands of giant kelp, *Macrocystis pyrifera*. Other factors likely to have been important were outcrop or platform depth and relief height. These local scale features sufficiently decoupled sites within an oceanographic region (cool- or warm-temperate) to make broad generalizations about fish assemblages difficult, especially within platform habitats.

Temporal dynamics of reef fish assemblages also resulted from a complex, dynamic interaction between regional oceanography and local habitat features. The diverse array of oceanographic conditions that occurred during the six-year survey period appeared to strongly influence regional dynamics of fish assemblages. The 1997–1998 El Niño event corresponded to a large increase in juvenile recruitment of species which dominated the warm-temperate fish assemblage (e.g., blacksmith), while the 1999 La Niña event corresponded to a large increase of juvenile recruitment of species which dominated the cool-temperate fish assemblage (e.g., rockfishes). Severe winter storms that accompany El Niño events propagated into small-scale variability at some sites. For example, the scouring effect of severe storm waves depleted red algal turf (a forage base for small crustaceans and fish) on two shallow natural outcrops. This forage base reduction may have been the primary cause of the observed synchronous decline in surfperch abundance at the same outcrops.



Kelp bass at a nearshore platform.

JAMES FORTE

may be due to water depth in which the platform is positioned, where deeper water can inhibit species such as surfperches from migrating onto platform habitat. Among-platform differences may also be influenced by food availability or other factors. During the 1997–1998 El Niño event, juvenile blacksmith recruited onto all platforms, but did not recruit onto Tarantula Reef, the closest natural reef to west channel platforms surveyed in this study. This observation suggests that platforms may “capture” pelagic stages of some reef fish species that might have otherwise perished.

The fish assemblage observed at Platform Gina (depth 29 m, 95 ft.) is noteworthy because of its very high density of kelp bass and because of the large diversity of rockfishes that recruit to its shell mound

**1b. Shallow Water Fish Assemblages Surrounding Oil/Gas Production Platforms**

As observed on natural outcrops (see Section 1d), shallow water fish assemblages surrounding oil/gas production platforms show distinct spatial patterns which correspond to oceanographic patterns in the Santa Barbara Channel. Rockfishes are numerically dominant in west channel platform fish communities, although 1999 was a strong recruitment year for juvenile rockfish at all platforms. Blacksmith and halfmoon are numerically dominant in east channel platform assemblages. Platform fish assemblages appeared to respond faster and more dramatically to changing oceanographic conditions than natural reef assemblages, perhaps due to their offshore position and higher proportion of juvenile fishes.

There were notable differences among platforms within an oceanographic region. These differences

habitat. Anecdotal observations at a nearby shipwreck did not record either of these characteristics in its local fish assemblage. High turnover of fish species diversity has also been noted at Platform Gina (Love, Nishimoto, Schroeder, and Caselle 1999).

**1c. Depth Distribution of Juvenile Fish Recruitment on Oil Platforms**

For all fishes observed at all Southern California Bight platforms surveyed at shallow depths, approximately 27% were observed in the shallowest portions of platform habitat (6–12 m, 20–40 ft.). Most of these were pelagic fishes, such as anchovy and barracuda. Twenty-seven percent of all fishes were observed at intermediate depths (15–26 m, 50–86 ft.), and 46% were observed at deeper depths (27–36 m, 89–119 ft.). We observed that the majority of juvenile rockfish recruits resided at depths

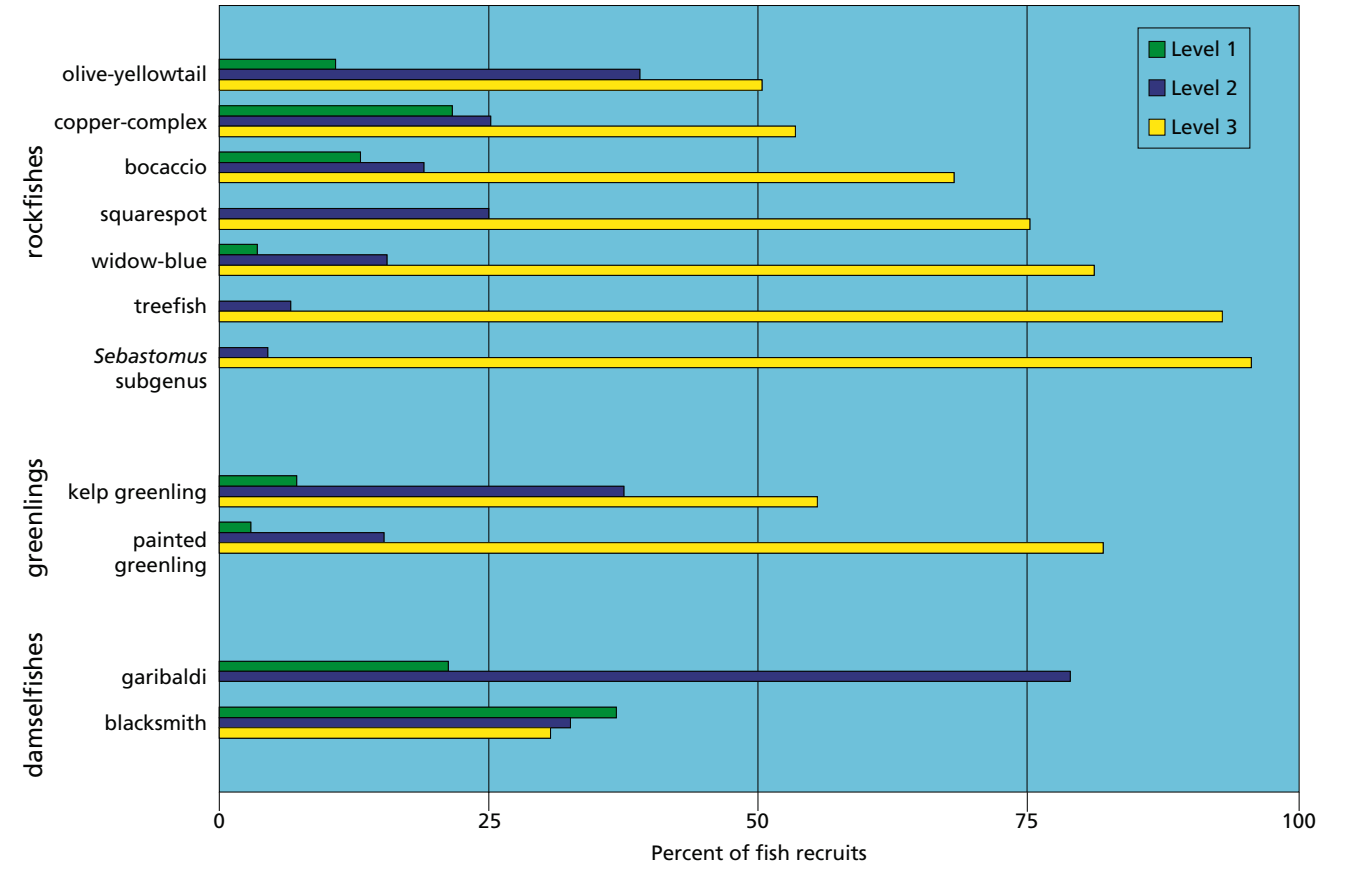


Figure 3.1. Percent of juvenile fish density observed during scuba surveys at different depths on offshore platforms during 1995–2000. Depth ranges for each strata: level 1 (6–12 m), level 2 (15–26 m), level 3 (27–36 m).

greater than 26 m (96 ft.) (Figure 3.1), although there were differences among species. The olive-yellowtail group and copper-complex species group (black-and-yellow, copper, gopher, and kelp rockfishes) had the largest percentages residing at shallower depths. Our observations on copper-complex rockfishes represent a somewhat different vertical distribution than that described by Holbrook et al. (2000). This disparity may be due to differences in surveyed platforms and program duration (6 platforms within one biogeographic area during 1995–7 versus 9 platforms in 3 biogeographic areas during 1995–2000). This difference underscores the importance of evaluating platforms on a case-by-case basis and in developing monitoring programs over multiple years.

Our results correspond with Holbrook et al. (2000) regarding vertical distribution of midwater juvenile rockfishes (e.g., bocaccio, blue, and widow) where the vast majority of individuals recruited to depths greater than 26 m (86 ft.). The majority of individuals of other rockfish species such as squarespot, treefish, and the *Sebastomus* subgenus (e.g., rosy, greenspotted, starry

rockfishes, and others) are also found below 26 m (86 ft.). Kelp and painted greenling recruits, two species associated with the cool-temperate fish fauna, mimic the vertical distribution of rockfish recruits, preferring deeper portions. In contrast, garibaldi and blacksmith recruits, two species associated with the warm-temperate fish fauna, favor upper portions of platforms, suggesting temperature may play a role in determining depth distribution of juvenile fishes at platforms.

**1d. Fish Assemblages on Nearshore Natural Outcrops**

The relative importance of spatial versus temporal variability in structuring fish assemblages on shallow natural outcrops differed among sites. Ordination analysis revealed that natural outcrops in the west channel tended to be more sensitive to temporal variability than those outcrops positioned in the east channel. This seems intuitive since west channel outcrops are closer to areas of intense and temporally variable upwelling processes which affect mean water temperature, primary production, and dispersal processes of larvae.

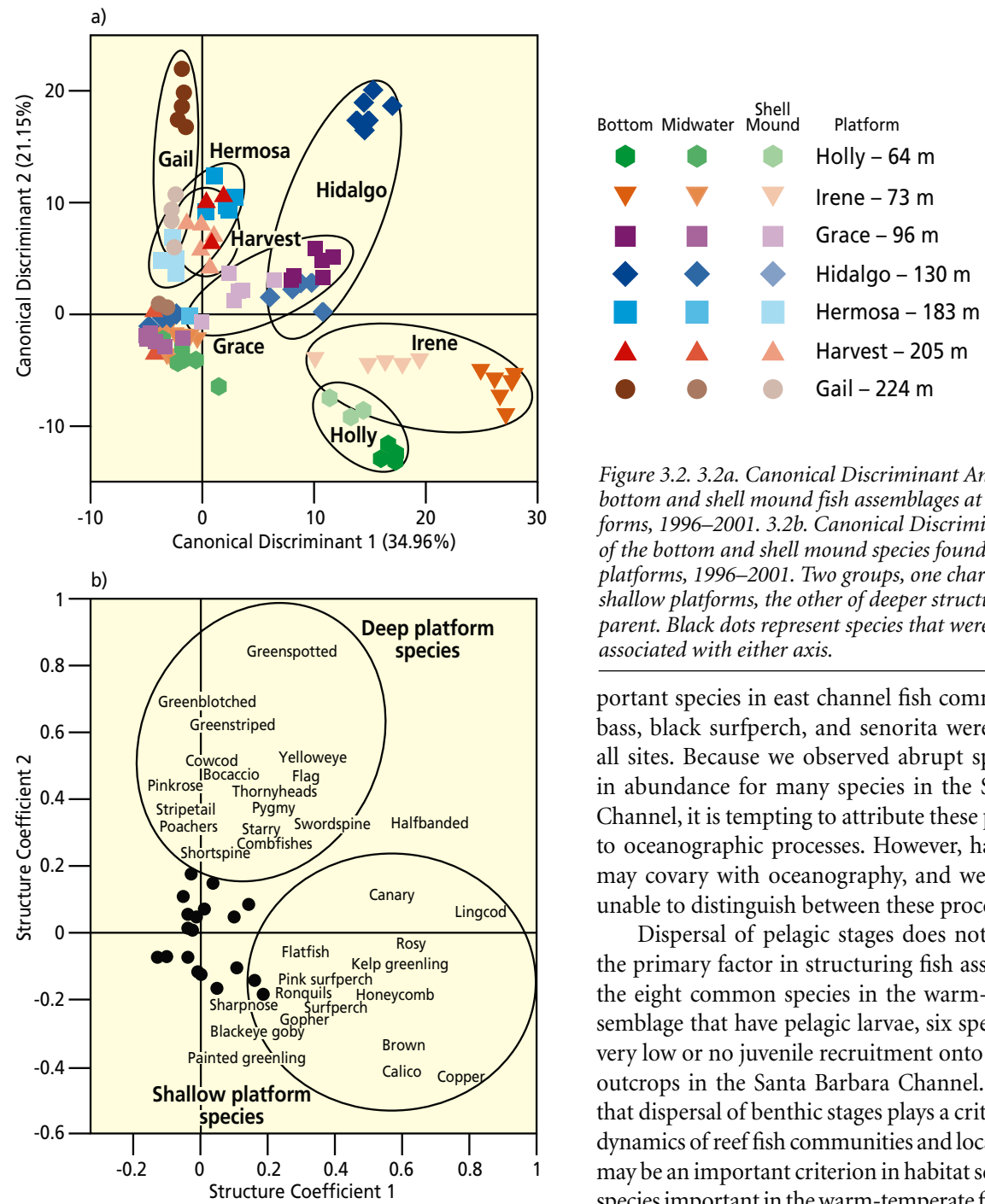


Figure 3.2. 3.2a. Canonical Discriminant Analysis of the bottom and shell mound fish assemblages at seven platforms, 1996–2001. 3.2b. Canonical Discriminant Analysis of the bottom and shell mound species found around seven platforms, 1996–2001. Two groups, one characteristic of shallow platforms, the other of deeper structures are apparent. Black dots represent species that were not strongly associated with either axis.

portant species in east channel fish communities. Kelp bass, black surfperch, and seniorita were abundant at all sites. Because we observed abrupt spatial changes in abundance for many species in the Santa Barbara Channel, it is tempting to attribute these patterns solely to oceanographic processes. However, habitat features may covary with oceanography, and we are currently unable to distinguish between these processes.

Dispersal of pelagic stages does not appear to be the primary factor in structuring fish assemblages. For the eight common species in the warm-temperate assemblage that have pelagic larvae, six species exhibited very low or no juvenile recruitment onto shallow rocky outcrops in the Santa Barbara Channel. This suggests that dispersal of benthic stages plays a critical role in the dynamics of reef fish communities and local temperature may be an important criterion in habitat selection. Some species important in the warm-temperate fish assemblage (e.g., kelp bass and opaleye) declined in abundance during the cold La Niña year of 1999. The response of reef fish communities to oceanographic regime shifts may be faster and less persistent than previously thought.

**2. Deeper-water Platform Fish Assemblages: 31–224 m (103–739 ft.)**

Except where noted, the following synopsis encompasses platforms Irene, Hidalgo, Harvest, Hermosa, Holly,

Similar to platform habitats, the fish assemblages on natural outcrops showed distinct spatial patterns that seemed to correspond to regional oceanographic patterns in the Santa Barbara Channel. Rockfishes and surfperches were important species in west channel fish communities, although 1999 was a strong recruitment year for juvenile rockfishes at most natural outcrops. Blacksmith, garibaldi, sheephead, opaleye, and rock wrasse were im-

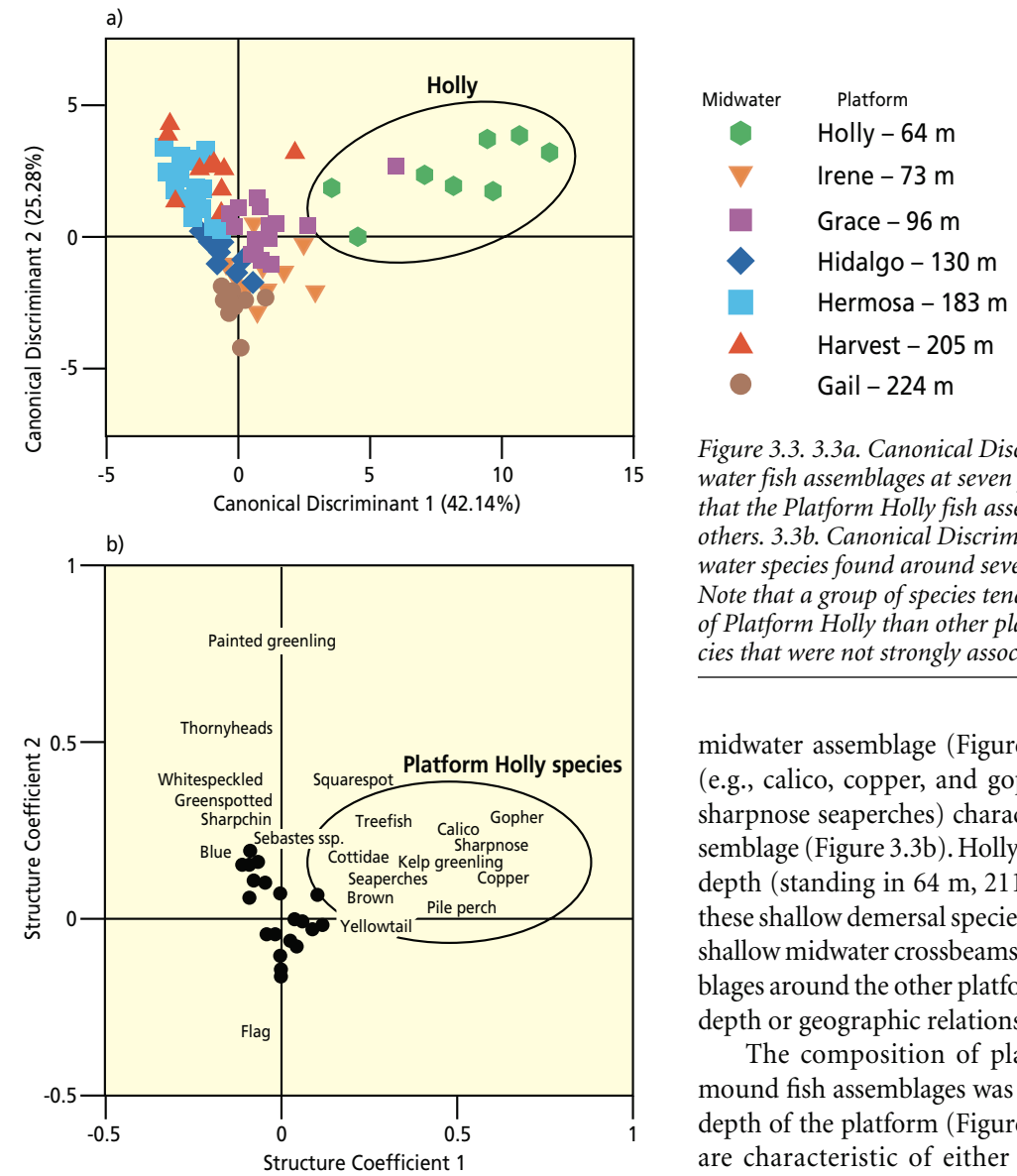


Figure 3.3. 3.3a. Canonical Discriminant Analysis of mid-water fish assemblages at seven platforms, 1996–2001. Note that the Platform Holly fish assemblage is distinct from the others. 3.3b. Canonical Discriminant Analysis of the mid-water species found around seven platforms, 1996–2001. Note that a group of species tends to be more characteristic of Platform Holly than other platforms. Dots represent species that were not strongly associated with either axis.

midwater assemblage (Figure 3.3a). A suite of species (e.g., calico, copper, and gopher rockfishes, pile, and sharpnose seaperches) characterized this particular assemblage (Figure 3.3b). Holly has the shallowest bottom depth (standing in 64 m, 211 ft.), and it might be that these shallow demersal species were able to occupy these shallow midwater crossbeams. The midwater fish assemblages around the other platforms showed no systematic depth or geographic relationships.

The composition of platform bottom and shell mound fish assemblages was dependent on the bottom depth of the platform (Figure 3.2a) and certain species are characteristic of either shallow or deep benthic habitats (Figure 3.2b). Platforms Holly and Irene (64 m and 73 m; 211 and 241 ft., respectively) were dominated by brown, calico, copper, and vermilion rockfishes and lingcod. In deeper waters, Platforms Hermosa, Harvest, and Gail (183 m, 205 m, and 224 m; 604, 677, and 739 ft., respectively) were dominated by greenblotched, greenspotted, and greenstriped rockfishes. Platform Hidalgo, and to a certain extent Platform Grace, both at intermediate depths (130 m and 96 m, 429 and 317 ft., respectively), were inhabited by species common to both the shallower and deeper platforms. In general, our data suggests that shell mound fish assemblages most closely resemble the fish assemblages of their adjacent platform bottoms (Figure 3.2a). Fishes living on the shell mounds are generally smaller, and presumably younger, than the same species living around the platform bottom.

Grace, and Gail, based on surveys conducted between 1995 and 2001 from the research submersible *Delta*.

**2a. General Patterns**

All of the platforms studied by submersible had three distinct fish assemblages, midwater, bottom, and shell mound (Figure 3.2a). Rockfishes, totaling about 35 species, dominated all three fish assemblages. Fish densities at most platforms tended to be highest in the midwater reflecting the depth preferences of young-of-the-year rockfishes that represented the most abundant size class of fishes.

Midwater assemblages were more similar to each other regardless of platform location and bottom depth. The assemblage at Platform Holly had the only distinct



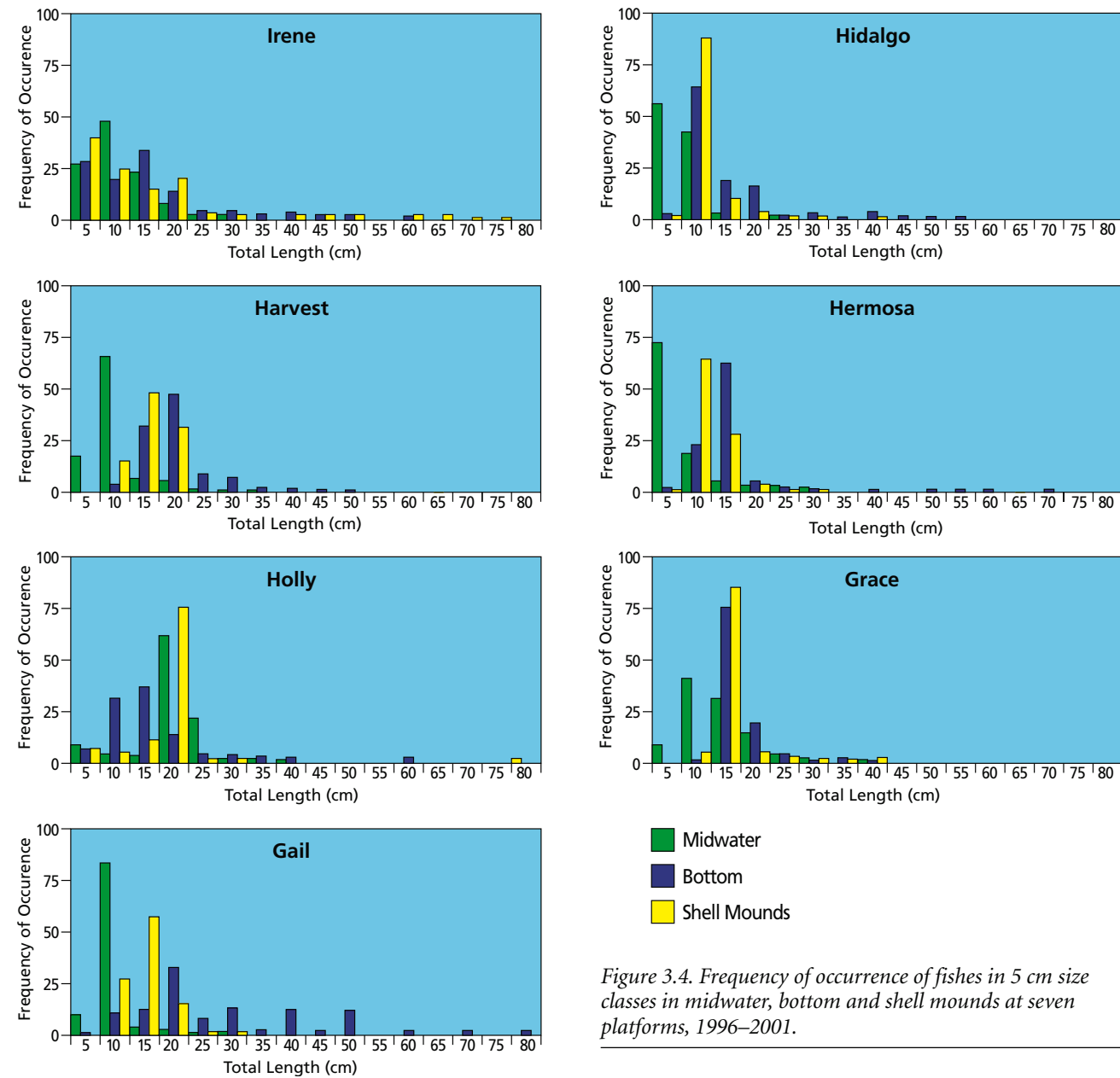


Figure 3.4. Frequency of occurrence of fishes in 5 cm size classes in midwater, bottom and shell mounds at seven platforms, 1996–2001.

The size distribution of fishes differed by habitat type. The midwater assemblages harbored few fishes over 20 cm (8 in.) long (Figure 3.4). Immature, mostly young-of-the-year rockfishes and young painted greenling dominated midwater depths. In addition, seaperches, blacksmith, and several less abundant species inhabited this zone. In contrast, older and larger rockfishes, lingcod, and several other benthic species, occupied the platform bottom habitat. Rockfishes also dominated the shell mounds. The size frequency of shell mound fishes tended to be intermediate between the two other habitats (Figure 3.4). This apparent partitioning of different size modes

was most evident in the deepest platforms. Around shallow platforms, there was significant settlement of young-of-the-year rockfishes both in the midwater and at the bottom. This common feature blurred the distinctions between these two habitats.

Young-of-the-year rockfishes showed strong depth preferences around platforms (Figure 3.5). Young-of-the-year were often very abundant in the shallowest portions (above 30 m, 100 ft., depths) of the platform but were also abundant between 31 and 120 m depths (102–396 ft.). They were most abundant at depths between 61 and 90 m (201–297 ft.).

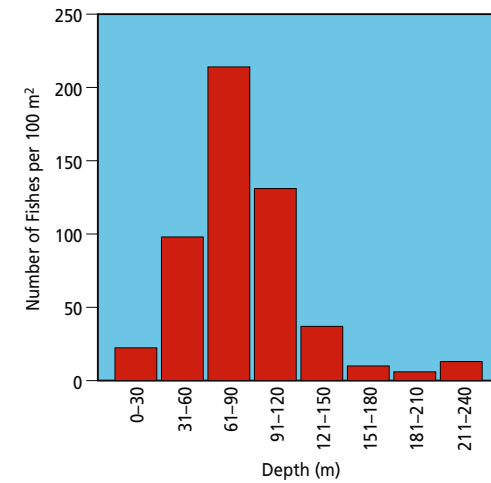


Figure 3.5. Density of young-of-the-year rockfishes observed from the Delta submersible, by depth, at all platforms surveyed, 1995–2001. Note that large numbers of these fishes were also observed by scuba divers in the shallower sections of the platforms.

Among platforms, total fish densities typically fell within a relatively small range (Figure 3.6). In general, platforms furthest offshore and in deepest waters had somewhat lower fish densities than did those closer to shore in shallower waters. However, the absolute number of fishes around deeper water platforms may be greater than those in shallower waters, as deeper platforms are much larger than shallower water structures.

## 2b. Midwater Assemblages

### Findings at a Glance

Platform midwaters are nursery grounds for rockfishes as well as for other marine fish species such as cabezon and painted greenling. The young-of-the-year of at least 15 rockfish species inhabit these midwater habitats.

Benthic settlement success is greatly influenced by oceanographic conditions. During our study, densities of young fishes varied greatly between years and platforms. Young-of-the-year rockfish densities often varied

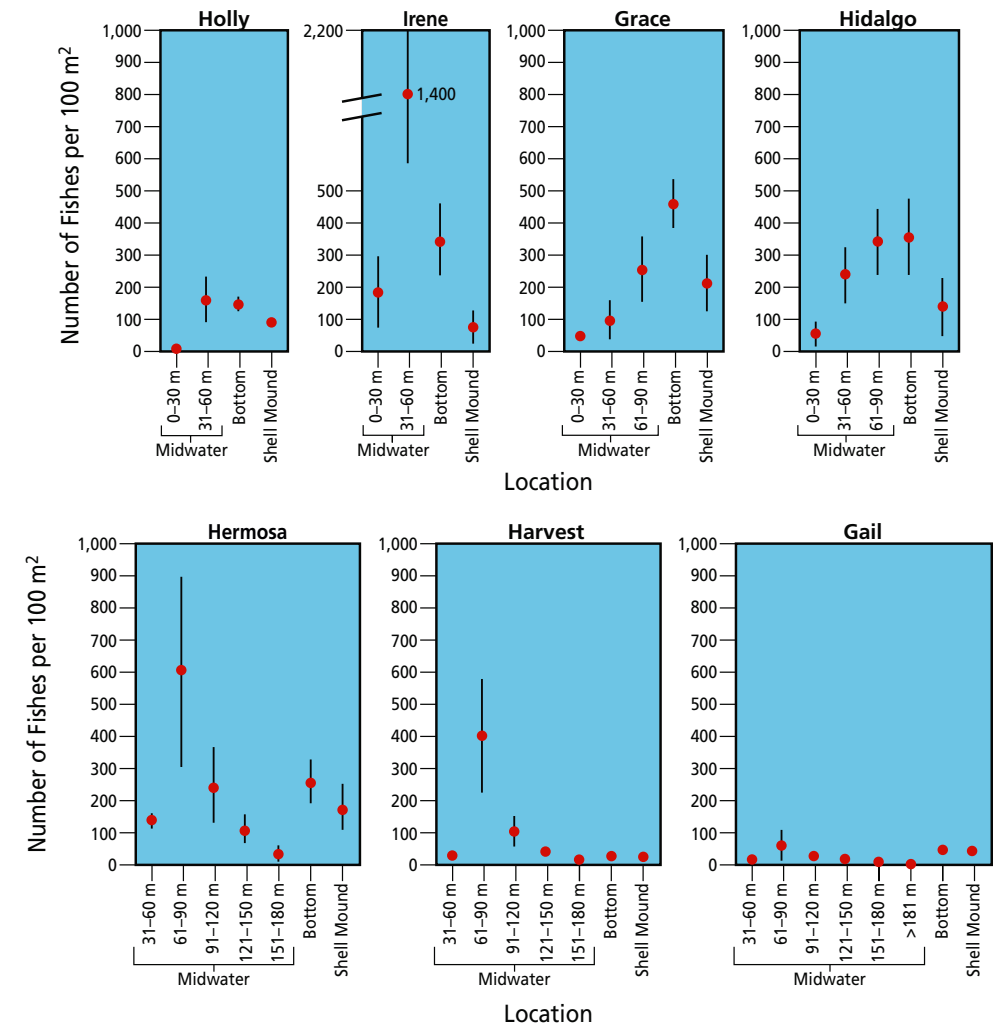


Figure 3.6. Density, with standard error bars, of all fishes in midwater (by 30 m depth zones), bottom and shell mounds, at seven platforms, 1996–2001.

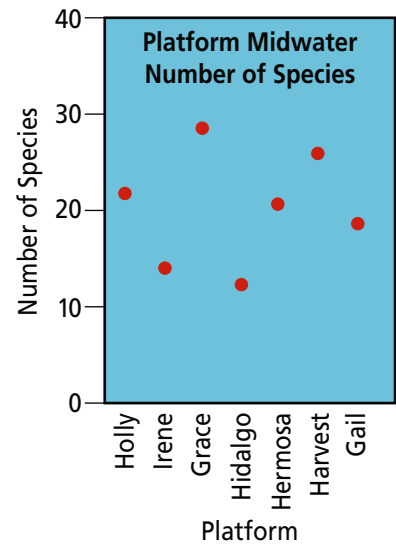


Figure 3.7. Number of species observed in the midwaters of seven platforms, 1996–2001. Platforms are listed from left to right, from shallowest to deepest.

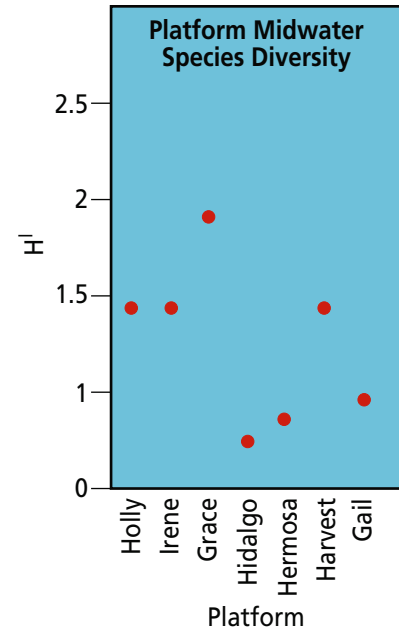


Figure 3.8. Species diversity of fishes in the midwaters of seven platforms, 1996–2001. Platforms are listed from left to right, from shallowest to deepest.

by a factor of 10 or even 100 among survey years at some platforms. From 1996 through 1998, rockfish settlement was generally higher around the platforms north of Point Conception compared to those structures in the Santa Barbara Channel, reflective of generally colder, more productive waters in central California. Colder waters in 1999 were associated with relatively high densities of young-of-the-year rockfish recruitment at all of the platforms surveyed. In 2000 and 2001, rockfish recruitment at platforms in the Santa Barbara Channel remained higher than pre-1999 levels. We hypothesize that this was related to the oceanographic regime shift to cooler temperatures that may be occurring in southern California.

Depending on platform location, we observed between 13 and 29 fish species in the midwater habitats below 31 m (102 ft.) depths (Appendix 3). There was no relationship between platform bottom depth and either the number of species or species diversity in the midwater habitat (Figures 3.7 and 3.8). Relatively abundant non-rockfish species included blacksmith, sharpnose seaperch, and juvenile painted greenling. Occasionally, we observed influxes of migratory species such as Pacific sardine, jack mackerel, and Pacific mackerel. However, because our surveys are snapshots in time, they do not adequately capture the importance of platform habitats to these and other pelagic species. The most abundant fishes were young-of-the-year and older juvenile rockfishes and blacksmith. These are planktivorous and thus are not dependent on

the platform for food. They utilize these structures for orientation in the water column and as refuge from predation. Less common species, such as seaperches, painted greenling, opaleye, and cabezon do feed on animals or algae living on the platform jacket or conductors.

Our research shows that oil and gas platforms off California provide important nursery grounds for many species of rockfishes. The most conspicuous faunal characteristic of the platform midwaters below scuba depth is the dominance of young rockfishes. Over the course of the study, young-of-the-year and older juvenile rockfishes almost always comprised more than 90% of all fishes observed in this habitat (Appendix 3). In some years, young-of-the-year rockfishes were virtually the only fishes present at some platform midwaters (Appendix 3).

The young-of-the-year of at least 16 rockfish species (bank, blue, copper, darkblotched, flag, gopher, kelp, olive, pygmy, shortbelly, squarespot, widow, yellowtail rockfishes, bocaccio, cowcod, and one or more members of the subgenus *Sebastomus*) recruited to the midwater habitat. Many of the species that were most abundant (e.g., blue, olive, pygmy, squarespot, widow, and yellowtail rockfishes and bocaccio) are those that are epibenthic or semipelagic as adults. Of these diverse young rockfishes, widow rockfishes were consistently the most abundant species at platforms. Among adult rockfishes, kelp and whitespeckled rockfishes were commonly observed.

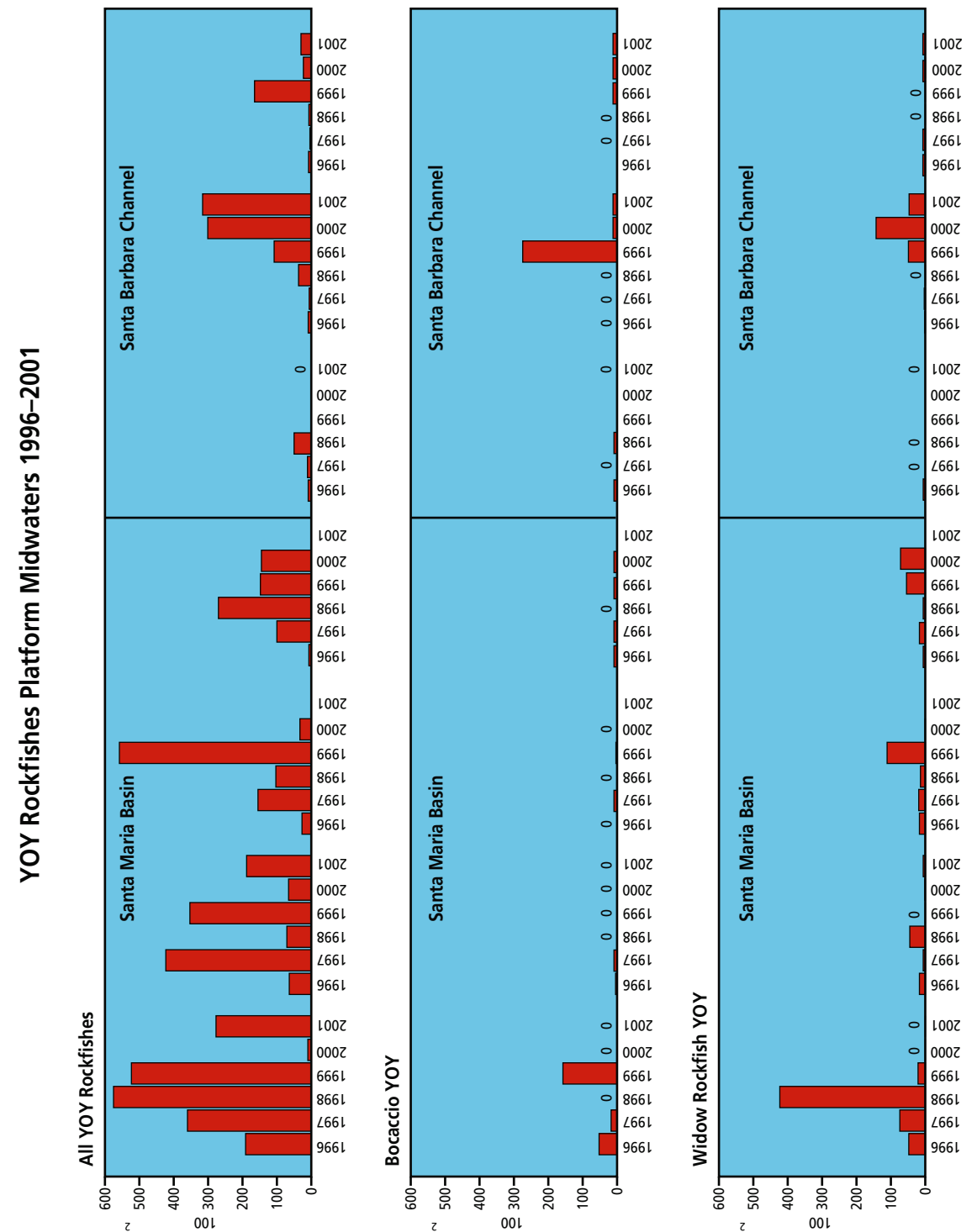


Figure 3.9. Density of all young-of-the-year bocaccio and widow rockfish and all YOY rockfishes combined in platform midwaters, by year and platform, 1996–2001.





DAN DUGAN

Pacific sardines, midwaters of Platform Holly.



RICK STARR

Young-of-the-year yellowtail rockfish, midwaters of Platform Irene.



MARY NISHIMOTO

Juvenile bocaccio and widow rockfish, midwaters of Platform Grace.

Young-of-the-year and 1-yr old rockfishes of many species (e.g., bank, blue, olive, pygmy, shortbelly, square-spot, widow, and yellowtail rockfishes, and bocaccio) often formed highly mobile schools in the midwater habitat. During years of high abundance, these schools contained many thousands of individuals. Our experience suggests that these schools remained either inside the platform or ventured only a few meters outside it. Schools of young rockfishes tended to more closely associate with the jacket substrate during years of low recruitment or when water visibility was poor. However, when their numbers were high or water clarity was good, young rockfishes, while still living within the platform structure, only loosely associated with the crossbeams and vertical structure. In general, the schools occurred throughout 50 to 100 m or more (150–300 ft.) of the water column. Young copper, gopher, kelp, and flag rockfishes, treefish, and cowcod, as well as cabezon and painted greenling were generally observed either as solitary individuals or in small groups, usually intimately associated with the platform jacket.

Young-of-the-year rockfish settlement (recruitment) to midwater habitats is also strongly influenced by oceanographic conditions. The density of these fishes varied greatly inter-annually by location and among platforms (Figure 3.9). Spatial and temporal differences in young-of-the-year rockfish densities often varied by a factor of 10 or even 100. In several instances, a species that was entirely absent from a platform midwater in one year would recruit in great numbers in the following year. Between 1996 and 1998, young-of-the-year rockfish recruitment was generally higher around the platforms north of Point Conception in the Santa Maria Basin (Irene, Hidalgo, Harvest, and Hermosa) than at the structures in the Santa Barbara Channel (Holly, Grace, and Gail) (Figure 3.9). In contrast, these three years were a period of low rockfish recruitment for many species south of Point Conception both at platforms (Holly, Grace, and Gail) and natural outcrops. The colder water conditions of 1999 brought with it widespread recruitment for a number of rockfish species in California compared to the previous decades. This was reflected at all of the platforms surveyed (Figure 3.9). We should note that the 2000 data at Platforms A, B, C, Hillhouse, Hogan, Houchin, and Henry (see sidebar) strongly suggest that recruitment for some rockfish species, particularly blue and widow rockfishes, had been very successful in 1999. In 2000 and 2001, recruitment of some rockfish at Platforms Gail and Grace remained higher than pre-1999 levels (Figure 3.9). We hypothesize that this represents a successful response to the oceanographic regime shift to cooler temperatures that may be occurring in southern California and the greater northeast Pacific.

The population dynamics of bocaccio exemplifies the annual and geographic variability that occurs in rockfish recruitment at both platforms (Figure 3.9) and natural



Figure 3.10. Patterns of young-of-the-year (YOY) bocaccio settlement in 1999, as observed from the Delta submersible surveys.

outcrops (Figure 3.10). Prior to 1999, young-of-the-year bocaccio were absent at the platforms we surveyed (except Irene in 1996 and 1997). During 1999, large densities of young-of-the-year bocaccio were observed at Platforms Irene and Grace; small numbers of at least a few individuals were observed at most other platforms. Platform Grace provided the most striking example of inter-annual variability. Almost no young-of-the-year bocaccio were observed at Platform Grace prior to 1999. In contrast, during 1999, the platform harbored the third highest densities (after 1996 and 1999 at Platform Irene) of young bocaccio we observed around either platforms or natural outcrops during the six years of research. It is important to realize that even in years of relatively high rockfish recruitment, the actual process of settlement may result in a patchy distribution of young-of-the-year benthic recruits. Such patchiness was observed in the bocaccio recruitment pattern in 1999 at Platforms Grace and Gail, which are located only 8 km (5 miles) apart. While Platform Grace harbored large numbers of young bocaccio, they were much less abundant at nearby Platform Gail. Furthermore, our research has shown that successful rockfish recruitment at platforms does not always translate to

similar high densities of these species at nearby natural outcrops. Using the *Delta*, in 1999 we also surveyed 12 natural outcrops located in depths suitable for bocaccio recruitment and found little evidence of bocaccio recruitment over any of these structures (Figure 3.10).

In 2000, we studied the midwater habitats of Platforms C, B, A, Hillhouse, Henry, Houchin, Hogan, and Habitat. These platforms, located off Summerland east of Santa Barbara (Figure 1.1), were home to many typical midwater reef fishes, including juvenile blue, olive, and widow rockfishes (of the 1999 year class), blacksmith, kelp rockfish, kelp bass, painted greenling, halfmoon, and sharpnose seaperch. Unlike the species assemblage of the further offshore and the more northerly platforms, both garibaldi and California sheephead were common. In 1998, we surveyed Platform Edith and again found a typical mix of reef fishes, including blacksmith, halfmoon, opaleye, sheephead, and garibaldi. Complete species assemblages for all of these platforms are found in Appendix 3.



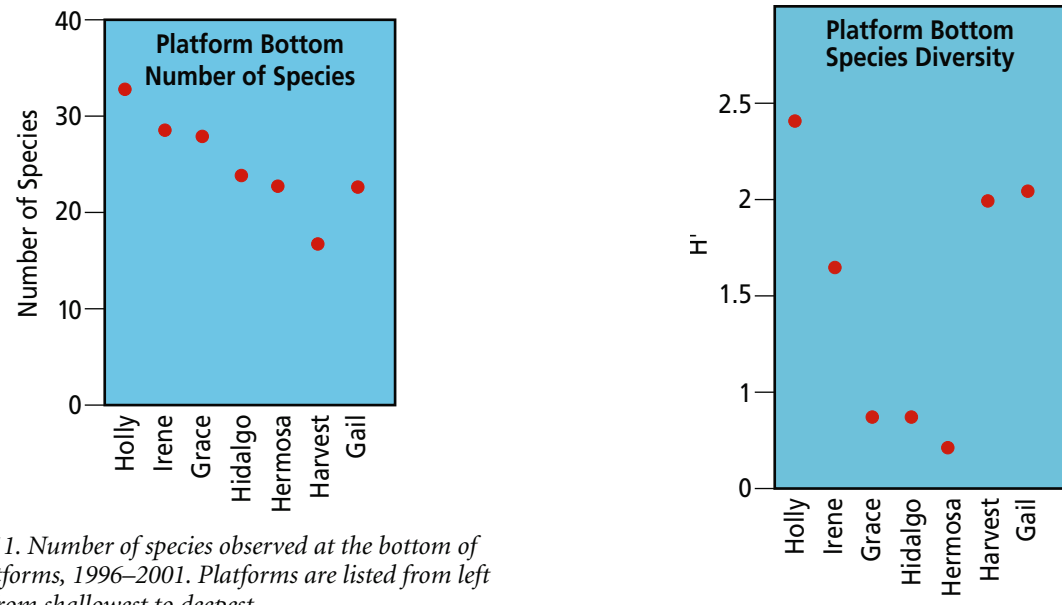


Figure 3.11. Number of species observed at the bottom of seven platforms, 1996–2001. Platforms are listed from left to right, from shallowest to deepest.

2c. Bottom Assemblages

Findings at a Glance

The bottom habitat of platforms is dominated by subadult and adult rockfishes. Young-of-the-year rockfishes were also abundant around some platform bottoms, occasionally in large numbers. In general, more than 90% of all the fishes found around platform bottoms were rockfishes. The numbers and estimated densities of all fishes in the bottom habitats are shown by platform in Appendix 3. Bottom depth strongly influenced the number of species, species diversity, and density of fishes living around platform bases. This is in direct contrast to the midwater habitat. The presence of young-of-the-year and older aged juveniles indicates that the bottom habitat of some platforms may be important nursery habitat for some species. The platform base appears to be important to many marine species, as it provides both refuge and prey.

Depth strongly influences fish assemblages in platform bottom habitat. Species richness varied widely from about 33 species at Platform Holly to 17 species at Platform Harvest. Generally, the shallower-water platforms harbored more species than platforms in deeper depths although this trend may have begun to reverse at Gail, the deepest platform (Figure 3.11). Species diversity was high at the shallowest and deepest platforms and lowest among the mid-depth structures (Figure 3.12). Conversely, overall fish densities were much higher at the mid-depth platforms than at the deepest platforms (Figure 3.13).

Figure 3.12. Diversity of fishes at the bottom of seven platforms, 1996–2001. Platforms are listed from left to right, from shallowest to deepest.

Diversity and abundance patterns were driven by the depth preferences of a suite of rockfishes that dominate the bottom habitats. For instance, brown, calico, copper, and vermilion rockfishes were most abundant around the shallower structures but were absent from the deepest platforms (Figure 3.13). Pile perch, painted greenling, and young-of-the-year lingcod displayed the same pattern. Juvenile lingcod were also abundant at the shallowest platforms, particularly at Platform Irene, but these were also occasional around even the deepest structures surveyed. Halfbanded rockfish and flag rockfish were typically found at the intermediate-depth platforms. Greenblotched, greenspotted, greenstriped, pinkrose, and striptail rockfishes were most abundant around the deeper structures (Figure 3.13). The juveniles of many of these species were found in shallower water or on the shell mounds.

Platform structure in the bottom habitats may influence the distribution of fishes. This habitat encompasses that area where the platform jacket and conductors physically meet the seafloor. At all of the platforms surveyed, there is a crossbeam that rests on, or is close to, the bottom. Some portions of this crossbeam may be completely buried by sediment or undercut by currents. The platform jacket and, in particular, the undercut crossbeam, appears to provide many of the attributes of a natural outcrop, providing high relief and large crevices. Many species, such as canary, flag, vermilion, and widow rock-

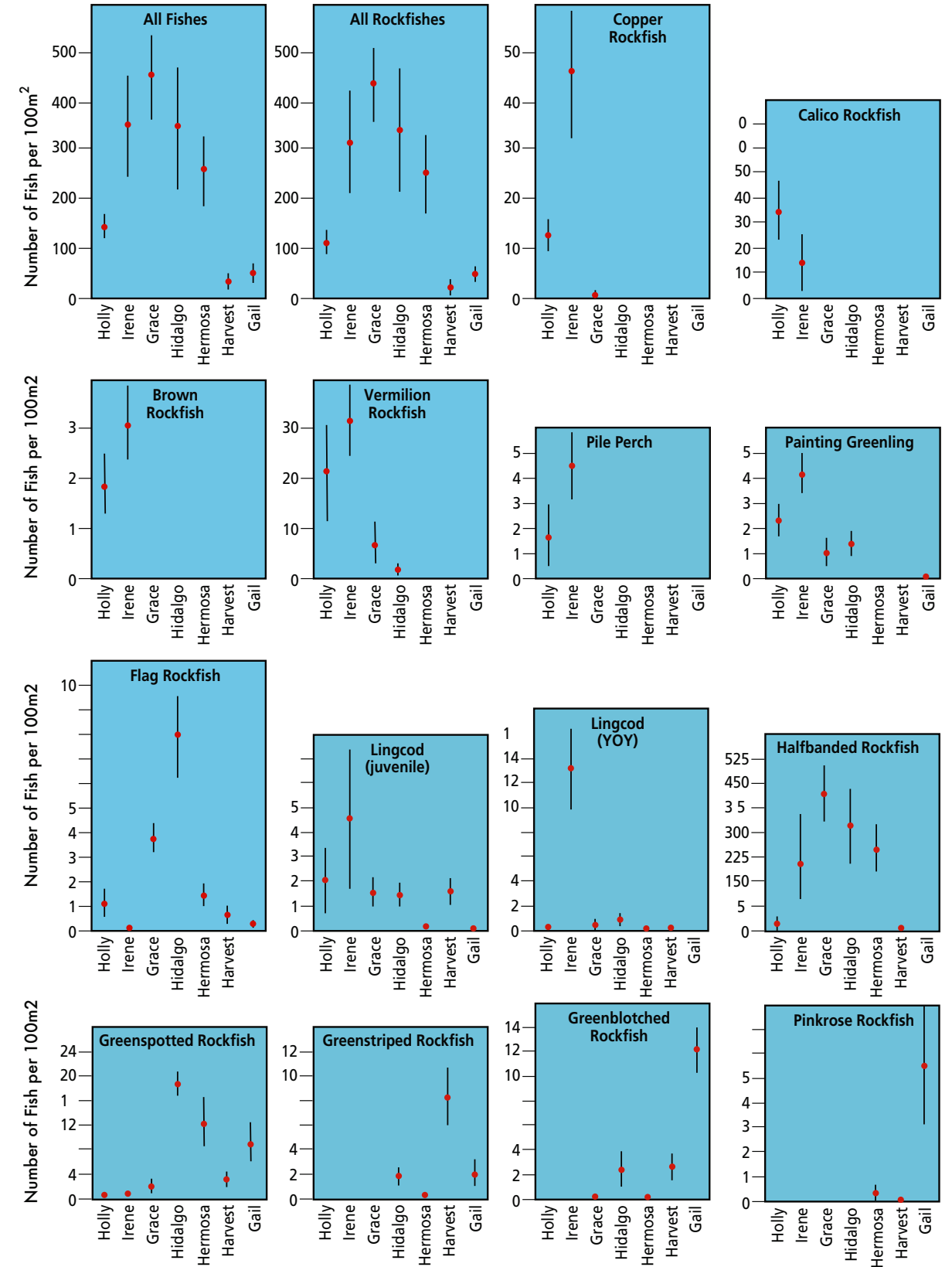


Figure 3.13. Densities (with standard error bars) of all fishes, all rockfishes and the most important species at the bottom of seven platforms, years combined, 1996–2001.

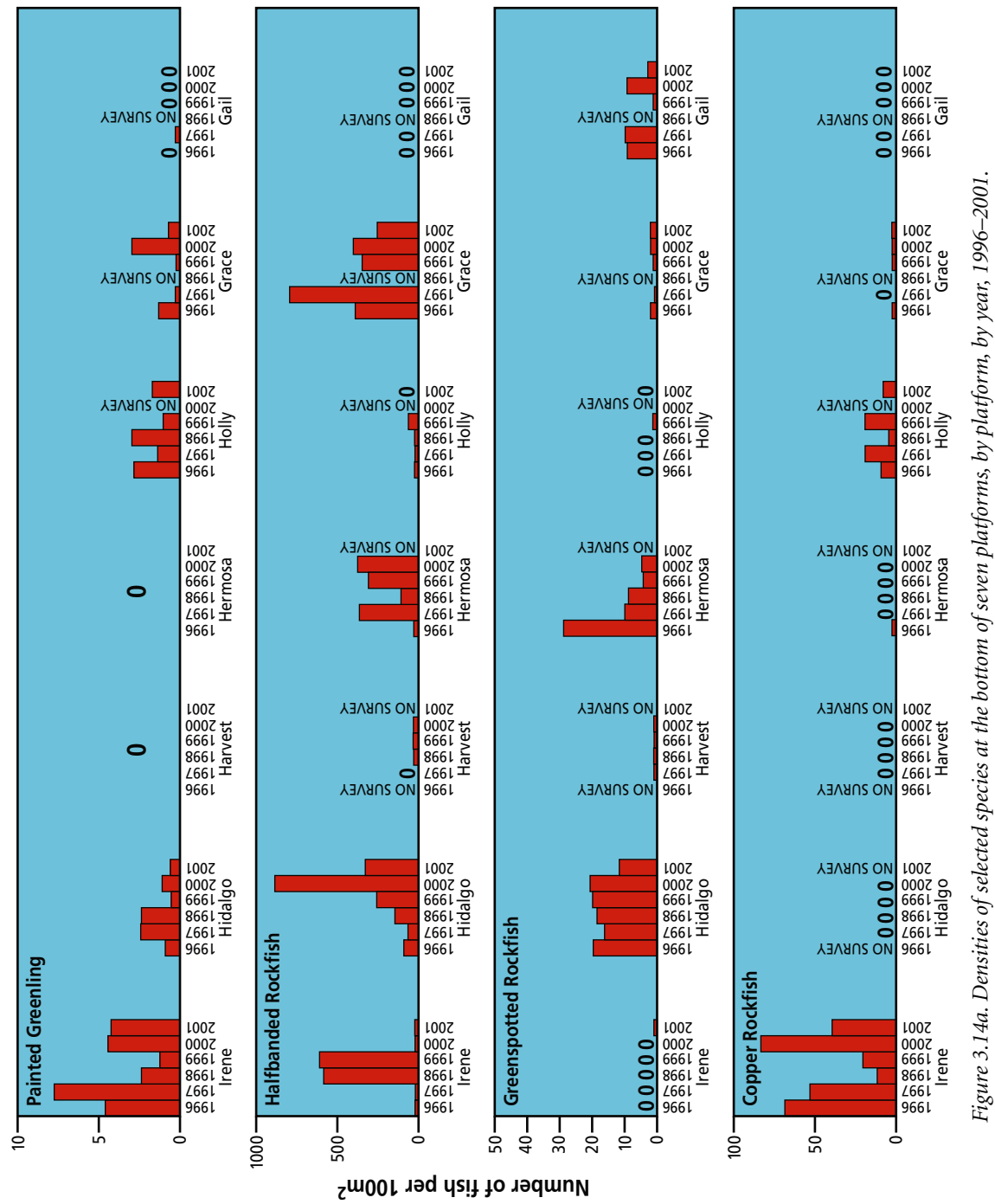


Figure 3.14a. Densities of selected species at the bottom of seven platforms, by platform, by year, 1996–2001.

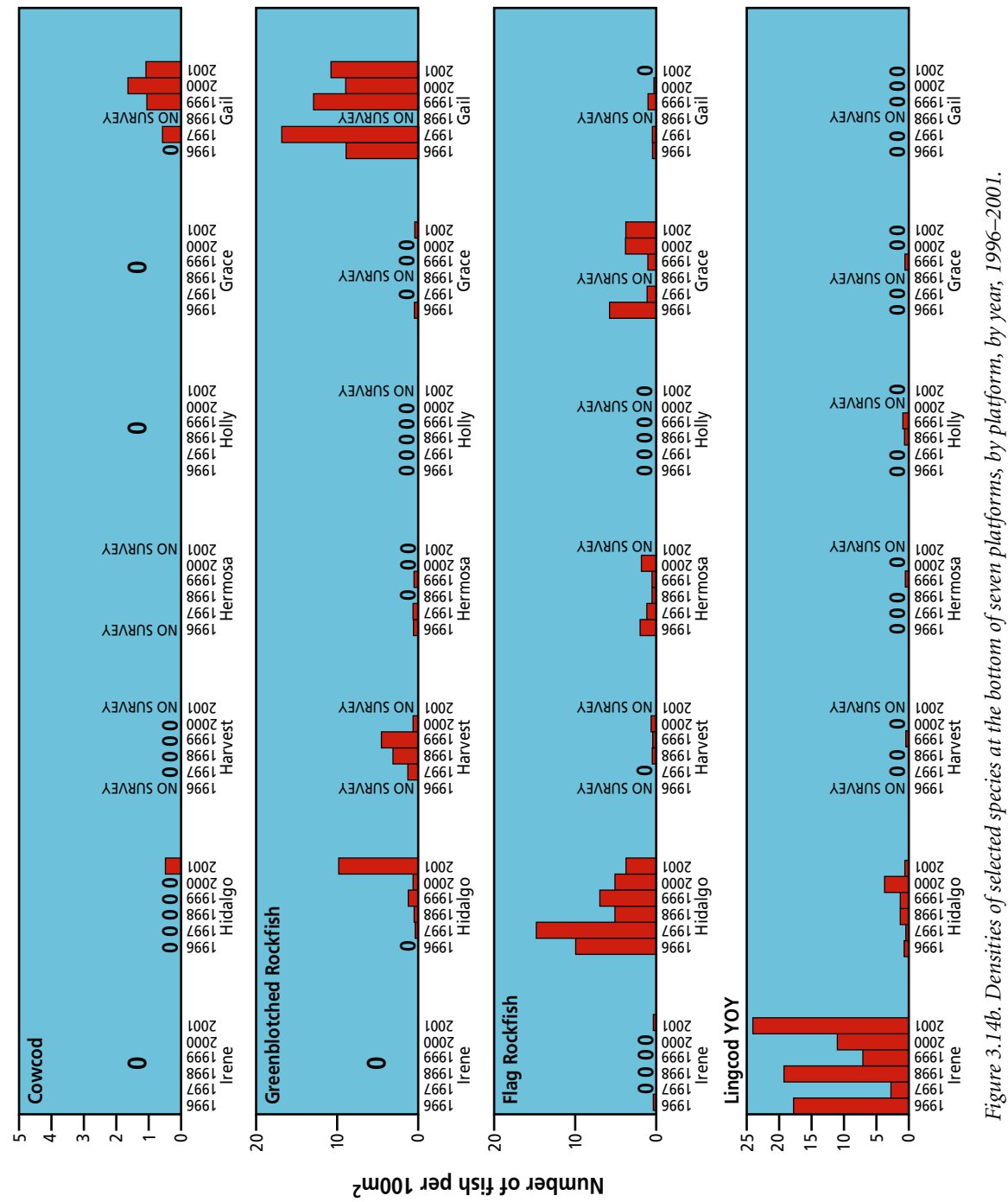


Figure 3.14b. Densities of selected species at the bottom of seven platforms, by platform, by year, 1996–2001.





MILTON LOVE

*Bocaccio, bottom of Platform Gail.*

DONNA SCHROEDER

*Subadult vermilion rockfish, bottom of Platform Grace.*

LINDA SNOOK

*Cowcod, bottom of Platform Gail.*

MILTON LOVE

*Lingcod, bottom of Platform Gail.*

fishes, bocaccio, pile perch, and painted greenling closely associate themselves with the platform jacket, particularly with the crossbeam. Similarly, larger copper, greenspotted, greenblotched, and pinkrose rockfishes and cowcod tend to shelter inside or immediately next to the platform. These fishes were particularly abundant where a space formed between the lowest crossbeam and the seafloor. Calico and greenstriped rockfishes and various life stages of lingcod were less closely associated with the structure. While most species rarely ascend more than a meter or two above the seafloor, bocaccio and halfbanded rockfish often rose as much as 5 m (17 ft.) above the bottom.

Most platform bottom species are either solitary or shelter in small groups. The exceptions are young-of-the-year rockfishes, juvenile and subadult brown, copper, halfbanded, and vermilion rockfishes, and bocaccio. On a number of occasions, we observed aggregations of tens



LINDA SNOOK

*Mexican and greenspotted rockfishes, bottom of Platform Gail.*

and hundreds of brown, copper, and vermilion rockfishes and bocaccio and large schools of halfbanded rockfish comprised of thousands of individuals.

Compared to midwater habitats, the fish species compositions at platform bottoms were relatively stable over time (Figures 3.14a, b). The dominant spe-

cies varied little between years at any platform. Thus a platform, such as Gail, that was dominated by adult greenspotted and greenblotched rockfishes, bocaccio, and cowcod in one year tended to be inhabited by these same species in all years in about the same abundances. Similar patterns were observed for such common species as painted greenling (Platforms Irene and Holly), greenspotted rockfish (Platforms Hidalgo and Hermosa), copper rockfish (Platforms Irene and Holly), and flag rockfish (Platform Hidalgo). It is likely that we were observing some of the same individuals each year. This constancy would be expected as these assemblages are at least partially composed of subadult and adult stages of relatively sedentary and long-lived rockfishes. Thus, the composition of the bottom assemblages is not determined by the year-to-year fluctuations in year-class success that is characteristic of the platform midwaters. However, the densities of a few important species, particularly halfbanded rockfish, varied annually. In some years halfbanded rockfish were essentially absent from a platform bottom, only to be extremely abundant the following year. Schools of this species are highly mobile and may have been present but not in the vicinity of the submersible when the survey was made.

Our observations indicate that the bottom habitat of some platforms may be particularly important for certain species. For example, young-of-the-year lingcod densities were much higher at Platform Irene and Hidalgo than at any natural outcrop during any year of the survey (Appendix 4).

Unlike most of the fishes living in the platform midwater, it is likely that the majority of the platform bottom-dwelling species feed on platform-associated prey. Many of these species, such as brown, copper, and flag rockfishes, eat a variety of crustaceans, molluscs, and small fishes, many of which live in and around the jacket, conductors, and shell mound. Other species, such as lingcod, cowcod, and bocaccio are opportunistic feeders, preying on a very wide range of organisms, including benthic and water column fishes, molluscs, and crustaceans (Love et al. 2002). Thus, for many benthic fishes, the platform base provides not only shelter but also an abundant source of food.

We conducted one survey, in 1998, around the base of Platform Edith. We found that California scorpionfish, sharpnose seaperch, blacksmith, and blackeye goby were the most abundant species. See Appendix 3 for a complete species list.

## 2d. Shell Mound Assemblages

### Findings at a Glance

Shell mounds support a rich and diverse fish assemblage. As at other platform habitats, rockfishes comprise the vast majority of the fishes. The many small sheltering sites created by mussels, anemones, and other invertebrates on the shell mounds provided structure in a habitat dominated by small fishes. Many of these fishes are the young-of-the-year and older-aged juveniles of lingcod and copper, flag, greenblotched, and pinkrose rockfishes and cowcod. The adults of these species inhabit the platform bottom.

Depending on platform, we observed between 17 and 30 species living on this habitat. In the shell mound habitat, the patterns of species numbers, diversity, and fish densities were similar to those observed around the platform bottoms. Species numbers generally decreased with increasing depth (Figure 3.15) although it increased sharply at the Platform Gail, the deepest structure. This increase was due to the occurrence of a number of deeper water species (e. g., rex sole, blackgill rockfish, and California smoothtongue) that were absent from other platforms. As in the platform bottom habitat, species diversity was highest at the shallowest and deepest platforms compared to shell mounds in intermediate depths (Figure 3.16).

The shell mounds surrounding all platforms provided habitat and refuge for a diverse assemblage of fishes. Fish densities were highest on the intermediate-depth platform shell mounds (Figure 3.17). However, as in the platform midwater and bottom, a majority of these fishes are rockfishes; between 53% and 98% of all fishes living on the shell mounds are rockfishes (Appendix 3). Furthermore, when highly migratory and non-resident species, such as Pacific hake and Pacific sardine, are eliminated from the analysis, rockfishes comprise more than 80% of the shell mound fauna at each of the seven platforms surveyed. Those species most characteristic of the shell mounds exhibited distinct depth preferences (Figure 3.17) and the abundance of some of these fishes was responsible for the higher densities in the intermediate bottom depths. The dominant species of the shallow water shell mounds were vermilion, copper, and calico rockfishes, young-of-the-year and immature lingcod, and painted greenling. A few species, such as greenspotted and halfbanded rockfishes, were most common in the intermediate bottom depths. It was primarily the very high densities of halfbanded rockfish that were responsible for the overall high densities at intermediate-depth shell mounds. Greenstriped, pinkrose, and stripetail rockfishes



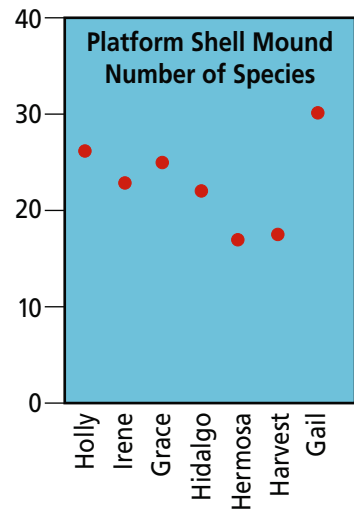


Figure 3.15. Number of fish species observed on the shell mounds of seven platforms, 1996–2001. Platforms listed left to right from shallowest to deepest.

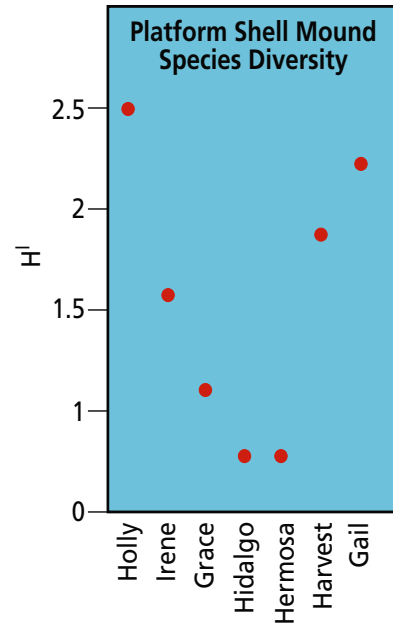


Figure 3.16. Diversity of all fishes observed on the shell mounds of seven platforms, 1996–2001. Platforms are listed left to right from shallowest to deepest.

were most abundant at the deepest platforms surveyed.

The mosaic of small refuge sites created by mussels, anemones, and other invertebrates are occupied by small fishes. Many of these fishes are the juveniles of such species as lingcod and copper, flag, greenblotched, and pinkrose rockfishes and cowcod, whose adults inhabit the adjacent platform bottom. Small sheltering sites are rarely found at the platform bottom. In part, this explains why fishes tend to be smaller on a shell mound than on the associated platform bottom (Table 2). This also explains why the shell mound assemblage so closely resembles its counterpart around the adjacent platform bottom. Painted greenling, calico, and halfbanded rockfishes, shortspine combfish, blackeye goby, and the poachers are among the dwarf species occupying the shell mound. Juveniles of the species characteristic of platform midwaters, such as blue and widow rockfishes, are rare over the shell mounds.

Most shell mound species are solitary fishes, living just above the seafloor or nestled among the shell debris or around anemones, seastars, and other large invertebrates. The only schooling species is the halfbanded rockfish that often forms highly mobile schools of 100 to 1,000 or more individuals.

It is likely that many of the fishes, including most of the rockfishes, combfishes, painted greenling, and other benthic species are resident to the shell mound habitat. Highly mobile and migratory species, such as northern anchovy, Pacific sardine, and juvenile Pacific hake, that were observed over the shell mounds probably spend only a relatively short period associated with this habitat.

Shell mound surveys were conducted around Platform Edith in 1998 and around Platform C in 2000. Young vermilion rockfish, as well as halfbanded and calico rockfish, were the most abundant species around Platform C. These species were also characteristic of the shell mound at Platform Holly, which lies in a similar depth. California scorpionfish and blackeye goby dominated the shell mound around platform Edith. Edith lies a few miles southeast of Long Beach and near a known California scorpionfish spawning grounds (Love et al. 1987). California scorpionfish are relatively uncommon in the Santa Barbara Channel and are rare north of Point Conception. This distribution explains the near absence of this species from other shell mounds we surveyed.

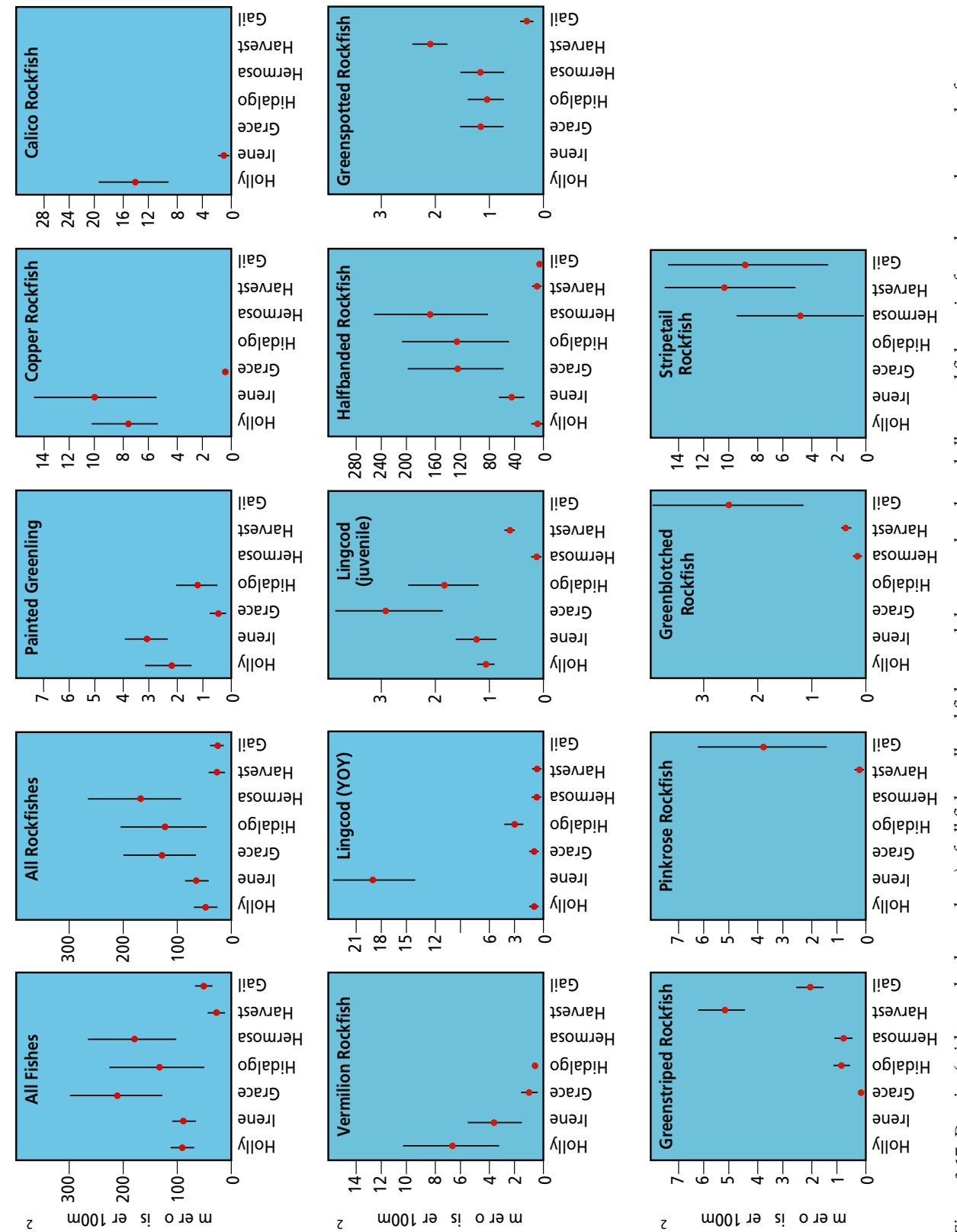


Figure 3.17. Density (with standard error bars) of all fishes, all rockfishes, and the most abundant shell mound fish species found around seven platforms, 1996–2001. Platforms are listed left to right from shallowest to deepest.



MILTON LOVE

Pinkrose rockfish, shell mound of Platform Gail.



MILTON LOVE

Greenspotted and flag rockfishes, shell mound of Platform Gail.



LOVELAB, UC SANTA BARBARA

Young-of-the-year cowcod on shell mound of Platform Gail.



MILTON LOVE

Halfbanded rockfish, shell mound of Platform Hidalgo.

### 3. A Comparison of Fish Assemblages at a Deeper Platform and a Nearby Natural Outcrop: Hidalgo and North Reef

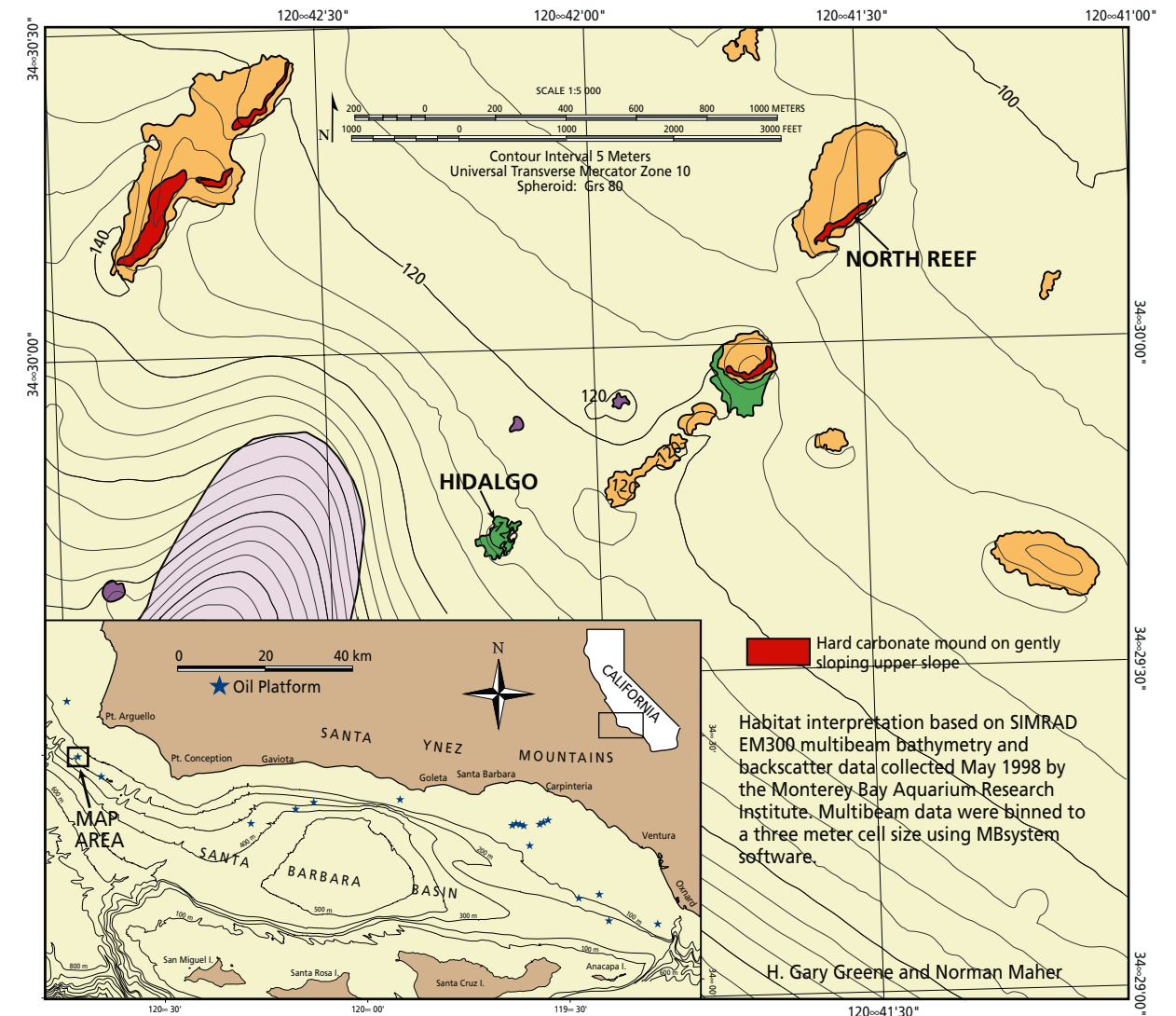
#### Findings at a Glance

The species composition at Platform Hidalgo and North Reef are quite similar as both structures are dominated by rockfishes. In general, the distinctions between the platform and reef assemblages were based on differences in species densities (rather than species presence or absence). Most species were more abundant at Platform Hidalgo than at North Reef. Halfbanded, greenspotted, flag, greenstriped, and canary rockfishes, all three life stages of lingcod (young-of-the-year, immature, adult), and painted greenling all had higher densities around the platform. Five species (i.e., pink seaperch, shortspine combfish, pygmy, squarespot, and yellowtail rockfishes) were more abundant at the reef. The dominance of small fishes at North Reef probably reflects fishing pressure that has cropped larger individuals. Young-of-the-year

rockfishes were found at both Platform Hidalgo (primarily in the midwaters) and at North Reef. In each of five years, young-of-the-year rockfish density was higher at the platform than at the reef. In several years, densities of these young fishes were more than 100 times greater at Platform Hidalgo than at North Reef.

We surveyed the fish assemblages at Platform Hidalgo and a nearby natural outcrop, North Reef, for the period 1996–2001. North Reef was compared with Platform Hidalgo because it is close to the platform (about 1,000 m, 3,300 ft., north of the platform) (Figure 3.18), and its depth (112 m, 370 ft.) is comparable to the platform's 130 m (430 ft.). North Reef is a hard carbonate scarp, which is 1–4 m (3–13 ft.) high, 3,353 m<sup>2</sup> in area and contains numerous boulders, caves, and crevices.

The species composition at Platform Hidalgo and North Reef are very similar (Table 3). Both habitats are dominated by rockfishes; they comprised 98.3% and



Benthic Habitats: Hidalgo Oil Platform and Surrounding Seafloor Including North Reef

Figure 3.18. Locations of Platform Hidalgo and North Reef. Seafloor characterization by Gary Greene, Moss Landing Marine Laboratory.

96.6% of all fishes at Platform Hidalgo and North Reef, respectively. We observed a minimum of 34 fish species at each location. A few species were unique to each structure. Copper and striptail rockfishes and California scorpionfish were found only at Platform Hidalgo, while blackeye goby, bluebarred prickleback, Pacific argentine, speckled sanddab, and an unidentified cuskeel were present only at North Reef. None of these species were major constituents of their respective fish communities.

However, when taking into consideration the fish assemblages of the three habitats (midwater, bottom, and shell mounds) at Platform Hidalgo, each was somewhat distinct from that of North Reef (Figure 3.19). To char-

acterize and distinguish between the species assemblages at Platform Hidalgo and North Reef, we compared only the benthic assemblages of the platform bottom and shell mound and North Reef. Canonical discriminant analysis showed that species assemblages at the bottom of Platform Hidalgo and its shell mound were somewhat different from each other and from the North Reef assemblages (Figure 3.20a). The platform bottom assemblage was characterized by a suite of rockfishes, including bocaccio and cowcod, flag, vermilion, and widow rockfishes and lingcod. The shell mound assemblage was similar to and overlapped with the platform bottom, but was characterized by smaller fishes, such as swordspine,



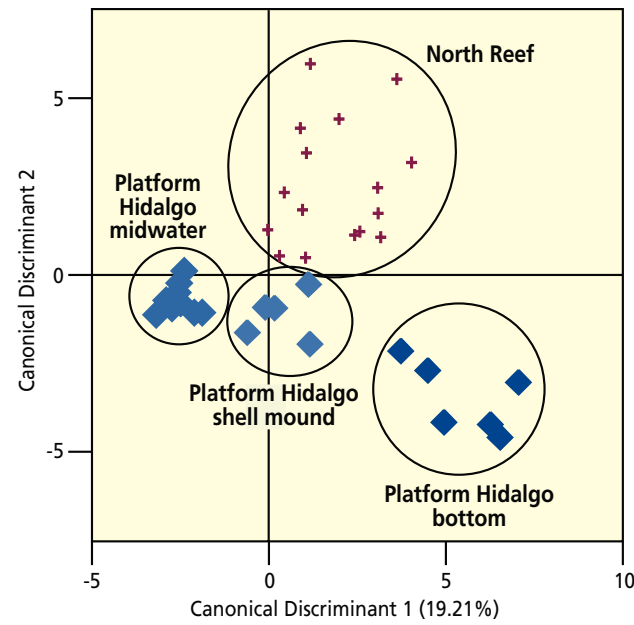


Figure 3.19. Canonical Discriminant Analysis of fish assemblages at Platform Hidalgo, midwater, bottom, and shell mound habitats and North Reef, 1996–2001.

greenstriped and halfbanded rockfishes, painted greenling, and juvenile lingcod (Figure 3.20b).

In general, the distinctions between the platform and reef assemblages were based on differences in species densities rather than species presence and absence. The densities of a range of species varied between the two sites (Figure 3.21) and most exhibited higher densities at Platform Hidalgo than at North Reef (Figure 3.21). Halfbanded, greenspotted, flag, greenstriped, canary rockfishes, all three life stages of lingcod (young-of-the-year, immature, adult), and painted greenling were among the species that were more abundant around the platform. Five species (pink seaperch, shortspine combfish, pygmy, squarespot, and yellowtail rockfishes) were more abundant at the reef.

Young-of-the-year rockfishes were common at both Platform Hidalgo (primarily in the midwaters) and at North Reef, although species differences were observed. From our submersible surveys, we identified at least seven species of young-of-the-year rockfishes at Hidalgo (e.g., blue, bocaccio, olive, pygmy, squarespot, widow, and yellowtail). Our scuba surveys around that platform also noted young-of-the-year of the “copper complex,” composed of black-and-yellow, copper, gopher, and kelp rockfishes. Most of the young-of-the-year rockfishes at North Reef appeared to be pygmy, squarespot, and widow rockfishes.

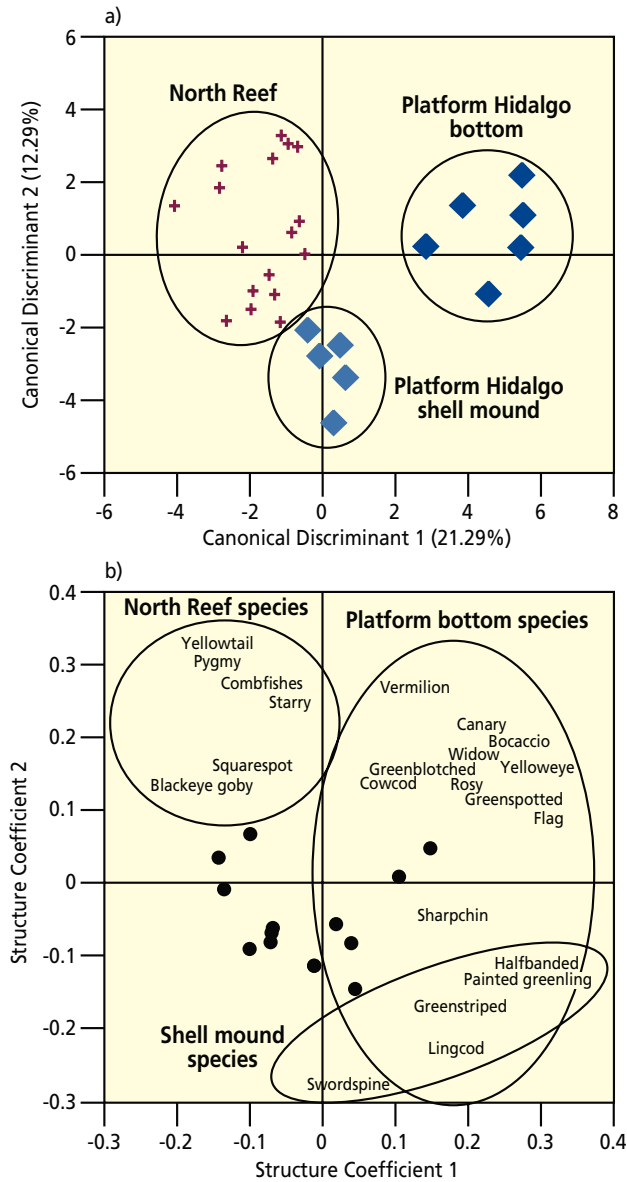


Figure 3.20. 3.20a. Canonical Discriminant Analysis of fish assemblages at Platform Hidalgo bottom and shell mound habitats and North Reef, 1996–2001. Each yearly survey at North Reef was comprised of 2–3 transects and thus each year’s survey is represented by more than one cross. 3.20b. Canonical Discriminant Analysis of the species found around Platform Hidalgo, bottom and shell mound and North Reef, 1996–2001. Dots represent species that were not strongly associated with either axis.

The mean density of young-of-the-year rockfishes in the midwater habitat of Platform Hidalgo was higher than at North Reef (Figure 3.21). This probably reflects greater rockfish recruitment to the platform. This has important implications with respect to platform habitat values regarding settlement and fish production around

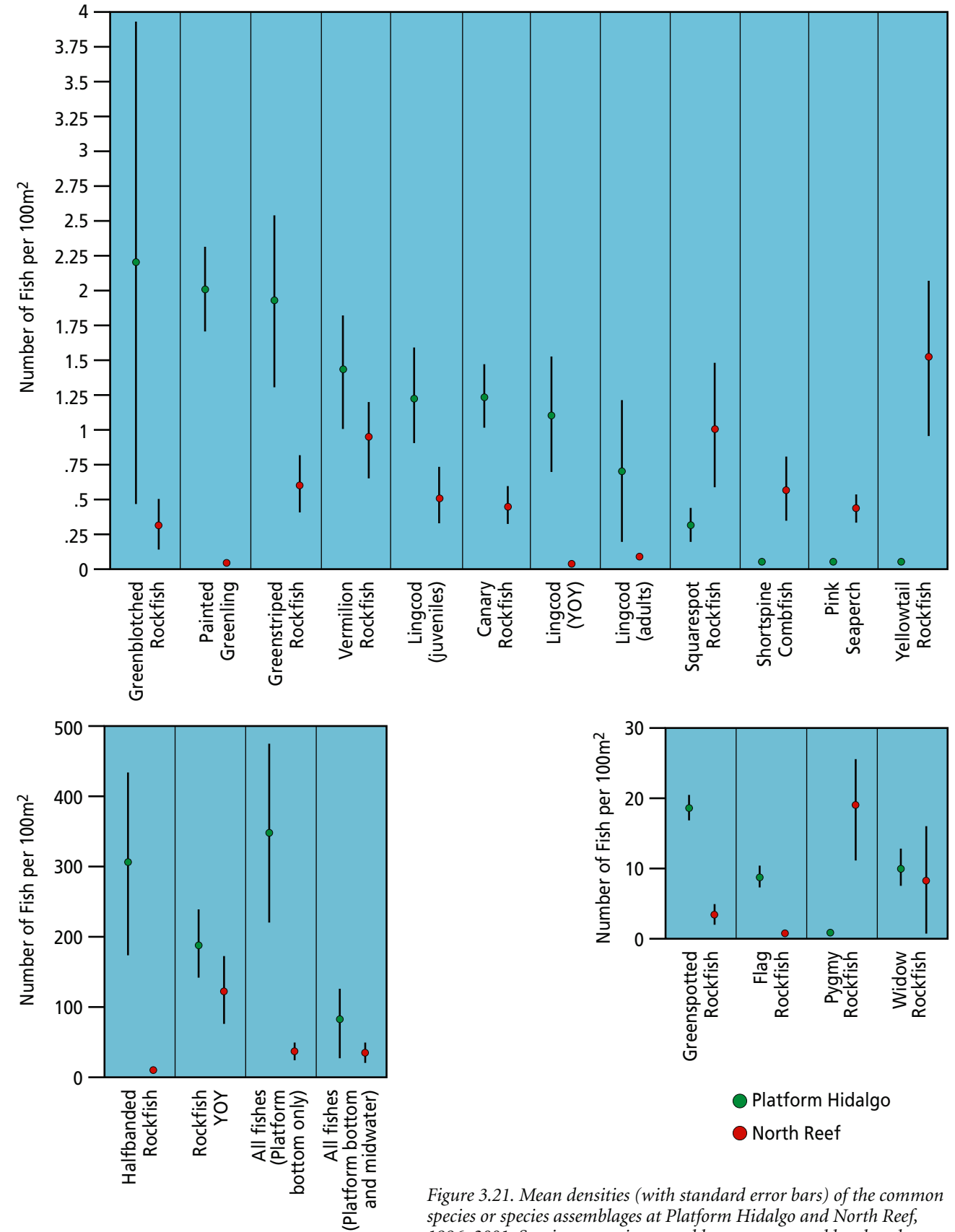


Figure 3.21. Mean densities (with standard error bars) of the common species or species assemblages at Platform Hidalgo and North Reef, 1996–2001. Species or species assemblages are grouped by abundance.

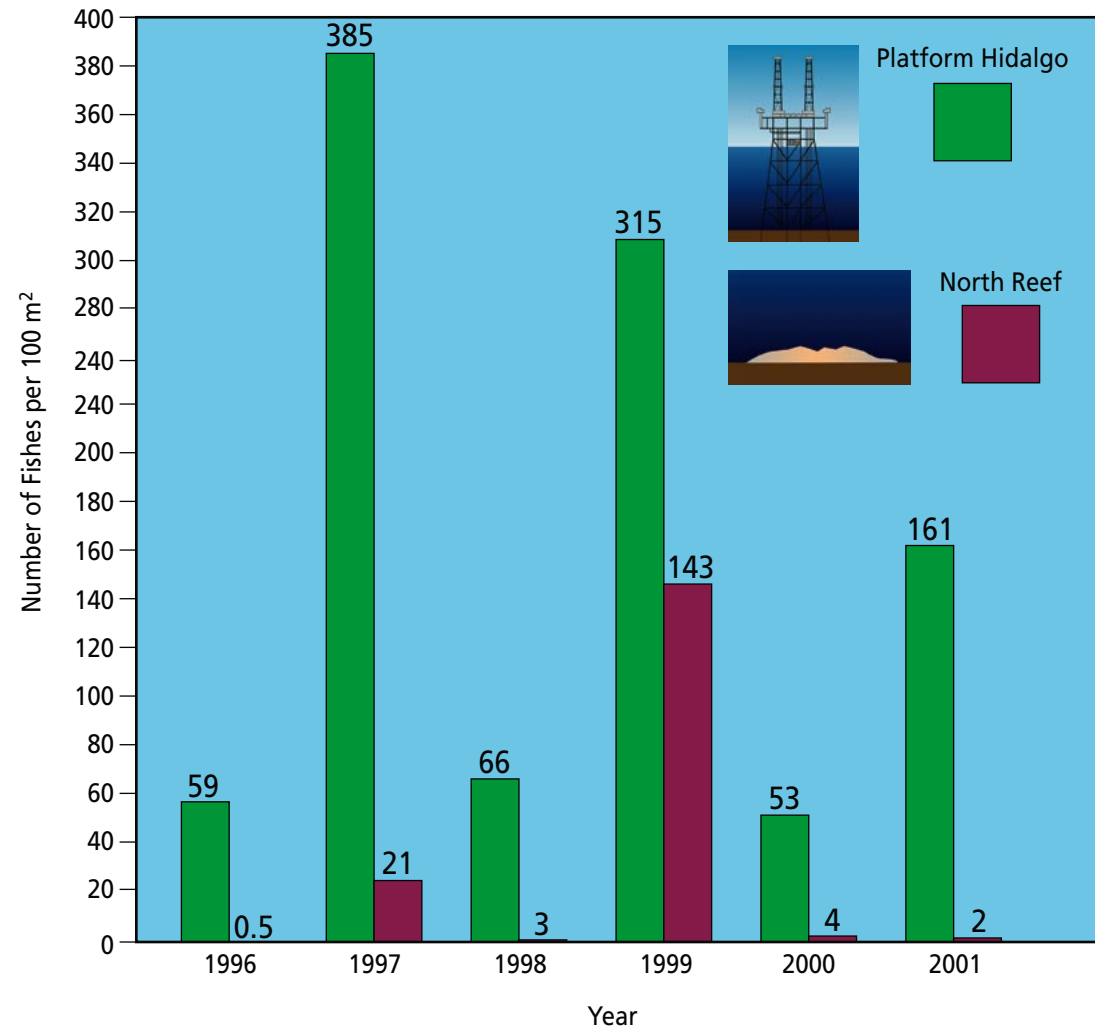


Figure 3.22. Mean densities of young-of-the-year rockfishes, all species combined, at Platform Hidalgo midwater and North Reef, 1996–2001.

these structures. This recruitment pattern was repeated in each year of our surveys as young-of-the-year rockfish densities were always greater at the platform than at the outcrop (Figure 3.22). In some years, densities were more than 100 times greater at the platform.

#### 4. A Comparison of Fish Assemblages of Platforms and Natural Outcrops off Central and Southern California

##### Findings at a Glance

Based on surveys of seven platforms and over 80 natural outcrops, rockfishes dominate almost all of the platform and hard seafloor habitats. A greater number of species was observed at the natural outcrops (94) than at the platforms (85). There is a high degree of overlap in species composition and differences are primarily

due to generally higher densities for more species at platforms. In particular, widow rockfish young-of-the-year, canary, copper, flag, greenblotched, greenspotted, greenstriped, halfbanded, and vermilion rockfishes, bocaccio, painted greenling and all life history stages of lingcod were more abundant at platforms. Yellowtail rockfish and the dwarf species pygmy, squarespot, and swordspine rockfishes were more abundant on natural outcrops. Some of these differences can be explained by recruitment (settlement) processes and the greater chance for survival at the platform habitats. We believe that as fish size increases with age the platforms act as de facto marine reserves because fishing pressure is light or nonexistent. Platforms can be characterized as having higher densities of young-of-the-year rockfishes than natural outcrops.

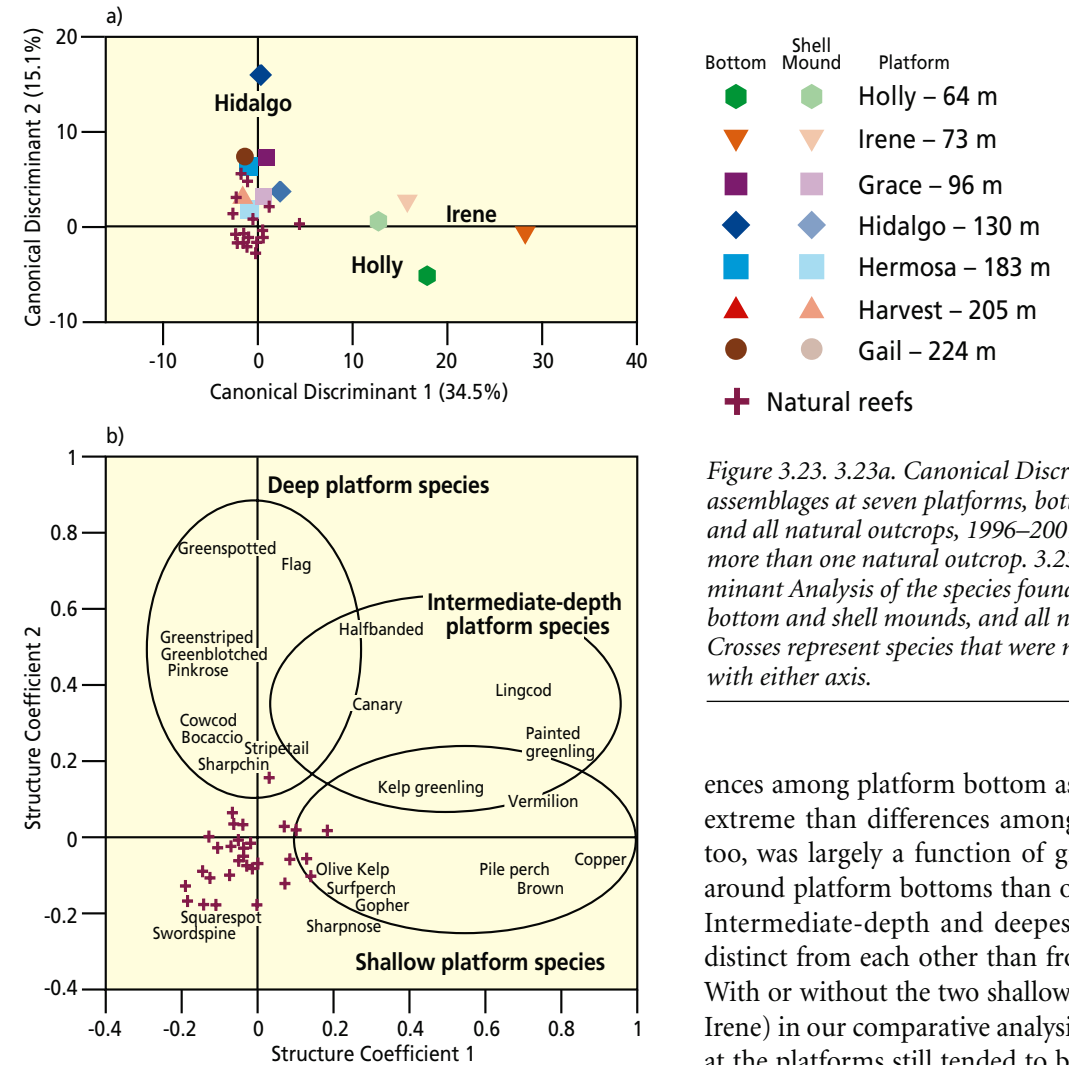


Figure 3.23. 3.23a. Canonical Discriminant Analysis of fish assemblages at seven platforms, bottom and shell mound, and all natural outcrops, 1996–2001. Each cross represents more than one natural outcrop. 3.23b. Canonical Discriminant Analysis of the species found at seven platforms, bottom and shell mounds, and all natural reefs, 1996–2001. Crosses represent species that were not strongly associated with either axis.

ences among platform bottom assemblages were more extreme than differences among shell mounds. This, too, was largely a function of greater fish abundance around platform bottoms than over the shell mounds. Intermediate-depth and deepest platforms were less distinct from each other than from shallow platforms. With or without the two shallow platforms (Holly and Irene) in our comparative analysis, the fish assemblages at the platforms still tended to be different from those at the natural outcrops (Figures 3.24a, b). These differences were primarily due to most fish species being more abundant at platforms than at outcrops (Figure 3.25). Widow rockfish young-of-the-year, canary, copper, flag, greenblotched, greenspotted, greenstriped, halfbanded, and vermilion rockfishes, bocaccio, painted greenling, and all life history stages of lingcod were more abundant at platforms. Species that were more abundant at natural outcrops than platforms included pygmy, squarespot, swordspine, and yellowtail rockfishes.

Platforms tended to harbor higher densities of young-of-the-year rockfishes than did natural outcrops. Young-of-the-year rockfishes primarily occurred in the platform midwaters. Thirteen of the 20 highest young-of-the-year rockfish densities were observed at Platforms Grace, Harvest, Hermosa, Hidalgo, Holly, and Irene (Table 5). The highest young-of-the-year rockfish densities over natural outcrops were usually at high relief sites well away from the mainland. The California Current, which is centered

We compared the fish assemblages from the deeper parts of seven platforms (below about 30 m, 100 ft.) with those of similar depth natural outcrops. Analyses were based on platform surveys and on 133 dives at over 80 natural outcrops throughout southern California and off Point Conception and Point Arguello (Figure 1.5).

We observed at least 85 species at platforms and 94 species at outcrops (Table 4). Rockfishes dominated both habitats, comprising 89.7% of all fishes at platforms and 92.5% at outcrops. Platform fish assemblages were somewhat different from those of natural outcrops (Figures 3.23a, b). However, these differences were due almost entirely to the generally greater numbers, of more species, of fishes around platforms, rather than differences in species composition between platforms and outcrops.

There was a distinct assemblage of fishes at the two shallow platforms, Holly and Irene, and another composed of species occupying the deeper platforms. Differ-

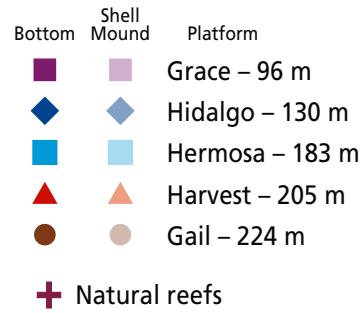
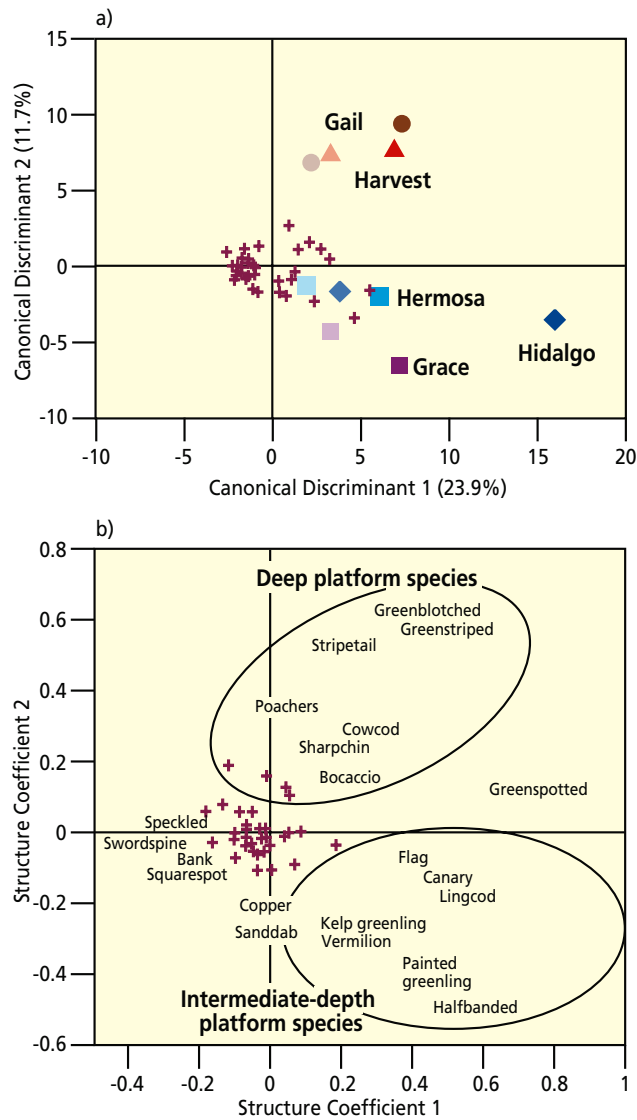


Figure 3.24. 3.24a. Canonical Discriminant Analysis of fish assemblages at five platforms (shallower platforms Holly and Irene deleted), bottom and shell mound, and all natural outcrops, 1996–2001. Each cross represents more than one natural outcrop. 3.24b. Canonical Discriminant Analysis of the species found at five platforms (shallower platforms Holly and Irene deleted), bottom and shell mound, and all natural outcrops, 1996–2001. Crosses represent species that were not strongly associated with either axis.

rockfishes greater than or equal to 30 cm (12 in.), (3) adult bocaccio, and (4) adult cowcod (Figures 3.26–3.29). Our experience is that rockfishes are most susceptible to being caught by both recreational and commercial gear when they reach about 30 cm (12 in.); thus, densities of fishes of this or larger sizes would be an indication of fishing pressure. Adult bocaccio and cowcod are overfished species with population sizes at levels less than 10% of unfished stock. These fishes at one time were abundant in southern California.

Rockfishes were observed at all of the platforms and outcrops we surveyed, with the exception of two sites on Piggy Bank (Figure 3.26). The highest rockfish densities (500 rockfishes or more per 100 m<sup>2</sup>) occurred at four platforms and at five natural outcrops; all of these structures were nursery grounds for young-of-the-year rockfishes. The assemblages of most of the other platforms and outcrops that harbored relatively high rockfish densities also were primarily composed of small rockfishes, both immature individuals and dwarf species. This can be clearly seen when we focussed on rockfishes 30 cm (12 in.) or larger (Figure 3.27). The paucity of rockfishes 30 cm (12 in.) or larger is evident even at the most productive sites (Figure 3.27). Highest densities of large rockfishes (10 rockfishes or more per 100 m<sup>2</sup>) occurred at three platforms and two natural outcrops. Many sites harbored no or only a few larger rockfishes.

Almost all of the natural outcrops we studied should have harbored large numbers of larger rockfishes. Their absence or rarity is almost certainly attributable at least

offshore of the coastal shelf, influences these locations (e.g., San Nicolas and San Miguel islands) more than the mainland sites we surveyed. Furthermore, our observations strongly imply that the midwaters of many platforms bear a striking resemblance to some of the relatively shallow and steep-sided outcrops (such as those on Hidden Reef) that dot the outer continental shelf of southern California. In both cases, the assemblages are dominated by young rockfishes and larger fish predators are relatively uncommon. Thus, survivorship of young fishes may be higher in both habitats due to lowered predation rates.

The role that some platforms play as defacto marine refuges is supported by evidence of greater densities of rockfishes, particularly the larger size classes, at platforms compared to natural outcrops. As an example, densities tended to be higher at some platforms than at natural outcrops for: (1) all rockfishes regardless of size, (2) all

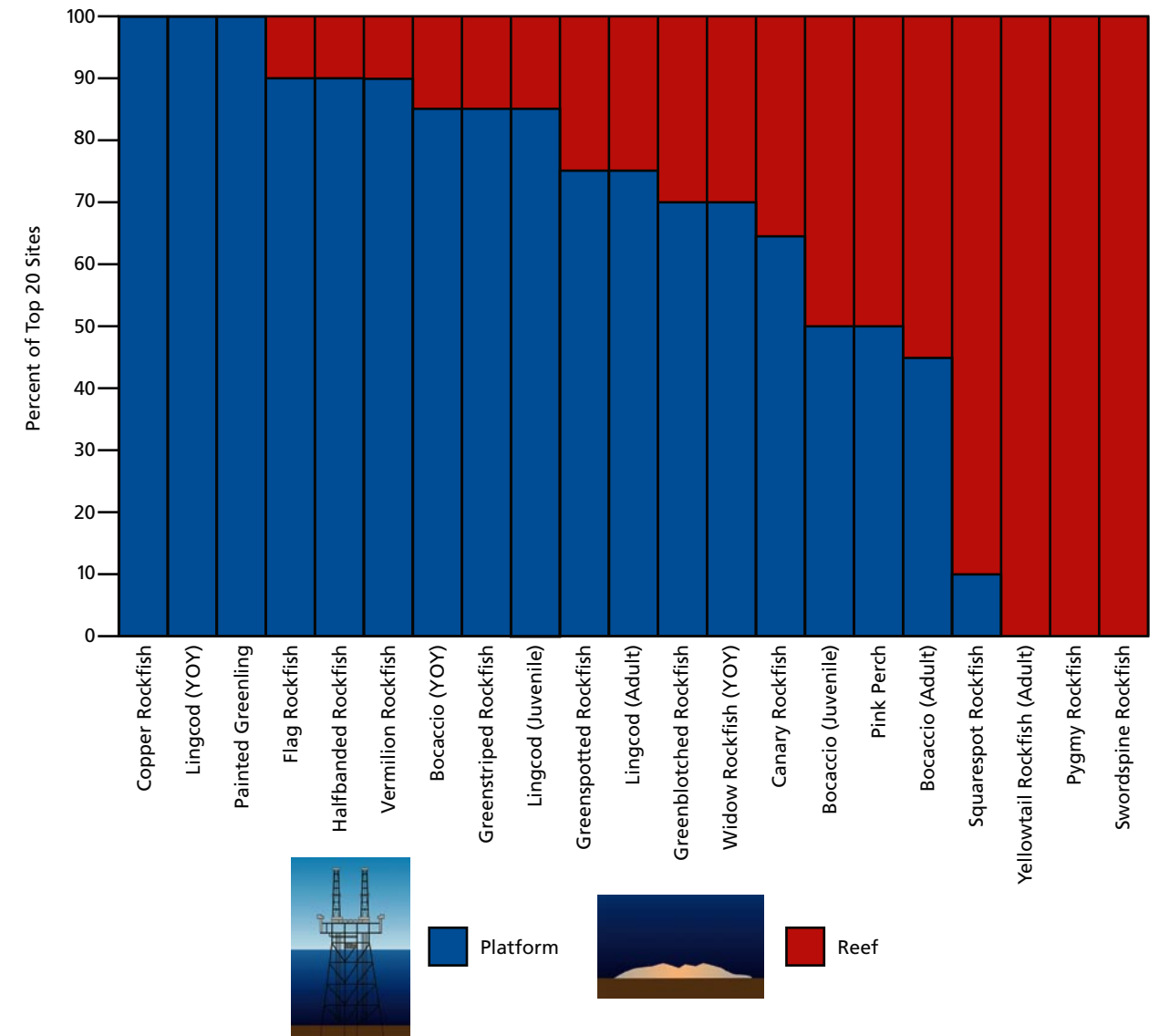


Figure 3.25. The relative importance of seven platforms (Irene, Hidalgo, Harvest, Hermosa, Holly, Grace, and Gail) and about 80 natural outcrops off central and southern California as habitat for common reef fish species. Densities of these species were computed for each year, at each location (platform midwater, bottom and shell mound, and natural outcrops) and ranked from highest to lowest. This figure displays the percentage that platforms or natural outcrops comprised of the top 20 densities for each species (or species' life history stage). For example, of all sites where copper rockfish were observed, the highest 20 densities were at various platforms, in a number of years. Similarly, the highest 20 densities of swordspine rockfish were all at natural outcrops. See Appendix 4 for underlying data.

in part to fishing pressure. These sites were comprised of boulders or other structures that were suitable shelter sites for larger sized rockfishes. A few outcrops, such as sites near the Potato and Osborn Banks, were composed of cobble, a habitat that is less likely to harbor large rockfishes. Adult bocaccio were only abundant around Platform Gail and were relatively common at Platform Hidalgo, Reef “D” near that platform and a few sites around the northern Channel Islands (Figure 3.28). Even at these natural out-

crops, many shelter structures contained no or few adult bocaccio. Cowcod densities were also depressed (Figure 3.29). Relatively few rock outcrops surveyed contained adults, and platform Gail harbored the highest densities, although even here numbers were low. In general, the highest densities of adult bocaccio and cowcod occurred at platforms or at those outcrops that were protected from harvest by distance from ports or by being situated in areas susceptible to poor weather conditions.



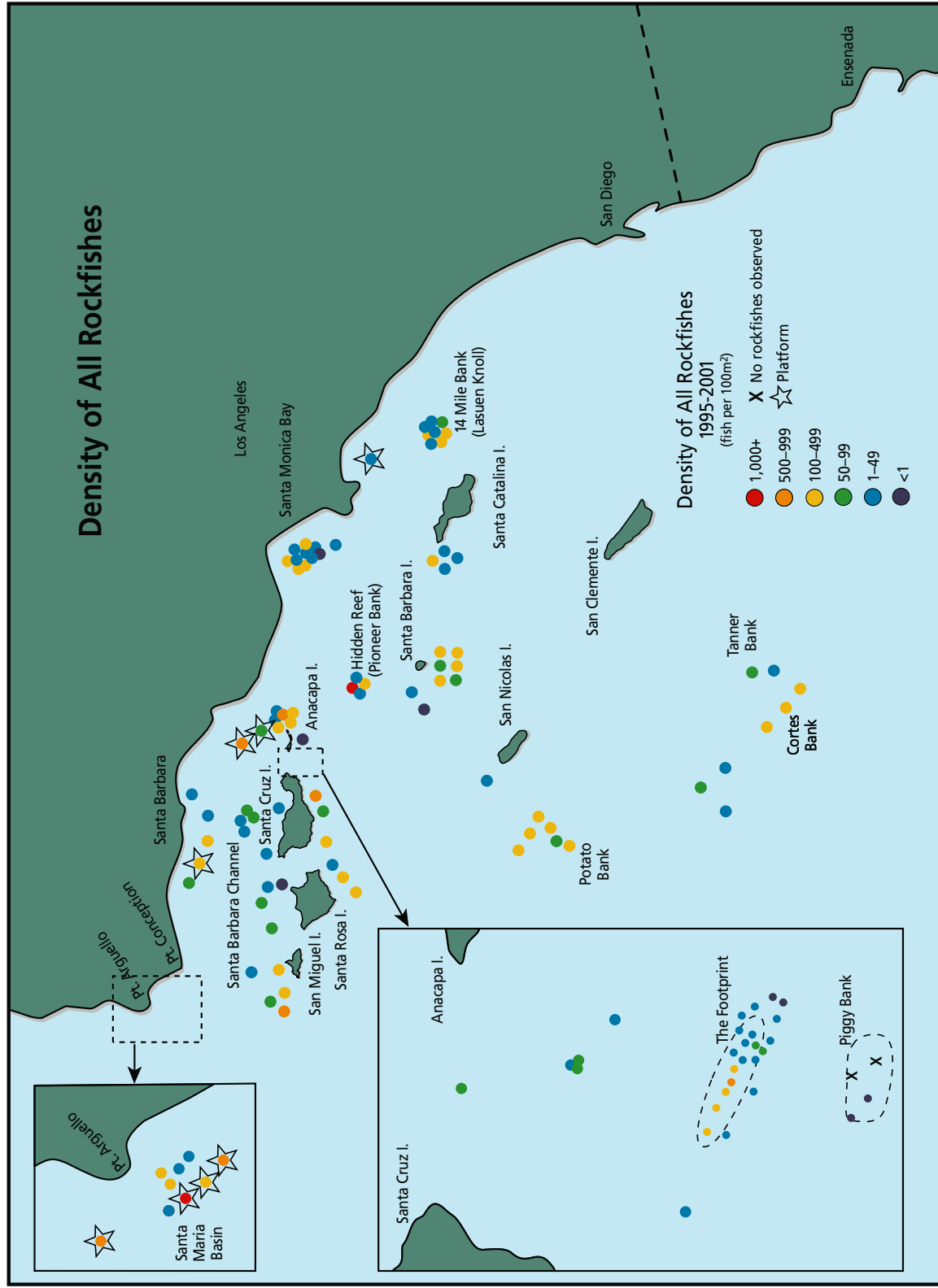


Figure 3.26. Density of all rockfishes, regardless of size, as observed from the Delta submersible on platforms and natural outcrops, 1995–2001. Fish densities for Platforms Irene, Hidalgo, Harvest, Hermosa, Holly, Grace and Gail, North Reef and reefs “A”, “B”, “C” and “D” in the vicinity of Platform Hidalgo represent means of years.

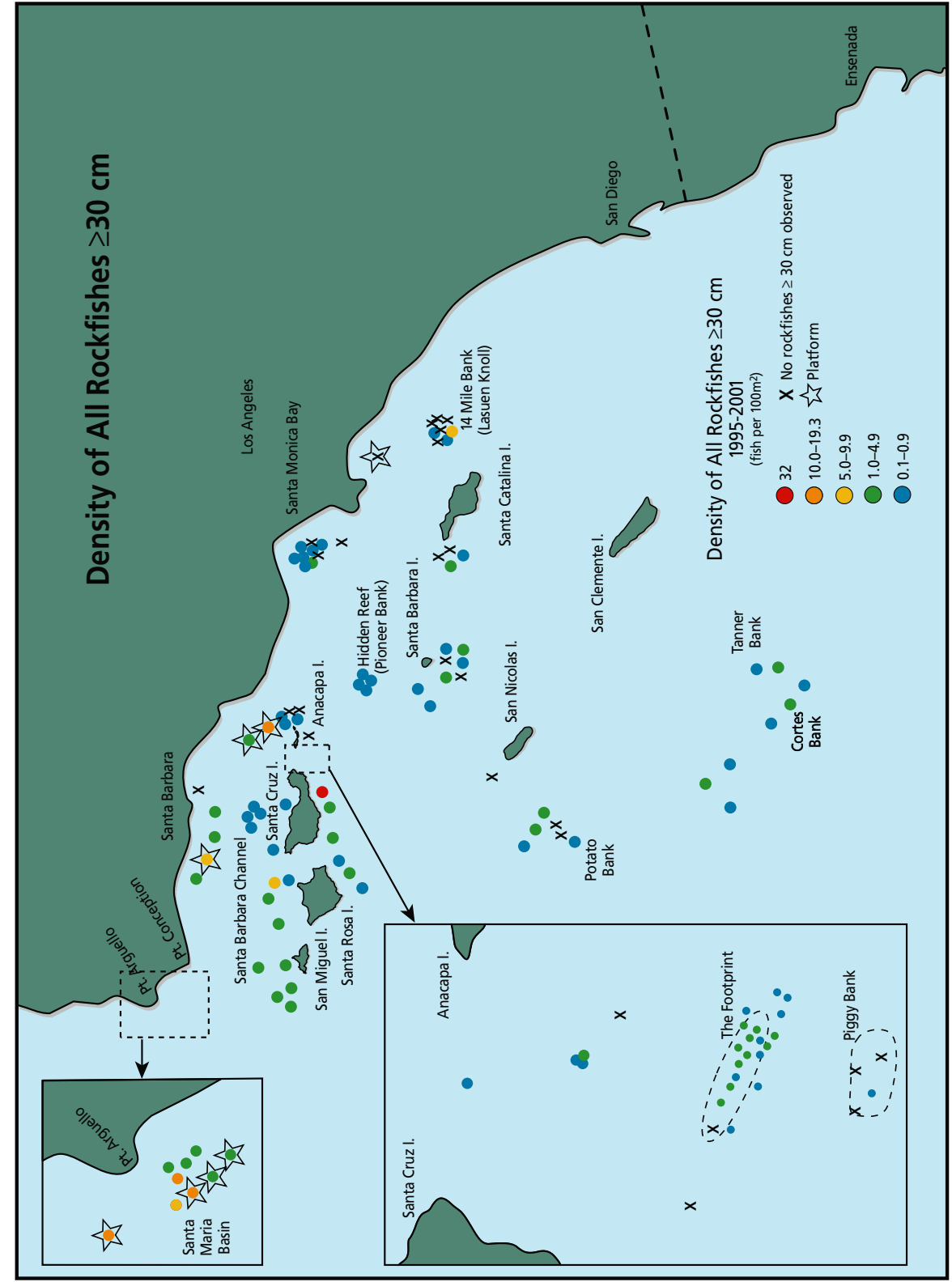


Figure 3.27. Density of all rockfishes larger than or equal to 30 cm as observed from the Delta submersible on platforms and natural outcrops, 1995–2001. Fish densities for Platforms Irene, Hidalgo, Harvest, Hermosa, Holly, Grace and Gail are from platform bottoms and densities for these seven platforms and for North Reef and reefs “A”, “B”, “C”, and “D” in the vicinity of Platform Hidalgo represent means of years. Platforms C, B, A, Hillhouse, Hogan, Houchin, and Henry were not included because they were not completely surveyed.

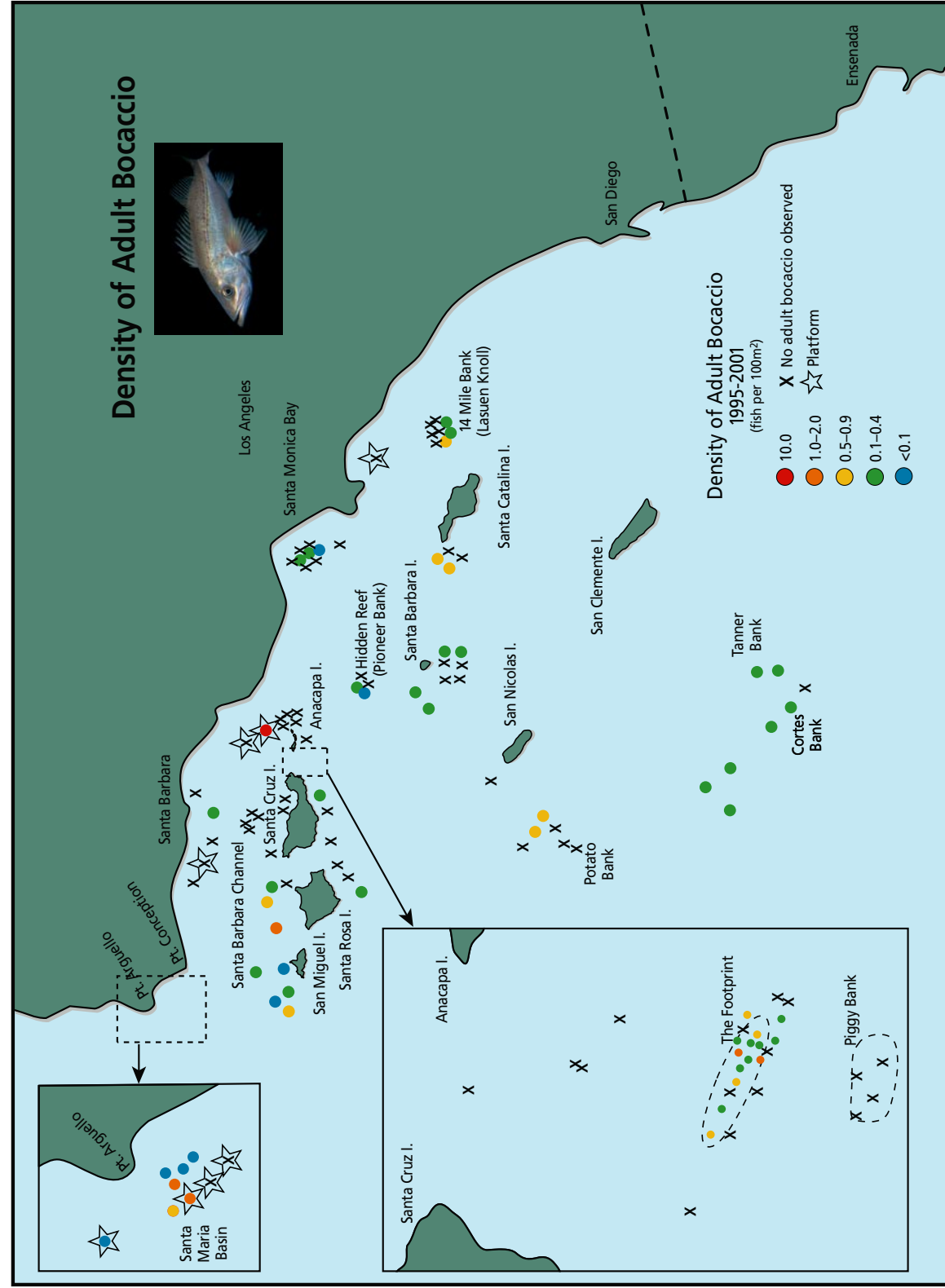


Figure 3.28. Density of adult bocaccio (defined as fish larger than 35 cm total length) as observed from the Delta submersible on platforms and natural outcrops, 1995–2001. Bocaccio densities for Platforms Irene, Hidalgo, Harvest, Hermosa, Holly, Grace and Gail are from platform bottoms and densities for these seven platforms and for North Reef and reefs “A,” “B,” “C,” and “D” in the vicinity of Platform Hidalgo represent means of years. Platforms C, B, A, Hillhouse, Hogan, Houchin, and Henry were not included because they were not completely surveyed.

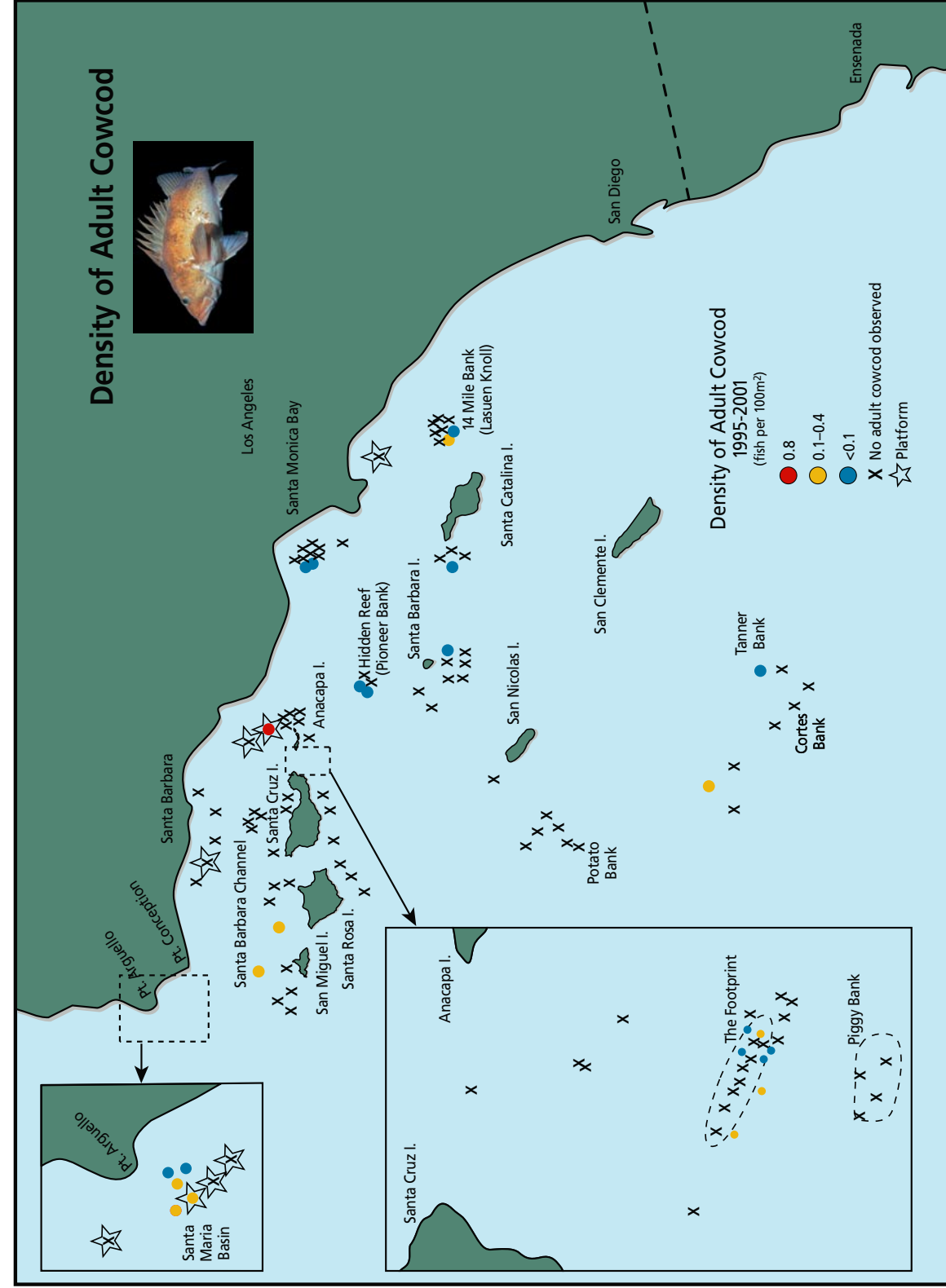


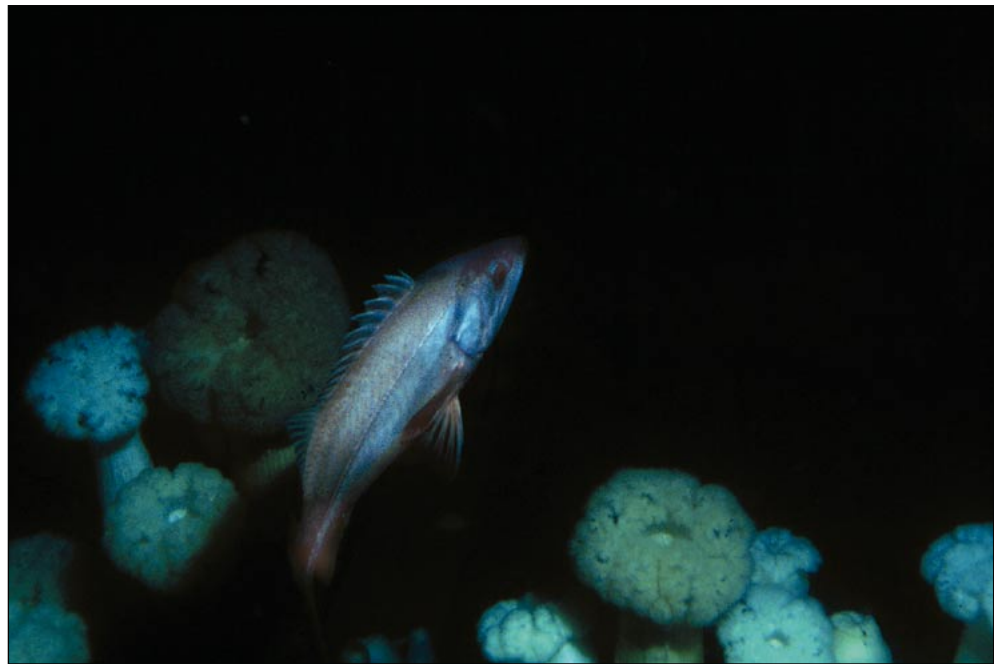
Figure 3.29. Density of adult cowcod (defined as fish larger than 45 cm TL) as observed from the Delta submersible on platforms and natural outcrops, 1995–2001. Cowcod densities for Platforms Irene, Hidalgo, Harvest, Hermosa, Holly, Grace and Gail are from platform bottoms and densities for these seven platforms and for North Reef and reefs “A,” “B,” “C,” and “D” in the vicinity of Platform Hidalgo represent means of years. Platforms C, B, A, Hillhouse, Hogan, Houchin, and Henry were not included because they were not completely surveyed.

### Why platforms support higher densities of young rockfishes than do nearby natural outcrops.

Platforms are important nursery habitat for many species of rockfishes. This research demonstrates that, in general, platforms may be more important nursery habitats than nearby natural outcrops or, indeed, most other outcrops surveyed in central and southern California. Why is this? First, platforms occupy more of the water column than do most natural outcrops. Presettlement juvenile rockfishes, swimming in the midwater, are much more likely to encounter these tall structures than the relatively low-lying natural rock outcrops. It is interesting to note that most of the natural outcrops we found that had high densities of young-of-the-year rockfishes (e.g., Hidden Reef and outcrops around islands) were very high relief features that thrust their way well into the water column.

In addition, there are also relatively fewer large predators in the platform midwaters. By comparison, even on heavily fished outcrops there tend to be at least a few larger fishes. Many of the major predators of young rockfishes are species that live close to the bottom, such as lingcod, copper and vermilion rockfishes, cowcod and large bocaccio. In general, these species do not ascend the platform jacket. Thus, even when they are abundant at the bottom of a platform, they are absent from the platform midwaters. In this respect, platforms are similar to some of the offshore pinnacles on the southern California continental shelf. Predatory species, such as cowcod, lingcod, and greenblotched rockfishes are also not abundant around the steep, smooth sides of offshore outcrops.

At most of the platforms, we observed both harbor seals and California sea lions, both resting on the platforms and swimming in the water column among the jackets and conductors. Based on the known food habits of these animals, it is likely that they feed on platform fishes, but their low numbers probably have little effect on the abundance of young rockfishes. We also observed both harbor seals and California sea lions swimming over natural outcrops and it likely that here, too, predation on young rockfishes occurs.



*Bocaccio.*

LOVELAB, UC SANTA BARBARA

### Platforms as defacto marine refuges

The role that some platforms play as defacto marine refuges is supported by evidence of greater densities of rockfishes, particularly the larger size classes, at platforms than at natural outcrops. The role that platforms may play as de facto reserves should not be underestimated at a time when many fish populations are in decline on natural outcrops. A number of benthic fishes, including such economically important species as bocaccio, cowcod, copper, and vermilion rockfishes and lingcod find refuge within the platforms and this is probably a factor in their relatively high densities compared to most natural outcrops. Schroeder and Love (2002) compared the rockfish assemblages at three deeper-water areas subjected to variable fishing pressures. Two were natural outcrops, one outcrop open to all fishing and one open only to recreational fishing, and the third was Platform Gail, acting as a de facto marine refuge. The outcrop allowing open fishing had the highest densities of rockfishes (7,212 fish/ha); however, the assemblage was dominated by dwarf species. The recreational fishing area had the lowest rockfish density (423 fish/ha) and this assemblage was also dominated by small fishes. Platform Gail possessed a relatively high density (5,635 fish/ha), and the fishes tended to be larger than individuals at either of the fished sites. Two federally listed overfished species, cowcod and bocaccio, had 32- and 408-fold higher densities, respectively, at Platform Gail than the recreational site, and 8- and 18-fold higher densities, respectively, than the all-fishing area.

There is some fishing effort around most platforms in the Southern California Bight and Santa Maria Basin. The relative amount of fish pressure among platforms is dependent on ease of access and local ocean conditions. Platforms in the Santa Maria Basin are located in an area that is far from ports, usually windy, and unprotected from weather. It is difficult to fish around the bottom of platforms, especially the deeper ones, because of the threat to gear imposed by the large number of crossbeams, other platform structural elements, conductors, and strong currents. Many anglers also believe that operators do not welcome fishing near their platforms.

Some platforms are important fishing areas for recreational anglers. Historically, commercial passenger fishing vessels and small private vessels fished around some of the shallower platforms in the Santa Barbara Channel (Love and Westphal 1990). Platforms Hilda and Hazel were targeted for kelp bass. During years with strong rockfish recruitment, large numbers of juvenile bocaccio, blue, olive, and widow rockfishes were caught at Platforms Holly, A, B, C and Hillhouse. In all of these instances, fishing effort was directed at surface or midwaters, rather than at the platform bottom. The removal of Hilda and Hazel and the poor rockfish recruitment of the 1980s and much of the 1990s reduced the overall fishing effort at oil/gas platforms. Some recreational fishing continues around Platform Gina, and there is minimal effort around a few other structures in the Santa Barbara Channel.

Overfishing has drastically altered the species composition of many outcrops off central and southern California (Yoklavich et al. 2000; M. Love, unpublished data). Over most moderate-depth and deep outcrops in central and southern California, many, or sometimes all, of the larger predatory fishes, such as lingcod, cowcod, bocaccio, yelloweye, and canary rockfishes are gone. In contrast, surveys made over an unfished outcrop in central California showed very high densities of large predatory fishes, including lingcod, cowcod, bocaccio, and yelloweye rockfish (Yoklavich et al. 2000). At many natural outcrops, these larger individuals have been replaced by very large numbers of dwarf species, particularly pygmy, swordspine, and squarespot rockfishes. Fish assemblages at platforms, such as Gail, Hidalgo, and Irene, with relatively high densities of many economically important species and low numbers of dwarf species, may more closely resemble unfished assemblages than those at many natural outcrops.



## 5. The Origins of Platform Fishes: Production and Attraction

### Finding at a Glance

Our research suggests that platforms, like natural outcrops, both produce and attract fishes, depending on species and location. Platform fish assemblages around the deeper and further offshore platforms may be generated primarily from the recruitment of larval and pelagic juvenile fishes, not from attraction of fishes from natural outcrops. Some fishes may live their entire lives around a single platform but their movement patterns are poorly known. A pilot study comparing growth rates showed that young-of-the-year blue rockfish grew faster at a platform than at a natural outcrop.

In recent years, public attention has been drawn to artificial reefs and their function in the marine environment. While a variety of issues have been raised, much of the discussion has centered around the question of whether artificial reefs are producers or attractors of marine life (Carr and Hixon 1997; Lindberg 1997). Some researchers suggest this question is biologically simplistic, because it “imposes an unrealistic either-or-dichotomy...” (Lindberg 1997). Nevertheless, this issue continues to arise in the context of the importance of platforms as fish habitat off California (Carr and Stephens 1998; Krop 1998).

Attraction suggests the net movement of juvenile and adult fishes away from natural outcrops to platforms. While there is not complete agreement on the definition of production, most researchers agree that it involves larval or pelagic juvenile settlement at a structure and the survival and growth of these organisms in this habitat (Carr and Hixon 1997). The attraction/production debate is framed around three questions (Carr and Stephens 1998; Krop 1998): (1) Do larval and juvenile fishes settle onto platforms from the plankton, or do fishes move from other structures to platforms as older juveniles or adults? (2) If a species does settle onto a platform, are growth and survivorship at least as good as on a natural outcrop? (3) If a species does grow and survive well around a platform, did the structure take away larvae or pelagic juveniles that would have settled onto natural outcrops?

### 5a. Do Fishes Settle from the Plankton onto Platforms or Do They Swim There from Other Structures as Juveniles or Adults?

A large number of fish species settled out of the plankton and took up residence around platforms. We observed young-of-the-year of about 46 fish species at these structures (Table 6) and, including species observed by other researchers (Carlisle et al. 1964), at least 50 fish settle on to platforms from the plankton. During some years, the midwaters of many platforms had very high densities of juvenile rockfishes. Young-of-the-year blacksmith, kelp and painted greenlings, and cabezon also were abundant in this habitat at times. Young-of-the-year rockfishes, lingcod, and other species were abundant around platform bottoms and shell mounds. With a few exceptions, species that settled on the bottom and shell mound were different from those found in the midwaters.

Juveniles of some species were rarely or never observed around platforms. For instance, young-of-the-year kelp bass were rarely seen around any platform, although adults were very abundant at one platform. Young sea-perches also were rare or absent. In these cases, older juveniles or adults immigrated to the platforms or juveniles settled there at times other than our surveys.

### 5b. The Biological Influence of Oceanographic Conditions on Recruitment Success at Platforms and Natural Outcrops in the Santa Barbara Channel and Santa Maria Basin

Most coastal fishes and invertebrates, including those inhabiting platforms, are planktonic during early stages of their life histories. These life stages, which may last from weeks to months, can begin as fertilized eggs (e.g., lingcod, cabezon, and garibaldi) or larvae (e.g., rockfishes). Some fishes, including rockfishes, continue to develop in the pelagic environment until they transform to the juvenile stage (Figure 3.30).

Pelagic life stages are at risk from starvation and predation and transport away from the specific habitats required for their growth and survival. Therefore, the type of water mass an animal finds itself may have a profound effect on its survival. There are a number of water masses in our study area, including waters from the Southern California Bight, the central California coast, upwelling from Point Conception, and from more distant places such as Baja California. How these waters enter, circulate and mix in the Santa Barbara Channel and Santa Maria Basin affects marine populations and community diversity on both platforms and natural habitats.

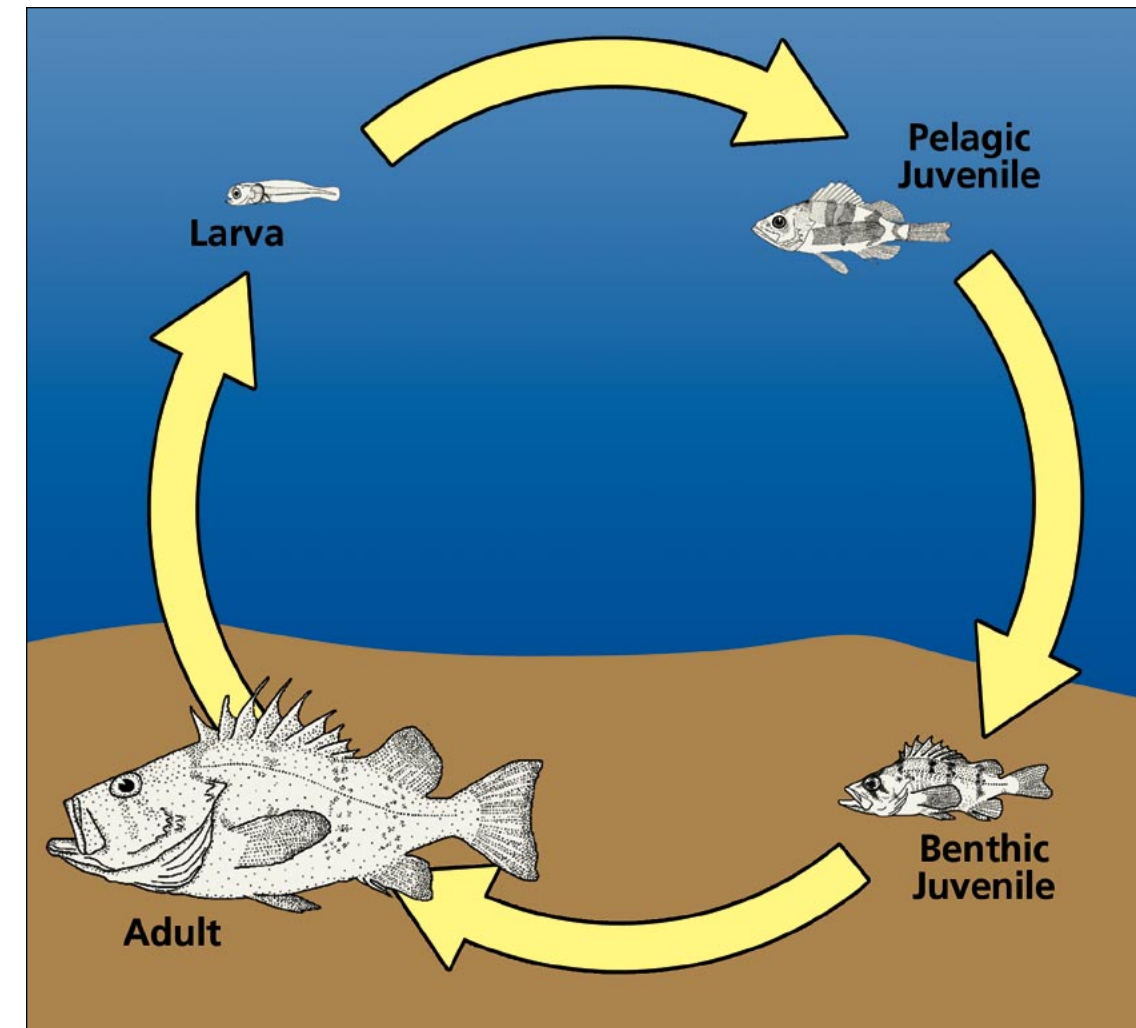


Figure 3.30. A typical rockfish life history cycle using the cowcod as an example.

Upwelling processes, the wind-induced pulling of deeper, colder water to the surface and displacement of warmer waters offshore, is a major factor in larval and pelagic juvenile survival. During years when upwelling coincides with larval fish production, fish survival may be enhanced. Because deep waters are nutrient-rich, upwelling increases reproduction of phytoplankton and encourages the growth of zooplankton, providing food for larval and pelagic juvenile fishes. Upwelling may also increase survivorship of some species by moving larvae and pelagic juveniles somewhat offshore, away from high densities of nearshore predators. Conversely, the offshore transport that accompanies upwelling can be detrimental to the survival of larvae and pelagic juveniles. Wind-induced turbulence in surface waters can make it difficult for larvae to come into contact with prey. Larvae risk being swept well offshore by strong upwelling and far removed from suitable habitat. Spatial and

temporal variability in circulation, however, can provide some larvae and pelagic juveniles with conditions that enhance survivorship including delivery to optimum settlement.

The timing, location, intensity, and duration of upwelling events may have a large effect on rockfish settlement. For instance, recruitment may be hampered at sites constantly exposed to newly upwelled water. Through much of the late-spring and summer when presettlement-stage rockfishes are in the pelagic environment, upwelling from the mainland at Point Conception impacts the west channel. Our summer oceanographic data confirm that the upwelling plume can extend across the western portion of the Northern Channel Islands (Love et al. 1999). We found that pelagic juvenile rockfishes were relatively rare in this newly upwelled water (Figure 3.31) (Nishimoto 2000). As an example, when cool upwelled waters moved into an area off the south side



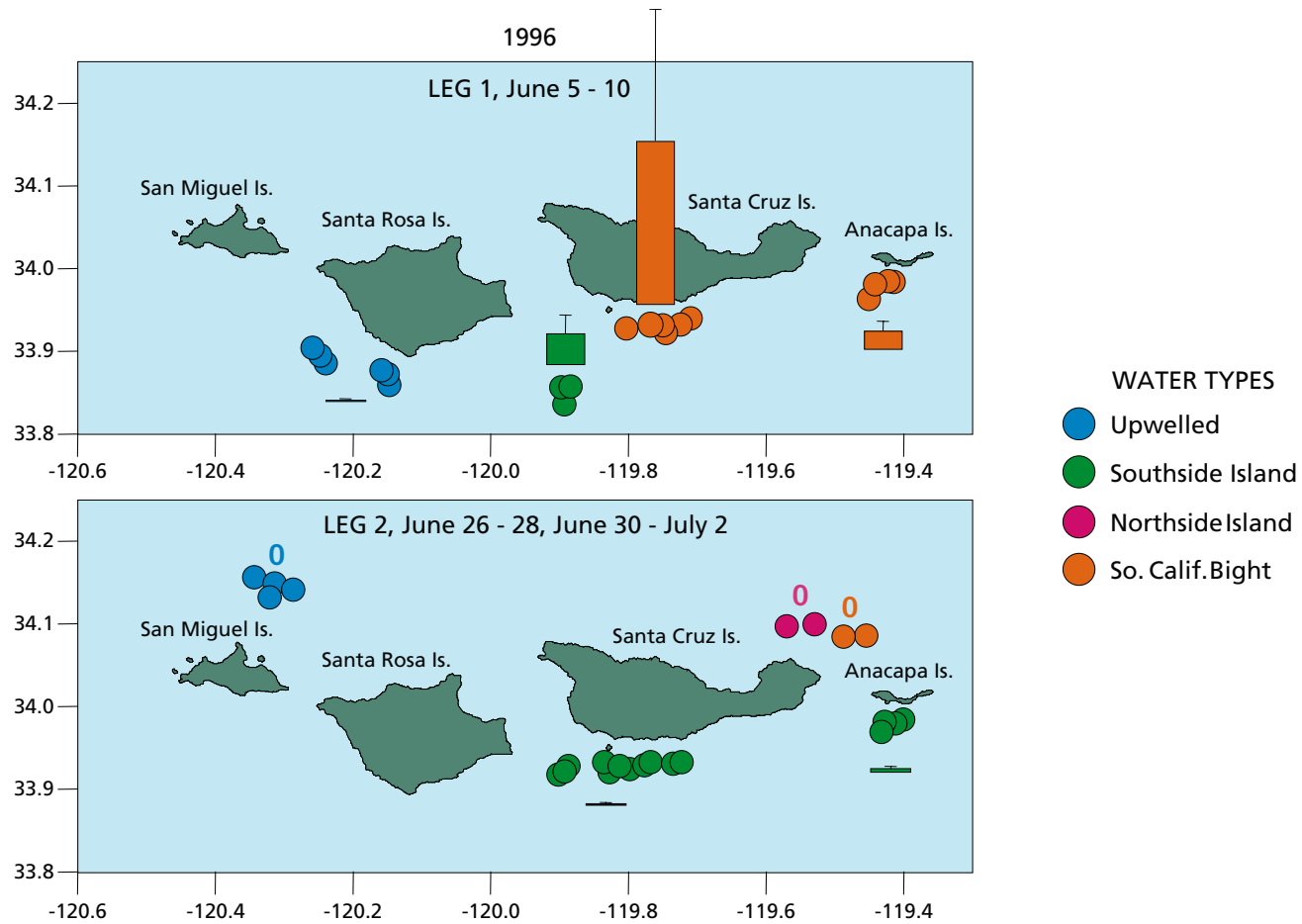


Figure 3.31. The abundance of late-larval stage and pelagic juvenile rockfishes decreases off the south side of Santa Cruz Island when one water mass replaced another between two sampling periods, June–July 1996. Temperature and salinity properties were used to identify four water masses: Upwelled water, Southside Island water, Northside Island water, and Southern California Bight water. Hauls are represented by colored circles. Fish abundance was estimated using the mean collected in midwater trawl hauls within a water mass. Bars illustrate the relative abundances among the water masses. Zeros indicate that no rockfishes were collected in the hauls within a water mass.

of Santa Cruz Island, the fish assemblage changed from one with relatively abundant pelagic juvenile rockfishes to one where these fishes were almost absent. We suspect that the upwelled water, the coldest and most saline water mass that we identified, was recently brought to the surface from depths where few larval and juvenile rockfishes reside.

Inter-annual oceanographic conditions, including the intensity of seasonal, coastal upwelling, are highly variable and this affects year class success and population variability. A shift from El Niño to La Niña conditions between 1998 and 1999 was marked by abrupt changes in the marine ecosystem off southern and central California. Our survey data of young-of-the-year rockfishes in 1999 indicates an increase in rockfish recruitment.

The number of several juvenile rockfishes and other fish species observed on oil/gas production platforms and rocky outcrops in 1999 far exceeded those of 1998 and previous years. This increased recruitment coincided with intense coastal upwelling off Central California (among the strongest events in 50 years) in spring 1999 followed by high phyto- and zooplankton production (Lynn et al. 1998; Hayward et al. 1999). High productivity in the region likely contributed to the increased survivorship of the fishes including those that recruited to the platforms and natural outcrops.

Relatively transitory phenomena, such as fronts and eddies, may also play an important role in fish settlement and year-class success. Fronts, the zones where different water masses collide and mix, may prevent weak-swimming

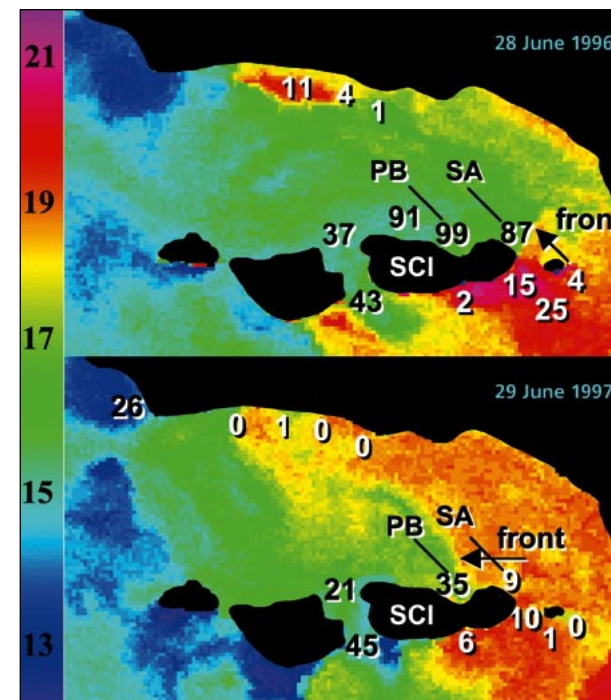


Figure 3.32. The strong correspondence between exposure to cool water and young-of-the-year rockfish density. A shift in position of the thermal front on the north shore of Santa Cruz Island (SCI) in 1996 and 1997 corresponded with a striking spatial shift in juvenile rockfish densities (see sampling sites, Pelican Bay (PB) and Scorpion Anchorage (SA)). Numbers overlaid on images represent mean densities of juvenile rockfishes (number/60 m<sup>2</sup>) that recruited to giant kelp canopy at sites within the survey area.

planktonic animals from swimming between these masses (Moser and Smith 1993; Wing et al. 1998). The strength of recruitment to a platform or outcrop may be determined in part by the habitat's exposure to those fronts carrying ready-to-settle fish larvae and juveniles. Our research at Santa Cruz and Anacapa islands indicates that the recruitment of near-shore rockfishes was sparse on outcrops separated from cool, fish-rich waters by a frontal boundary (Figure 3.32) (Love, Nishimoto, Schroeder, and Caselle 1999).

Eddies, cyclonic currents that can concentrate and retain plankton, may retain fishes and affect the dispersal of larval and juvenile fishes to outcrops and platforms. For instance, in summer 1998 we sampled a stationary and persistent cold-core cyclonic eddy in the western Santa Barbara Channel. In this feature, we found very high concentrations of small fishes, including late-stage larval and pelagic juvenile rockfishes (Figure 3.33). Eddies may also be very transitory. During the summer of 1999, we observed a much different circulation pattern of shorter-lived, propagating eddies and collected few young rockfishes.

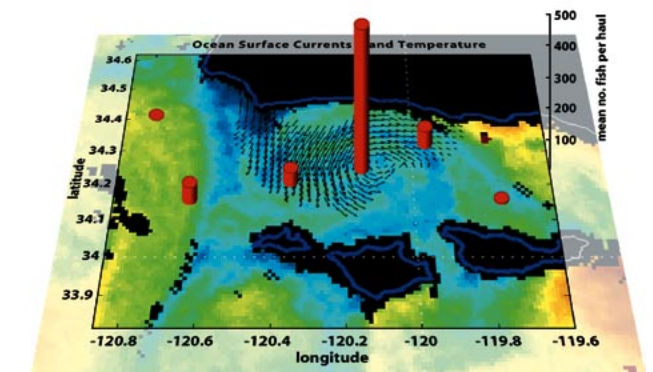


Figure 3.33. The strong link between eddy circulation and the distribution of pelagic young-of-year rockfishes. A persistent eddy about 30 km (19 mi.) wide was evident in satellite sea surface temperature imagery and in surface current mapping generated from coastal-based high frequency radar observations. The abundance of fishes were extraordinarily high in the center of the eddy (red bars represent the mean number of late-stage larval and pelagic juvenile rockfishes in midwater trawl samples from different areas).



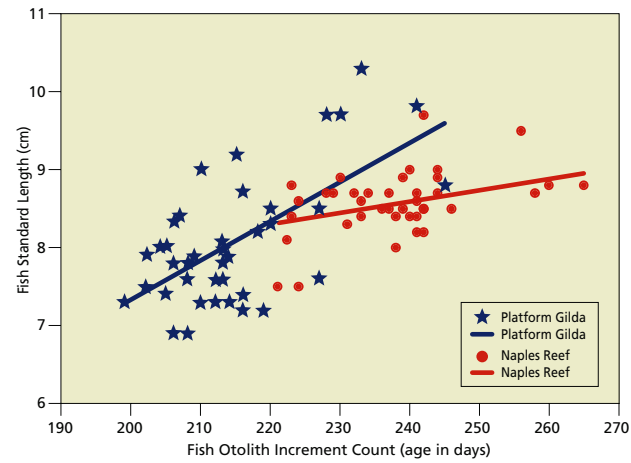


Figure 3.34. A comparison of daily growth rates of young-of-the-year blue rockfish collected at Platform Gilda and Naples Reef in 1999. Fish from Platform Gilda grew at a statistically faster rate than did those from the natural outcrop.

the Santa Barbara Channel during 1996 through 1998, the cooler waters of 1999 brought with it a relatively good year for cool-temperate rockfish recruitment throughout the channel.

The timing of this upsurge in young-of-the-year rockfish settlement in the Santa Barbara Channel also coincided with what may have been a Northeast Pacific oceanographic regime shift from warm to cool waters that overlaid the El Niño and La Niña events. This may have been reflected in the 2000 and 2001 rockfish recruitment at platforms in the eastern channel, which remained higher than pre-1999 levels. We should note that the last cold water regime off southern California occurred in the 1970s, a period that saw heavy settlement of young-of-the-year blue, olive, and widow rockfishes and bocaccio to some of the platforms near Santa Barbara (Love and Westphal 1990).

**5c. If a Species Does Settle around a Platform, How Well Does It Grow and Survive, Particularly Compared to the Same Species on a Natural Outcrop?**

While our studies in this area are preliminary, they are sufficiently compelling that we can begin to draw some conclusion regarding production of fishes at platforms. On many platforms, we believe that larval and pelagic juvenile recruitment is a major force in shaping platform fish assemblages. We have observed young-of-the-year of about 46 species at the



Figure 3.35. Flag rockfish at the bottom of Platform Grace, 2001. These fish recruited to the platform as pelagic juveniles in 1999 and moved to the bottom in 2000.

platforms. Of these species, at least 35 were observed as adults at the same structures (Table 7). Adults of some species, such as pygmy, widow, and yellowtail rockfishes, are relatively uncommon around platforms suggesting different habitat requirements. Conversely, adults of many more species, including blacksmith, bocaccio, cabezon, cowcod, lingcod, painted greenling, shortspine and longspine combfishes, and calico, copper, flag, greenblotched, greenspotted, greenstriped, halfbanded, kelp, and pinkrose rockfishes are abundant at the platforms.

Pilot research suggests that at least some juvenile fishes may be growing as well or better at the platforms than at natural outcrops. In 1999, we collected young-of-the-year blue rockfish from Platform Gilda and from Naples Reef (Figure 1.1). Daily growth rates derived from these fishes from otoliths (ear bones) indicated that the platform fish grew at a statistically faster rate than did those from the natural outcrop (F-test,  $F = 2.96$ ,  $p = 0.0006$ ) (Figure 3.34).

Recruitment patterns of flag rockfish at Platform Grace and bocaccio at Platform Gail in 1999 and subsequent annual monitoring of year classes at these sites is providing important new information about the production value of platform habitats. In 2000, and again in 2001, we observed the 1999 year classes of these species at the bottoms of the platforms (Figures 3.35 and 3.36). Length-frequency data indicate substantial survival of the 1999 year classes at the platforms (Figure 3.36). Flag rockfish mature at about six years of age (M. Love and M. Yoklavich, unpublished data) and bocaccio at four or five years (A. MacCall, personal communication). Thus,

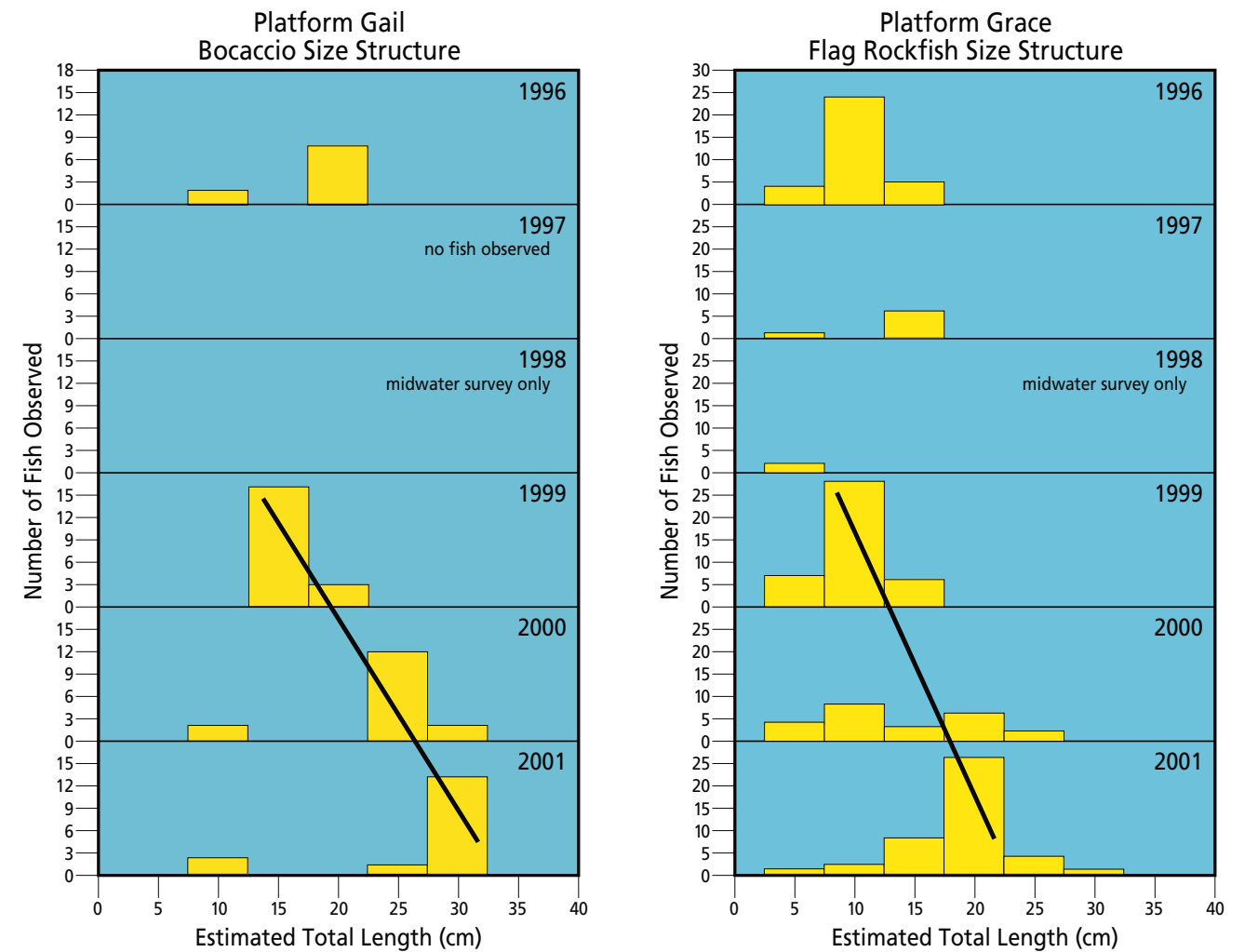


Figure 3.36. Size structure of young bocaccio observed at Platform Gail and flag rockfish observed at Platform Grace, 1996 to 2001. Black line denotes persistence of the successful 1999 year class.

it is conceivable that these fishes will mature at the platforms. This would be strong evidence of production at these structures. [Added in proof: We again observed these fishes during our 2002 surveys of Platforms Gail and Grace.]

**5d. Both Attraction and Production Play Important Roles in Shaping Fish Assemblages at Platforms**

Our research suggests that populations of fishes at platforms far removed from natural outcrops, as is true for Platforms Gail and Grace, are most likely dependent on larval and juvenile recruitment from the plankton. Our research is developing information about recruitment and residence of fishes at platforms and we have provided evidence of fishes not only settling out at platforms but also maturing there. Recruitment process

is highly variable at all habitats from year to year. Adult abundance, at least for some species, is dependent on the strength of recruitment in previous years. Furthermore, recruitment variability may contribute to the year class success (i.e., demographics) of platform and outcrop species such as flag rockfish and bocaccio.

While the movement patterns of some deeper-water rockfishes are unknown, it is likely that many benthic species, such as greenspotted, greenblotched, pinkrose, and cowcod are residential (Starr et al. 2001; Love et al. 2002). Certainly many are restricted to hard substrata seafloors and probably rarely traverse large expanses of soft sediment (Love et al. 2002). Thus, it is likely that the high densities of many platform rockfishes, as well as such species as combfishes, painted greenling, and perhaps lingcod, are due to successful settlement from



the plankton and subsequent survival.

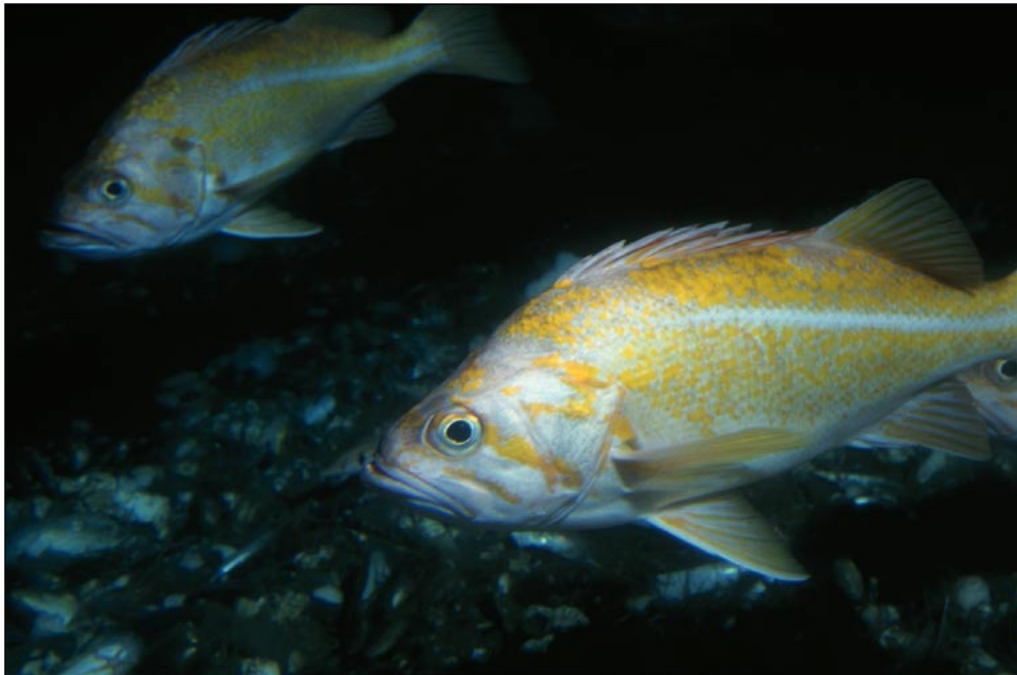
The shallow-water species that do inhabit offshore platforms are further evidence that larval and juvenile recruitment play a dominant role in these structures' assemblages. Shallow species that do occur on Gail and/or Grace include kelp bass, garibaldi, and grass and kelp rockfishes. All of these fishes have pelagic larvae. Pile perch and rubberlip seaperch, species without a pelagic life stage, while found on the shallower platforms, are not present on Gail and Grace. This reflects the difficulty these species have in crossing deep waters along the seafloor.

Thus, there is growing evidence that individuals of a number of species, particularly those that are relatively resident and benthic, not only settle out at platforms but also mature there. Such species include, but are not limited to, blacksmith, bocaccio, cowcod, flag, grass, greenblotched, greenspotted, kelp, pinkrose rockfishes, painted greenling, and combfishes.

A dependence on pelagic juvenile recruitment, rather than attraction of older fishes from other structures, explains some of the differences in species composition we observed among the platforms. For instance, until 1999, we observed high densities of adult flag rockfish only at Platform Hidalgo. These densities were far higher than at other platforms or natural outcrops. In 1999, there was

a strong recruitment of pelagic juvenile flag rockfish to Platform Grace, and as noted above, these fish remained there at least through 2001. [Added in proof: We observed these fish in 2002.] Annual recruitment of rockfish is highly variable. Thus, the large numbers of flag rockfish observed at Platform Hidalgo are almost certainly the result of a previous successful recruitment, similar to that at Platform Grace. Spatial variability is indicated by the paucity of this species at the other platforms. Similarly, the high densities of adult bocaccio at Platform Gail, and their absence at Platform Harvest (which is located in about the same depth), also suggests spatial variability in the recruitment process.

In contrast, the fish assemblages at platforms that are closer to shore, and in shallow waters, are probably derived both from larval/pelagic juvenile settlement and movements of juveniles and adults from other structures. Carlisle et al. (1964) clearly demonstrated that inshore reef species, such as kelp bass and sheephead, are very mobile and able to traverse shallow, soft seafloors from outcrop to artificial reef. Platform Gina, for instance, is a shallow water platform that seasonally harbors very large numbers of kelp bass, halfmoon, opaleye, pile perch, and other reef species. Fishes are abundant around that platform during summer and fall, but move elsewhere in late winter and spring.



MARY NISHIMOTO

*Adult canary rockfish at bottom of Platform Hidalgo.*