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COMPLETION OF FISH ASSEMBLAGE SURVEYS AROUND MANMADE STRUCTURES AND NATURAL REEFS OFF CALIFORNIA

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COMPLETION OF FISH ASSEMBLAGE SURVEYS AROUND MANMADE STRUCTURES AND NATURAL REEFS OFF CALIFORNIA

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TECHNICAL SUMMARY

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Report Title: Completion Of Fish Assemblage Surveys Around Manmade Structures and Natural Reefs off California
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Background and Objectives

The BOEM defines decommissioning as the process of ending oil, gas, or sulfur operations and returning the lease or pipeline right-of-way to a condition that meets the requirements of the regulations. The BOEM works to ensure that wells are plugged to prevent pollution; that pipelines are decommissioned and sometimes removed to prevent seepage of hydrocarbons and to resolve conflicts with other uses of the OCS; and that all sites are cleared of obstructions to minimize use conflicts. The BOEM will conduct detailed environmental reviews of any proposed decommissioning projects to evaluate the impacts from platform removal on regional fish populations. Obviously, when a platform is disassembled, habitat is removed, and numerous fishes and invertebrates are killed. However, yet unknown are the impacts of platform removal on regional populations of coastal organisms, particularly the economically important rockfish species, on the Pacific OCS. The assessment of the effects of platform activities and of the habitat created by the structure of platforms on marine populations greatly bears upon decommissioning issues, as questions about Essential Fish Habitat and the ecological role of Pacific OCS platforms are still unresolved.

At this time there are several key issues in the Pacific OCS platform decommissioning and reefing debate. Included is defining the ecological performance and role that platforms off California may play in the recovery of important groundfish populations (such as bocaccio, *Sebastes paucispinis*, and cowcod, *Sebastes levis*) in southern California. The Secretary of the Department of Commerce in January 2000 declared the West Coast groundfish fishery a disaster with extremely small populations remaining. BOEM-funded studies (Love et al. 2005, Love et al. 2006) have revealed that some of the platforms hold large numbers of both juvenile and reproductively mature rockfishes in numbers far greater than any natural reef that has been surveyed. The observed rockfish species include bocaccio and cowcod, both of which are species of concern, with bocaccio once considered for listing as threatened under the Endangered Species Act. Additionally, four more federally declared overfished species have been observed, sometimes in large numbers, at some platforms: canary, darkblotched, widow and yelloweye rockfishes. All of these species are subject to federal rebuilding plans, as specified by the Magnuson-Stevens Fishery Conservation Act. The Pacific Fishery Management Council and the State of California began to severely restrict targeted fishing for these species in 2002 and 2003 and created the Cowcod Conservation Area in southern California to protect that species. Since 2001, cowcod have been managed as a no-retention fishery in California. In addition, the State of

California banned the spot prawn trawl fishery in order to eliminate all by-catch of bocaccio. Populations of rockfishes at platforms, and the platforms as habitat for specific life history stages (e.g., nursery habitat for juveniles), may prove to be vital for timely recovery of the regional rockfish populations and fisheries. In order to understand the environmental consequences of decommissioning platforms on local and regional fish populations, there is a need to know the importance of platforms as fish habitat when compared to adjacent natural reefs. In particular, it is necessary to know the densities, abundances, and size classes of economically important species over both artificial and natural substrates. Such information is particularly important when the platforms harbor large numbers of resident, reproducing adults and serve as nursery habitat for juvenile fishes that eventually may "spillover" or migrate to natural areas and help to replenish populations that are commercial and recreational fishery resources. Natural reefs need to be surveyed in order to provide the context to which densities of rockfishes at oil platforms may be evaluated, and the ecological importance of platform habitat may be interpreted.

Several BOEM- and USGS-funded investigations have been completed and provide background for the present effort. The habitat value of a number of platforms on the Pacific OCS was determined during a multi-year study that was synthesized in MMS 2003-032, *The Ecological Role of Natural Reefs and Oil and Gas Production Platforms on Rocky Reef Fishes in Southern California* (Love et al. 2003). Dr. Love and co-researchers from the Marine Science Institute (MSI) at the University of California at Santa Barbara compared fish assemblages from eight platforms and eight natural outcrops at similar depth. The observations were from the surface to the seafloor on both platforms and natural reefs over a six-year period including 2001. The analyses were based on at least 40 submersible and hundreds of SCUBA dives on platforms and on 133 submersible and hundreds of SCUBA dives on natural outcrops located throughout southern California, the Santa Barbara Channel, and off Pt. Conception and Pt. Arguello.

The MSI researchers found that platform fish assemblages are somewhat different from those of natural reefs. However, these differences were due almost entirely to the greater numbers of fishes around platforms, rather than large differences in species composition between platforms and natural outcrops. At least 85 species of fish were observed at platforms and 94 species at the outcrops. Rockfishes dominated both habitats, comprising 89.7% of all fishes at platforms and 92.5% at outcrops. Almost all of the more abundant species that the researchers observed were more common around platforms. Tremendous numbers of young-of-the-year (YOY) rockfish from several species settled at Platform Gail in 1999 with a lesser number recruiting to Platform Gilda. Species that were more common at one or more platforms than at natural reefs included cowcod and bocaccio (YOY, juvenile, and adult), copper, greenspotted, greenstriped, YOY and juvenile widow, vermilion, canary and flag rockfishes and YOY, juvenile, and adult lingcod.

A BOEM-sponsored study *Fish Assemblages Associated with Platforms and Natural Reefs in Areas Where Data are Non-Existent or Limited*, BOEMRE Study 2010-012, expanded on the results of the earlier study. It summarized work from 2004–2009 at 20 platforms and 110 natural reefs off southern and central California. This study again found that rockfishes were dominant around both platforms and natural reefs: 42 rockfish species, comprising 83.8% of all fishes, were observed around platforms and 43 species (87.5% of all fishes) were observed at natural reefs. It was clear that the midwaters of many platforms serve as nursery grounds, at least in some years, for a range of rockfish species including blue, squarespot and widow rockfishes and bocaccio. In general, densities of young rockfishes were higher around platform midwaters than around most natural reefs. Platform bottoms varied greatly in fish assemblage composition, primarily reflecting differences in platform bottom depth. While rockfish YOY sometimes occurred in substantial numbers around platforms, platform bottom assemblages were more characterized by subadult and adult rockfishes. Shell

mound fishes assemblages somewhat resembled those of the associated platform bottoms, but also included more dwarf species, as well as those species that were adapted to living on low, but hard, relief and in the ecotonal areas between soft substrata and hard bottom. In general, this study found that the fish assemblages of platforms and natural reefs were different, and that this difference was based on densities of individual species, rather than by the presence or absence of those species. It was also found that the bottoms of some platforms harbor higher densities of larger, and economically important, fishes than do most natural reefs.

Additional BOEM-supported research has further examined the role that platforms play as fish habitat. Emery et al. (2006) demonstrated that, in the absence of a platform, many of the young rockfishes that recruited to this human-made structure would not have survived to find natural reefs. In a limited survey, Love and York (2005) found that at least one pipeline can provide considerable habitat for many juvenile rockfishes, particularly for young cowcod. Densities of most fish species were far higher around the pipeline than on adjacent soft substrate sea floors. Love and York (2006) examined the role that platform bottom complexity plays in species composition. They found that large economically important species, such as cowcod and bocaccio, are found around those parts of a platform where the bottom crossbeam has been undercut, creating a crevice used for sheltering. In addition, research has shown that, compared to natural reefs, some platforms harbor much higher densities of large individuals of overfished species (Love et al. 2003). Results from a pilot study (Love et al. 2005) indicated that these platforms likely produce far more larvae of these overfished species per unit area than do natural reefs.

The BOEM has recognized that there is not yet enough data to extrapolate the importance of platforms and associated structures fish assemblages when compared to those of natural reefs. One data gap has been information about the number and size of natural reefs in the vicinity of platforms. Recognizing this need, BOEM has funded through USGS sea floor mapping in the eastern Santa Barbara Channel, currently being conducted by Dr. Guy Cochrane, United States Geological Survey.

Pacific OCS platforms reside in a variety of depths and oceanographic conditions (Love et al. 2003). This physical variability propagates to the biotic populations associated with these offshore structures, and suggests that a case-bay-case scenario is likely for decommissioning decisions. In order to analyze the environmental consequences of platform decommissioning on local or regional fish populations, it is essential to know the role that each platform plays as fish habitat, particularly as compared to those natural reefs in the vicinity of platforms. Data necessary for these comparisons include densities and size structures of the fishes inhabiting both platforms and natural reefs and the location, area, and number of these natural reefs.

The primary goal of the present study is to fill gaps in information about the importance of POCS platform fish assemblages in southern and central California compared to those of nearby natural reefs.

a) What is the relative contribution of platform fishes to the total hard structure fish assemblages (platforms and natural reefs) in the region?

b) What is the comparative importance of various platforms as fish nursery grounds?

c) What is the relative importance of platforms as regional fish larvae producers?

Specific objectives of this study were:
1) To survey the fish assemblages at platforms in order to continue long-term and short-term studies, to acquire information from platforms that have never been surveyed, to encompass a wide range of structures, occupying a diversity of water depths, geographic locations, and water masses.

2) Estimate the densities of all species at both platform and natural reef habitat and characterize the habitat of each fish observed.

3) To synthesize the data into a report describing the ecological performance of platforms as rockfish habitat and as rockfish producers.

Literature Cited

Emery, B. M., L. Washburn, M. S. Love, M. N. Nishimoto, and J. C. Ohlmann. 2006. Do oil and gas platforms off California reduce recruitment of bocaccio (*Sebastes paucispinis*) to natural habitats? Analysis on trajectories derived from high frequency radar. Fish. Bull. 104:391–400.

Love, M. S. and A. York. 2005. A comparison of the fish assemblages associated with an oil/gas pipeline and adjacent seafloor in the Santa Barbara Channel, southern California Bight. Bull. Mar. Sci. 77:101–117.

Love, M. S. and A. York. 2006. The role of bottom crossbeam complexity in influencing the fish assemblages at California oil and gas platforms. Fish. Bull. 104:542–549.

Love, M. S., D. M. Schroeder, and W. H. Lenarz. 2005. Distribution of bocaccio (*Sebastes paucispinis*) and cowcod (*Sebastes levis*) around oil platforms and natural outcrops off California with implications for larval production. Bull. Mar. Sci. 77:397–408.

Love, M. S., D. M. Schroeder, and M. M. Nishimoto. 2003. The ecological role of oil and gas production platforms and natural outcrops on fishes in southern and central California: a synthesis of information. U. S. Department of the Interior, U. S. Geological Survey, Biological Resources Division, Seattle, Washington, 98104, OCS Study MMS 2003-032.

Love, M. S., D. M. Schroeder, W. Lenarz, A. MacCall, A. Scarborough-Bull, and L. Thorsteinson. 2006. Potential utility of offshore marine structures in rebuilding an overfished rockfish species, bocaccio (*Sebastes paucispinis*). Fish. Bull. 104:383– 390.

Description

We conducted surveys around 11 platforms and two natural reefs in the southern California Bight using the research submarine *Dual DeepWorker*. Around platforms, we surveyed fishes in the midwaters, around the bottoms, and over the shell mounds.

Significant Results

We conducted 87 transects around 11 platforms, encompassing 32,816 m^2 of habitat and we made two dives (13 transects, 5469 m^2) on natural reefs in shallow (46–47 m) and somewhat deeper (145 m) waters.

Over all platforms, we observed 158,129 individuals, comprising a minimum of 56 species. Rockfishes dominated platform fish assemblages; we observed 155,239 individuals (98.2% of all fishes), of at least 36 species. Squarespot and halfbanded rockfishes, and small, unidentified rockfishes (primarily young-of-the-year and likely mostly squarespot and widow rockfishes) dominated the surveys. Other abundant rockfishes included widow and bank rockfishes and bocaccio. Among non-rockfish species, blacksmith, painted greenling, California sheephead, and sharpnose seaperch were frequently observed.

Fish densities were extremely variable among platforms and between depths within platforms. Fish densities were lowest in the shallower depth strata, particularly in 0–30 m, and densities generally increased with depth. For those platforms whose midwaters, bottoms, and shell mounds were all surveyed, fish densities were always highest around the platform bottom. Fish densities over shell mounds were lower than those at the adjacent platform bottom.

Generally, the midwater fish assemblages across all platforms were similar. YOY fishes (e.g., squarespot and widow rockfish, bocaccio, and painted greenling) dominated a number of platform midwaters. Also important around some platforms were such nearshore reef species as garibaldi, blacksmith, cabezon, sheephead, and white and sharpnose seaperches. Platform Eureka, with a more structurally complex midwater platform jacket, harbored relative high densities of such typically deeper-dwelling rocky-reef rockfishes as bank, speckled, rosy, dwarf-red and starry leading to a unique midwater assemblage of the platforms surveyed.

At the bottom of all platforms other than Gail, halfbanded and/or squarespot rockfishes dominated the habitats. Other important species included calico, flag, rosy, vermilion and widow rockfishes, and lingcod. At a few platforms, notably Edith and Elly, YOY rockfishes (halfbanded and unidentified), comprised a substantial part of the assemblage, otherwise young fishes were not abundant. At Platform Gail, with a bottom depth considerably deeper than the other structures, a different suite of species dominated, including bocaccio, cowcod, pinkrose and greenblotched rockfishes. Overall, depending on platform, rockfishes were the most important group in the bottom assemblage, they comprised as much as 99.9% of all fishes observed.

The assemblage of fishes occupying the low-relief shell mounds was composed of 1) juvenile fishes of larger species and juveniles and adults of dwarf species that utilize small sheltering sites (e.g., juvenile cowcod and lingcod, blackeye goby, and calico rockfish), 2) ecotonal species that favor soft sea floor-low, hard-relief bottom (greenstriped and stripetail rockfishes), and 3) a few schooling taxa (notably halfbanded rockfish) that are habitat generalists.

The shallow reef was dominated by blackeye goby and halfbanded rockfish; squarespot, blue, and vermilion rockfishes and lingcod were also frequently observed. At the deeper site, squarespot, pygmy, swordspine, and halfbanded rockfishes and unidentified rockfishes (likely primarily YOY swordspine and squarespot rockfishes) were very abundant.

Overall, the data from 2010–2011 supports the observations of previous surveys that: 1) There are three distinct fish assemblages around each platform: midwater, bottom, and shell mound. Within these assemblages, those of the midwaters tend to be the most similar across platforms although there may be substantial interannual and some geographic differences. The bottom and shell mound assemblages tend to be somewhat similar within a platform (but are still distinct), but are often quite dissimilar among platforms and 2) During at least some years, platforms serve as nursery grounds for a variety of rockfishes and other taxa.

Completion Of Fish Assemblage Surveys Around Manmade Structures and Natural Reefs off California

EXECUTIVE SUMMARY

Information Needed

There are 27 oil and gas platforms in the waters off California, located between 1.2 and 10.5 miles from shore and at depths ranging from 11 to 363 m (35–1,198 ft). All platforms have a finite economic life and the life spans of some California platforms may be nearing an end. Once an industrial decision is made to cease oil and gas production at a platform, managers must decide what to do with the structure, a process known as decommissioning. The BOEM defines decommissioning as the process of ending oil, gas, or sulfur operations and returning the lease or pipeline right-of-way to a condition that meets the requirements of the regulations. The BOEM will conduct detailed environmental reviews of any proposed decommissioning projects to evaluate the impacts from platform removal on regional fish populations. When a platform is disassembled, habitat is removed, and numerous fishes and invertebrates are killed. However, yet unknown are the impacts of platform removal on regional populations of coastal organisms, particularly the economically important rockfish species, on the Pacific OCS. The assessment of the effects of platform activities and of the habitat created by the structure of platforms on marine populations greatly bears upon decommissioning issues, as questions about Essential Fish Habitat and the ecological role of Pacific OCS platforms are still unresolved.

At this time there are several key issues in the Pacific OCS platform decommissioning and reefing debate. Included is defining the ecological performance and role that platforms off California may play in the recovery of important groundfish populations (such as bocaccio, *Sebastes paucispinis*, and cowcod, *Sebastes levis*) in southern California. The Secretary of the Department of Commerce in January 2000 declared the West Coast groundfish fishery a disaster with extremely small populations remaining. Recent BOEM -funded studies have revealed that some of the platforms hold large numbers of both juvenile and reproductively mature rockfishes in numbers far greater than any natural reef that has been surveyed. The observed rockfish species include bocaccio and cowcod, both of which are species of concern, with bocaccio once considered for listing as threatened under the Endangered Species Act. Additionally, four more federally declared overfished species have been observed, sometimes in large numbers, at some platforms: canary, darkblotched, widow and yelloweye rockfishes. All of these species are subject to federal rebuilding plans, as specified by the Magnuson-Stevens Fishery Conservation Act. Populations of rockfishes at platforms, and the platforms as habitat for specific life history stages (e.g., nursery habitat for juveniles), may prove to be vital for timely recovery of the regional rockfish populations and fisheries.

However, in order to understand the environmental consequences of decommissioning platforms on local and regional fish populations, there is a need to know the importance of platforms as fish habitat when compared to adjacent natural reefs. In particular, it is necessary to know the densities, abundances, and size classes of economically important species over both artificial and natural substrates. Such information is particularly important when the platforms harbor large numbers of resident, reproducing adults and serve as nursery habitat for juvenile fishes that eventually may "spillover" or migrate to natural areas and help to replenish populations that are commercial and recreational fishery resources. Natural reefs need to be surveyed in order to provide the context to which densities of rockfishes at oil platforms may be evaluated, and the ecological importance of platform habitat may be interpreted.

Several BOEM - and USGS-funded investigations have been completed and provide background for the present effort. The habitat value of a number of platforms on the Pacific OCS was synthesized in MMS 2003-032, *The Ecological Role of Natural Reefs and Oil and Gas Production Platforms on Rocky Reef Fishes in Southern California.* In this study, the fish assemblages from eight platforms and eight natural outcrops at similar depth were compared. The observations were from the surface to the seafloor on both platforms and natural reefs over a six-year period including 2001. The analyses were based on at least 40 submersible and hundreds of SCUBA dives on platforms and on 133 submersible and hundreds of SCUBA dives on natural outcrops located throughout southern California, the Santa Barbara Channel, and off Pt. Conception and Pt. Arguello.

The study found that platform fish assemblages are somewhat different from those of natural reefs. However, these differences were due almost entirely to the greater numbers of fishes around platforms, rather than large differences in species composition between platforms and natural outcrops. At least 85 species of fish were observed at platforms and 94 species at the outcrops. Rockfishes dominated both habitats, comprising 89.7% of all fishes at platforms and 92.5% at outcrops. Almost all of the more abundant species that the researchers observed were more common around platforms. Tremendous numbers of young-of-the-year (YOY) rockfish from several species settled at Platform Gail in 1999 with a lesser number recruiting to Platform Gilda. Species that were more common at one or more platforms than at natural reefs included cowcod and bocaccio (YOY, juvenile, and adult), copper, greenspotted, greenstriped, YOY and juvenile widow, vermilion, canary and flag rockfishes and YOY, juvenile, and adult lingcod.

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The MMS has recognized that there is not yet enough data to extrapolate the importance of platforms and associated structures fish assemblages when compared to those of natural reefs. One data gap has been information about the number and size of natural reefs in the vicinity of platforms. Recognizing this need, BOEM has funded through USGS sea floor mapping in the eastern Santa Barbara Channel, currently being conducted by Dr. Guy Cochrane, United States Geological Survey.

Pacific OCS platforms reside in a variety of depths and oceanographic conditions. This physical variability propagates to the biotic populations associated with these offshore structures, and suggests that a case-by-case scenario is likely for decommissioning decisions. In order to analyze the environmental consequences of platform decommissioning on local or regional fish populations, it is essential to know the role that each platform plays as fish habitat, particularly as compared to those natural reefs in the vicinity of platforms. Data necessary for these comparisons include densities and size structures of the fishes inhabiting both platforms and natural reefs and the location, area, and number of these natural reefs.

The primary goal of the present study was to fill gaps in information about the importance of POCS platform fish assemblages in southern and central California.

a) What is the relative contribution of platform fishes to the total hard structure fish assemblages (platforms and natural reefs) in the region?

b) What is the comparative importance of various platforms as fish nursery grounds?

c) What is the relative importance of platforms as regional fish larvae producers?

Specific objectives of this study were:

1) To survey the fish assemblages at platforms in order to continue long-term and short-term studies, to acquire information from platforms that have never been surveyed, to encompass a wide range of structures, occupying a diversity of water depths, geographic locations, and water masses.

2) Estimate the densities of all species at both platform and natural reef habitat and characterize the habitat of each fish observed.

3) To synthesize the data into a report describing the ecological performance of platforms as rockfish habitat and as rockfish producers.

Research Summary

Surveys were conducted at southern California platforms and natural reefs in 2010 and 2011 aboard the research submarine *Dual DeepWorker*. We conducted 87 transects around 11 platforms, encompassing 32,816 m^2 of habitat and we made two dives (13 transects, 5469 m^2) on natural reefs in shallow (46–47 m) and somewhat deeper (145 m) waters.

Over all platforms, we observed 158,129 individuals, comprising a minimum of 56 species. Rockfishes dominated platform fish assemblages; we observed 155,239 individuals (98.2% of all fishes), of at least 36 species. Squarespot and halfbanded rockfishes, and small, unidentified rockfishes (primarily young-of-the-year and likely mostly squarespot and widow rockfishes) dominated the surveys. Other abundant rockfishes included widow and bank rockfishes and bocaccio. Among non-rockfish species, blacksmith, painted greenling, California sheephead, and sharpnose seaperch were frequently observed.

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depth. For those platforms whose midwaters, bottoms, and shell mounds were all surveyed, fish densities were always highest around the platform bottom. Fish densities over shell mounds were lower than those at the adjacent platform bottom.

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At the bottom of all platforms other than Gail, halfbanded and/or squarespot rockfishes dominated the habitats. Other important species included calico, flag, rosy, vermilion and widow rockfishes, and lingcod. At a few platforms, notably Edith and Elly, YOY rockfishes (halfbanded and unidentified), comprised a substantial part of the assemblage; otherwise young fishes were not abundant. At Platform Gail, with a bottom depth considerably deeper than the other structures, a different suite of species dominated, including bocaccio, cowcod, pinkrose and greenblotched rockfishes. Overall, depending on platform, rockfishes were the most important group in the bottom assemblage, they comprised as much as 99.9% of all fishes observed.

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The shallow reef was dominated by blackeye goby and halfbanded rockfish; squarespot, blue, and vermilion rockfishes and lingcod were also frequently observed. At the deeper site, squarespot, pygmy, swordspine, and halfbanded rockfishes and unidentified rockfishes (likely primarily YOY swordspine and squarespot rockfishes) were very abundant.

Conclusions

Overall, the data from 2010–2011 supports two of the observations of previous surveys:
1) There are three distinct fish assemblages around each platform: midwater, bottom, and shell mound. Within these assemblages, those of the midwaters tend to be the most similar across platforms although there may be substantial interannual and some geographic differences. The bottom and shell mound assemblages tend to be somewhat similar within a platform (but are still distinct), but are often quite dissimilar among platforms.

Rockfishes (Scorpaenidae: *Sebastes*) remain the dominant group of fishes in most of the three platform assemblages. However, the importance of this group at any given platform will vary between years. The best example occurs in the midwater assemblage. Much of this assemblage (and to a lesser extent that of the bottom and shell mound assemblages) is composed of YOY rockfishes of a number of species. In turn, the success of each year class of each species is dependent on such oceanographic conditions as time and strength of upwelling, as well as current patterns. These vary inannually. Thus, recruitment strength and composition varies greatly between years and even between closely sited platforms.

Structurally, platform midwaters are composed of horizontal crossbeams and vertical piling-like supports and pipes carrying oil or gas. The bottom of each platform is similar to the midwaters in that it, too, has vertical pilings and a crossbeam designed to more or less run along the sea floor. However, unlike the midwaters, the bottom habitat contains both the structural elements and a sea floor that is often covered with shells. In addition, the bottom crossbeam is variably undercut or covered over, providing a greater or lesser "cave-like" habitat that is not found in the midwaters. Lastly, where mussel shells and other debris have fallen on the sea floor away from the platform bottom (i.e., the shell mound), these produce a myriad of small crevices and other hiding areas unique to this habitat.

Midwater fish assemblages tend to be similar because they tend to share a common structure (and thus a uniformity of habitat) and a common depth range (varying only at the maximum, bottom, depth). What assemblage variability does occur is likely due to 1) geographic variability in water masses and 2) the previously mentioned stochasticity in juvenile recruitment events. Variability in the bottom and shell mound assemblages reflects geographic differences, habitat differences (e.g., undercut versus no undercut crossbeams) and, particularly, depth – a major driver of both fish densities and species occurrences.

The integral role that habitat complexity plays in structuring platform fish assemblages can be observed in the midwaters of Platform Eureka. Among California platforms Eureka is structurally unique, having multiple bundles of pilings and large and quite complex horizontal struts, thus producing far more horizontal and vertical relief in platform midwaters. This atypical structural complexity plays a role in the uniquely high species richness and densities of the midwater assemblage at Platform Eureka. Many normally benthic sea floor species, usually missing or uncommon around other platform midwaters, are abundant at Eureka. As an example, compared to Platform Gail (found in about the same water depth), the midwater assemblage of Eureka harbors 1) higher densities both of all species combined and of most species held in common, 2) far more mature individuals of most species held in common, 3) greater species richness, and 4) much higher densities of those species that, on natural reefs, live over complex high relief.

In the midwaters, rockfishes, particularly YOY and slightly older juveniles, often dominate. Among the most abundant rockfish taxa are blue, copper, flag, gopher, kelp, olive, shortbelly, squarespot, widow, and yellowtail rockfishes, treefish, and bocaccio. With the exception of bocaccio and shortbelly rockfish, most of these species are relatively nearshore and shallow-water dwellers (bocaccio and shortbelly juveniles live in shallow waters and move deeper with age). This habitat is also occupied by a number of reef species including a number of sedentary or territorial taxa, such as garibaldi, sheephead, painted greenling, and cabezon. Less closely tied to platforms are schooling, pelagic species, such as jack mackerel, Pacific mackerel, and Pacific sardine, that are transient visitors. The abundance, and even the presence, of a number of species varies along a north-south gradient. This is particularly true for some warm-temperate species (e.g., garibaldi, kelp bass, and sheephead) that are abundant off Long Beach, but less so in the Santa Barbara Channel.

Unlike platform midwaters, which often are dominated by YOY rockfishes, platform bottoms vary considerably in their species assemblages and this variability is directly related to both bottom depth and to the structural complexity of the sea floor – bottom crossbeam association. The bottom assemblages of platforms situated in relatively shallow waters (e.g., Irene, Holly, Gilda, Edith, and Elly) usually have a mixture of YOY rockfishes and juvenile and adult rockfishes. Some of these YOYs and juveniles are of species that are also found in platform midwaters. Some of these fishes may have first settled out in the platform midwaters and then later descended to the platform bottom. Others probably settle from the plankton directly to the platform bottom or the surrounding shell mound. Along with the usual dominance of rockfishes, blackeye goby,

lingcod, painted greenling, spotted scorpionfish, and several species of seaperch are all characteristically observed on the bottom. Many California platforms are in the "species maxima" depth zone (about 50–150 m) that also occurs on natural reefs in the same region. This helps explain the high species richness and high fish densities of a number of these structures. Deeper-water platforms, below this species maximum, such as Eureka and Gail, harbor mostly adult of a few taxa including greenblotched, greenspotted, Mexican, and pinkrose rockfishes, and lingcod.

In contrast to the rich and diverse habitat opportunities of platform bottoms, with horizontal crossbeams and vertical pilings, the surrounding shell mounds provide only a modest amount of shelter created by the interstices of fallen shells. Thus, fishes occupying this habitat are limited to those species that favor low and hard relief. In practice, this describes a complex of juvenile fishes and juveniles and adults of dwarf species that need modest sheltering sites (e.g., juvenile cowcod and lingcod, blackeye goby, and calico rockfish), ecotonal species that favor soft sea floor-low, hard-relief bottom (greenstriped and stripetail rockfishes), and a few schooling taxa (notably halfbanded rockfish) that seem to be habitat generalists. In deeper water, a few species that are generally considered high relief dwellers, such as greenblotched, greenstriped, and pinkrose rockfishes, will also venture away from the platform bottoms out onto the shell mounds. It should also be noted that lingcod, also a habitat generalist, is the only very large predator routinely seen occupying this habitat.

2) During at least some years, platforms serve as nursery grounds for a variety of rockfishes and other taxa.

Platform midwaters tend to harbor higher densities of YOY rockfishes (sometimes extremely high densities) than do platform bottoms and shell mounds. This appears to be linked to several factors. First, when at sea, the locations of most pelagic juvenile and larval rockfishes lie within the upper 30–80 m of the water column and prerecruits would be unlikely to encounter those platform bottoms and shell mounds that lie deeper than this. In addition, many rockfish species are adapted to recruit to high relief structures – in nature this would include kelp beds and pinnacles. The steep platform midwater jacket more closely resembles these habitats than do shell mounds. Lastly, predation rates on YOYs may be relatively low as predatory fishes are relatively scarce in platform midwaters (particularly compared to platform bottoms. Nevertheless, in some years substantial numbers of YOYs also inhabit these sea floor habitats. In the 2010–2011 surveys, for instance, a combination of YOY halfbanded and unidentified rockfishes comprised about 50% of the fishes observed at the bottom of Platform Edith (these were also quite dense around the Edith shell mound) and YOY rockfish densities were also relatively high at the bottoms of platforms Ellen, Elly, and Grace.

Platform midwaters tend to harbor different YOY rockfishes than do adjacent bottom and shell mounds. Rockfishes that recruit in large numbers to platform midwaters include schooling epibenthic taxa (e.g., blue, olive, squarespot, widow, and yellowtail rockfishes, and bocaccio), as well as more solitary and benthic species (copper and gopher rockfishes, and treefish). While some of these species also recruit to the bottoms or shell mounds (e.g., squarespot and widow rockfishes and bocaccio), halfbanded rockfish are by far the most abundant of the YOY rockfishes around many California platforms. Interestingly, and with the singular exception of Platform Eureka, YOY halfbanded rockfish are relatively rare in platform midwaters. Other species that recruit to bottom waters include cowcod, various members of the *Sebastomus* subgenus (greenspotted, greenblotched, rosy, and starry rockfishes), blackgill, and vermilion rockfishes. All of these species tend to recruit to relatively low relief and are likely keying in on the mussels that cover the bottoms around platforms, rather than to the platform jackets.

There is relatively little rockfish recruitment around the bottoms/shell mounds of the deepest platforms (i.e., Harvest, Hermosa, Harmony, and Heritage). This probably reflects a number of factors. First, compared to more nearshore waters, relatively few rockfish species inhabit these depths. Second, most rockfish species recruit out of the plankton into waters shallower than the adult depth. Third, the adult abundances of these deeper-water species (such as blackgill and darkblotched rockfishes and cowcod) off California are far lower than those of the more shallow water species (a reflection of intense fishing); thus the numbers of larval and subsequent juveniles of the deeper-water species is also lower.

COMPLETION OF FISH ASSEMBLAGE SURVEYS AROUND MANMADE STRUCTURES AND NATURAL REEFS OFF CALIFORNIA

Milton S. Love and Mary Nishimoto

Abstract

Surveys were conducted at southern California platforms and natural reefs in 2010 and 2011 aboard the research submarine *Dual DeepWorker*. We conducted 87 transects around 11 platforms, encompassing 32,816 m^2 of habitat and we made two dives (13 transects, 5469 m^2) on natural reefs in shallow (46–47 m) and somewhat deeper (145 m) waters.

Over all platforms, we observed 158,129 individuals, comprising a minimum of 56 species. Rockfishes dominated platform fish assemblages; we observed 155,239 individuals (98.2% of all fishes), of at least 36 species. Squarespot and halfbanded rockfishes, and small, unidentified rockfishes (primarily young-of-the-year, and likely mostly squarespot and widow rockfishes) dominated the surveys. Other abundant rockfishes included widow and bank rockfishes and bocaccio. Among non-rockfish species, blacksmith, painted greenling, California sheephead, and sharpnose seaperch were frequently observed.

Fish densities were extremely variable among platforms and between depths within platforms. Fish densities were lowest in the shallower depth strata, particularly in 0–30 m, and densities generally increased with depth. For those platforms whose midwaters, bottoms, and shell mounds were all surveyed, fish densities were always highest around the platform bottom. Fish densities over shell mounds were lower than those at the adjacent platform bottom.

Generally, the midwater fish assemblages across all platforms were similar. Young-of-the-year (YOY) fishes (e.g., squarespot and widow rockfish, bocaccio, and painted greenling) dominated a number of platform midwaters. Also important around some platforms were such nearshore reef species as garibaldi, blacksmith, cabezon, sheephead, and white and sharpnose seaperches. Platform Eureka, with a more structurally complex midwater platform jacket harbored relative high densities of such typically deeper-dwelling rocky reef rockfishes as bank, speckled, rosy, dwarf-red and starry leading to a unique midwater assemblage of the platforms surveyed.

At the bottom of all platforms other than Gail, halfbanded and/or squarespot rockfishes dominated the habitats. Other important species included calico, flag, rosy, vermilion and widow rockfishes, and lingcod. At a few platforms, notably Edith and Elly, YOY rockfishes (halfbanded and unidentified), comprised a substantial part of the assemblage; otherwise these young fishes were not abundant. At Platform Gail, with a bottom depth considerably deeper than the other structures, a different suite of species dominated including bocaccio, cowcod, pinkrose and greenblotched rockfishes. Overall, depending on platform, rockfishes were the most important group in the bottom assemblage, they comprised as much as 99.9% of all fishes observed.

The assemblage of fishes occupying the low-relief shell mounds was composed of 1) juvenile fishes of larger species and juveniles and adults of dwarf species that utilize small sheltering sites (e.g., juvenile cowcod and lingcod, blackeye goby, and calico rockfish), 2) ecotonal species that favor soft sea floor-low, hard-relief bottom (greenstriped and stripetail rockfishes), and 3) a few schooling taxa (notably halfbanded rockfish) that are habitat generalists.

The shallow reef was dominated by blackeye goby and halfbanded rockfish; squarespot, blue, and vermilion rockfishes and lingcod were also frequently observed. At the deeper site, squarespot, pygmy, swordspine, and halfbanded rockfishes and unidentified rockfishes (likely primarily YOY swordspine and squarespot rockfishes) were very abundant.

Overall, the data from 2010–2011 supports the observations of previous surveys that: 1) There are three distinct fish assemblages around each platform: midwater, bottom, and shell mound. Within these assemblages, those of the midwaters tend to be the most similar across platforms although there may be substantial interannual and some geographic differences. The bottom and shell mound assemblages tend to be somewhat similar within a platform (but are still distinct), but are often quite dissimilar among platforms and 2) During at least some years, platforms serve as nursery grounds for a variety of rockfishes and other taxa.

Introduction

Offshore oil and gas platforms have continuously occupied California marine waters since 1958. Currently, there are 26 platforms in California waters, 23 are in federal waters and 3 are in state waters. They are located between 2 and 17 km from shore, in waters between 11 and 363 m deep. Other details regarding platform placement are found in Love et al. (2003). California platforms are steel structures and all are attached to the sea floor. The platform structure, referred as the jacket, is composed of vertical pilings, and horizontal and diagonal crossbeams. The crossbeams are located at about 30 m intervals and range from near the surface to the bottom. A shell mound, composed of mussels and other invertebrates that have fallen from the jacket, surrounds each platform.

All oil and gas platforms have a finite economic life, one driven by the price of oil and gas and by operating costs. Thus, at some point, all platforms become uneconomical to operate and become candidates for decommissioning. Decommissioning may take a number of forms, ranging from leaving much, or all, of the jacket in place to complete removal (Schroeder and Love 2004). Off California, seven platforms (Harry – 1974, Helen – 1978, Herman – 1978, Hilda, Hazel, Hope, and Heidi – 1996) have been decommissioned by complete removal, although the removal of the latter 4 platforms was not without controversy (Love et al. 2003).

Management decisions regarding decommissioning (in federal waters involving a number of agencies including the Bureau of Ocean Energy Management (BOEM) (Schroeder and Love 2004) are based on both biological and socioeconomic information. In order to better understand the role that platforms might play as fish habitat, beginning in 1995 our group, funded by the BOEM, National Biological Survey, United States Geological Survey, and California Artificial Reef Enhancement, has conducted research around California oil platforms and natural reefs. A summary of the first six years of that research was published in Love et al. (2003) and for years 2004–2009 in Love et al. (2010). This report presents data from submersible surveys of platforms and natural reefs conducted in 2010–2011.

Methods

Fish Surveys

Surveys were conducted at platforms and natural sites in 2010 and 2011 aboard the research submersible *Dual DeepWorker*. The *Dual DeepWorker* is 7.2 m in length, accommodates one scientific observer and one pilot, and has a maximum operating depth of 610 m. Dives were made in September and October, during daytime hours, and were documented with an externally mounted video camera positioned on the bow and starboard side of the submersible. The scientific observer also conducted a belt-transect survey on the starboard side, verbally recording onto the videotape all fishes and identifying each to the lowest possible taxon. The observer estimated the total length (cm) of these fishes using reference light points from two parallel lasers installed 20 cm apart on either side of the external video camera. These lasers, and a single crossing laser, also helped delineate the width (2 meters) of the transects. A constant speed between 0.5 and 1.0 knot was attempted. During dives on both shell mounds and natural sites, we attempted to maintain a constant distance within 1 meter of the seafloor. For each platform, we attempted to conduct surveys 1) on the shell mound, 2) platform bottom, and 3) platform midwaters.

This survey methodology underestimates the densities of some fish species. In particular, small and cryptic taxa, such as the bluebanded and zebra gobies (*Lythrypnus dalli* and *L. zebra*, respectively) are rarely observed and a number of flatfish species are difficult to visually identify. In addition, schools of benthopelagic forms, such as yellowtail rockfish, will occasionally aggregate in the water column above the *Dual DeepWorker* and are not counted.

Platform transect lengths were estimated in the following manner: 1) The bottoms lengths of platforms Gail, A, B, and C were known. 2) Midwater and bottom transects of all platforms with straight sides (this include all platforms except Eureka): After visually assessing the accuracy of corner locations from USBL data, straight line distances between the four corner locations were added to obtain the platform perimeter at each depth surveyed. 3) For shell mound transects, platform Eureka, and for natural reef data, submarine position was recorded at a 2 second frequency with a USBL tracking system. These positions were plotted, visually assessed, and obvious erroneous data points were removed. The distances between the remaining sequential points were calculated, and divided by the time elapsed between the points to obtain submarine speed. When this speed exceeded 1 m/sec, the fixes were assumed to be erroneous and were removed. The points were then smoothed using a 20 point moving average, and the total distance between the smoothed points was used as an estimated transect length.

Data Analysis

We treated transect densities (count/100 m^2) of each taxon as observations. Densities were transformed to the fourth root to satisfy variance homogeneity assumptions for discriminant analyses. We used the same transformation for cluster analysis to be consistent. Densities for each species were standardized to a mean of zero and standard deviation of one. We used the lda procedure of R(R 2005) to perform discriminant analysis. The procedure hclust was used for the analysis, along with the average linkage option of the Unweighted Pair-Groups Method for performing the hierarchical agglomerative clustering. The Euclidean method was used for calculating distances. Averages of standardized transformed densities of taxa within high order clusters were calculated for each habitat type.

Note: We used these multivariate analyses only to analyze the midwater surveys, as we made insufficient bottom and shell mound transects in 2010 and 2011 to allow for meaningful multivariate analyses for these two habitats. As an example, there were only 8 transects from platform bottom habitats, but 49 taxa were observed. The maximum number of taxa that could be used for canonical discriminant analysis is one less than the number of transects or 7 for platform bottom habitats. There is not an objective procedure for selection of the taxa and results from the use of only 7 taxa would likely not be representative of these species rich communities. Thus, for the bottom and shell mound habitats we will rely on a discussion of species densities and richness.

Results

Summary of Platform Fish Assemblages

We conducted 87 transects around 11 platforms, encompassing 32,815 m^2 of habitat (Figure 1, Tables 1, 2). The midwaters of most of these platforms were surveyed in both years (Table 1). While the bottoms and shell mounds of some platforms were surveyed annually (Edith, Ellen, and Elly), poor visibility prevented these surveys during one of two years for some platforms (Gail and Grace) and for both years at others (A, B, C, Eureka, Hogan, and Holly) (Table 1).

Over all platforms, we observed 158,129 individuals, comprising a minimum of 56 species (Table 3). Rockfishes dominated platform fish assemblages; we observed 155,239 individuals (98.2% of all fishes), of at least 36 species. Squarespot and halfbanded rockfishes, and small, unidentified rockfishes (primarily young-

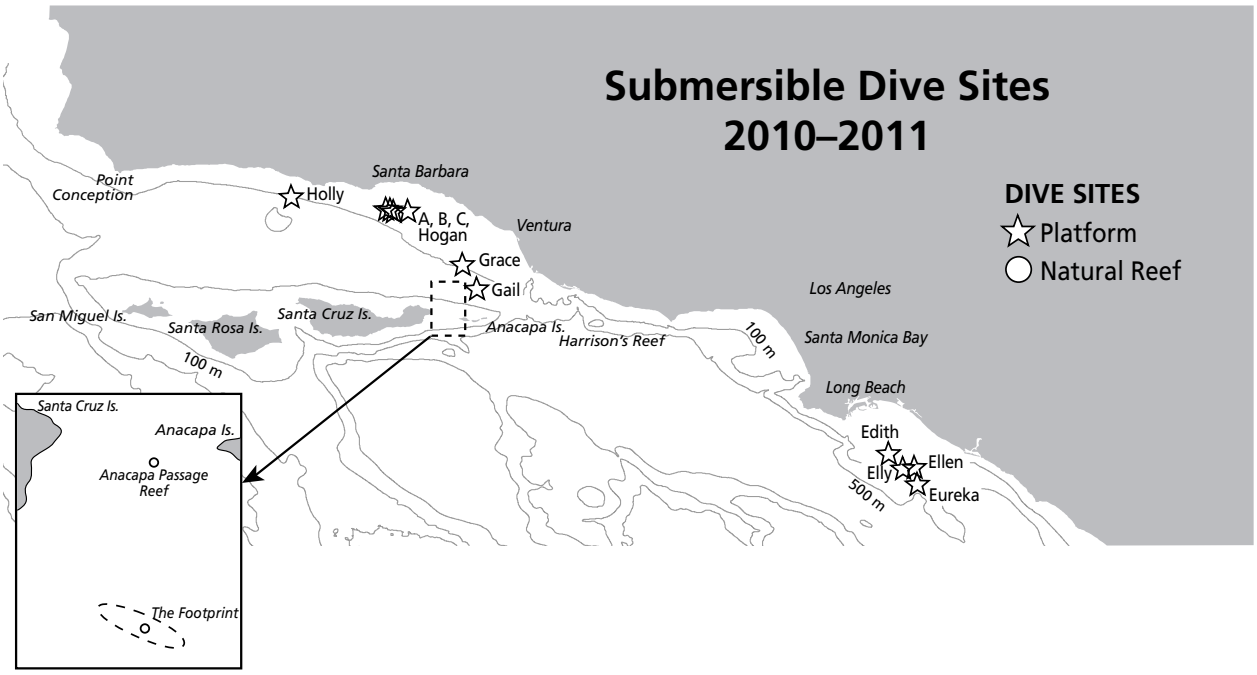

Figure 1. Location of fish surveys, 2010–2011, at platforms (stars) and natural sites (circles), off California.

Table 1. Platforms surveyed, 2010–2011. Note: In some years not all habitats (midwater, bottom or shell mound) were surveyed.

	2010	2011
A		
Midwater	X	X
B		
Midwater		X
C		
Midwater		X
EDITH		
Midwater	X	
Bottom	X	X
Shell mound	X	X
ELLEN		
Midwater	X	X
Bottom	X	X
Shell mound	X	X
ELLY		
Midwater	X	X
Bottom	X	X
Shell mound	X	X

	2010	2011
EUREKA		
Midwater	X	X
GAIL		
Midwater	X	X
Bottom		X
Shell mound		X
GRACE		
Midwater	X	X
Bottom	X	
Shell mound	X	X
HOGAN		
Midwater	X	
HOLLY		
Midwater	X	X

Table 2. Area surveyed (m^2) by habitat type.

HABITAT	NUMBER OF TRANSECTS	AREA SURVEYED (M^2)
Platform midwater	70	25,476
Platform bottom	8	3611
Platform shell mound	9	3728
Natural reefs	13	5469
TOTAL	**100**	**38,285**

of-the-year and likely mostly squarespot and widow rockfishes) dominated the surveys. Other abundant rockfishes included widow and bank rockfishes and bocaccio. Among non-rockfish species, blacksmith, painted greenling, California sheephead, and sharpnose seaperch were frequently observed.

Fish densities were extremely variable among platforms and between depths within platforms (Figure 2). At the extremes, few fishes were observed at platforms B and C (note that only the midwaters were surveyed), while very high densities occurred at Grace, Edith, Elly, Ellen, and Eureka. In general, fish densities were lowest in the shallower depth strata, particularly in 0–30 m, and there was a tendency for densities to increase to a deeper midwater or bottom maximum. For those platforms whose midwaters, bottoms, and shell mounds were all surveyed (i.e., Grace, Gail, Edith, Elly, and Ellen), fish densities were usually highest around the platform bottom. At all of these five platforms, fish densities over shell mounds were lower than those at the adjacent platform bottom.

Platform Midwaters

The number of species inhabiting platform midwaters varied greatly, from a high of 30 at Platform Eureka to a low of four at Platform C, although most platforms harbored between 9 and 20 taxa (Figure 4, Table 4). Generally, the midwater fish assemblages across all platforms were more similar to each other than to platform bottoms or shell mounds (Figure 3). Young-of-the-year (YOY) of a number of rockfish species (e.g., squarespot and widow rockfish, bocaccio, and painted greenling) sometimes dominated the assemblage; rockfish YOY comprised between 75.8% (Platform Hogan) to 0% of the observed fishes. Similarly, rockfishes, in general, were sometimes overwhelmingly important, 99.7% of all fishes at Platform Grace were rockfishes (Table 4). We also observed a suite of nearshore (nonrockfish) reef species, including garibaldi, blacksmith, painted greenling, cabezon, and sheephead, along with white and sharpnose seaperches. Platform Eureka harbored relative high densities of such typically deeper-dwelling rocky reef rockfishes as bank, speckled, rosy, dwarf-red and starry. Both Platform A and Eureka harbored somewhat different assemblages (Table 4, Figures 5–7).

There appeared to be no pattern to species richness when platforms were plotted from north to south. That is, we observed no geographic differences in species richness between platforms in the Santa Barbara Channel and those off Long Beach (Figure 4). However, in general, platforms situated in deeper waters harbored a slightly larger number of species than did those in shallower depths (Figure 4). Interannual variation in midwater communities at a platform tended to be low and thus the overall fish assemblage in the midwaters of a particular platform varied little between the two years (Figure 5).

Platform Bottoms

We observed between 10 and 24 species around the bottoms of the platforms (Table 5, Figure 8). There were some interplatform differences in fish assemblages (Figure 3). These differences were related to bottom depth. As an example, note that the assemblage at Platform Gail, the deepest of the surveyed platforms, harbored the most unique assemblage. At all platforms other than Gail, schooling halfbanded and/or

Table 3. Numbers and densities (average number/100m^2) of fish taxons at platforms (2010-2011).
Rankings of counts and densities may differ because densities are averages of transect densities and area surveyed differed among transects.

Common Name	Scientific Name	Number	Density
Squarespot rockfish	*Sebastes hopkinsi*	68,975	214.5
Halfbanded rockfish	*Sebastes semicinctus*	49,323	142.3
Unidentified rockfishes	*Sebastes* spp.	18,061	61.7
Widow rockfish	*Sebastes entomelas*	8987	29.0
Bocaccio	*Sebastes paucispinis*	4495	18.0
Blacksmith	*Chromis punctipinnis*	1540	5.2
Bank rockfish	*Sebastes rufus*	1494	3.4
Vermilion rockfish	*Sebastes miniatus*	691	1.9
Blue rockfish	*Sebastes mystinus*	683	2.0
Speckled rockfish	*Sebastes ovalis*	531	1.3
Calico rockfish	*Sebastes dallii*	357	0.9
Flag rockfish	*Sebastes rubrivinctus*	286	0.7
Painted greenling	*Oxylebius pictus*	272	0.9
California sheephead	*Semicossyphus pulcher*	255	0.9
Unidentified *Sebastomus*	*Sebastes* spp.	255	0.6
Kelp rockfish	*Sebastes atrovirens*	252	0.8
Sharpnose surfperch	*Phanerodon atripes*	194	0.8
Rosy rockfish	*Sebastes rosaceus*	140	0.4
Copper rockfish	*Sebastes caurinus*	136	0.4
Garibaldi	*Hypsypops rubicunda*	122	0.4
Lingcod	*Ophiodon elongatus*	95	0.3
White seaperch	*Phanerodon furcatus*	91	0.3
Cabezon	*Scorpaenichthys marmoratus*	87	0.3
Pinkrose rockfish	*Sebastes simulator*	64	0.1
Greenstriped rockfish	*Sebastes elongatus*	63	0.1
Pile perch	*Rhacochilus vacca*	58	0.2
Olive rockfish	*Sebastes serranoides*	56	0.1
Pygmy rockfish	*Sebastes wilsoni*	51	0.1
Starry rockfish	*Sebastes constellatus*	47	0.1
Greenblotched rockfish	*Sebastes rosenblatti*	44	0.1
Honeycomb rockfish	*Sebastes umbrosus*	44	0.1
Unidentified surfperch		44	0.1

Table 3. (continued)

Dwarf-red rockfish	*Sebastes rufinanus*	35	0.1
Halfmoon	*Medialuna californiensis*	34	0.1
Unidentified fishes		34	0.1
Greenspotted rockfish	*Sebastes chlorostictus*	30	0.1
Blackeye goby	*Rhinogobiops nicholsii*	26	0.1
Cowcod	*Sebastes levis*	26	0.1
Treefish	*Sebastes serriceps*	22	0.1
Gopher rockfish	*Sebastes carnatus*	20	0.1
Yellowtail rockfish	*Sebastes flavidus*	15	0.1
Brown rockfish	*Sebastes auriculatus*	13	<0.1
Shortbelly rockfish	*Sebastes jordani*	13	0.1
Pink seaperch	*Zalembius rosaceus*	8	<0.1
Darkblotched rockfish	*Sebastes crameri*	6	<0.1
Spotted scorpionfish	*Scorpaena guttata*	6	<0.1
Swordspine rockfish	*Sebastes ensifer*	6	<0.1
Spotted ratfish	*Hydrolagus colliei*	5	<0.1
Kelp greenling	*Hexagrammos decagrammus*	4	<0.1
Mexican rockfish	*Sebastes macdonaldi*	4	<0.1
Unidentified sculpin		4	<0.1
Grass rockfish	*Sebastes rastrelliger*	3	<0.1
Juvenile unknown rockfish	*Sebastes* spp.	3	<0.1
Stripetail rockfish	*Sebastes saxicola*	3	<0.1
Yelloweye rockfish	*Sebastes ruberrimus*	3	<0.1
Freckled rockfish	*Sebastes lentiginosus*	2	<0.1
Pygmy poacher	*Odontopyxis trispinosa*	2	<0.1
Wolf-eel	*Anarrhichthys ocellatus*	2	<0.1
Kelp bass	*Paralabrax clathratus*	1	<0.1
Ocean sunfish	*Mola mola*	1	<0.1
Pacific sanddab	*Citharichthys sordidus*	1	<0.1
Shortspine combfish	*Zaniolepis frenata*	1	<0.1
Unidentified combfishes	*Zaniolepis* spp.	1	<0.1
Unidentified flatfishes		1	<0.1
Total		158,129	489.5
Minimum number of species		57	

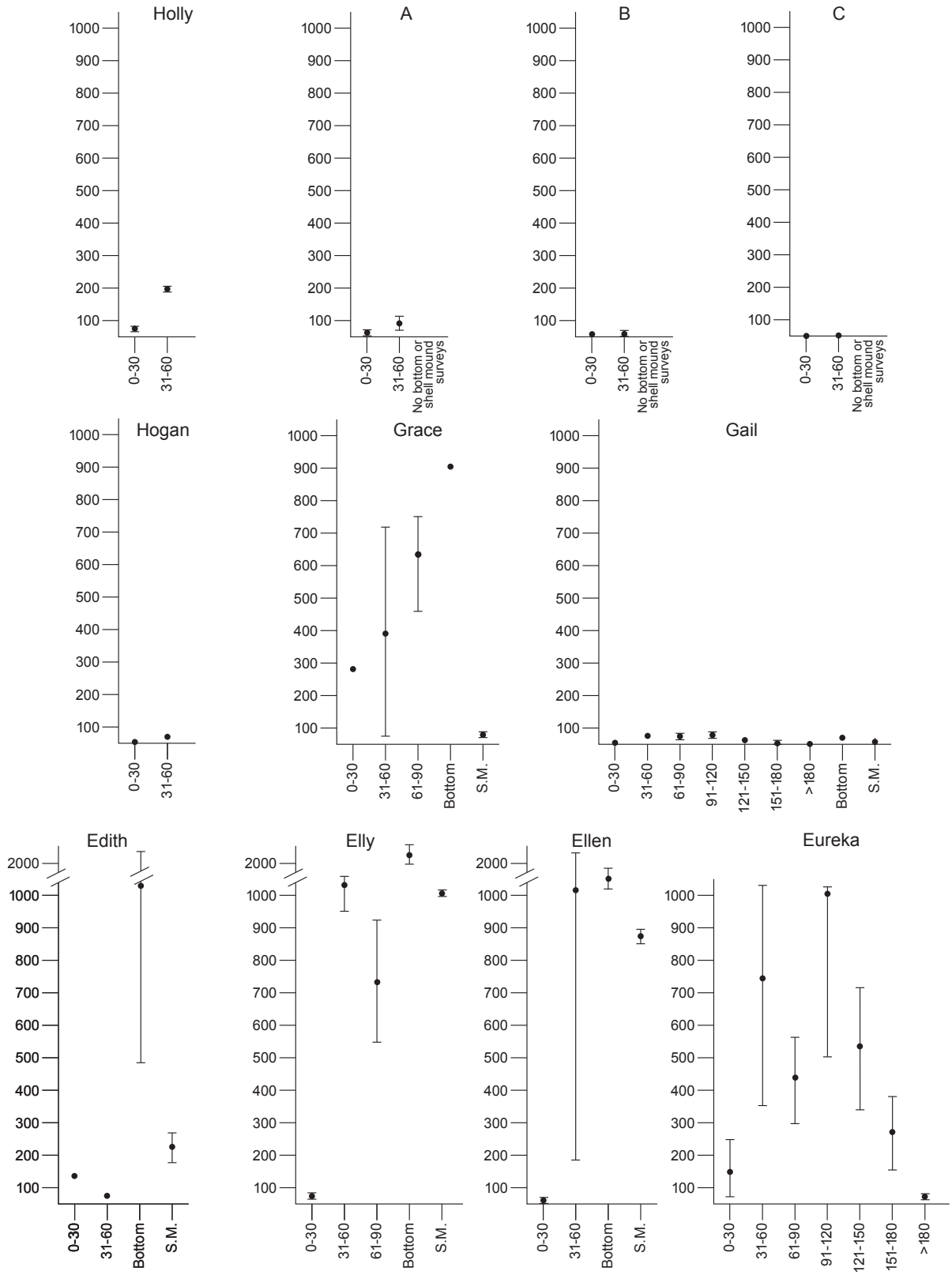

Figure 2. Density, with standard error bars, of all fishes (per 100 m^2) at platform midwaters, bottom, and shell mound, 2010–2011. Platforms are listed from northernmost to southernmost. Note that densities on y-axis vary among platforms.

squarespot rockfishes were the most important species. Other important species included calico, flag, rosy, vermilion and widow rockfishes, and lingcod. At a few platforms, notably Edith and Elly, YOY rockfishes (halfbanded and unidentified), comprised a substantial part of the assemblage. Rockfish YOY comprised between 0 and 35.3% of all fishes observed (Table 5). At Platform Gail, with a bottom depth considerably deeper than the other structures, a different suite of species dominated and these included bocaccio, cowcod, pinkrose and greenblotched rockfishes. Overall, rockfishes were the most important group, they comprised as much as 99.9% (Platform Grace) of all fishes observed (Table 5). Based on a limited number of platforms, we observed that those structures located off Long Beach, in middle bottom depths harbored the greatest number of species.

Platform Shell Mounds

Shell mound fish assemblages varied between five and 19 species (Table 6, Figure 9). Similar to observations around platform bottoms, we found that shell mound assemblages, while generally similar to one another, were differentiated by bottom depth (Figure 3). At four of the six platforms (Edith, Ellen, Elly, and Grace), halfbanded rockfish (both YOY and adults) dominated the assemblage. Around these structures, calico, squarespot, and vermilion rockfishes were also important. Greenstriped and pinkrose rockfishes were most abundant at Platform Gail. The geographical and depth patterns of species richness was similar to that of the bottom assemblages; richness was highest at two of the Long Beach platforms and peaked at platforms in the middle depth range (Figure 9).

Summary of Natural Reef Assemblages

We made two dives (13 transects, 5469 m^2) (Figure 1, Table 2) on natural reefs. One site, in the Anacapa Passage, was in 46–47 m, while the other site (The Footprint) was in 145 m.

The Anacapa Passage reef, with 22 observed species, was dominated by blackeye goby and halfbanded rockfish, squarespot, blue, and vermilion rockfishes and lingcod were also frequently observed (Table 7). At The Footprint (23 species observed), squarespot, pygmy, swordspine, and halfbanded rockfishes and unidentified rockfishes (likely primarily YOY swordspine and squarespot rockfishes) were very abundant.

Discussion

We discuss the results of the 2010–2011 surveys in the context of what was previously observed in surveys conducted during 1995–2009 and summarized in Love et al. (2003, 2010):

1) *There are three distinct fish assemblages around each platform: midwater, bottom, and shell mound. Within these assemblages, those of the midwaters tend to be the most similar across platforms although there may be substantial interannual and some geographic differences. The bottom and shell mound assemblages tend to be somewhat similar within a platform (but still distinct), but often quite dissimilar among platforms.*

Throughout the course of our studies, and reinforced by the 2010–2011 surveys, it has become clear that the habitats created by the jacket in the midwater and bottom and by the shell mound of each platform are quite distinct from one another, engendering significant differences in fish species assemblages. In addition, each habitat (midwater, bottom, and shell mound) is sufficiently similar *among* a number of platforms that the associated fish assemblages are also kindred.

It might be expected that these similarities would occur as (with the exception of Platform Eureka, see below) all of the platforms off California are similarly configured. And, in general, this assumption has proven to be reasonably correct. Structurally, platform midwaters are composed of horizontal crossbeams and vertical piling-like supports and pipes carrying oil or gas. The bottom of each platform is similar to the midwaters in that it, too, has vertical pilings and a crossbeam designed to more or less run along the sea floor. However, unlike the midwaters, the bottom habitat contains both the structural elements and a sea

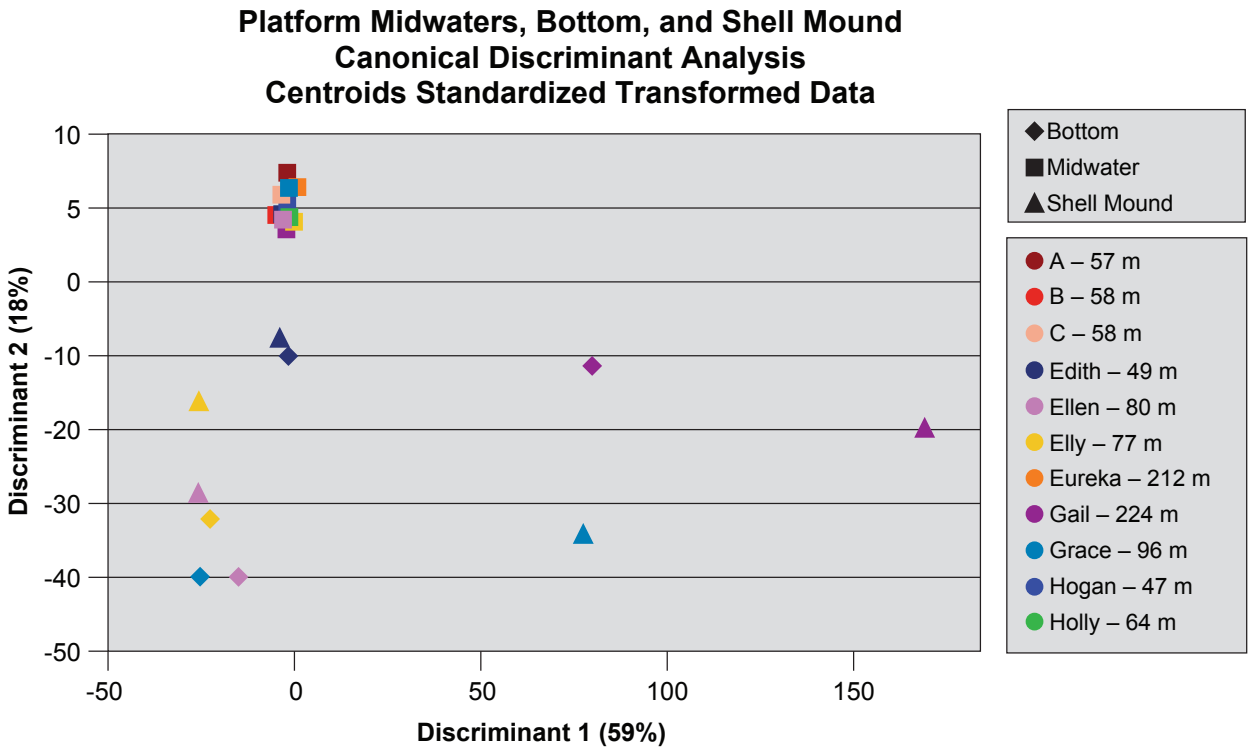

Figure 3. A canonical discriminant analysis of platform midwaters, bottom, and shell mound fish assemblages, based on centroids of surveys conducted in 2010–2011.

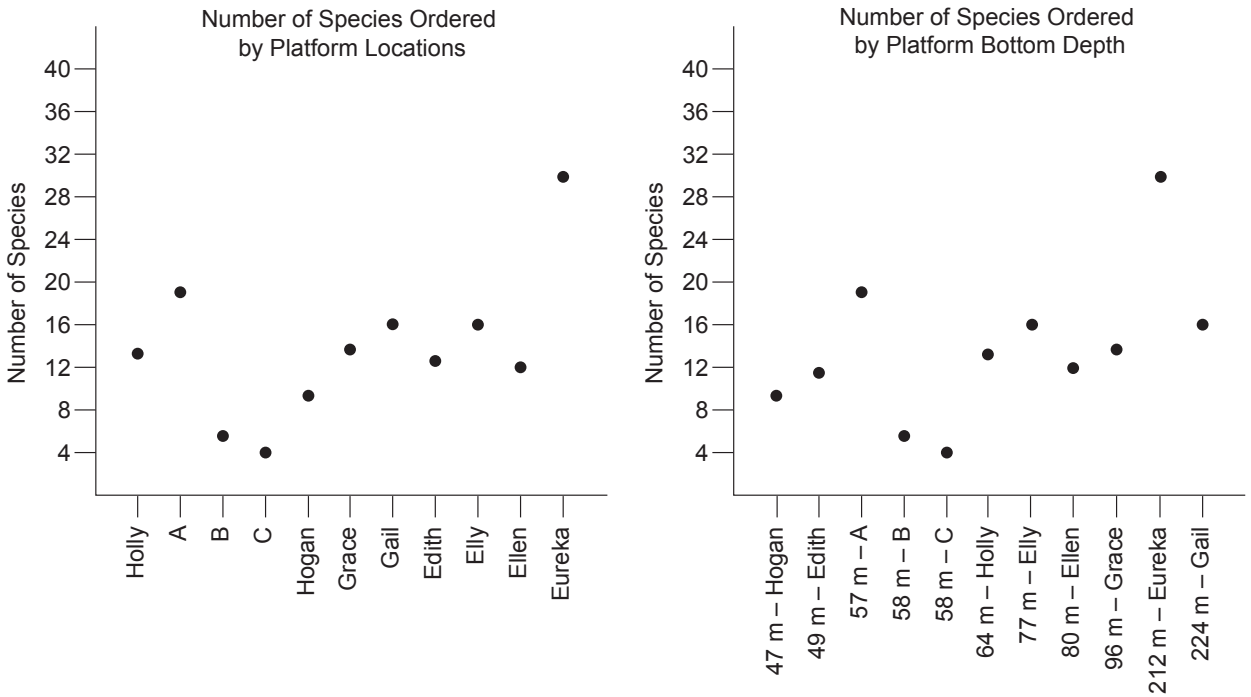

Figure 4. Number of species observed in the midwaters of platforms, 2010–2011. Platforms are listed first from northernmost to southernmost and then from shallowest to deepest.

Table 4. Numbers and densities (average number per 100 m^2) of fish species observed in the midwaters of platforms, 2010–2011. Rankings of total counts and average densities may differ because densities are averages of transect densities and area surveyed varied among transects. Young-of-the-year (YOY) and older fish are listed separately.

PLATFORM A (Surveyed 2010–11)

Species	Number	Density
Squarespot rockfish YOY	387	20.0
Squarespot rockfish	192	9.9
Sharpnose surfperch	187	10.7
Bocaccio YOY	114	5.9
Blue rockfish	85	4.4
White seaperch	71	3.8
Unidentified rockfishes YOY	65	3.4
Pile perch	25	1.4
Blacksmith	20	1.2
Unidentified surfperch	19	1.1
Kelp rockfish	13	0.8
Painted greenling	12	0.7
California sheephead	9	0.5
Brown rockfish	7	0.4
Yellowtail rockfish	6	0.3
Unidentified rockfishes	5	0.3
Juvenile unknown rockfish YOY	3	0.2
Stripetail rockfish	3	0.2
Unidentified fishes	3	0.2
Blue rockfish YOY	2	0.1
Copper rockfish	2	0.1
Painted greenling YOY	2	0.1
Speckled rockfish	2	0.1
Cabezon	1	0.1
Kelp greenling	1	0.1
Kelp rockfish YOY	1	0.1
Olive rockfish	1	0.1
Total	1238	
Minimum Number of Species	18	
Total Rockfish YOY	572	
Total Rockfish	888	

Rockfish YOY comprised 46.2% of all fish surveyed
All rockfishes comprised 71.7% of all fish surveyed

PLATFORM B (Surveyed in 2011)

Species	Number	Density
Painted greenling	8	0.9
Pile perch	6	0.6
California sheephead	2	0.2
Cabezon	1	0.1
Kelp rockfish	1	0.1
Unidentified rockfishes	1	0.1
Total	19	
Minimum Number of Species	5	
Total Rockfish YOY	0	
Total Rockfish	2	

Rockfish YOY comprised 0.0% of all fish surveyed
All rockfishes comprised 10.5% of all fish surveyed

PLATFORM C (Surveyed in 2011)

Species	Number	Density
California sheephead	2	0.3
Painted greenling	2	0.2
Pile perch	2	0.2
Garibaldi	1	0.1
Total	7	
Minimum Number of Species	4	
Total Rockfish YOY	0	
Total Rockfish	0	

Rockfish YOY comprised 0.0% of all fish surveyed
All rockfishes comprised 0.0% of all fish surveyed

PLATFORM EDITH (Surveyed in 2010–11)

Species	Number	Density
Blacksmith	269	40.5
California sheephead	95	14.2
Unidentified rockfishes YOY	90	13.0
Garibaldi	49	7.4
Shortbelly rockfish	10	1.5
Painted greenling	7	1.0
Brown rockfish	4	0.6
Squarespot rockfish	4	0.6
Cabezon	2	0.3
Gopher rockfish	2	0.3
Lingcod	2	0.3
Kelp rockfish	1	0.2
Unidentified fishes	1	0.2
Painted greenling YOY	1	0.1
Total	537	
Minimum Number of Species	11	
Total Rockfish YOY	90	
Total Rockfish	111	

Rockfish YOY comprised 16.8% of all fish surveyedA l l rockfishes comprised 20.7% of all fish surveyed

Table 4 (continued)

PLATFORM ELLEN (Surveyed in 2010–11)

Species	Number	Density
Squarespot rockfish	11,036	737.4
Unidentified rockfishes YOY	1305	92.3
Squarespot rockfish YOY	348	19.2
California sheephead	31	1.9
Bocaccio YOY	26	1.7
Blacksmith	21	1.2
Kelp rockfish	21	1.1
Cabezon	12	0.6
Blue rockfish	6	0.4
Sharpnose surfperch	5	0.2
Painted greenling	2	0.1
Unidentified *Sebastomus* YOY	2	0.1
White seaperch	2	0.1
Lingcod	1	<0.1
Painted greenling YOY	1	<0.1
Unidentified *Sebastomus*	1	<0.1
Total	12,820	
Minimum Number of Species	12	
Total Rockfish YOY	1681	
Total Rockfish	12,745	

Rockfish YOY comprised 13.1% of all fish surveyed
All rockfishes comprised 99.4% of all fish surveyed

PLATFORM ELLY (Surveyed in 2010–11)

Species	Number	Density
Squarespot rockfish	7305	383.6
Unidentified rockfishes YOY	4971	293.9
Squarespot rockfish YOY	1772	97.9
Blacksmith	222	9.7
Blue rockfish	51	1.9
Bocaccio YOY	42	2.4
Halfmoon	34	1.5
Unidentified rockfishes	30	1.7
California sheephead	24	1.5
Cabezon	13	0.6
White seaperch	12	0.5
Garibaldi	9	0.5
Kelp rockfish	9	0.6
Painted greenling	3	0.2
Unidentified surfperch	3	0.1
Lingcod	2	0.1
Gopher rockfish	1	0.1
Pile perch	1	0.1
Copper rockfish	1	<0.1
Painted greenling YOY	1	<0.1
Sharpnose surfperch	1	<0.1
Unidentified fishes	1	<0.1
Total	14,508	
Minimum Number of Species	16	
Total Rockfish YOY	6785	
Total Rockfish	14,182	

Rockfish YOY comprised 46.8% of all fish surveyed
All rockfishes comprised 97.8% of all fish surveyed

PLATFORM EUREKA (Surveyed in 2010–11)

Species	Number	Density
Squarespot rockfish	8201	161.9
Squarespot rockfish YOY	6237	138.6
Unidentified rockfishes YOY	3452	75.2
Bank rockfish	855	14.6
Blacksmith	812	20.5
Bocaccio YOY	765	15.9
Unidentified rockfishes	488	10.1
Halfbanded rockfish YOY	353	8.0
Speckled rockfish	335	6.0
Bank rockfish YOY	275	4.5
Widow rockfish	139	2.7
Speckled rockfish YOY	115	2.1
Unidentified *Sebastomus*	75	1.4
Rosy rockfish	51	1.0
Blue rockfish	42	0.9
Pygmy rockfish	33	0.7
California sheephead	26	0.7
Dwarf-red rockfish	25	0.5
Kelp rockfish	23	0.5
Starry rockfish	23	0.4
Garibaldi	22	0.6
Copper rockfish	13	0.3
Bocaccio	10	0.2
Dwarf-red rockfish YOY	10	0.2
Greenspotted rockfish	9	0.2
Painted greenling	8	0.1
Cabezon	6	0.1
Flag rockfish	6	0.1
Widow rockfish YOY	6	0.1
Blue rockfish YOY	5	0.1
Darkblotched rockfish	5	0.1
Gopher rockfish	5	0.1
Greenblotched rockfish	4	0.1
Swordspine rockfish	4	0.1
Pygmy rockfish YOY	3	0.1
Starry rockfish YOY	3	0.1
Pygmy poacher	2	<0.1
Unidentified fishes	2	<0.1
Unidentified sculpin	2	<0.1
Unidentified *Sebastomus* YOY	2	<0.1
Grass rockfish	1	<0.1
Olive rockfish	1	<0.1

Table 4 (continued)

Pacific sanddab	1	<0.1
Painted greenling YOY	1	<0.1
Treefish	1	<0.1
Total	22,457	
Minimum Number of Species	30	
Total Rockfish YOY	11,226	
Total Rockfish	21,575	

Rockfish YOY comprised 50.0% of all fish surveyed
All rockfishes comprised 96.1% of all fish surveyed

PLATFORM GAIL (Surveyed in 2010–11)

Species	Number	Density
Squarespot rockfish	312	7.9
Unidentified rockfishes YOY	165	4.3
Squarespot rockfish YOY	115	2.9
Painted greenling	68	1.8
Bocaccio	36	0.8
Bocaccio YOY	33	1.2
Copper rockfish	29	0.8
Flag rockfish	29	0.7
Widow rockfish YOY	24	0.5
Painted greenling YOY	20	0.5
Unidentified rockfishes	19	0.5
Unidentified *Sebastomus*	14	0.3
Widow rockfish	12	0.2
Pinkrose rockfish	11	0.2
Greenspotted rockfish	6	0.2
Greenblotched rockfish	6	0.1
Halfbanded rockfish YOY	5	0.1
Cabezon	4	0.1
Unidentified fishes	4	0.1
Kelp greenling	3	0.1
Calico rockfish	1	<0.1
Flag rockfish YOY	1	<0.1
Lingcod	1	<0.1
Unidentified sculpin	1	<0.1
Unidentified *Sebastomus* YOY	1	<0.1
Yelloweye rockfish	1	<0.1
Total	921	
Minimum Number of Species	16	
Total Rockfish YOY	344	
Total Rockfish	820	

Rockfish YOY comprised 37.3% of all fish surveyed
All rockfishes comprised 89.0% of all fish surveyed

PLATFORM GRACE (Surveyed in 2010–11)

Species	Number	Density
Widow rockfish	3795	128.4
Widow rockfish YOY	3637	124.5
Bocaccio YOY	2264	112.9
Squarespot rockfish	1821	65.7
Squarespot rockfish YOY	1570	55.1
Bocaccio	448	27.3
Unidentified rockfishes YOY	294	10.6
Unidentified rockfishes	126	4.0
Kelp rockfish	36	1.3
Painted greenling	13	0.4
Blacksmith	11	0.4
Copper rockfish	9	0.4
Painted greenling YOY	9	0.3
Blue rockfish	7	0.2
Cabezon	5	0.2
Unidentified surfperch	2	0.1
Blue rockfish YOY	1	<0.1
Flag rockfish	1	<0.1
Rosy rockfish	1	<0.1
Unidentified fishes	1	<0.1
Vermilion rockfish	1	<0.1
Total	14,052	
Minimum Number of Species	13	
Total Rockfish YOY	7766	
Total Rockfish	14,011	

Rockfish YOY comprised 55.3% of all fish surveyed
All rockfishes comprised 99.7% of all fish surveyed

PLATFORM HOGAN (Surveyed in 2010)

Species	Number	Density
Squarespot rockfish YOY	47	3.9
Unidentified rockfishes YOY	16	1.3
California sheephead	7	0.7
Copper rockfish YOY	4	0.3
Painted greenling	4	0.3
Pile perch	3	0.2
Halfbanded rockfish YOY	2	0.2
Painted greenling YOY	2	0.2
Unidentified fishes	2	0.2
Cabezon	1	0.1
Kelp bass	1	0.1
Kelp rockfish	1	0.1
Unidentified surfperch	1	0.1
Total	91	
Minimum Number of Species	9	
Total Rockfish YOY	69	
Total Rockfish	70	

Rockfish YOY comprised 75.8% of all fish surveyed
All rockfishes comprised 76.9% of all fish surveyed

Table 4 (continued)

PLATFORM HOLLY (Surveyed in 2010–11)

Species	Number	Density
Widow rockfish YOY	893	57.6
Squarespot rockfish	647	33.8
Unidentified rockfishes	82	6.3
Bocaccio YOY	43	2.3
Copper rockfish	39	2.0
Kelp rockfish	38	2.0
Blacksmith	32	2.1
Widow rockfish	29	2.2
Painted greenling	22	1.6
Blue rockfish YOY	20	2.4
Unidentified rockfishes YOY	12	0.7
Painted greenling YOY	9	0.5
Yellowtail rockfish	9	0.4
Squarespot rockfish YOY	8	0.5
Calico rockfish	7	0.3
Copper rockfish YOY	4	0.2
Unidentified fishes	3	0.2
Bocaccio	2	0.1
Pile perch	2	0.1
Shortbelly rockfish YOY	2	0.2
Unidentified surfperch	2	0.1
Ocean sunfish	1	0.1
Total	1906	
Minimum Number of Species	13	
Total Rockfish YOY	982	
Total Rockfish	1835	

Rockfish YOY comprised 51.5% of all fish surveyed
All rockfishes comprised 96.3% of all fish surveyed

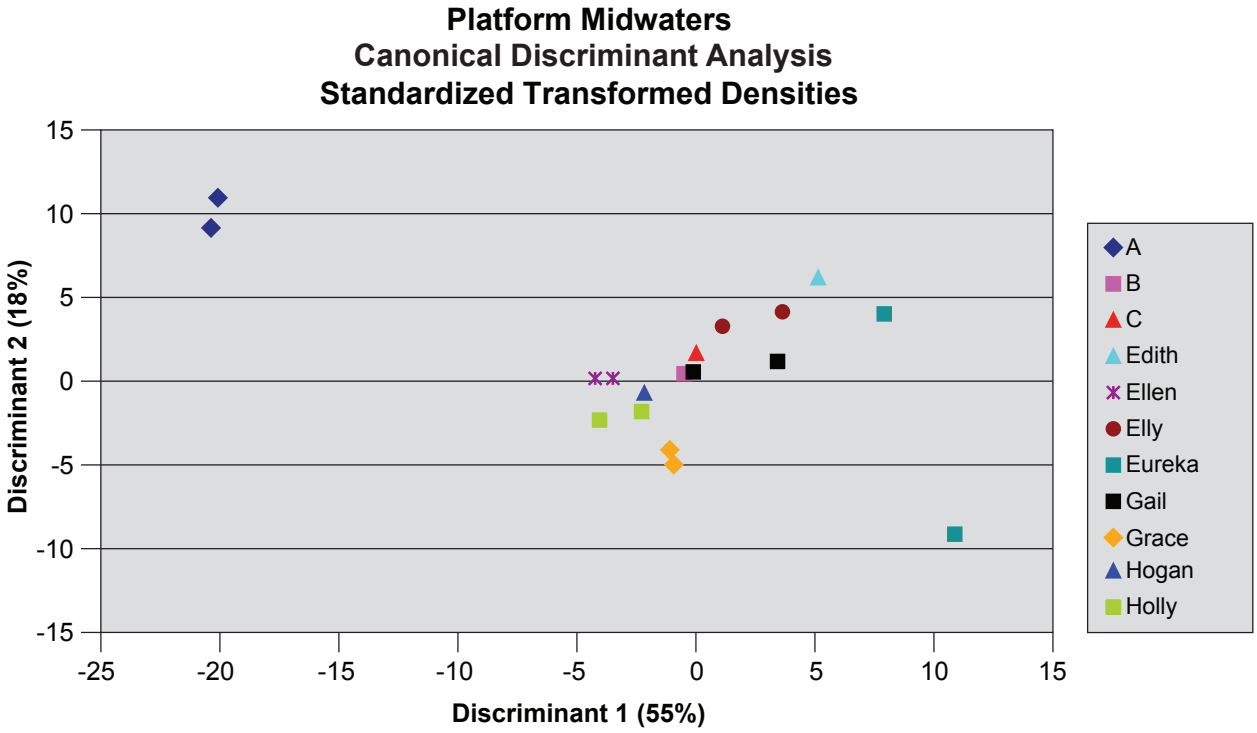

Figure 5. A canonical discriminant analysis of platform midwaters fish assemblages, by year, 2010–2011.

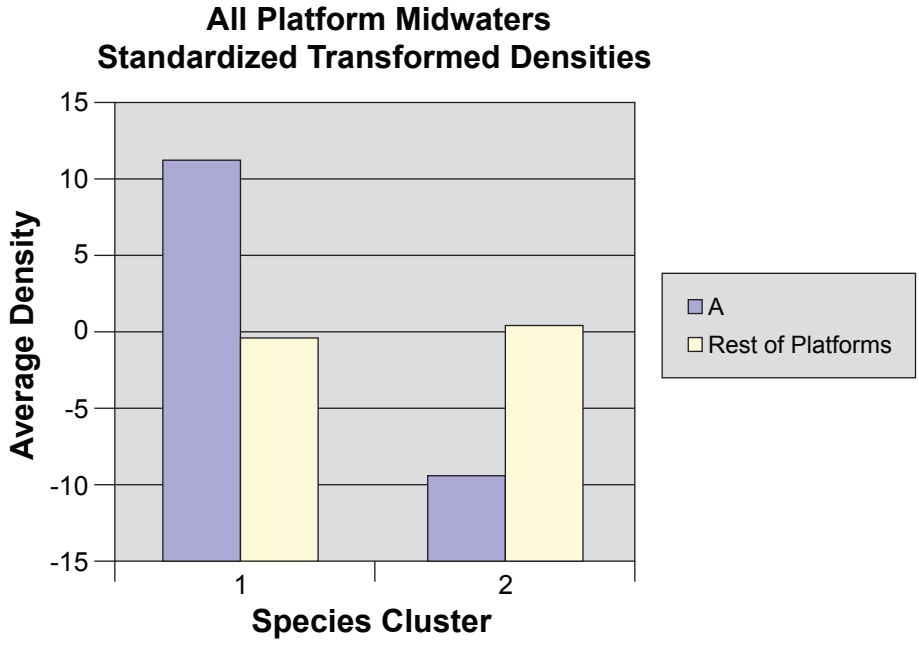

Figure 6. A comparison of densities of the three midwater species clusters shown in Figure 7.

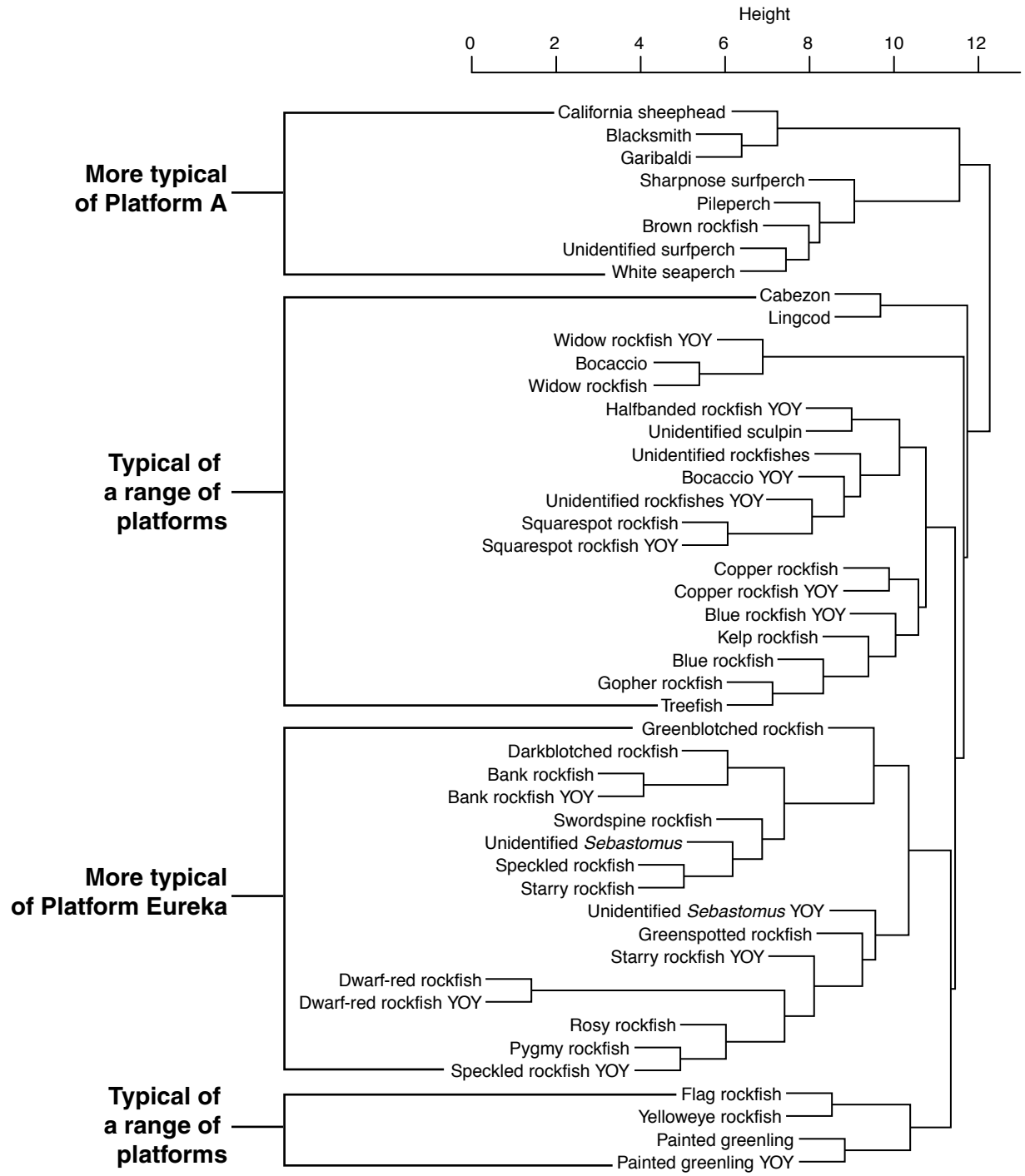

Figure 7. A cluster analysis of the characteristic species of platform midwaters, 2010–2011.

Table 5. Numbers and densities (average number per 100 m^2) of fish species observed on the bottoms of platforms, 2010–2011. Rankings of total counts and average densities may differ because densities are averages of transect densities and area surveyed varied among transects. Young-of-the-year (YOY) and older fish are listed separately.

PLATFORM EDITH (Surveyed 2010–11)

Species	Number	Density
Halfbanded rockfish	7660	884.7
Halfbanded rockfish YOY	2163	249.8
unidentified rockfishes YOY	2085	240.8
Cabezon	28	3.2
Kelp rockfish	17	2.0
Blackeye goby	14	1.6
California sheephead	14	1.6
Lingcod	10	1.2
Pile perch	9	1.0
Painted greenling	5	0.6
Spotted scorpionfish	5	0.6
Squarespot rockfish	5	0.6
Brown rockfish	2	0.2
Copper rockfish	2	0.2
Unidentified surfperch	2	0.2
Unidentified fishes	1	0.1
unidentified rockfishes	1	0.1
Wolf-eel	1	0.1
Total	12,024	
Minimum Number of Species	13	
Total Rockfish YOY	4248	
Total Rockfish	11935	

Rockfish YOY comprised 35.3% of all fish surveyed
All rockfishes comprised 99.3% of all fish surveyed

PLATFORM ELLEN (Surveyed 2010–11)

Species	Number	Density
Halfbanded rockfish	8697	1070.8
Squarespot rockfish	2458	302.6
Vermilion rockfish	253	31.1
Unidentified rockfishes YOY	196	24.1
Halfbanded rockfish YOY	128	15.8
Calico rockfish	35	4.3
Blue rockfish	31	3.8
Flag rockfish	25	3.1
Unidentified *Sebastomus*	19	2.3
Bocaccio YOY	17	2.1
Painted greenling	17	2.1
Rosy rockfish	11	1.4
Squarespot rockfish YOY	11	1.4
Honeycomb rockfish	8	1.0
Olive rockfish	8	1.0
Greenspotted rockfish	5	0.6
Lingcod	5	0.6
Vermilion rockfish YOY	5	0.6
Treefish	4	0.5
Bocaccio	1	0.1
Cabezon	1	0.1
Flag rockfish YOY	1	0.1
Freckled rockfish	1	0.1
Pink seaperch	1	0.1
Sharpnose surfperch	1	0.1
unidentified rockfishes	1	0.1
Unidentified *Sebastomus* YOY	1	0.1
Total	11,941	
Minimum Number of Species	18	
Total Rockfish YOY	359	
Total Rockfish	11,916	

Rockfish YOY comprised 3.0% of all fish surveyed
All rockfishes comprised 99.8% of all fish surveyed

PLATFORM ELLY (Surveyed 2010–11)

Species	Number	Density
Squarespot rockfish	9139	1038.0
Halfbanded rockfish	7406	841.1
unidentified rockfishes YOY	1590	180.6
Calico rockfish	245	27.8
Bocaccio YOY	239	27.1
Halfbanded rockfish YOY	222	25.2
Flag rockfish	173	19.6
Vermilion rockfish	162	18.4
Squarespot rockfish YOY	70	8.0
Rosy rockfish	60	6.8
Bocaccio	50	5.7
Olive rockfish	39	4.4
Unidentified *Sebastomus*	29	3.3
Lingcod	25	2.8
Honeycomb rockfish	24	2.7
Painted greenling	16	1.8
Blue rockfish	15	1.7
Treefish	10	1.1
Unidentified surfperch	6	0.7
Copper rockfish	5	0.6
Flag rockfish YOY	5	0.6
Pink seaperch	5	0.6
Greenspotted rockfish	4	0.5
unidentified rockfishes	3	0.3
California sheephead	2	0.2
Pile perch	2	0.2
Starry rockfish	2	0.2
White seaperch	2	0.2
Cabezon	1	0.1
Gopher rockfish	1	0.1
Kelp rockfish	1	0.1
Painted greenling YOY	1	0.1
Widow rockfish	1	0.1
Total	19,555	
Minimum Number of Species	24	

Table 5 (continued)

Total Rockfish YOY	2126
Total Rockfish	19,495

Rockfish YOY comprised 10.9% of all fish surveyed
All rockfishes comprised 99.7% of all fish surveyed

PLATFORM GAIL (Surveyed 2011)

Species	Number	Density
Bocaccio	108	18.0
Unidentified *Sebastomus*	39	6.5
Pinkrose rockfish	37	6.2
Greenblotched rockfish	30	5.0
Cowcod	24	4.0
Lingcod	6	1.0
Mexican rockfish	4	0.7
Greenstriped rockfish	3	0.5
Widow rockfish	3	0.5
Unidentified fishes	2	0.3
Flag rockfish	1	0.2
Greenspotted rockfish	1	0.2
Unidentified rockfishes	1	0.2
Total	259	

Minimum Number of Species	10
Total Rockfish YOY	0
Total Rockfish	251

Rockfish YOY comprised 0.0% of all fish surveyed
All rockfishes comprised 96.9% of all fish surveyed

PLATFORM GRACE (Surveyed 2010)

Species	Number	Density
Halfbanded rockfish	3479	768.9
Vermilion rockfish	167	36.9
Bocaccio YOY	154	34.0
Widow rockfish	90	19.9
Bocaccio	86	19.0
Unidentified rockfishes YOY	70	15.5
Unidentified rockfishes	21	4.6
Flag rockfish	13	2.9
Widow rockfish YOY	10	2.2
Blue rockfish	4	0.9
Unidentified *Sebastomus*	3	0.7
Squarespot rockfish	2	0.4
Unidentified fishes	2	0.4
Copper rockfish	1	0.2
Lingcod YOY	1	0.2
Painted greenling	1	0.2
Total	4104	

Minimum Number of Species	11
Total Rockfish YOY	234
Total Rockfish	4100

Rockfish YOY comprised 5.7% of all fish surveyed
All rockfishes comprised 99.9% of all fish surveyed

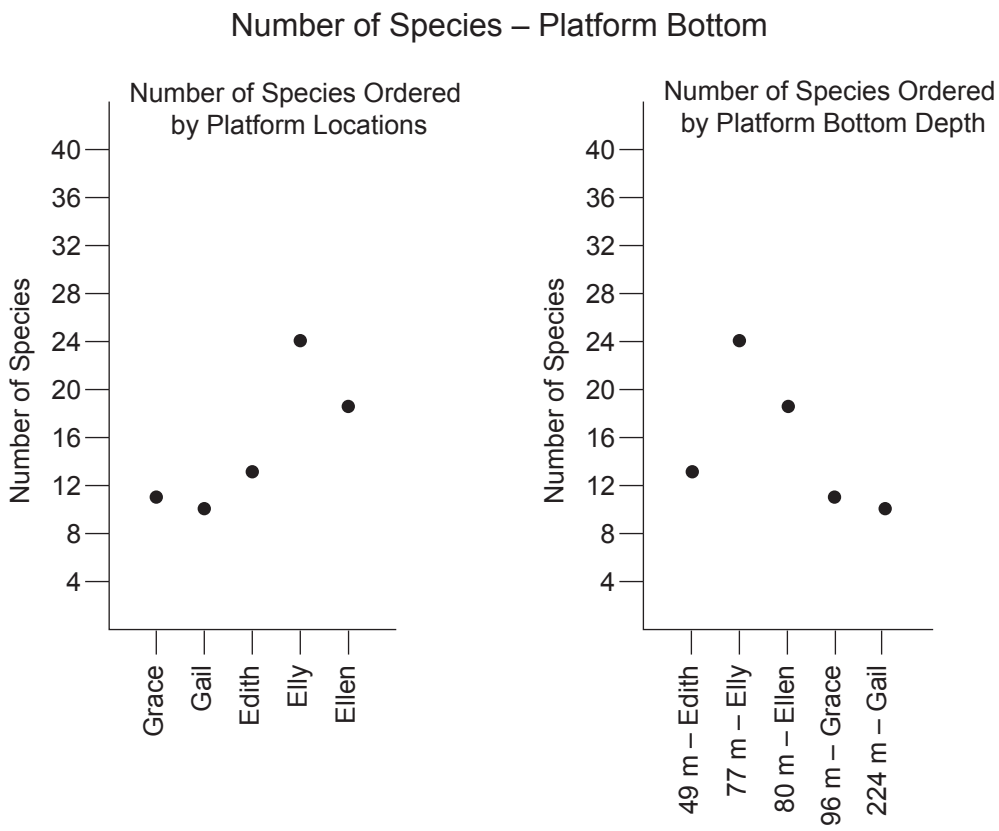

Figure 8. Number of species observed at bottoms of platforms, 2010–2011. Platforms are listed first from northernmost to southernmost and then from shallowest to deepest.

floor that is often covered with shells. In addition, the bottom crossbeam is variably undercut or covered over, providing a greater or lesser "cave-like" habitat that is not found in the midwaters. Lastly, where mussel shells and other debris have fallen on the sea floor away from the platform bottom, these produce a myriad of small crevices and other hiding areas unique to this habitat.

Two other factors, other than the physical attributes of these three habitats, help structure these assemblages. Bottom depth is a major driving force for both platform bottoms and shell mounds. Love et al. (2009) found that for natural reef fish assemblages in California, bottom depth played a significant role in species assemblages, reef species richness, and overall density of individuals. Geography, in this case a surrogate for water mass characteristics, also plays a role. Platforms north of Point Conception (not surveyed in 2010–2011) lie within the California Current and within a regime that is more heavily dominated by cold-temperate species than platforms in the Santa Barbara Channel or off Long Beach.

Thus, midwater assemblages tend to be similar because they (with the exception of Platform Eureka) share a common structure (and thus a uniformity of habitat) and a common depth range (varying only at the maximum, bottom, depth). What variability does occur is likely due to 1) geographic variability in water masses and 2) stochasticity in juvenile recruitment events. On the other hand, variability in the bottom and shell mound assemblages reflects geographic differences, habitat differences (e.g., undercut versus no undercut crossbeams) and, particularly, depth – a major driver of both fish densities and species occurrences (Love et al. 2009).

Regardless of where a platform is situated, the fish assemblages of all of the structures that we have surveyed are characterized by various species of rockfishes, reflecting the dominance of this genus on both natural and man-made reefs in the eastern Pacific (Love and Yoklavich 2006, Love et al. 2002, 2009). As might

Table 6. Numbers and densities (average number per 100 m^2) of fish species observed on the shellmounds of platforms, 2010–2011. Rankings of total counts and average densities may differ because densities are averages of transect densities and area surveyed varied among transects. Young-of-the-year (YOY) and older fish are listed separately.

PLATFORM EDITH (Surveyed 2010–11)

Species	Number
Halfbanded rockfish	6230
Halfbanded rockfish YOY	1990
Unidentified rockfishes YOY	771
Unidentified rockfishes	50
Blackeye goby	9
Cabezon	9
California sheephead	6
Lingcod	6
Pile perch	4
Unidentified fishes	4
Painted greenling	3
White seaperch	3
Wolf-eel	1
Lingcod YOY	1
Pink seaperch	1
Spotted scorpionfish	1
Unidentified surfperch	1
Total	9090
Minimum Number of Species	11
Total Rockfish YOY	2761
Total Rockfish	9041

Rockfish YOY comprised 30.4% of all fish surveyed
All rockfishes comprised 99.5% of all fish surveyed

PLATFORM ELLEN (Surveyed 2010–11)

Species	Number
Halfbanded rockfish	5012
Halfbanded rockfish YOY	460
Unidentified rockfishes YOY	353
Squarespot rockfish	109
Vermilion rockfish	45
Bocaccio YOY	11
Flag rockfish	9
Unidentified *Sebastomus*	8
Unidentified surfperch	8
Lingcod	7
Honeycomb rockfish	5
Squarespot rockfish YOY	5
Unidentified *Sebastomus* YOY	5
Painted greenling	4
Greenspotted rockfish	4
Rosy rockfish	3
Calico rockfish	3
Treefish	2
Pile perch	2
Freckled rockfish	1
Lingcod YOY	1
Starry rockfish	1
Pink seaperch	1
Cowcod	1
Olive rockfish	1
Copper rockfish	1
Unidentified rockfishes	1
Total	6063
Minimum Number of Species	20
Total Rockfish YOY	834
Total Rockfish	6040

Rockfish YOY comprised 13.8% of all fish surveyed
All rockfishes comprised 99.6% of all fish surveyed

PLATFORM ELLY (Surveyed 2010–11)

Species	Number
Halfbanded rockfish	3545
Squarespot rockfish	2816
Halfbanded rockfish YOY	1510
Unidentified rockfishes YOY	1029
Calico rockfish	63
Bocaccio YOY	30
Squarespot rockfish YOY	16
Vermilion rockfish	16
Lingcod	15
Unidentified *Sebastomus* YOY	13
Painted greenling	10
Rosy rockfish	10
Unidentified *Sebastomus*	10
Honeycomb rockfish	6
Olive rockfish	6
Bocaccio	5
Flag rockfish	5
Unidentified rockfishes	3
Pile perch	2
Blue rockfish	1
Cabezon	1
Cowcod YOY	1
Starry rockfish	1
Treefish	1
Unidentified fishes	1
White seaperch	1
Total	9117
Minimum Number of Species	19
Total Rockfish YOY	2599
Total Rockfish	9087

Rockfish YOY comprised 28.5% of all fish surveyed
All rockfishes comprised 99.7% of all fish surveyed

Table 6 (continued)

PLATFORM GAIL (Surveyed 2011)

Species	Number
Greenstriped rockfish	54
Pinkrose rockfish	16
Unidentified *Sebastomus*	8
Spotted ratfish	5
Greenblotched rockfish	4
Unidentified rockfishes	3
Bocaccio	2
Lingcod YOY	2
Unidentified fishes	2
Shortbelly rockfish	1
Unidentified flatfishes	1
Total	98
Minimum Number of Species	8
Total Rockfish YOY	0
Total Rockfish	88

Rockfish YOY comprised 0.0% of all fish surveyed
All rockfishes comprised 89.8% of all fish surveyed

PLATFORM GRACE (Surveyed 2010–11)

Species	Number
Halfbanded rockfish	458
Unidentified rockfishes	52
Vermilion rockfish	42
Blue rockfish	12
Flag rockfish	8
Greenstriped rockfish	6
Lingcod	5
Lingcod YOY	5
Bocaccio	4
Widow rockfish	4
Calico rockfish	3
Unidentified fishes	3
Unidentified *Sebastomus*	2
Greenspotted rockfish	1
Shortspine combfish	1
Squarespot rockfish	1
Unidentified combfishes	1
Total	608
Minimum Number of Species	12
Total Rockfish YOY	0
Total Rockfish	593

Rockfish YOY comprised 0.0% of all fish surveyed
All rockfishes comprised 97.5% of all fish surveyed

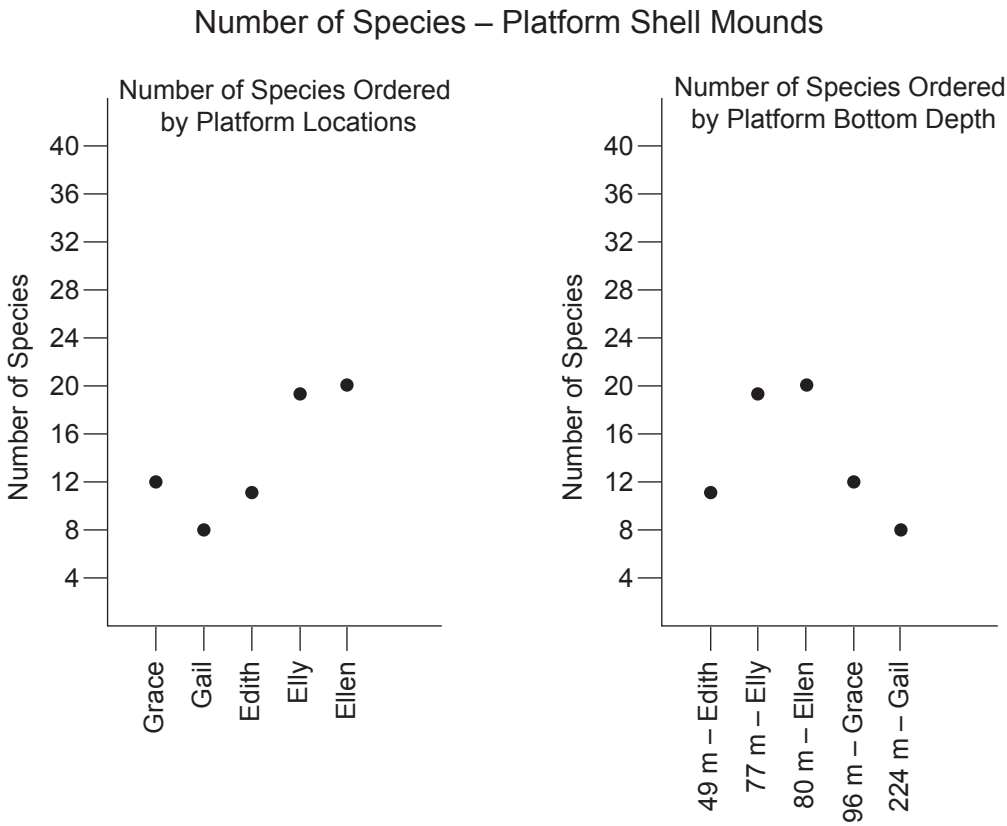

Figure 9. Number of species observed on shell mounds of platforms, 2010–2011. Platforms are listed first from northernmost to southernmost and then from shallowest to deepest.

be expected, the species of rockfishes that dominate these systems vary considerably depending of habitat type and bottom depth. Which fish species, then, are most important to the various platform assemblages?

In the midwaters, rockfishes, particularly YOY and slightly older juveniles, often dominate. Among the most abundant rockfish taxa are blue, copper, flag, gopher, kelp, olive, shortbelly, squarespot, widow, and yellowtail rockfishes, treefish, and bocaccio. With the exception of bocaccio and shortbelly rockfish, most of these species are relatively nearshore and shallow-water dwellers (bocaccio and shortbelly juveniles live in shallow waters and move deeper with age). Many of these species, particularly schooling forms such as blue, olive, shortbelly, widow, and yellowtail rockfishes and bocaccio, are found both close to, and in the open waters inside, the platform jacket. On the other hand, more benthic-oriented taxa (e.g., copper, gopher, and kelp rockfishes, and treefish) rarely venture far from the shelter of crossbeams and pilings. Other midwater schooling fishes, such as blacksmith and halfmoon are also typically found here. This habitat is also occupied by a number of reef species that are more closely associated with the platform structure. These include a number of sedentary or territorial taxa, such as garibaldi, sheephead, painted greenling, and cabezon. Less closely tied to platforms are schooling, pelagic species, such as jack mackerel, Pacific mackerel, and Pacific sardine, that are transient visitors. The abundance, and even the presence, of a number of species varies along a north-south gradient. This is particularly true for some warm-temperate species (e.g., garibaldi, kelp bass, and sheephead) that are abundant off Long Beach, are less so in the Santa Barbara Channel, and are absent from platforms north of Point Conception (Love et al. 2010, Martin and Lowe 2010, this paper).

Previously, we alluded to the uniqueness of the midwater habitat, and fish assemblage, at Platform Eureka; here the role that habitat complexity plays in structuring midwater fish assemblages can be clearly seen. The midwater structures of most California platforms are a framework of rounded steel crossbeams

Table 7. Numbers and densities (average number/100m^2) of fish taxons at natural reefs (2010–2011). Rankings of counts and densities may differ because densities are averages of transect densities and area surveyed differed among transects.

Anacapa Passage (Surveyed in 2011)

Common Name	Scientific Name	Count	Density
Blackeye goby	*Rhinogobiops nicholsii*	242	120.0
Halfbanded rockfish	*Sebastes semicinctus*	202	55.7
Squarespot rockfish	*Sebastes hopkinsi*	89	38.5
Blue rockfish	*Sebastes mystinus*	87	113.0
Lingcod	*Ophiodon elongatus*	70	159.3
Vermilion rockfish	*Sebastes miniatus*	49	90.8
unidentified rockfishes	*Sebastes* spp.	24	11.6
Unidentified fishes		21	7.8
Copper rockfish	*Sebastes caurinus*	13	20.5
Rosy rockfish	*Sebastes rosaceus*	12	12.4
Olive rockfish	*Sebastes serranoides*	11	20.8
Painted greenling	*Oxylebius pictus*	10	8.1
California sheephead	*Semicossyphus pulcher*	9	14.7
Gopher rockfish	*Sebastes carnatus*	9	11.2
Starry rockfish	*Sebastes constellatus*	6	6.5
Treefish	*Sebastes serriceps*	6	8.2
Spotted scorpionfish	*Scorpaena guttata*	3	4.7
Unidentified *Sebastomus*	*Sebastes* spp.	3	3.8
Wolf-eel	*Anarrhichthys ocellatus*	3	6.9
Flag rockfish	*Sebastes rubrivinctus*	2	2.7
Pile perch	*Rhacochilus vacca*	1	1.8
Greenspotted rockfish	*Sebastes chlorostictus*	1	1.7
Blacksmith	*Chromis punctipinnis*	1	1.2
Honeycomb rockfish	*Sebastes umbrosus*	1	1.2
Pygmy rockfish	*Sebastes wilsoni*	1	0.6
Total		876	723.8
Minimum number of species		22	

Table 7 (continued)

Footprint (Surveyed in 2010)

Common Name	Scientific Name	Count	Density
Squarespot rockfish	*Sebastes hopkinsi*	3781	260.4
Pygmy rockfish	*Sebastes wilsoni*	1548	97.1
Swordspine rockfish	*Sebastes ensifer*	1256	243.2
Unidentified rockfishes	*Sebastes* spp.	1166	31.4
Unidentified Sebastomus	*Sebastes* spp.	989	237.8
Halfbanded rockfish	*Sebastes semicinctus*	652	121.3
Bank rockfish	*Sebastes rufus*	57	8.6
Speckled rockfish	*Sebastes ovalis*	54	21.6
Unidentified combfishes	*Zaniolepis* spp.	34	14.9
Shortbelly rockfish	*Sebastes jordani*	33	3.3
Bocaccio	*Sebastes paucispinis*	30	19.2
Flag rockfish	*Sebastes rubrivinctus*	11	6.0
Cowcod	*Sebastes levis*	10	11.6
Pinkrose rockfish	*Sebastes simulator*	10	2.7
Unidentified fishes		10	3.3
Shortspine combfish	*Zaniolepis frenata*	9	5.3
Lingcod	*Ophiodon elongatus*	5	7.2
Vermilion rockfish	*Sebastes miniatus*	4	3.4
Longspine combfish	*Zaniolepis latipinnis*	3	1.4
Spotted ratfish	*Hydrolagus colliei*	2	1.6
Widow rockfish	*Sebastes entomelas*	2	1.4
Greenspotted rockfish	*Sebastes chlorostictus*	2	1.0
Greenblotched rockfish	*Sebastes rosenblatti*	1	0.6
Rosy rockfish	*Sebastes rosaceus*	1	0.5
Greenstriped rockfish	*Sebastes elongatus*	1	0.4
Starry rockfish	*Sebastes constellatus*	1	0.3
Unidentified flatfishes		1	0.2
Total		9673	1105.6
Minimum number of species		23	

and tubular vertical sleeves. The main pilings are driven through these sleeves, which are located at the corners and sometimes at widely spaced intervals between the corners of the jacket. Amid these platforms, Platform Eureka is structurally unique. Instead of pilings driven through vertical sleeves, it has a series of narrow "skirt pilings" that are attached to the outside of the jacket. These are in fascicles of three closely bundled pilings. To guide these pilings into the sea floor, large circular guides were constructed at each crossbeam directly above the piling's location. Compared to all other California platforms, these skirt pilings and guides produce far more horizontal relief in platform midwaters. This atypical structural complexity plays a role in the very high species richness and densities of the midwater assemblage at Platform Eureka. Many normally benthic, sea floor species, usually missing or uncommon around other platform midwaters, are abundant at Eureka. As an example, compared to Platform Gail (found in about the same water depth), the midwater assemblage of Eureka harbors 1) higher densities both of all species combined and of most species held in common, 2) far more mature individuals of most species held in common, 3) greater species richness, and 4) much higher densities of those species that, on natural reefs, live over complex high relief (Love and Lenarz 2010).

Unlike platform midwaters, which often are dominated by YOY rockfishes, platform bottoms vary considerably in their species assemblages and this variability is directly related to both bottom depth and to the structural complexity of the sea floor – bottom crossbeam association (Love et al. 2000, 2010, Love and York 2006, this paper).

The bottom assemblages of platforms situated in relatively shallow waters (e.g., Irene, Holly, Gilda, Edith, and Elly) usually have a mixture of YOY rockfishes (e.g., halfbanded and squarespot) and juvenile and adult rockfishes (e.g., brown, calico, copper, flag, halfbanded, honeycomb, vermilion, and vermilion and bocaccio). Some of these YOYs and juveniles (e.g., bocaccio and squarespot rockfish) are of species that are also found in platform midwaters and, indeed, these fishes may have first settled out in the midwaters, later to descend to the platform bottom. However, the YOYs of a number of other bottom assemblage species (particularly lingcod and halfbanded rockfish) do not appear to recruit to the platform midwaters and probably settled from the plankton directly to the platform bottom or the surrounding shell mound. Along with the usual dominance of rockfishes, blackeye goby, lingcod, painted greenling, spotted scorpionfish, and several species of seaperch are all characteristically observed on the bottom.

Many California platforms are in the "species maxima" depth zone (about 50–150 m) identified for natural reefs by Love et al. (2009). This helps explain the high species richness and high fish densities of a number of these structures. Deeper-water platforms, below this species maximum, such as Eureka and Gail, harbor mostly adults of a few taxa including bocaccio, cowcod, greenblotched, greenspotted, Mexican, and pinkrose rockfishes, and lingcod. Deeper-water platforms whose bottom crossbeam has been either deeply undercut (forming a large gap) or covered over (thus disappearing) tend to have fewer large fish and more "dwarf" species, such as halfbanded rockfish; these are more mobile and not as tied to sheltering sites.

In contrast to the rich and diverse habitat opportunities of platform bottoms, with horizontal crossbeams and vertical pilings, the surrounding shell mounds provide only a modest amount of shelter created by the interstices of fallen shells. Thus, fishes occupying this habitat are limited to those species that favor low and hard relief. In practice, this describes a complex of juvenile fishes and juveniles and adults of dwarf species that need modest sheltering sites (e.g., juvenile cowcod and lingcod, blackeye goby, and calico rockfish), ecotonal species that favor soft sea floor-low, hard-relief bottom (greenstriped and stripetail rockfishes), and a few schooling taxa (notably halfbanded rockfish) that seem to be habitat generalists (Love et al. 1999, 2009, this paper). In deeper water, a few species that are generally considered high relief dwellers, such as greenblotched, greenstriped, and pinkrose rockfishes (Love et al. 2009), will also venture away from the platform bottoms out onto the shell mounds. It should also be noted that lingcod, also a habitat generalist, is the only very large predator routinely seen occupying this habitat.

2) *During at least some years, platforms serve as nursery grounds for a variety of rockfishes and other taxa.*

The 2010–2011 surveys demonstrated that, as in the past, many (if not all) platforms act as nursery grounds for a variety of fishes, particularly for rockfishes, but also for such taxa as lingcod and painted greenling. It is important to emphasize that YOY recruitment success to any habitat, natural or human-made, is dependent on fluctuating oceanographic conditions acting on pelagic juveniles or larvae. Thus, the relative importance of any given platform as nursery habitat (i.e., the relative recruitment success of YOYs) in any given year is both variable and unpredictable (Figure 10, also see Figure 48b in Love et al. 2010). To this end, in the 2010–2011 surveys, we observed great differences in YOY recruitment between years at a platform and between platforms within a year. It is also noteworthy that in those years with excellent larval/juvenile rockfish survivorship (e.g., 2011 - this paper and 2009 - Love et al. 2010), high densities of YOYs appear at many platforms across California waters.

Despite these uncertainties, a number of observations do seem to hold true. First, platform midwaters tend to harbor higher densities of YOY rockfishes (sometimes extremely high densities) than do platform bottoms and shell mounds. Several factors may promulgate higher YOY densities in platform midwaters. First, when at sea, the location of most pelagic juvenile and larval rockfishes lies within the upper 30–80 m of the water column (Lenarz et al. 1991, Love et al. 2002) and prerecruits would be unlikely to encounter those platform bottoms and shell mounds that lie deeper than this. In addition, many rockfish species are adapted to recruit to high relief structures – in nature this would include kelp beds and pinnacles. The steep platform midwater jacket more closely resembles these habitats than do shell mounds. Lastly, predation rates on YOYs may be relatively low as predatory fishes are relatively scarce in platform midwaters (particularly compared to platform bottoms, Schroeder and Love 2006). Nevertheless, in some years substantial numbers of YOYs also inhabit these sea floor habitats. In the 2010–2011 surveys, for instance, a combination of YOY halfbanded and unidentified rockfishes comprised about 50% of the fishes observed at the bottom of Platform Edith (these were also quite dense around the Edith shell mound) and YOY rockfish densities were also relatively high at the bottoms of platforms Ellen, Elly, and Grace.

Second, platform midwaters tend to harbor different YOY rockfishes than do adjacent bottom and shell mounds. Rockfishes that recruit in large numbers to platform midwaters include schooling epibenthic taxa (e.g., blue, olive, squarespot, widow, and yellowtail rockfishes, and bocaccio), as well as more solitary and benthic species (copper and gopher rockfishes, and treefish) (Nishimoto et al. 2008, Love et al. 2010, this paper). While some of these species also recruit to the bottoms or shell mounds (e.g., squarespot and widow rockfishes and bocaccio), halfbanded rockfish are by far the most abundant of the YOY rockfishes around many California platforms. Interestingly, and with the singular exception of Platform Eureka, YOY halfbanded rockfish are relatively rare in platform midwaters. Other species that recruit to bottom waters include cowcod, various members of the *Sebastomus* subgenus (greenspotted, greenblotched, rosy, and starry rockfishes), blackgill, and vermilion rockfishes. All of these species tend to recruit to relatively low relief and are likely keying in on the mussels that cover the bottoms around platforms, rather than to the platform jackets.

Third, as measured by fish density, there is relatively little rockfish recruitment around the bottoms/shell mounds of the deepest platforms (i.e., Harvest, Hermosa, Harmony, and Heritage). This probably reflects a number of factors. First, compared to more nearshore waters, relatively few rockfish species inhabit these depths (Love et al. 2002). Second, most rockfish species recruit out of the plankton into waters shallower than the adult depth. Third, the adult abundances of these deeper-water species (such as blackgill and darkblotched rockfishes and cowcod) off California are far lower than those of the more shallow water species (a reflection of intense fishing); thus the numbers of larval and subsequent juveniles of the deeper-water species is also lower.

Elsewhere we have alluded to the stochasticity, the basic unpredictability, of the midwater fish assemblages and this deserves additional attention. Much of this assemblage, far more than those of the bottoms and shell mounds, is based on rockfishes that recruit as juveniles. These remain in place for from less than a

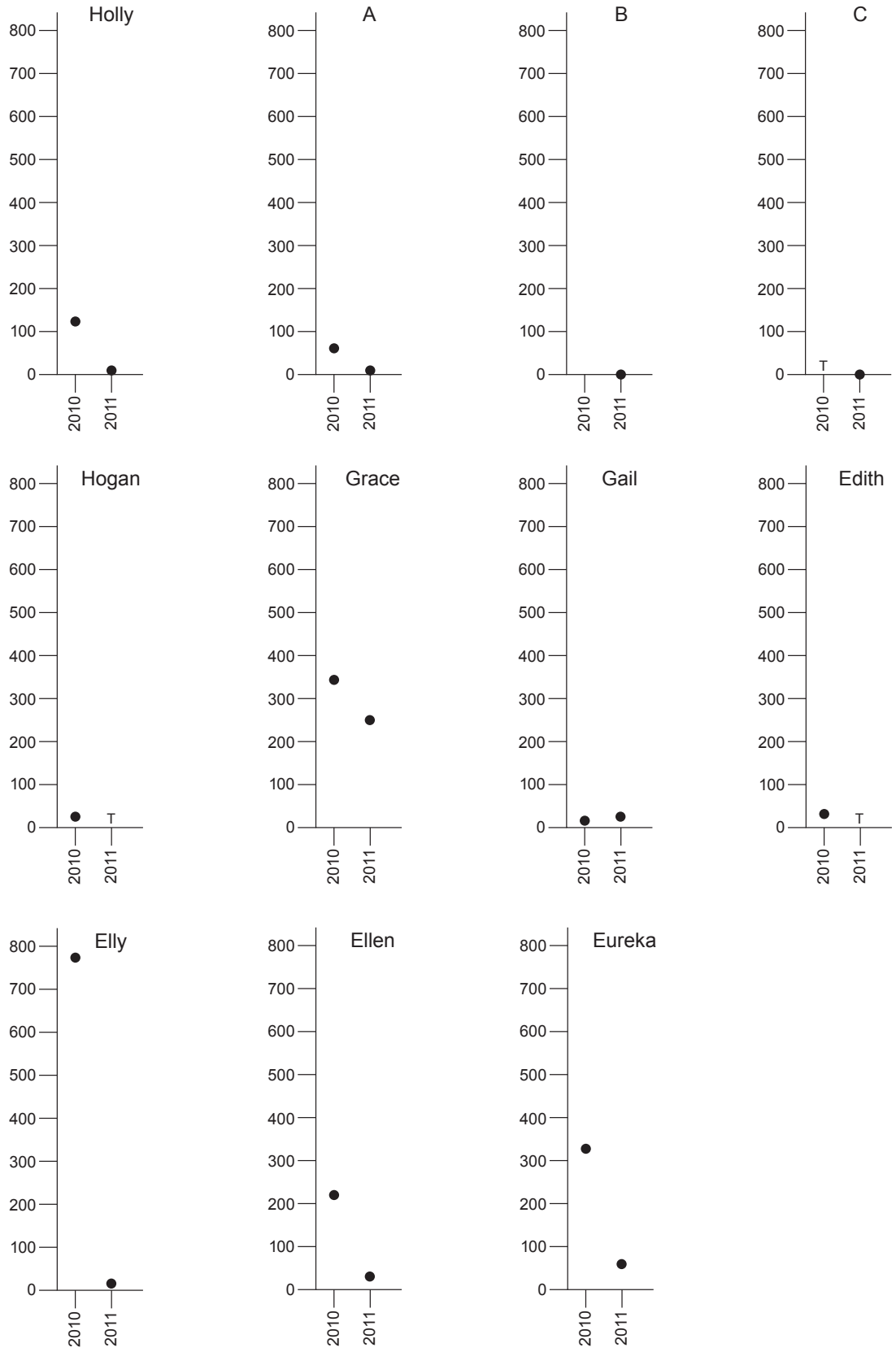

Figure 10. Densities of young-of-the-year rockfishes in the midwaters of all platforms, by year, 2010–2011. T = trace.

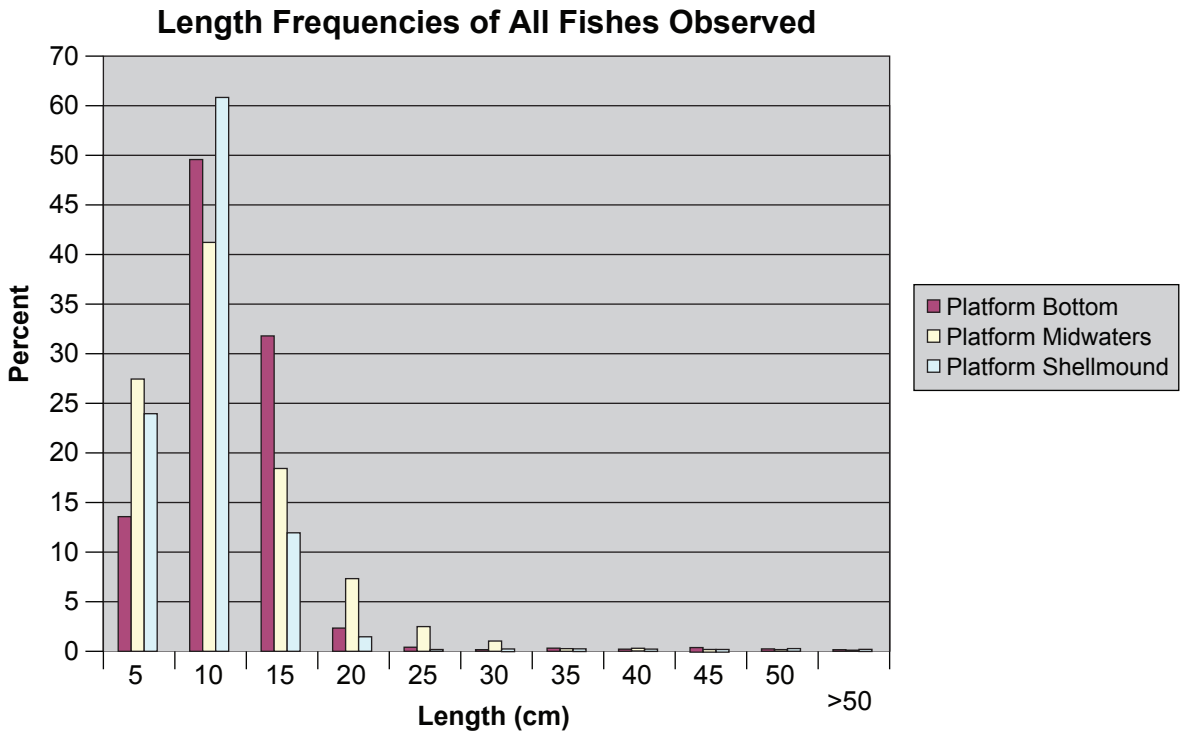

Figure 11. A length frequency histogram of all fishes observed at platform midwaters, bottoms, and shell mounds, 2010–2011.

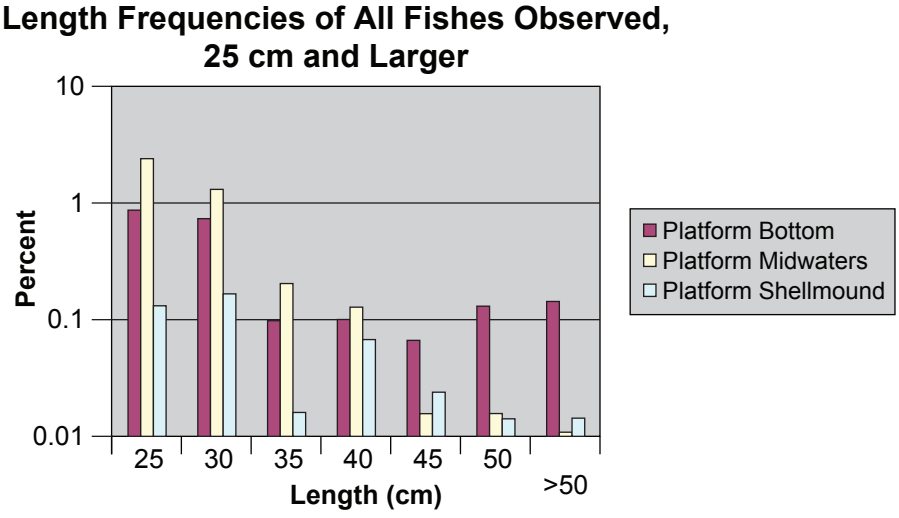

Figure 12. A length frequency histogram of all fishes larger than 25 cm observed at platform midwaters, bottoms, and shell mounds, 2010–2011. Note that the percent observed on the y-axis is on a log scale.

year to a few years at most, at which time these young fishes depart for subadult and adult habitats. Thus, in any given year, the midwater assemblage is heavily dependent on recruitment success and, in turn, recruitment success is dependent on annually variable (and currently unpredictable) oceanographic events. This is not to say that, at many platforms, there is not also a group of resident fishes, such as grass and kelp rockfishes and garibaldi, that provide some stability to the assemblage. However, for many platforms, particularly those furthest north, where these resident species are not present, there is a very large annual turnover in individuals and species. By comparison, bottom assemblages, particularly those of platforms situated in deeper waters, are more predictable, as they tend to be composed of fishes older than YOYs. However, even among these assemblages there is likely considerable variability. As an example, the bottom assemblages around the medium-depth platforms Holly, Irene, and Grace contain YOY rockfishes, older juveniles of such species as vermilion and widow rockfishes, and adult brown, calico, and copper rockfishes. On the other hand, the bottom assemblage of the deeper-water platforms Gail and Eureka harbor very few juvenile fishes and the adult bocaccio, cowcod, Mexican rockfish, and lingcod probably are residential. By the same token, YOY cowcod on shell mounds clearly depart that habitat (perhaps for the platform bottom), but the myriads of juvenile and adult halfbandeds probably do not.

Similar to the results of previous surveys (Love et al. 2010), most of the fishes observed at all platform habitats during 2010–2011 were small, most were 15 cm or less in length (Figures 11, 12). In addition, most of the larger fishes we observed (particularly those 45 cm or greater) occurred around the platform bottoms. This is reflective of the great importance of YOY and juvenile rockfishes of a number of species, as well as the co-dominance of such dwarf species as halfbanded and squarespot rockfishes and painted greenling. However, care should be taken not to misinterpret these data, as the substantial numbers of larger fishes that we did observe formed only a small percentage against a backdrop of very large numbers of small individuals. For instance, the over 100,000 halfbanded and squarespot rockfish observed tended to swamp the hundreds of larger sheephead, cowcod, bocaccio, and lingcod dwelling in this habitat. Clearly, these small fishes dominated many platforms habitats, but their presence did not necessarily define these assemblages. In addition, our inability to survey in both years the bottom of Platform Holly and Eureka and in one year the bottom of Platform Gail (both sites of substantial large fishes) may have skewed the overall data towards smaller individuals.

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Literature Cited

Lenarz, W. H., R. J. Larson, and S. Ralston. 1991. Depth distributions of late larvae and pelagic juveniles of some fishes of the California Current. CalCOFI Rep. 32:41–46.

Love, M. S. and W. H. Lenarz. 2010. A comparison of fish assemblages in the midwaters of two California oil and gas platforms, p. 72–86. *In* Love, M. S., M. Nishimoto, and D. Schroeder. 2010. Fish assemblages associated with platforms and natural reefs in areas where data are non-existent or limited. BOEMRE OCS Study 2010-012. Marine Science Institute, University of California, Santa Barbara, California. MMS Cooperative Agreement No.: 1435-01-05-CA-39322; NSL-PC-05-01 and MMS Cooperative Agreement No.: M07AC13380; NSL-PC-07-04.

Love, M. S. and M. Yoklavich. 2006. Deep rock habitats, p. 253–266. *In* L. G. Allen, D. J. Pondella II, and M.H. Horn (eds.). The Ecology of Marine Fishes California and Adjacent Waters. University of California Press, Berkeley, California.

Love, M. S. and A. York. 2006. The role of bottom crossbeam complexity in influencing the fish assemblages at California oil and gas platforms. Fishery Bulletin 104:542–549.

Love, M. S., J. Caselle, and L. Snook. 1999. Fish assemblages on mussel mounds surrounding seven oil platforms in the Santa Barbara Channel and Santa Maria Basin. Bull. Mar. Sci. 65:497–513. Love, M. S., J. E. Caselle and L. Snook. 2000. Fish assemblages around seven oil platforms in the Santa Barbara Channel. Fishery Bulletin 98:96–117.

Love, M. S., M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the northeast Pacific. University of California Press, Berkeley, California. Love, M. S., M. Nishimoto, and D. Schroeder. 2010. Fish assemblages associated with platforms and natural reefs in areas where data are non-existent or limited. BOEMRE OCS Study 2010-012. Marine Science Institute, University of California, Santa Barbara, California. MMS Cooperative Agreement No.: 1435- 01-05-CA-39322; NSL-PC-05-01 and MMS Cooperative Agreement No.: M07AC13380; NSL-PC-07-04.

Love, M. S., D. M. Schroeder, and M. M. Nishimoto. 2003. The ecological role of oil and gas production platforms and natural outcrops on fishes in southern and central California: a synthesis of information. U. S. Department of the Interior, U. S. Geological Survey, Biological Resources Division, Seattle, Washington, 98104, OCS Study MMS 2003-032.

Love, M. S., M. Yoklavich, and D. M. Schroeder. 2009. Demersal fish assemblages in the Southern California Bight based on visual surveys in deep water. Environmental Biology of Fishes 84:55–68. Martin, C. J. B. and C. G. Lowe. 2010. Assemblage structure of fish at offshore petroleum platforms on the San Pedro Shelf of southern California. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 2:180–194.

Nishimoto, M. M., M. S. Love, L. Washburn, D. M. Schroeder, and B. M. Emery. 2008. Assessing the fate of juvenile rockfish at offshore petroleum platforms and natural reefs in the Santa Barbara Channel. MMS OCS Study 2007-008. Marine Science Institute, University of California, Santa Barbara, California. MMS Cooperative Agreement Number 1435-01-04-CA-35031. R (2005). The R Foundation for Statistical computing. Version 2.1.1 (2005-06-20).

Schroeder, D. M. and M. S. Love. 2004. Ecological and political issues surrounding oil platform decommissioning in the southern California Bight. Ocean and Coast Management 47:21–48. Schroeder, D. M. and M. S. Love. 2006. Comparative predation rate on painted greenling between natural habitat and an offshore oil platform, p. 28–33. *In* Love, M. S. and D. M. Schroeder. 2006. Ecological performance of OCS platforms as fish habitat off California. MMS OCS Study 2004-005. Marine Science Institute, University of California, Santa Barbara, California. MMS Cooperative Agreement Number 1435-01-03-CA-72694.