Pacific Outer Continental Shelf Region

OCS Study
BOEMRE Study 2010-012

FISH ASSEMBLAGES ASSOCIATED WITH PLATFORMS AND NATURAL REEFS IN AREAS WHERE DATA ARE NON-EXISTENT OR LIMITED

FISH ASSEMBLAGES ASSOCIATED WITH PLATFORMS AND NATURAL REEFS IN AREAS WHERE DATA ARE NON-EXISTENT OR LIMITED

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Prepared under:
MMS Cooperative Agreement No.: 1435-01-05-CA-39322; NSL-PC-05-01 and
MMS Cooperative Agreement No.: M07AC13380; NSL-PC-07-04

U.S. Department of Interior
Bureau of Ocean Energy Management, Regulation and Enforcement
Pacific OCS Region
Camarillo, CA, 93010

August 2010

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This report had been reviewed by the Pacific Outer Continental Shelf Region, Bureau of Ocean Energy Management, Regulation and Enforcement, U. S. Department of Interior and approved for publication. The opinions, findings, conclusions, or recom¬mendations in this report are those of the authors, and do not necessarily reflect the views and policies of the Bureau of Ocean Energy Management, Regulation and Enforcement. Mention of trade names or commercial products does not constitute an endorsement or recommendation for use. This report has not been edited for conformity with Bureau of Ocean Energy Management, Regulation and Enforcement editorial standards.

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Suggested Citation

Love, M. S., M. M. Nishimoto, and D. M. 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.

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TECHNICAL SUMMARY

Study Title: Fish Assemblages Associated with Platforms and Natural Reefs in Areas Where Data are Non-Existent or Limited
Report Title: Fish Assemblages Associated with Platforms and Natural Reefs in Areas Where Data are Non-Existent or Limited
Contract Numbers: 1435-01-05-CA39322 and M05AC12299
Sponsoring OCS Region: Pacific
Applicable Planning Area: Central and Southern California
Fiscal Years of Project Funding: 2005–2010
Completion Date of the Report: August 2010
Costs: $1,280,000
Cumulative Project Cost: $1,280,000
Principal Investigator: Milton Love
Key Words: oil platforms, platforms, California, rockfishes, *Sebastes*, decommissioning, platform decommissioning

Background and Objectives:

The BOEMRE 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 BOEMRE 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 BOEMRE -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 BOEMRE - 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.

The BOEMRE 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, BOEMRE 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 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 reef) in the region?

b) What is the comparative importance of platforms and natural reefs as fish nursery grounds?

Specific objectives of this study were:

- 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.

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

- To synthesize the data into a report describing the ecological performance of platforms as rockfish habitat and as rockfish producers in comparison to natural reefs off California.

Description:

Results of this research are summarized in two tasks.

Task One: Fish Assemblages at Central and Southern California Oil Platforms and Natural Sites: 2004–2009

In this task, we conducted surveys around a majority of the platforms off California and at many natural sites, using the research submarine *Delta*. We surveyed fishes around the midwaters, bottoms, and the surrounding shell mounds of platforms.

Task Two: A Comparison of Fish Assemblages in the Midwaters of Two California Oil and Gas Platforms

It is unclear what role habitat complexity plays in structuring fish assemblages around oil and gas platforms. In this task, we compared the midwater fish assemblages at a platform with relatively little jacket complexity (Gail) with one that is quite complex (Eureka).

Significant Results:

Task 1:

Surveys were conducted at platforms and natural sites between 2004 and 2009 aboard the research submersible *Delta*. Natural sites were comprised of both high and low rocky reefs. We conducted 803 transects around 20 platforms, encompassing 144,022 m^2 of habitat. The habitats of almost all platforms were surveyed at least once and some platforms were surveyed in a majority of years. In addition, we made 134 natural site dives (422 transects, 377,851 m^2), at bottom depths of 17–343 m. A total of at least 110 unique natural sites were assessed and some sites, such as North Reef, were surveyed in more than one year. Over all habitats, we observed 687,142 fishes, comprising a minimum of 128 species. Of these, 317,583 fishes, of 95 species, inhabited platforms and 369,559 fish, of 114 species, lived on natural sites. On average, fish densities were over twice as high at platforms (257.4 individuals/100 m^2) compared to natural sites (104 individuals/100m^2). Rockfishes, of 45 species (at least 45 species at platforms and 43 species at natural sites) dominated the survey, as they comprised 85.8% of all fishes observed (83.8% at platforms and 87.5% at natural sites).

Among the highest density species or species complexes, squarespot, halfbanded, and shortbelly rockfishes, and a complex of young-of-the-year (YOY) rockfishes dominated both platform and natural sites. Blacksmith, widow rockfish, jack mackerel, unidentified *Sebastomus* rockfishes, blackeye goby, and calico rockfish rounded out the top ten platform species. A somewhat different suite of species, including pygmy,

blackeye goby, unidentified *Sebastomus* rockfishes, swordspine rockfish, blacksmith, and blue rockfish comprised the top ten species by density at natural sites.

We observed three distinct fish assemblages around each platform: midwaters, bottom, and shell mound. These assemblages did not appreciably change over the course of the study. There was a tendency for densities of fishes to increase and peak in deeper midwater depths or at the bottom. Fish densities over shell mounds were usually lower than those at the adjacent platform bottom. In addition, fish densities varied greatly between platforms at similar depths. However, there appeared to be no geographic pattern to these differences. There was a tendency for fish densities on the bottoms and shell mounds of the deepest platforms to be lower than those at shallower structures.

Midwater assemblages were similar across platforms, while bottom and shell mound assemblages varied with platform bottom depth. In general, all of these assemblages were at least somewhat different from the assemblages observed on natural sites. There tended to be higher densities of young-of-the-year fishes, particularly rockfishes, around many platforms than at most natural sites. Older juveniles and adults of economically important species were also more likely to be found at higher densities at some platforms than at most natural sites. This latter may reflect 1) an extensive and complex bottom habitat around the bottoms of some platforms that serve as sheltering areas for economically important species and 2) the lower fishing effort (a *de facto* marine reserve effect) of platforms as many of these structures appear to be rarely fished.

The shell mounds surrounding California platforms are a unique feature of these structures and are composed primarily of living and dead mussels, and associated marine life. They form an extensive web of low, but rugose, sea floor. The relatively small crevices created by mussel shells deter large numbers of many high-relief species from venturing onto these areas. Rather, most shell mound species are either the juveniles of larger species, whose juvenile stages require small sheltering sites, or somewhat generalist species that live over 1) soft sea floors, 2) the ecotones between soft and low-relief hard bottom, and 3) low-relief reefs. While shell mound assemblages in shallow and middle depth waters tend to be different from those of natural sites of the same depths, deep depth shell mound assemblages more closely resemble those at natural sites. This is likely because reefs in the deeper waters of California tend to be low relief and thus more like shell mounds.

Task 2:

We observed 13,609 fishes of at least 32 species at Platform Eureka and 2,980 fishes of at least 20 species at Platform Gail. Total average fish density was much higher at Eureka (135.9 individuals per 100 m^2) than at Gail (28.7 individuals per 100 m^2). Rockfishes (genus *Sebastes*) dominated both assemblages, comprising 99.5% and 96.7% of all fishes observed at Eureka and Gail, respectively. A minimum of 28 rockfish species (28 species at Eureka and 14 at Gail) inhabited the platform midwaters. Those species with highest densities at Eureka included squarespot, widow, speckled, and blue rockfishes, while squarespot and widow rockfishes and bocaccio dominated the midwaters of Gail. Fifteen species were unique to Eureka and four species were found only at Gail. Of the species shared by the two structures, the densities of almost all species were higher at Eureka, sometimes by a factor of 10 or more. The number of species around the crossbeams varied with depth (ranging from 6-11 at Gail, and 14-18 at Eureka) and tended to be highest around the deeper members. Between the two platforms, species numbers were higher at all depths at Eureka and usually 2-3 times that of Gail.

Thus, while the assemblages of both platforms were dominated by rockfishes there were also significant differences between them. Compared to Gail, Eureka harbored 1) higher densities both of all species combined and of most species held in common, 2) far more mature individuals of most species, 3) greater species richness, and 4) much higher densities of species that live over complex high relief. We propose that from a fish's perspective, the complex midwater jacket of Eureka, with its many sheltering sites, mimics rugose natural reefs. This research both re-enforces the conclusion that many reef species have quite specific habitat requirements and that the platform decommissioning process must examine each platform individually.

STUDY PRODUCTS

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Fish Assemblages Associated with Platforms and Natural Reefs in Areas Where Data are Non-Existent or Limited

EXECUTIVE SUMMARY

Information Needed

There are 27 oil and gas platforms in the waters off California. These platforms are 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 BOEMRE 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 BOEMRE 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 BOEMRE -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 BOEMRE - 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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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 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 reef) in the region?

b) What is the comparative importance of platforms and natural reefs as fish nursery grounds?

Specific objectives of this study were:

- 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.

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

- To synthesize the data into a report describing the ecological performance of platforms as rockfish habitat and as rockfish producers in comparison to natural reefs off California.

Research Summary

Task 1: Fish Assemblages at Central and Southern California Oil Platforms and Natural Sites: 2004–2009

Surveys were conducted at platforms and natural sites between 2004 and 2009 aboard the research submersible Delta. Natural sites were comprised of both high and low rocky reefs. We conducted 803 transects around 20 platforms, encompassing 144,022 m^2 of habitat. The habitats of almost all platforms were surveyed at least once and some platforms were surveyed in a majority of years. In addition, we made 134 natural site dives (422 transects, 377,851 m^2), at bottom depths of 17–343 m. A total of at least 110 unique natural sites were assessed and some sites, such as North Reef, were surveyed in more than one year. Over all habitats, we observed 687,142 fishes, comprising a minimum of 128 species. Of these, 317,583 fishes, of 95 species, inhabited platforms and 369,559 fish, of 114 species, lived on natural sites. On average, fish densities were over twice as high at platforms (257.4 individuals/100 m^2) compared to natural sites (104 individuals/100m2). Rockfishes, of 45 species (at least 45 species at platforms and 43 species at natural sites) dominated the survey, as they comprised 85.8% of all fishes observed (83.8% at platforms and 87.5% at natural sites).

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We observed three distinct fish assemblages around each platform: midwaters, bottom, and shell mound. These assemblages did not change appreciably over the course of the study. There was a tendency for densities of fishes to increase and peak in deeper midwater depths or at the bottom. Fish densities over shell mounds were usually lower than those at the adjacent platform bottom. In addition, fish densities varied greatly between platforms at similar depths. However, there appeared to be no geographic pattern to these differences. There was a tendency for fish densities on the bottoms and shell mounds of the deepest platforms to be lower than those at shallower structures.

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than at most natural sites. This latter may reflect 1) an extensive and complex bottom habitat around the bottoms of some platforms that serve as sheltering areas for economically important species and 2) the lower fishing effort (a *de facto* marine reserve effect) of platforms as many of these structures appear to be rarely fished.

The shell mounds surrounding California platforms are a unique feature of these structures and are composed primarily of living and dead mussels, and associated marine life. They form an extensive web of low, but rugose, sea floor. The relatively small crevices created by mussel shells deter large numbers of many high-relief species from venturing onto these areas. Rather, most shell mound species are either the juveniles of larger species, whose juvenile stages require small sheltering sites, or somewhat generalist species that live over 1) soft sea floors, 2) the ecotones between soft and low-relief hard bottom, and 3) low-relief reefs. While shell mound assemblages in shallow and middle depth waters tend to be different from those of natural sites of the same depths, deep depth shell mound assemblages more closely resemble those at natural sites. This is likely because reefs in the deeper waters of California tend to be low relief and thus more like shell mounds.

Task 2: A Comparison of Fish Assemblages in the Midwaters of Two California Oil and Gas Platforms

In this study, we compared the midwater fish assemblages of Platform Eureka, whose midwater jacket is studded with fascicles of pilings and bowl-shaped piling guides, with that of Platform Gail, a more typically configured platform with rounded crossbeams and pilings. These two platforms are similar in other respects. They were constructed at about the same time, Eureka in 1984 and Gail in 1987. Both platforms are about 13 km from shore and stand in similar depths: Gail in 224 m, Eureka in 212 m. Both have nine midwater crossbeams and these crossbeams are situated at comparable depths. Although Eureka is found about 118 km to the southeast of Gail, both platforms are in the southern California Bight and are bathed by waters of similar temperatures. Lastly, the dominant natural reef species in the two areas are comparable.

While the fish assemblages of both platforms were dominated by rockfishes (*Sebastes*), there were significant differences. Compared to Gail, Eureka harbored 1) higher densities both of all species combined and of most species held in common, 2) far more mature individuals of most species, 3) greater species richness, and 4) much higher densities of species that live over complex high relief. We propose that from a fish's perspective, the complex midwater jacket of Eureka, with its many sheltering sites, mimics rugose natural reefs. This research both re-enforces the conclusion that many reef species have quite specific habitat requirements and that the platform decommissioning process must examine each platform individually.

Conclusions

This research strengthens and confirms observations made in previous studies.

1) There is very extensive diversity in the species assemblages around the oil and gas platforms of California. Factors driving this variability include A) location around the platform, B) geographic location of the platforms, and C) bottom depth of the platform.

2) Around each platform, there are three, unique, fish assemblages: midwaters, bottom, and shell mound. While a suite of rockfishes (of 43 species) dominate most platform assemblages, a number of other taxa (e.g., lingcod, combfishes, sculpins, and seaperches) are also important. These assemblages did not appreciably change over the course of the study.

3) Midwater fish assemblages tend to be similar across platforms; there are substantial differences among those found at bottoms and shell mounds. Platform bottom depth, and the complexity of the platform jacket at the bottom, is important in structuring bottom fish assemblages. Bottom depth also influences shell mound assemblages.

4) In general, the assemblages of platforms and natural sites are different. These differences are primarily based on differences in species' densities rather than the presence or absence of taxa. A) All of the platforms we surveyed serve as nursery grounds for a variety of rockfishes and other taxa and, in general, platform habitats harbor higher densities of young fishes than do many natural sites. B) The bottoms of a number of platforms have higher densities of economically important species than do most natural sites. This is probably due to a combination of extensive, complex habitat (most suitable for these species) and relatively low fishing pressure (a *de facto* marine reserve effect). C) The shell mounds surrounding California platforms are a unique feature of these structures and are composed primarily of living and dead mussels, and associated marine life. They form an extensive web of low, but rugose, sea floor. Most shell mound species are either the juveniles of larger species, whose juvenile stages require small sheltering sites, or somewhat generalist species that live over 1) soft sea floors, 2) the ecotones between soft and low-relief hard bottom, and 3) low-relief reefs. While shell mound assemblages in shallow and middle depth waters tend to be different from those of natural sites of the same depths, deep depth shell mound assemblages more closely resemble those at natural sites. This is likely because reefs in the deeper waters of California tend to be low relief and thus more like shell mounds.

5) The role that habitat complexity plays in structuring platform fish assemblages should not be underestimated. We compared the species assemblages of fishes living around two deepwater platforms, Eureka and Gail. Gail is a typical California platform, with rounded crossbeams and pilings, while the midwater jacket of Eureka, studded with fascicles of pilings and bowl-shaped piling guides, is much more complex. While rockfishes dominated the assemblages of both platforms, there were also significant differences. Compared to Gail, Eureka harbored 1) higher densities both of all species combined and of most species held in common, 2) far more mature individuals of most species, 3) greater species richness, and 4) much higher densities of species that live over complex high relief. Thus, it is likely that the complex midwater jacket of Eureka, with its many sheltering sites, mimics rugose natural reefs. This both re-enforces the conclusion that many reef species have quite specific habitat requirements and that the platform decommissioning process must examine each platform individually.

Task 1: Fish Assemblages at Central and Southern California Oil Platforms and Natural Sites: 2004–2009

Milton S. Love, William H. Lenarz, Mary Nishimoto, and Donna M. Schroeder

Abstract

Surveys were conducted at platforms and natural sites between 2004 and 2009 aboard the research submersible *Delta*. Natural sites were comprised of both high and low rocky reefs. We conducted 803 transects around 20 platforms, encompassing 144,022 m^2 of habitat. The habitats of almost all platforms were surveyed at least once and some platforms were surveyed in a majority of years. In addition, we made 134 natural site dives (422 transects, 377,851 m^2), at bottom depths of 17–343 m. A total of at least 110 unique natural sites were assessed and some sites, such as North Reef, were surveyed in more than one year. Over all habitats, we observed 687,142 fishes, comprising a minimum of 128 species. Of these, 317,583 fishes, of 95 species, inhabited platforms and 369,559 fish, of 114 species, lived on natural sites. On average, fish densities were over twice as high at platforms (257.4 individuals/100 m^2) compared to natural sites (104 individuals/100m^2). Rockfishes, of 45 species (at least 45 species at platforms and 43 species at natural sites) dominated the survey, as they comprised 85.8% of all fishes observed (83.8% at platforms and 87.5% at natural sites).

Among the highest density species or species complexes, squarespot, halfbanded, and shortbelly rockfishes, and a complex of young-of-the-year (YOY) rockfishes dominated both platform and natural sites. Blacksmith, widow rockfish, jack mackerel, unidentified *Sebastomus* rockfishes, blackeye goby, and calico rockfish rounded out the top ten platform species. A somewhat different suite of species, including pygmy, blackeye goby, unidentified *Sebastomus* rockfishes, swordspine rockfish, blacksmith, and blue rockfish comprised the top ten species by density at natural sites.

We observed three distinct fish assemblages around each platform: midwaters, bottom, and shell mound. These assemblages did not appreciably change over the course of the study. There was a tendency for densities of fishes to increase and peak in deeper midwater depths or at the bottom. Fish densities over shell mounds were usually lower than those at the adjacent platform bottom. In addition, fish densities varied greatly between platforms at similar depths. However, there appeared to be no geographic pattern to these differences. There was a tendency for fish densities on the bottoms and shell mounds of the deepest platforms to be lower than those at shallower structures.

Midwater assemblages were similar across platforms, while bottom and shell mound assemblages varied with platform bottom depth. In general, all of these assemblages were at least somewhat different from the assemblages observed on natural sites. There tended to be higher densities of young-of-the-year fishes, particularly rockfishes, around many platforms than at most natural sites. Older juveniles and adults of economically important species were also more likely to be found at higher densities at some platforms than at most natural sites. This latter may reflect 1) an extensive and complex bottom habitat around the bottoms of some platforms that serve as sheltering areas for economically important species and 2) the lower fishing effort (a *de facto* marine reserve effect) of platforms as many of these structures appear to be rarely fished.

The shell mounds surrounding California platforms are a unique feature of these structures and are composed primarily of living and dead mussels, and associated marine life. They form an extensive web of low, but rugose, sea floor. The relatively small crevices created by mussel shells deter large numbers of many high-relief species from venturing onto these areas. Rather, most shell mound species are either the juveniles of larger species, whose juvenile stages require small sheltering sites, or somewhat generalist species that live over 1) soft sea floors, 2) the ecotones between soft and low-relief hard bottom, and 3) low-relief reefs. While shell mound assemblages in shallow and middle depth waters tend to be different from those of natural sites of the same depths, deep depth shell mound assemblages more closely resemble those at natural sites. This is likely because reefs in the deeper waters of California tend to be low relief and thus more like shell mounds.

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, Regulation, and Enforcement (BOEMRE) (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 BOEMRE, 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 Table 1 lists additional papers and reports that have come from this research through 2009. This report presents data from submersible surveys of platforms and natural reefs conducted between 2004 and 2009.

Methods

Fish Surveys

Surveys were conducted at platforms and natural sites between 2004 and 2009 aboard the research submersible *Delta*. Natural sites were comprised of both high and low rocky reefs. *Delta* is 4.8 m in length, accommodates one scientific observer and one pilot, and has a maximum operating depth of 365 m. Dives were made between September and November, during daytime hours, and were documented with an externally mounted video camera positioned above the middle viewing-porthole on the starboard side of the submersible. The scientific observer conducted a belt-transect survey through this same starboard viewing port, 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 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 conducted surveys 1) on the shell mound, 2) platform bottom, and 3) platform midwaters.

Transect length was estimated using navigation fixes (latitude and longitude coordinates) received from a Thales GeoPacific Winfrog ORE Trackpoint 2 USBL system at two-second intervals, and a Winfrog DAT file was generated for each dive. Distance and duration between fixes were calculated to obtain a point-to-point submersible speed; errant navigation fixes were removed when speed exceeded 2 m/sec.

Table 1. A summary of platform and natural reef-related papers based on research conducted by Milton Love's laboratory, 1995–2009.

Authors	Date	Topic
Emery et al.	2006	Model of rockfish recruitment to platforms.
Love et al.	1997	A description of platform fish assemblage results from the first year of research.
Love et al.	1999	Fish assemblages of platform shell mounds.
Love et al.	1999	A description of several years of platform fish assemblage research.
Love et al.	2000	Fish assemblages of platform midwaters and bottoms.
Love et al.	2003	A synthesis of six years of platform surveys.
Schroeder and Love	2004	Ecological and political issues surrounding platform decommissioning.
Love and York	2005	Fish assemblages on oil pipelines.
Love et al.	2005	Estimates of larval production of two rockfish species around oil platforms.
Love and Schroeder	2006	A summary of three separate platform experiments.
Love et al.	2006	Role of platform crossbeam complexity in influencing fish assemblages.
Love et al.	2006	Potential for platforms to rebuild overfished rockfish stocks.
Love et al.	2006	Role of crevices in structuring deeper-water reef assemblages.
Goddard and Love	2007	A description of the larger invertebrates inhabiting platform shell mounds.
Love and Schroeder	2007	Characterization of fish assemblages in a moderately deep reef system.
Love et al.	2007	A comparison of growth rates of young rockfish at platforms and natural reefs.
Nishimoto et al.	2007	A assessment of the oceanographic factors involved in rockfish young-of-the-year recruitment to platforms.
Page et al.	2007	A comparison of trophic links and condition of fishes living on platforms and natural reefs.
Love and Yoklavich	2008	A description of the habitat of the cowcod, Sebastes levis.
Love and Goldberg	2009	A histological examination of ovaries of Pacific sanddab at platforms and natural reefs.
Love et al.	2009	A comparison of heavy metal burdens, otolith microchemistry signatures, and ovary condition of fishes living around platforms and natural reefs.
Love et al.	2009	A description of rocky reef fish assemblages throughout southern California

The navigation fixes were then smoothed using a nine-point moving average, and transect length was estimated from the total distance between the smoothed points. Transect length was divided by transect duration to obtain an average transect speed. The length of individual habitat patches was estimated from average speed of the submersible during each transect.

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 (*Sebastes flavidus*), will occasionally aggregate in the water column above the Delta and are not counted.

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.

Results

Summary of Platform and Natural Site Fish Assemblages

We conducted 803 transects around 20 platforms, encompassing 144,022 m^2 of habitat (Figure 1, Tables 2, 3). The habitats of almost all platforms were surveyed at least once and some platforms (e.g., Irene, Hidalgo, Grace, Gilda, Gail, Edith, Elly, and Eureka) were surveyed in a majority of years. Poor visibility prevented us from surveying the bottoms and shell mounds of platforms A, B, C, Hillhouse, Henry, and Habitat. In addition, we made 134 natural site dives (422 transects, 377,851 m^2), at bottom depths of 17–343 m (Figure 1, Table 3). A total of at least 110 unique natural sites were assessed and some sites, such as North Reef, were surveyed in more than one year.

Over all habitats, we observed 687,142 individuals, comprising a minimum of 128 species (Table 4). Of these, 317,583 fishes, of 95 species, inhabited platforms and 369,559 fish, of 114 species, lived on natural

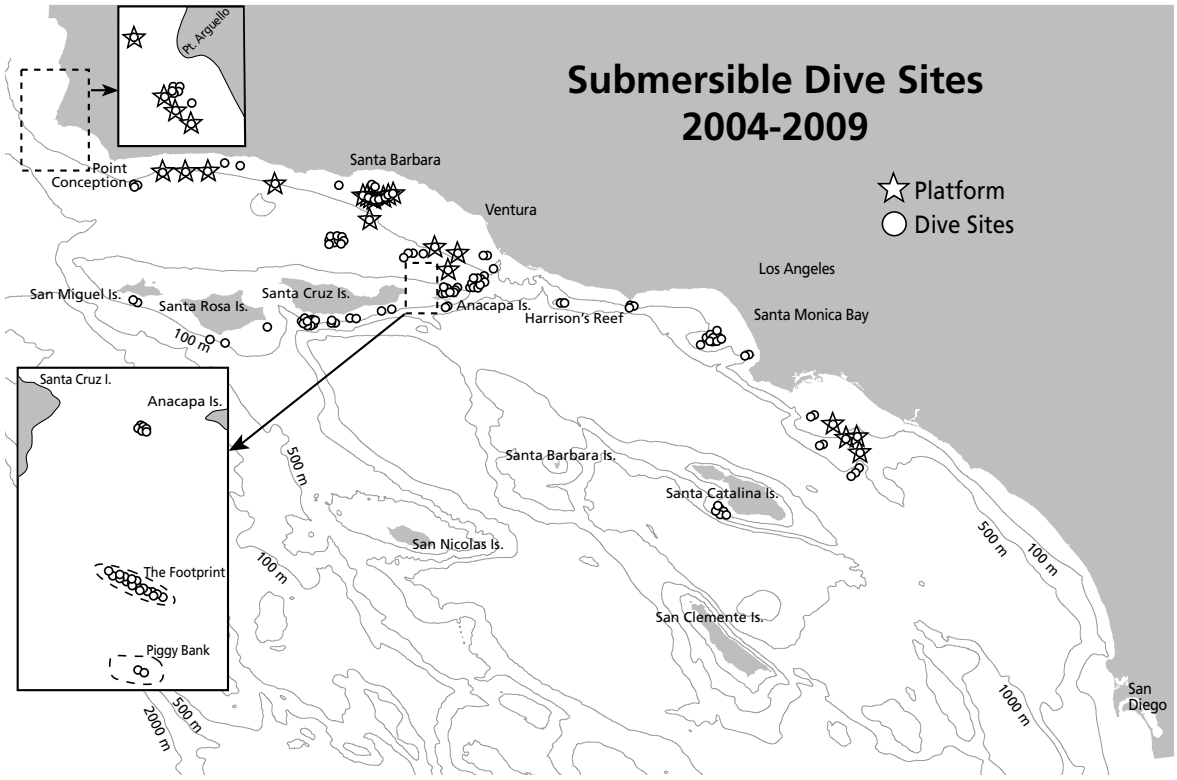

Figure 1. Location of fish surveys, 2004–2009, at platforms (stars) and natural sites (circles), off California.

Table 2. Platforms surveyed, 2004–2009. Note that in some years, not all habitats (midwater, bottom, and shell mound) at a platform were surveyed.

IRENE	2004	2005	2006	2007	2008	2009
Midwater	x	x	x		x	x
Bottom	x	x	x		x	x
Shell mound	x	x	x		x	x

HIDALGO	2004	2005	2006	2007	2008	2009
Midwater	x	x	x			x
Bottom	x	x	x			x
Shell mound	x	x	v			x

HARVEST	2004	2005	2006	2007	2008	2009
Midwater	x					
Bottom	x					
Shell mound	x					

HERMOSA	2004	2005	2006	2007	2008	2009
Midwater			x			
Bottom	x		x			
Shell mound	x		x			

HARMONY	2004	2005	2006	2007	2008	2009
Midwater	x					
Bottom	x					
Shell mound	x					

HERITAGE	2004	2005	2006	2007	2008	2009
Midwater					x	
Bottom					x	
Shell mound						

HONDO	2004	2005	2006	2007	2008	2009
Midwater	x		x		x	
Bottom	x		x		x	
Shell mound	x		x			

Holly	2004	2005	2006	2007	2008	2009
Midwater	x	x	x	x	x	x
Bottom	x	x	x	x	x	
Shell mound	x	x			x	

A	2004	2005	2006	2007	2008	2009
Midwater only	x		x	x		

B	2004	2005	2006	2007	2008	2009
Midwater only	x			x		

C	2004	2005	2006	2007	2008	2009
Midwater only	x			x		

HILLHOUSE	2004	2005	2006	2007	2008	2009
Midwater only	x			x		x

HENRY	2004	2005	2006	2007	2008	2009
Midwater only	x					

HABITAT	2004	2005	2006	2007	2008	2009
Midwater only	x			x		x

GRACE	2004	2005	2006	2007	2008	2009
Midwater	x	x		x	x	x
Bottom	x	x		x	x	x
Shell mound	x	x		x	x	x

GILDA	2004	2005	2006	2007	2008	2009
Midwater	x		x	x	x	x
Bottom	x			x	x	x
Shell mound	x			x	x	x

Gail	2004	2005	2006	2007	2008	2009
Midwater	x	x	x	x	x	x
Bottom	x	x	x	x	x	x
Shell mound	x	x	x	x	x	x

EDITH	2004	2005	2006	2007	2008	2009
Midwater		x	x	x	x	x
Bottom		x	x	x	x	x
Shell mound		x	x	x	x	x

ELLY	2004	2005	2006	2007	2008	2009
Midwater		x	x	x	x	x
Bottom		x	x	x	x	x
Shell mound		x	x	x	x	x

EUREKA	2004	2005	2006	2007	2008	2009
Midwater	x	x	x	x	x	x
Bottom		x		x		x
Shell mound		x		x		x

Table 3. Area surveyed (m^2) by habitat type, 2004–2009.

Habitat	Number of Transects[1]	Area Surveyed (m^2)
Platform midwater	275	82,846
Platform bottom	55	25,849
Platform shell mound	51	35,327
Natural sites	422	377,851
Total	803	521,773

[1]For platforms, transects are defined as a circumnavigation of a midwater cross beam, platform bottom or shell mound. For natural sites, transects are defined as 15 minute surveys.

Table 4. Numbers and densities (average number per 100 m^2) of fish species observed at platforms and natural reefs, 2004–2009. Rankings of total counts and average densities may differ because densities are averages of transect densities and area surveyed varied among transects.

Common Name	Scientific Name	Platforms		Natural Sites		Total Number
		Number	Density	Number	Density	
Squarespot rockfish	*Sebastes hopkinsi*	83,635	65.4	128,842	36.3	212,478
Halfbanded rockfish	*Sebastes semicinctus*	85,675	44.6	77,775	21.2	163,450
Unidentified rockfish[1]	*Sebastes* spp.	36,986	30.1	24,003	6.6	60,989
Shortbelly rockfish	*Sebastes jordani*	14,297	10.6	45,706	13.6	60,003
Blacksmith	*Chromis punctipinnis*	21,522	31.4	4,830	1.4	26,352
Widow rockfish	*Sebastes entomelas*	24,267	24.1	202	<0.1	24,469
Pygmy rockfish	*Sebastes wilsoni*	125	<0.1	18,755	5.6	18,880
Blackeye goby	*Rhinogobiops nicholsii*	3,018	1.8	13,843	3.6	16,861
Sebastomus sp.		3,028	1.9	12,286	3.5	15,314
Jack mackerel	*Trachurus symmetricus*	12,287	24.5	91	<0.1	12,378
Swordspine rockfish	*Sebastes ensifer*	42	<0.1	9,090	2.7	9,132
Bocaccio	*Sebastes paucispinis*	3,006	2.1	1,241	2.7	4,247
Vermilion rockfish[2]		2,435	1.5	1,777	0.5	4212
Calico rockfish	*Sebastes dallii*	3,341	2.2	176	<0.1	3,517
Rosy rockfish	*Sebastes rosaceus*	1,266	0.8	1,963	0.6	3,229
Pinkrose rockfish	*Sebastes simulator*	1,068	0.5	2,125	0.6	3,193
Blue rockfish[3]		524	0.5	2,550	0.6	3,074
Painted greenling	*Oxylebius pictus*	2,672	2.3	394	0.1	3,066
Bank rockfish	*Sebastes rufus*	943	0.7	1,870	0.5	2,813
Shortspine combfish	*Zaniolepis frenata*	144	<0.1	2,435	0.7	2,579
Northern anchovy	*Engraulis mordax*	2,130	2.4	0	0	2,130
Unidentified fishes		920	0.8	1,164	0.3	2,084
Lingcod	*Ophiodon elongatus*	1,107	0.6	835	0.2	1,942
Pink seaperch	*Zalembius rosaceus*	237	0.1	1,650	0.5	1,887
Stripetail rockfish	*Sebastes saxicola*	1,177	0.3	436	0.1	1,613
Flag rockfish	*Sebastes rubrivinctus*	1,083	0.7	476	0.1	1,559
Copper rockfish	*Sebastes caurinus*	1,023	0.7	371	0.1	1,394
Olive rockfish	*Sebastes serranoides*	827	0.8	564	0.1	1,391
Dwarf-red rockfish	*Sebastes rufianus*	116	0.7	1,236	0.5	1,352
Spotted scorpionfish	*Scorpaena guttata*	1,241	0.7	59	<0.1	1,300
Honeycomb rockfish	*Sebastes umbrosus*	1,085	0.7	168	<0.1	1,253
Starry rockfish	*Sebastes constellatus*	135	<0.1	1,056	<0.1	1,191

Table 4 (continued)

Common Name	Scientific Name	Platforms		Natural Sites		Total Number
		Number	Density	Number	Density	
Speckled rockfish	*Sebastes ovalis*	651	0.4	453	0.1	1,104
Splitnose rockfish	*Sebastes diploproa*	71	<0.1	793	0.2	864
Greenblotched rockfish	*Sebastes rosenblatti*	501	0.2	282	<0.1	783
Unidentified sanddabs	*Citharichthys* spp.	314	0.2	419	0.1	733
Greenstriped rockfish	*Sebastes elongatus*	386	0.2	318	<0.1	704
Unidentified combfishes	*Zaniolepis* spp.	40	<0.1	616	0.2	656
Sharpnose seaperch	*Phanerodon atripes*	220	0.2	418	0.1	638
Unidentified poachers	Family Agonidae	49	<0.1	576	0.1	625
Unidentified flatfishes		64	<0.1	526	0.1	590
California sheephead	*Semicossyphus pulcher*	178	0.2	396	0.1	574
Pile perch	*Rhacochilus vacca*	270	0.2	181	<0.1	451
Senorita	*Oxyjulis californica*	15	<0.1	430	0.1	445
White seaperch	*Phanerodon furcatus*	68	<0.1	377	<0.1	445
Deepwater blenny	*Cryptotrema corallinum*	3	<0.1	402	0.1	405
Spotted ratfish	*Hydrolagus colliei*	6	<0.1	364	<0.1	370
Unidentified surfperch	Family Embiotocidae	112	<0.1	251	<0.1	363
Longspine combfish	*Zaniolepis latipinnis*	32	<0.1	320	<0.1	352
Cowcod	*Sebastes levis*	151	<0.1	186	<0.1	337
Kelp rockfish	*Sebastes atrovirens*	287	0.3	7	<0.1	294
Unidentified ronquil	Family Bathymasteridae	132	<0.1	137	<0.1	269
Sharpchin rockfish	*Sebastes zacentrus*	201	<0.1	57	<0.1	258
Brown rockfish	*Sebastes auriculatus*	200	0.1	51	<0.1	251
Unidentified pricklebacks	Family Stichaeidae	8	<0.1	241	<0.1	249
Cabezon	*Scorpaenichthys marmoratus*	244	0.2	1	<0.1	245
Yellowtail rockfish	*Sebastes flavidus*	24	<0.1	207	<0.1	231
Bluebanded ronquil	*Rathbunella hypoplecta*	117	<0.1	111	<0.1	228
Treefish	*Sebastes serriceps*	101	<0.1	117	<0.1	218
Halfmoon	*Medialuna californiensis*	207	0.2	0	0	207
Canary rockfish	*Sebastes pinniger*	173	<0.1	23	<0.1	196
Dover sole	*Microstomus pacificus*	29	<0.1	163	<0.1	192
Pacific hake	*Merluccius productus*	3	<0.1	178	<0.1	181
Rubberlip seaperch	*Rhacochilus toxotes*	15	<0.1	160	<0.1	175
Gopher rockfish	*Sebastes carnatus*	45	<0.1	129	<0.1	174
Darkblotched rockfish	*Sebastes crameri*	123	<0.1	40	<0.1	163
Rainbow seaperch	*Hypsurus caryi*	0	0	163	<0.1	163
Unidentified thornyheads	*Sebastolobus* spp.	55	<0.1	101	<0.1	156
Pacific sanddab	*Citharichthys stigmaeus*	40	<0.1	109	<0.1	149
Rosethorn rockfish	*Sebastes helvomaculatus*	9	<0.1	139	<0.1	148
Unidentified sculpin	Family Cottidae	14	<0.1	121	<0.1	135
Spotfin sculpin	*Icelinus tenuis*	0	0	127	<0.1	127
Bluebarred prickleback	*Plectobranchus evides*	3	<0.1	114	<0.1	117
Unidentified eelpout	Family Zoarcidae	53	<0.1	47	<0.1	100
Mexican rockfish	*Sebastes macdonaldi*	94	<0.1	3	<0.1	97
Slender sole	*Lyopsetta exilis*	92	<0.1	0	0	92
Garibaldi	*Hypsypops rubicunda*	91	<0.1	0	0	91
Wolf-eel	*Anarrhichthys ocellatus*	81	<0.1	5	<0.1	86
Blackgill rockfish	*Sebastes melanostomus*	50	<0.1	26	<0.1	76
Freckled rockfish	*Sebastes lentiginosus*	28	<0.1	42	<0.1	70
Pacific argentine	*Argentina sialis*	1	<0.1	69	<0.1	70

Table 4 (continued)

Common Name	Scientific Name	Platforms		Natural Sites		Total Number
		Number	Density	Number	Density	
Bigfin eelpout	*Lycodes cortezianus*	0	0	52	<0.1	52
Kelp greenling	*Hexagrammos decagrammus*	38	<0.1	11	<0.1	49
Chilipepper	*Sebastes goodei*	5	<0.1	33	<0.1	38
California smoothtongue	*Leuroglossus stilbius*	1	<0.1	35	<0.1	36
Pink rockfish	*Sebastes eos*	2	<0.1	25	<0.1	27
Kelp bass	*Paralabrax clathratus*	24	<0.1	2	<0.1	26
Ocean whitefish	*Caulolatilus princeps*	0	0	25	<0.1	25
Pacific electric ray	*Torpedo californica*	2	<0.1	22	<0.1	24
Yelloweye rockfish	*Sebastes ruberrimus*	19	<0.1	5	<0.1	24
California lizardfish	*Synodus lucioceps*	3	<0.1	20	<0.1	23
Icelinus sp.		3	<0.1	20	<0.1	23
Unidentified hagfish	*Eptatretus* sp.	0	0	23	<0.1	23
Whitespotted rockfish	*Sebastes moseri*	0	0	19	<0.1	19
Unidentified cuskeel	Family Ophidiidae	3	<0.1	11	<0.1	14
English sole	*Parophrys vetulus*	1	<0.1	13	<0.1	14
Bronzespotted rockfish	*Sebastes gilli*	0	0	13	<0.1	13
Black perch	*Embiotoca jacksoni*	0	0	12	<0.1	12
Longnose skate	*Raja rhina*	0	0	11	<0.1	11
Shortspine thornyhead	*Sebastolobus alascanus*	0	0	11	<0.1	11
Threadfin bass	*Pronotogrammus multifasciatus*	1	<0.1	10	<0.1	11
Aurora rockfish	*Sebastes aurora*	9	<0.1	1	<0.1	10
Rex sole	*Glyptocephalus zachirus*	0	0	9	<0.1	9
Bearded eelpout	*Lyconema barbatum*	3	<0.1	4	<0.1	7
Blacktail snailfish	*Careproctus melanurus*	4	<0.1	2	<0.1	6
Bull sculpin	*Enophrys taurina*	5	<0.1	1	<0.1	6
Grass rockfish	*Sebastes rastrelliger*	6	<0.1	0	0	6
Fantail sole	*Xystreurys liolepis*	0	0	5	<0.1	5
Striped seaperch	*Embiotoca lateralis*	0	0	5	<0.1	5
Bay goby	*Lepidogobius lepidus*	0	0	4	<0.1	4
California grenadier	*Nezumia stelgidolepis*	0	0	4	<0.1	4
California halibut	*Paralichthys californicus*	2	<0.1	2	<0.1	4
Hornyhead turbot	*Pleuronichthys verticalis*	0	0	4	<0.1	4
Opaleye	*Girella nigricans*	4	<0.1	0	0	4
Threadfin sculpin	*Icelinus filamentosus*	4	<0.1	0	0	4
Unidentified skate	Family Rajidae	0	0	4	<0.1	4
Bat ray	*Myliobatis californica*	0	0	3	<0.1	3
Blackbelly eelpout	*Lycodes pacificus*	1	<0.1	3	<0.1	3
C-O sole	*Pleuronichthys coenosus*	0	0	3	<0.1	3
Plainfin midshipman	*Porichthys notatus*	0	0	3	<0.1	3
Red brotula	*Brosmophycis marginata*	0	0	3	<0.1	3
Spotted cusk-eel	*Chilara taylori*	1	<0.1	2	<0.1	3
California skate	*Raja inornata*	0	0	2	<0.1	2
Island kelpfish	*Alloclinus holderi*	0	0	2	<0.1	2
Petrale sole	*Eopsetta jordani*	0	0	2	<0.1	2
Redbanded rockfish	*Sebastes babcocki*	2	<0.1	0	0	2
Tiger rockfish	*Sebastes nigrocinctus*	1	<0.1	1	<0.1	2
Unidentified witch-eel	Family Nettastomatidae	2	<0.1	0	0	2
Barred sand bass	*Paralabrax nebulifer*	0	0	1	<0.1	1
Bluebanded goby	*Lythrypnus dalli*	0	0	1	<0.1	1
California tonguefish	*Symphurus atricauda*	0	0	1	<0.1	1

Table 4 (continued)

Common Name	Scientific Name	Platforms		Natural Sites		Total Number
		Number	Density	Number	Density	
Unidentified catshark	Family Scyliorhininidae	1	<0.1	0	0	1
Chameleon rockfish	*Sebastes phillipsi*	0	0	1	<0.1	1
Giant sea bass	*Stereolepis gigas*	0	0	1	<0.1	1
Pacific mackerel	*Scomber japonicus*	0	0	1	<0.1	1
Popeye catalufa	*Pristigenys serrula*	1	<0.1	0	0	1
Rock sole	*Lepidopsetta* sp.	0	0	1	<0.1	1
Rock wrasse	*Halichoeres semicinctus*	1	<0.1	0	0	1
Sablefish	*Anoplopoma fimbria*	0	0	1	<0.1	1
Unidentified Trichiuridae		0	0	1	<0.1	1
Semaphore rockfish	*Sebastes melanosema*	0	0	1	<0.1	1
Shiner perch	*Cymatogaster aggregata*	0	0	1	<0.1	1
Starry flounder	*Platichthys stellatus*	1	<0.1	0	0	1
Swell shark	*Cephaloscyllium ventriosum*	0	0	1	<0.1	1
Unidentified lanternfish	Family Myctophidae	0	0	1	<0.1	1
Unidentified snipe eel	Family Nemichthyidae	0	0	1	<0.1	1
Total		317,583	257.4	369,559	104.0	687,142
Minimum number of species		128	95		114	128

[1]Primarily young-of-the-year.
[2]Likely two species, *Sebastes miniatus* and an undescribed species.
[3]Likely two species, *Sebastes mystinus* and an undescribed species.

sites. On average, fish densities were over twice as high at platforms (257.4 individuals/100 m^2) compared to natural sites (104 individuals/100m^2). Rockfishes, of 45 species (at least 45 species at platforms and 43 species at natural sites) dominated the survey as they comprised 85.8% of all fishes observed (83.8% at platforms and 87.5% at natural sites).

Among the highest density species or species complexes, squarespot, halfbanded, and shortbelly rockfishes, and a complex of young-of-the-year (YOY) rockfishes dominated both platform and natural sites (Table 4). Blacksmith, widow rockfish, jack mackerel, unidentified *Sebastomus*, blackeye goby, and calico rockfish rounded out the top ten platform species. A somewhat different suite of species, including pygmy, blackeye goby, unidentified *Sebastomus*, swordspine rockfish, blacksmith, and blue rockfish comprised the top ten species by density at natural sites.

Platform Fish Assemblages

Fish densities were highly variable both between depths at each platform and between platforms (Figures 2a–c). While no single trend described these differences, several patterns were apparent. First, at most Santa Barbara Channel and Point Conception-Point Arguello platforms, fish densities were relatively low in the first 30 m of the water column. The one exception was at Platform Holly, where a single school of jack mackerel in one year dramatically increased the average upper water column density. By contrast, fish densities in the shallow waters of the more southerly platforms (Edith, Elly, Ellen, and Eureka) were high, primarily driven by high numbers of squarespot rockfish (adults and YOY) and blacksmith YOY (Table 5).

There was a tendency for densities of fishes to increase and peak in deeper midwater depths or at the bottom. Fish densities over shell mounds were usually lower than those at the adjacent platform bottom. In addition, fish densities varied greatly between platforms at similar depths. However, there appeared to be

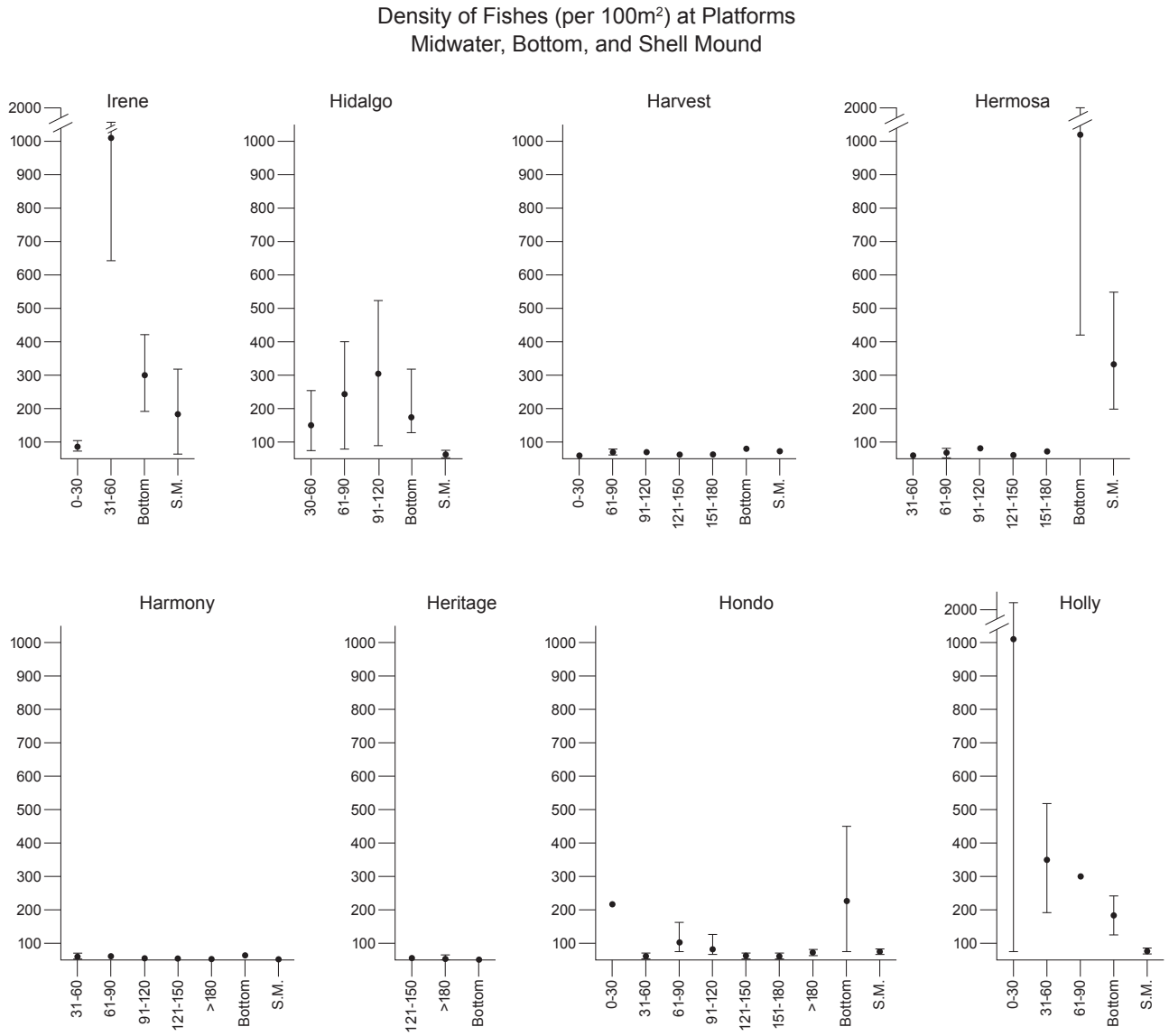

Figure 2a. Density, with standard error bars, of all fishes (per 100 m^2) at platform midwaters, bottom, and shell mound, 2004–2009. Platforms are listed from northernmost to southernmost. Note that densities on y-axis vary among platforms.

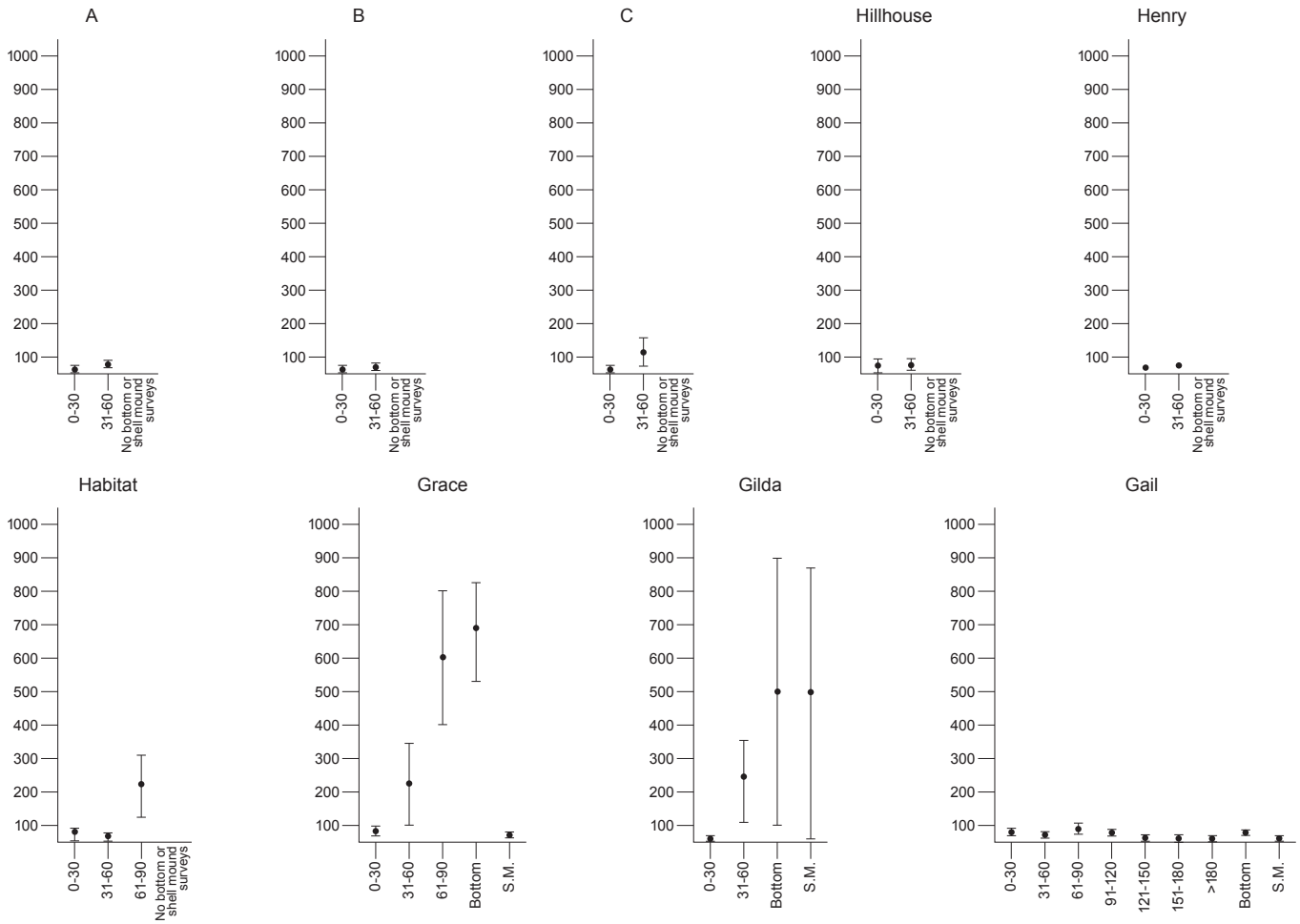

Figure 2b. Density, with standard error bars, of all fishes (per 100 m^2) at platform midwaters, bottom, and shell mound, 2004–2009. Platforms are listed from northernmost to southernmost. Note that densities on y-axis vary among platforms.

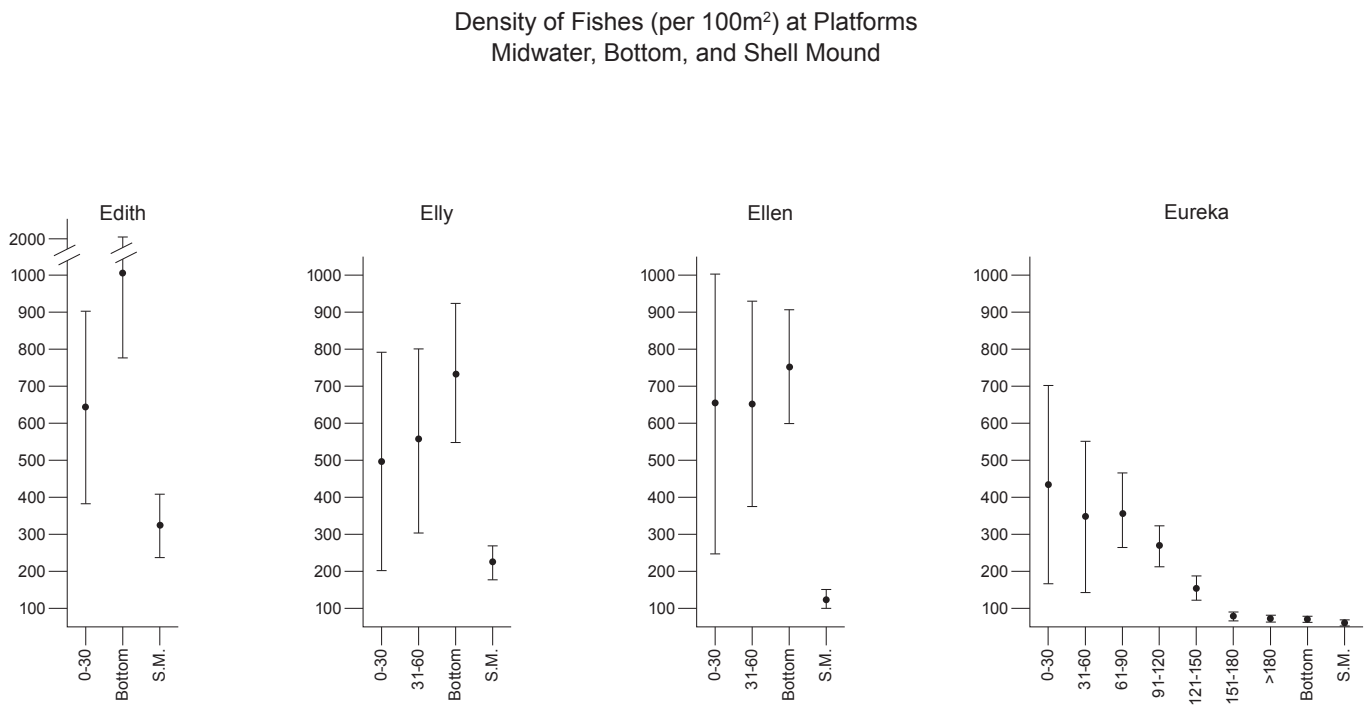

Figure 2c. Density, with standard error bars, of all fishes (per 100 m^2) at platform midwaters, bottom, and shell mound, 2004–2009. Platforms are listed from northernmost to southernmost. Note that densities on y-axis vary among platforms.

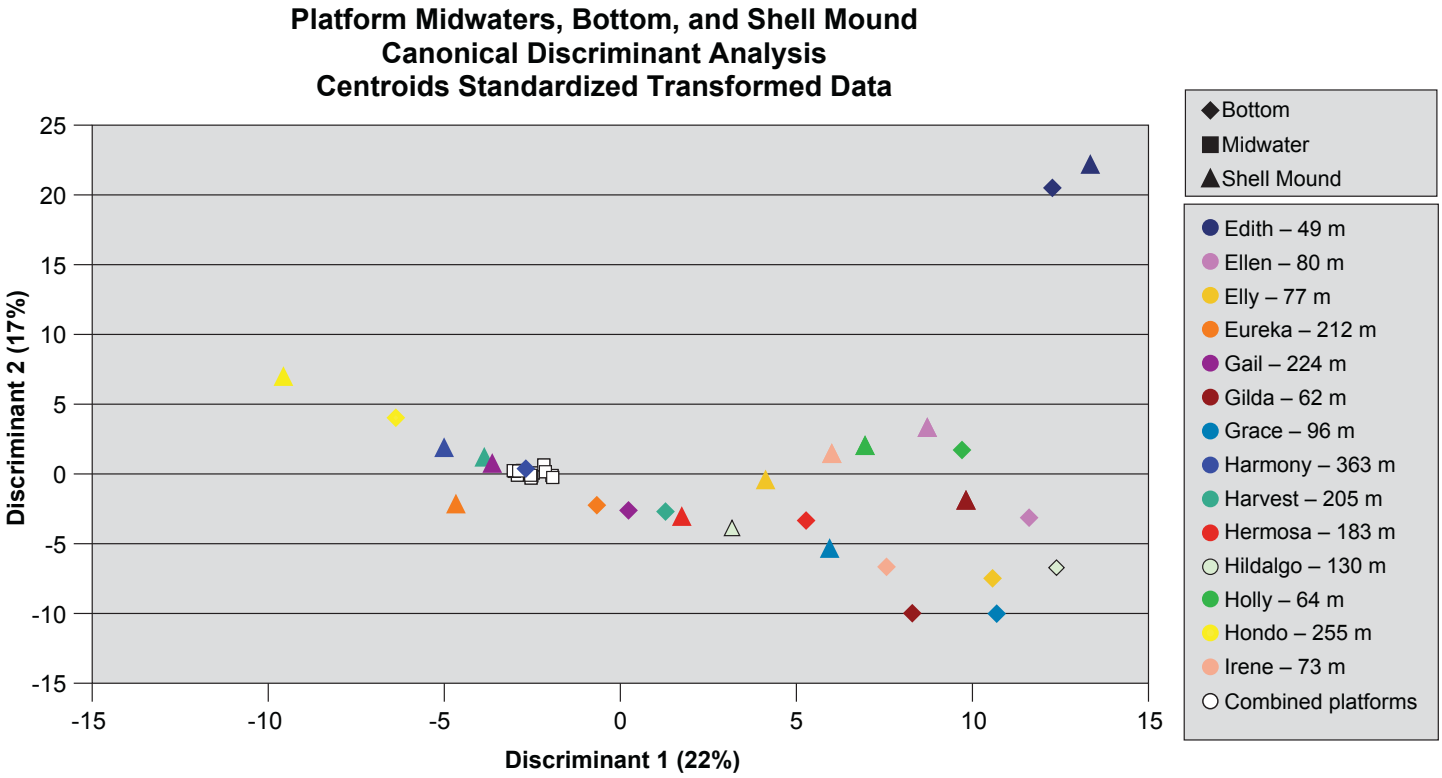

Figure 3. A canonical discriminant analysis of platform midwaters, bottom, and shell mound fish assemblages, based on centroids of surveys conducted in 2004–2009.

no geographic pattern to these differences. There was a tendency for fish densities on the bottoms and shell mounds of the deepest platforms to be lower than those at shallower structures.

There are three different fish assemblages, midwaters, bottom, and shell mound, around each platform (Figure 3). The fish assemblages in midwaters tended to be similar across platforms. On the other hand, substantial differences in fish assemblages were observed among platform bottoms and shell mounds, both at each platform and between them. Because of the differences among these three habitats, below we report separately upon each assemblage.

Platform Midwaters

We observed between 5 (Heritage) and 40 (Eureka) fish species in the platform midwaters (Figure 4, Table 5). The number of species tended to be lowest around the northern-most structures and highest around the southern-most ones (Figure 4). The relative paucity of species in the northern platform assemblage was at least partially due to the absence of a suite of warm-temperate taxa, such as blacksmith, sheephead, and garibaldi (Table 5). There did not appear to be a relationship between platform bottom depth and number of species in the midwaters (Figure 4). The exceptionally large number of species in the midwaters of Platform Eureka is related to the complex structure of Eureka's midwater jacket and is discussed in more detail in Task 2.

With a few exceptions, midwater fish assemblages were quite similar among platforms and at a platform among years (Figures 5–7, Table 5). These assemblages tended to be dominated by juvenile fishes, particularly juvenile rockfishes (e.g., squarespot and widow rockfishes, and bocaccio) and a range of shallow-water reef taxa (e.g., cabezon, painted greenling, pile perch, and blue rockfish). The assemblages of four closely situated platforms, Edith, Elly, Ellen, and Eureka were somewhat different from those of other structures

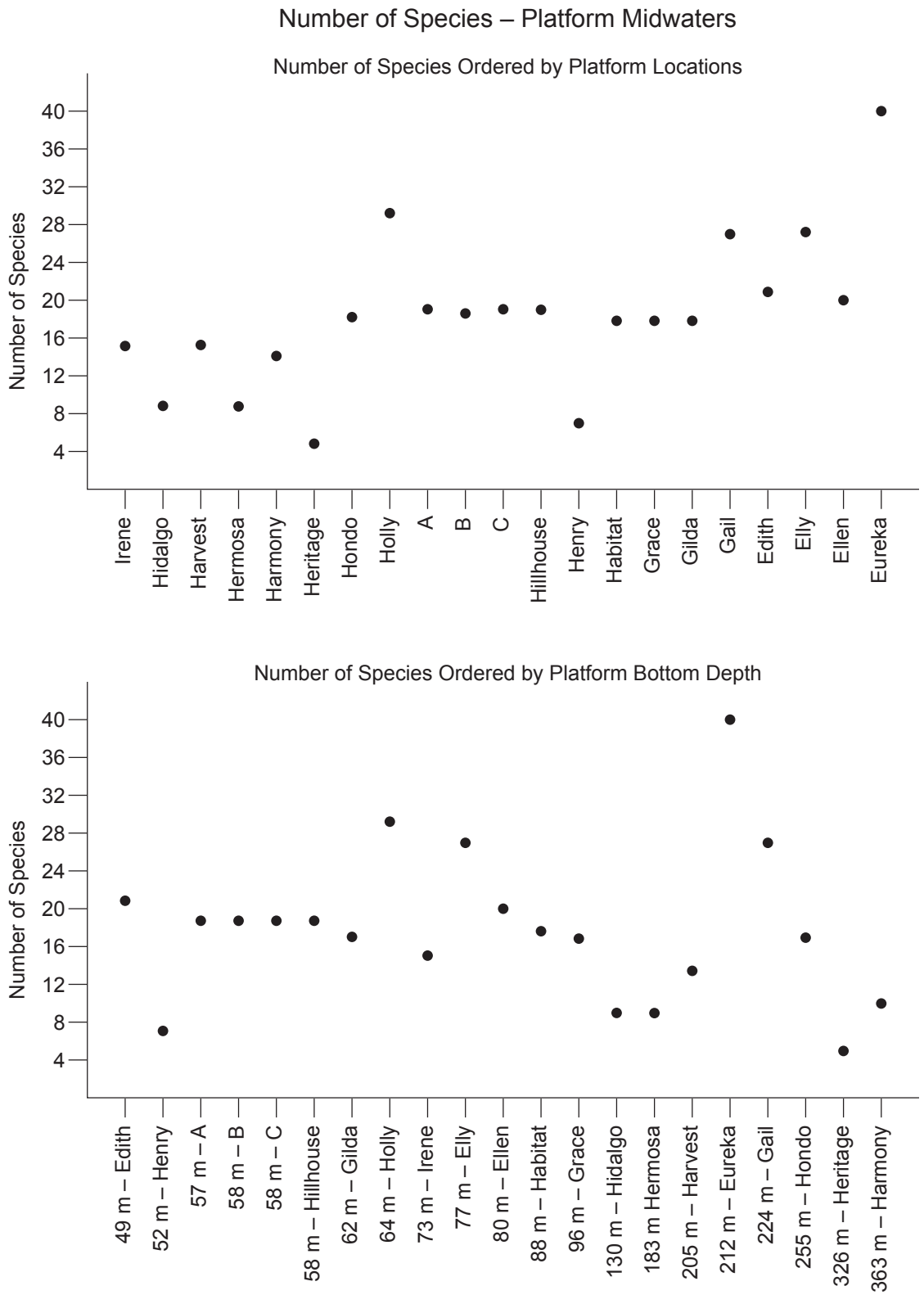

Figure 4. Number of species observed in the midwaters of platforms, 2004–2009. Platforms are listed first from northernmost to southernmost and then from shallowest to deepest.

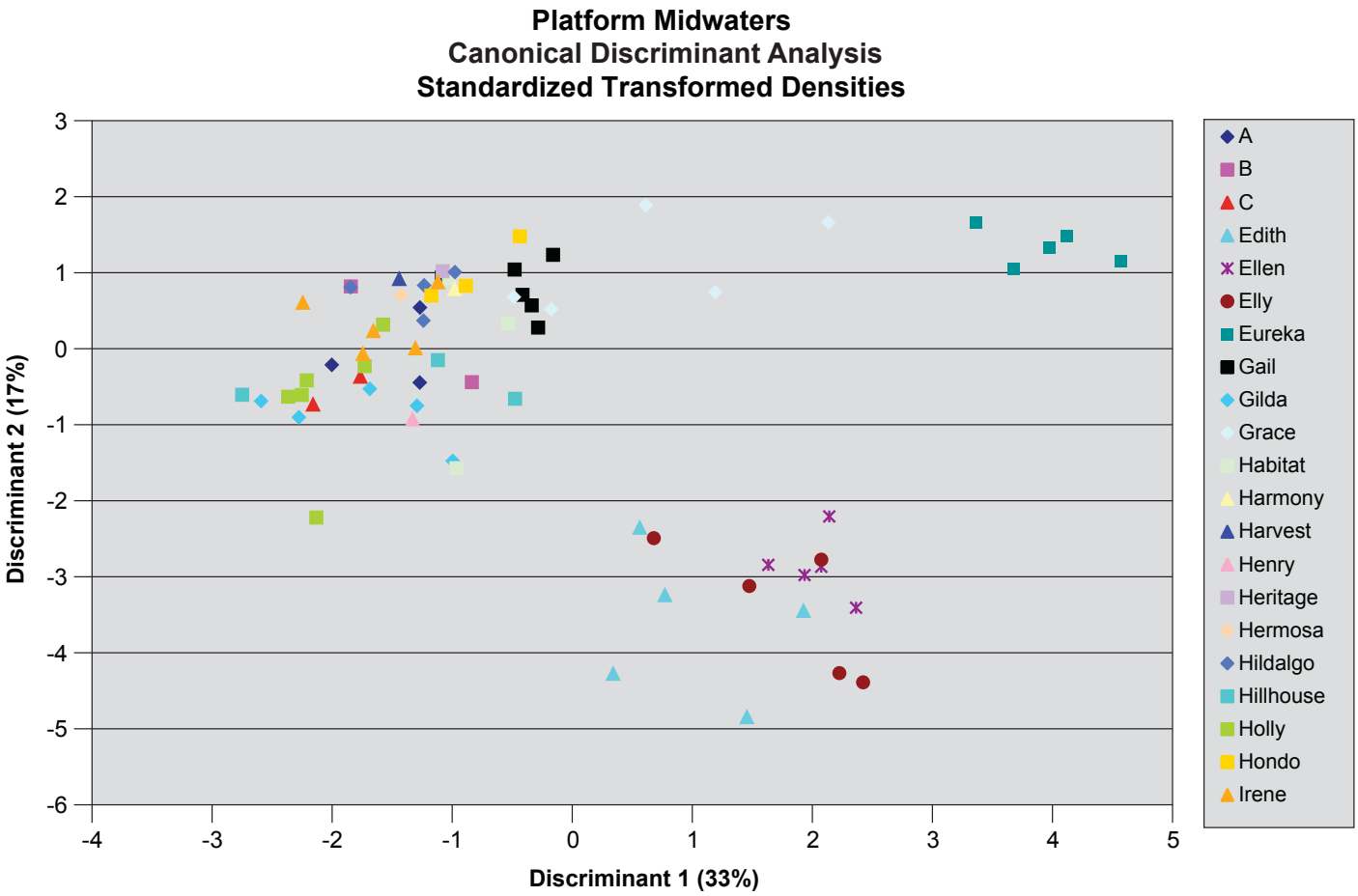

Figure 5. A canonical discriminant analysis of platform midwaters fish assemblages, by year, 2004–2009.

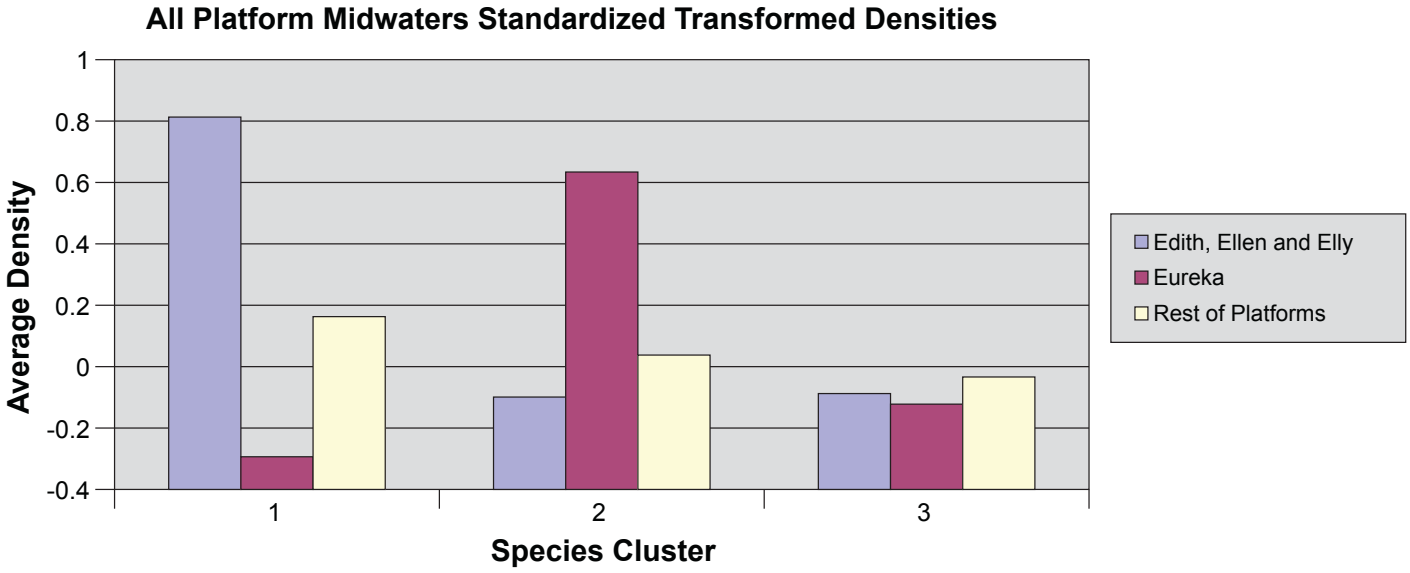

Figure 6. A comparison of densities of the three midwater species clusters shown in Figure 7.

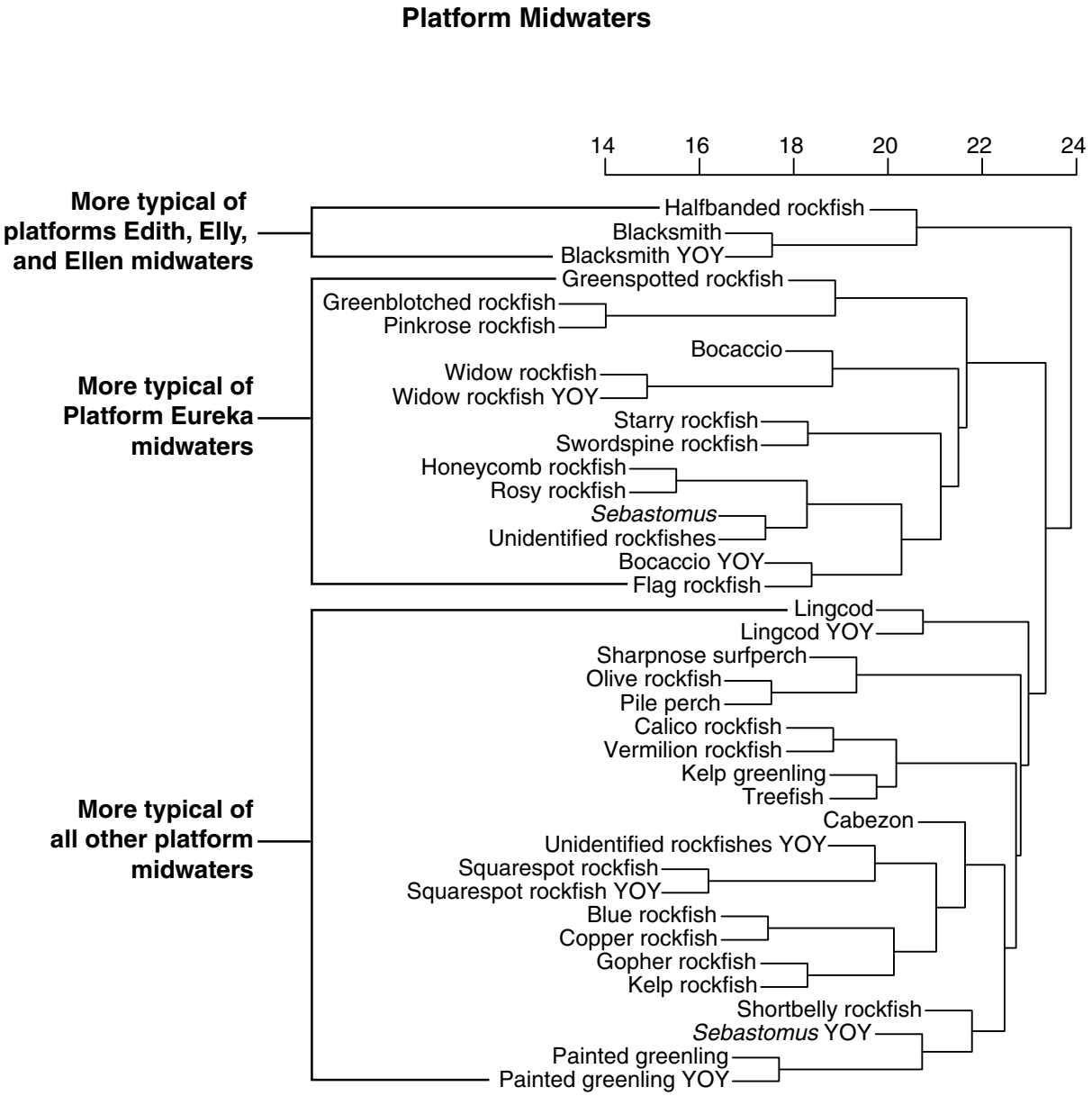

Figure 7. A cluster analysis of the characteristic species of platform midwaters, 2004–2009.

(Figures 5–7, Table 5). Edith, Elly, and Ellen harbored particularly high densities of juvenile blacksmith. A variety of both juvenile and adult deeper-water rockfishes, that were absent or rare around other platform midwaters, occupied Platform Eureka (see Task 2).

Platform Bottoms

We observed between 5 (Harmony) and 38 (Holly) fish species around platform bottoms (Figure 8, Table 6). While there appears to be little relationship between species richness and platform location, bottom depth was an important factor as there was a clear peak in species numbers at platforms situated in about 60–80 m and perhaps a second peak in about 220 m (Figure 8).

Table 5. Numbers and densities (average number per 100 m2) of fish species observed in the midwaters of platforms, 2004–2009. 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 IRENE (Surveyed 2004–6, 2008, 2009)

Species	Number	Density
Widow rockfish YOY	5,431	211.1
Unidentified rockfish YOY	3,316	126.1
Shortbelly rockfish YOY	2,100	78.8
Squarespot rockfish YOY	1,487	55.8
Widow rockfish	987	33.1
Olive rockfish YOY	610	22.9
Northern anchovy	300	16.9
Painted greenling	102	4.3
Unidentified rockfishes	67	2.4
Painted greenling YOY	65	2.8
Sebastomus sp.	11	0.4
Sebastomus sp. YOY	10	0.4
Copper rockfish	7	0.3
Blue rockfish	6	0.3
Lingcod YOY	4	0.1
Unidentified fishes	3	0.1
Yellowtail rockfish YY	3	0.1
Blacksmith YOY	1	<0.1
Bocaccio YOY	1	<0.1
Cabezon	1	<0.1
Flag rockfish YOY	1	<0.1
Total	14,513	
Minimum number of species	15	
Total rockfish YOY	12,959	
Total rockfishes	13,970	

Rockfish YOY comprised 89.3% of all fishes surveyed
All rockfishes comprised 96.3% of all fishes surveyed

PLATFORM HIDALGO (Surveyed 2004–2006, 2009)

Species	Number	Density
Unidentified rockfish YOY	11,406	205.3
Widow rockfish YOY	175	4.1
Squarespot rockfish	123	2.6
Unidentified rockfish	122	2.4
Painted greenling YOY	64	1.4
Painted greenling	52	1.1
Unidentified fishes	17	0.4
Sebastomus sp.	11	0.2
Widow rockfish	10	0.2
Squarespot rockfish YOY	8	0.2
Sebastomus sp. YOY	7	0.1
Flag rockfish	5	<0.1
Flag rockfish YOY	5	0.1
Halfbanded rockfish	2	<0.1
Pygmy rockfish	2	<0.1
Bocaccio	1	<0.1
Bocaccio YOY	1	<0.1
Cabezon	1	<0.1
Greenspotted rockfish	1	<0.1
Total	12,013	
Minimum number of species	9	
Total rockfish YOY	11,602	
Total rockfishes	11,879	

Rockfish YOY comprised 96.6% of all fishes surveyed
All rockfishes comprised 98.9% of all fishes surveyed

PLATFORM HARVEST (Surveyed 2004)

Species	Number	Density
Squarespot rockfish	247	9.5
Widow rockfish	191	7.8
Sharpchin rockfish	169	4.8
Painted greenling	72	2.5
Painted greenling YOY	21	0.9
Unidentified rockfish YOY	19	0.7
Widow rockfish YOY	10	0.4
Unidentified rockfish	6	0.2
Sebastomus sp.	4	0.1
Darkblotched rockfish	3	<0.1
Flag rockfish	3	0.1
Unidentified sculpin	3	0.1
Halfbanded rockfish	2	<0.1
Squarespot rockfish	2	<0.1
Blue rockfish	1	<0.1
Blue rockfish YOY	1	<0.1
Cabezon	1	<0.1
Unidentified Icelinus	1	<0.1
Kelp rockfish	1	<0.1
Pacific argentine	1	<0.1
Treefish YOY	1	<0.1
Total	759	
Minimum number of species	15	
Total rockfish YOY	33	
Total rockfishes	660	

Rockfish YOY comprised 4.3% of all fishes surveyed
All rockfishes comprised 87.0% of all fishes surveyed

PLATFORM HERMOSA (Surveyed 2006)

Species	Number	Density
Widow rockfish YOY	237	11.4
Widow rockfish	96	4.7
Painted greenling	81	4.0
Unidentified rockfish	81	3.5
Squarespot rockfish	55	2.2
Unidentified rockfish YOY	37	1.9
Painted greenling YOY	18	1.0
Sebastomus sp.	8	0.4
Cabezon	5	0.3
Flag rockfish	4	0.2
Blue rockfish	3	0.2
Bocaccio	1	<0.1
Darkblotched rockfish	1	<0.1
Rosy rockfish	1	<0.1
Squarespot rockfish YOY	1	<0.1
Unidentified fish	1	<0.1
Total	630	
Minimum number of species	9	
Total rockfish YOY	275	
Total rockfishes	525	

Rockfish YOY comprised 43.7% of all fishes surveyed
All rockfishes comprised 83.3% of all fishes surveyed

Table 5 (continued)

PLATFORM HARMONY (Surveyed 2004)

Species	Number	Density
Squarespot rockfish	39	1.8
Blue rockfish	17	1.0
Darkblotched rockfish	13	0.3
Squarespot rockfish YOY	8	0.4
Bocaccio YOY	7	0.3
Unidentified rockfish YOY	7	0.4
Painted greenling	6	0.3
Kelp rockfish	5	0.3
Painted greenling YOY	4	0.2
Unidentified rockfish	4	0.1
Widow rockfish YOY	4	0.2
Unidentified fishes	3	0.1
Aurora rockfish	2	<0.1
Bocaccio	2	<0.1
Sebastomus sp.	2	<0.1
Blackgill rockfish	1	<0.1
Sharpchin rockfish	1	<0.1
Splitnose rockfish	1	<0.1
Yelloweye rockfish	1	<0.1
Total	127	
Minimum number of species	14	
Total rockfish YOY	26	
Total rockfishes	114	

Rockfish YOY comprised 20.4% of all fishes surveyed
All rockfishes comprised 89.8% of all fishes surveyed

PLATFORM HERITAGE (Surveyed 2008)

Species	Number	Density
Bank rockfish	179	8.4
Pinkrose rockfish	22	1.0
Painted greenling	2	<0.1
Unidentified fishes	2	<0.1
Unidentified rockfish	2	<0.1
Sebastomus sp.	1	<0.1
Squarespot rockfish	1	<0.1
Unidentified rockfish YOY	1	<0.1
Total	210	
Minimum number of species	5	
Total rockfish YOY	1	
Total rockfishes	206	

Rockfish YOY comprised 0.5% of all fishes surveyed
All rockfishes comprised 98.1% of all fishes surveyed

PLATFORM HONDO (Surveyed 2004, 2006, 2008)

Species	Number	Density
Squarespot rockfish	704	19.4
Bank rockfish	558	8.6
Blacksmith	271	10.1
Northern anchovy	226	2.0
Widow rockfish	107	2.5
Squarespot rockfish YOY	56	1.1
Unidentified rockfish YOY	41	0.7
Widow rockfish YOY	40	1.3
Painted greenling	33	0.8
Bocaccio	31	0.8
Pinkrose rockfish	24	0.3
Sebastomus sp.	15	0.2
Painted greenling YOY	14	0.4
Unidentified rockfish	13	0.3
Bocaccio YOY	8	0.3
Bank rockfish YOY	5	<0.1
Blue rockfish	5	0.2
Darkblotched rockfish	5	<0.1
Flag rockfish	5	<0.1
Sharpchin rockfish	5	0.1
Cabezon	4	<0.1
Unidentified fishes	3	<0.1
Olive rockfish	2	<0.1
Sebastomus YOY	2	<0.1
Unidentified Icelinus	1	<0.1
Kelp greenling	1	<0.1
Shortbelly rockfish	1	<0.1
Yellowtail rockfish	1	√
Total	2,181	
Minimum number of species	18	
Total rockfish YOY	152	
Total rockfishes	1,628	

Rockfish YOY comprised 7.0% of all fishes surveyed
All rockfishes comprised 74.6% of all fishes surveyed

PLATFORM HOLLY (Surveyed 2004–2009)

Species	Number	Density
Jack mackerel	10,650	457.6
Squarespot rockfish	1,660	38.5
Unidentified rockfish YOY	1,401	37.7
Blacksmith YOY	534	12.5
Squarespot rockfish YOY	261	13.7
Widow rockfish	239	13.7
Painted greenling	186	5.5
Painted greenling YOY	110	4.2
Calico rockfish	89	1.3
Widow rockfish YOY	84	3.9
Blacksmith	53	2.0
Blackeye goby	41	0.6
Copper rockfish	35	1.0
Olive rockfish	27	1.4
Bocaccio YOY	21	0.4
Halfbanded rockfish	20	0.3
Halfbanded rockfish YOY	20	0.3
Rosy rockfish	17	0.2
Unidentified *Sebastomus*	16	0.2
Kelp rockfish	14	1.2
Blue rockfish	12	0.4
Pile perch	11	0.8
Lingcod YOY	10	0.2
Bluebanded ronquil	8	0.1
Kelp greenling	7	0.2
Flag rockfish	6	<0.1
Sebastomus YOY	6	<0.1
Unidentified rockfish	6	0.2
Blue rockfish YOY	4	0.4
Sharpnose seaperch	4	0.3
Cabezon	3	0.2
Copper rockfish YOY	3	<0.1
Bocaccio	2	<0.1

Table 5 (continued)

Calico rockfish	2	<0.1
Gopher rockfish	2	<0.1
Honeycomb rockfish	2	<0.1
Shortspine combfish	2	<0.1
Unidentified fishes	2	<0.1
Unidentified ronquil	2	<0.1
Vermilion rockfish	2	<0.1
Brown rockfish	1	<0.1
Unidentified combfish	1	<0.1
Flag rockfish YOY	1	<0.1
Lingcod	1	<0.1
Olive rockfish YOY	1	<0.1
Pink seaperch	1	<0.1
Unidentified surfperch	1	<0.1
Treefish	1	<0.1
Unidentified sanddab	1	<0.1
Unidentified sculpin	1	<0.1
Yelloweye rockfish YOY	1	<0.1
Total	15,585	
Minimum number of species	30	
Total rockfish YOY	1,805	
Total rockfishes	3,956	

Rockfish YOY comprised 11.6% of all fishes surveyed
All rockfishes comprised 25.4% of all fishes surveyed

PLATFORM A (Surveyed 2004, 2006, 2007)

Species	Number	Density
Unidentified rockfish YOY	218	8.5
Shortbelly rockfish YOY	206	8.5
Sebastomus YOY	147	5.8
Blacksmith	142	6.5
Olive rockfish	49	1.9
Blue rockfish	29	1.1
Pile perch	29	1.2
Widow rockfish	23	0.9
Squarespot rockfish YOY	21	0.8
Sharpnose seaperch	17	0.7
Painted greenling	15	0.6
Painted greenling YOY	15	0.6
Unidentified fishes	12	0.5
California sheephead	10	0.5
Bocaccio YOY	9	0.4
Widow rockfish YOY	8	0.3
Unidentified surfperch	7	0.3
Squarespot rockfish	5	0.2
Unidentified rockfish	4	0.2
Brown rockfish	3	0.1
Kelp rockfish	2	<0.1
Rubberlip seaperch	2	<0.1
Blacksmith YOY	1	<0.1
Copper rockfish	1	<0.1
Gopher rockfish	1	<0.1
Halfbanded rockfish YOY	1	<0.1
Starry rockfish YOY	1	<0.1
White seaperch	1	<0.1
Total	982	
Minimum number of species	19	
Total rockfish YOY	611	
Total rockfishes	728	

Rock YOY comprised 62.2% of all fishes surveyed
All rockfishes comprised 74.1% of all fishes surveyed.

PLATFORM B (Surveyed 2004 and 2007)

Species	Number	Density
Unidentified rockfish YOY	215	9.6
Blacksmith	79	4.1
Sharpnose seaperch	35	1.7
Olive rockfish	22	1.0
Kelp bass	19	1.0
Halfmoon	16	0.9
Unidentified rockfish	16	0.7
Blacksmith YOY	15	0.9
Blue rockfish	12	0.5
Pile perch	11	0.5
California sheephead	9	0.5
White seaperch	8	0.4
Painted greenling	7	0.3
Squarespot YOY	5	0.2
Widow rockfish YOY	5	0.2
Painted greenling	4	0.2
Unidentified surfperch	4	0.2
Brown rockfish	3	0.1
Copper rockfish	3	0.1
Kelp rockfish YOY	3	0.1
Kelp rockfish	2	0.1
Garibaldi	1	<0.1
Rubberlip seaperch	1	<0.1
Senorita	1	<0.1
Unidentified fishes	1	<0.1
Total	497	
Minimum number of species	19	
Total rockfish YOY	228	
Total rockfishes	286	

Rockfish YOY comprised 46.0% of all fishes surveyd
All rockfishes comprised 57.5% of all fishes surveyed.

PLATFORM C (Surveyed 2004, 2007)

Species	Number	Density
Unidentified rockfish YOY	518	23.2
Widow rockfish	373	16.6
Widow rockfish YOY	210	9.3
Blue rockfish	139	6.3
Squarespot rockfish YOY	89	4.0
Sebastomus YOY	47	2.1
Blacksmith	46	2.5
Blacksmith YOY	38	1.9
Olive rockfish	28	1.3
Painted greenling	26	1.2
Painted greenling YOY	21	1.0
Pile perch	20	1.0
White seaperch	18	0.9
Sharpnose seaperch	15	0.7
Copper rockfish YOY	7	0.3
Halfmoon	6	0.3
Bocaccio YOY	4	0.2
Kelp rockfish	4	0.2

Table 5 (continued)

Blackeye goby	3	0.1
Blue rockfish YOY	3	0.1
California sheephead	3	0.1
Speckled rockfish YOY	2	<0.1
Squarespot rockfish	2	<0.1
Unidentified rockfish	2	<0.1
Gopher rockfish	1	<0.1
Wolf-eel	1	<0.1
Total	1,626	
Minimum number of species	19	
Total rockfish YOY	1,399	
Total rockfishes	1,429	

Rockfish YOY comprised 86.0% of all fishes surveyed
All rockfishes comprised 87.8% of all fishes surveyed

PLATFORM HILLHOUSE (Surveyed 2004, 2007, 2009)

Species	Number	Density
Blacksmith YOY	569	28.2
Jack mackerel	330	12.8
Squarespot rockfish	81	3.1
Unidentified rockfish YOY	74	2.7
Unidentified surfperch	55	2.8
Blacksmith	41	2.0
Painted greenling	27	1.1
Squarespot rockfish YOY	24	0.9
Widow rockfish	17	0.6
Pile perch	13	0.6
Widow rockfish YOY	8	0.3
Olive rockfish	6	0.2
Blue rockfish	5	0.2
Halfbanded rockfish YOY	4	0.2
Kelp bass	3	0.2
Unidentified rockfish	3	0.1
Cabezon	2	0.1
Kelp rockfish	2	<0.1
Sebastomus YOY	2	<0.1
Sharpnose seaperch	2	<0.1
Blue rockfish YOY	1	<0.1
Copper rockfish	1	<0.1
Grass rockfish	1	<0.1
Rubberlip seaperch	1	<0.1
Unidentified *Sebastomus*	1	<0.1
Sheephead	1	<0.1
White seaperch	1	<0.1
Total	1,275	
Minimum number of species	19	
Total rockfish YOY	113	
Total rockfishes	230	

Rockfish YOY comprised 8.9% of all fishes surveyed
All rockfishes comprised 18.0% of all fishes surveyed

PLATFORM HENRY

Species	Number	Density
Unidentified rockfish YOY	75	12.5
Blacksmith YOY	48	9.1
Squarespot rockfish YOY	12	2.0
Widow rockfish YOY	5	0.8
Painted greenling	2	0.4
Blue rockfish YOY	1	0.2
Cabezon	1	0.2
Painted greenling YOY	1	0.2
Pile perch	1	0.1
Total	146	
Minimum number of species	7	
Total rockfish YOY	93	
Total rockfishes	93	

Rockfish YOY comprised 63.7% of all fishes surveyed
All rockfishes comprised 63.7% of all fishes surveyed

PLATFORM HABITAT (Surveyed 2004, 2007, 2009)

Species	Number	Density
Squarespot rockfish	1,094	30.9
Blacksmith YOY	666	26.1
Widow rockfish	565	16.1
Squarespot YOY	212	6.0
Widow rockfish YOY	163	4.6
Halfbanded rockfish	155	4.4
Unidentified rockfish YOY	100	3.0
Bocaccio YOY	85	2.4
Painted greenling	75	2.5
Blacksmith	52	1.9
Painted greenling YOY	35	1.1
Olive rockfish	25	0.8
Blue rockfish	24	0.7
Bocaccio	24	0.7
Halfbanded rockfish YOY	22	0.6
Unidentified rockfish	18	0.6
Sebastomus YOY	112	0.4
Copper rockfish	7	0.2
Sebastomus sp.	6	0.2
Flag rockfish	5	0.1
Unidentified surfperch	4	0.1
Unidentified fishes	4	0.1
Copper rockfish YOY	3	0.1
Halfmoon	3	0.1
Cabezon	2	<0.1
Calico rockfish	2	<0.1
Blackeye goby	1	<0.1
Blue rockfish YOY	1	<0.1
Gopher rockfish	1	<0.1
Kelp rockfish	1	<0.1
Rosy rockfish	1	<0.1
Total	3,368	
Minimum number of species	18	
Total rockfish YOY	598	
Total rockfishes	2,526	

Rockfish YOY comprised 17.8% of all fishes surveyed
All rockfishes comprised 75.0% of all fishes surveyed

PLATFORM GRACE (Surveyed 2004, 2005, 2007–2009)

Species	Number	Density
Widow rockfish YOY	8,099	225.3
Widow rockfish	2.151	57.5
Squarespot rockfish	1,868	37.3
Unidentified rockfish YOY	1,689	44.0
Squarespot rockfish	955	18.6

Table 5 (continued)

Bocaccio	182	4.8
Unidentified rockfish	163	3.2
Bocaccio YOY	145	2.8
Blacksmith	105	3.6
Painted greenling	25	0.6
Flag rockfish	24	0.5
Painted greenling YOY	24	0.6
Sebastomus sp.	18	0.4
Kelp rockfish	15	0.5
Blue rockfish	14	0.4
Rosy rockfish	11	0.2
Sebastomus YOY	8	0.3
Blacksmith YOY	6	0.2
Copper rockfish	6	0.2
Unidentified fishes	5	0.1
Cabezon	3	<0.1
Vermilion rockfish	3	<0.1
Greenspotted rockfish	2	<0.1
Olive rockfish	1	<0.1
Pygmy rockfish	1	<0.1
Starry rockfish	1	<0.1
Starry rockfish YOY	1	<0.1
Treefish	1	<0.1
Unidentified rockfish	1	<0.1
Total	15,527	
Minimum number of species	17	
Total rockfish YOY	10,897	
Total rockfishes	15,358	

Rockfish YOY comprised 71.0% of all fishes surveyed
All rockfishes comprised 98.9% of all fishes surveyed

PLATFORM GILDA (Surveyed 2004, 2006–2009)

Species	Number	Density
Shortbelly rockfish YOY	1,316	53.9
Unidentified rockfish YOY	501	20.6
Shortbelly rockfish	500	20.5
Squarespot rockfish YOY	156	6.9
Sharpnose seaperch	81	3.6
Painted greenling	61	2.8
Blacksmith YOY	35	2.1
Painted greenling YOY	27	1.1
Halfmoon	22	1.1
Blacksmith	18	0.9
Unidentified rockfish	16	0.7
Squarespot rockfish	15	0.7
Kelp rockfish	13	0.7
Pile perch	10	0.5
Cabezon	7	0.3
Sebastomus YOY	7	0.2
Copper rockfish YOY	5	0.3
Unidentified surfperch	4	0.2
Copper rockfish	2	<0.1
Opaleye	2	<0.1
Chilipepper YOY	1	<0.1
Grass rockfish	1	<0.1
Kelp greenling	1	<0.1
Olive rockfish	1	<0.1
Olive rockfish YOY	1	<0.1
Rosy rockfish YOY	1	<0.1
Stripetail rockfish	1	<0.1
Treefish	1	<0.1
Treefish YOY	1	<0.1
Unidentified fishes	1	<0.1
Total	2,808	
Minimum number of species	18	
Total rockfish YOY	1,989	
Total rockfishes	2,539	

Rockfish YOY comprised 70.8% of all fishes surveyed
All rockfishes comprised 90.4% of all fishes surveyed

PLATFORM GAIL (Surveyed 2004–2009)

Species	Number	Density
Squarespot rockfish	911	7.9
Unidentified rockfish YOY	805	5.8
Bocaccio YOY	624	4.8
Squarespot rockfish YOY	533	3.7
Bocaccio	525	3.7
Blacksmith	276	2.6
Widow rockfish YOY	275	3.0
Blacksmith YOY	99	0.9
Halfmoon	90	0.8
Unidentified rockfish	84	0.5
Painted greenling	76	0.6
Flag rockfish	58	0.4
Painted greenling YOY	50	0.3
Pinkrose rockfish	33	0.2
Sebastomus sp.	29	0.2
Unidentified fishes	26	0.2
Sebastomus YOY	18	0.1
Flag rockfish YOY	17	0.1
Widow rockfish	15	0.2
Cabezon	11	<0.1
Darkblotched rockfish	7	<0.1
Kelp greenling	3	<0.1
Pacific hake	3	<0.1
Bank rockfish	2	<0.1
Copper rockfish	2	<0.1
Greenblotched rockfish	2	<0.1
Greenspotted rockfish	2	<0.1
Sharpchin rockfish	2	<0.1
Unidentified sculpin	2	<0.1
Blue rockfish YOY	1	<0.1
Gopher rockfish	1	<0.1
Greenblotched rockfish YOY	1	<0.1
Kelp bass	1	<0.1
Northern anchovy	1	<0.1
Olive rockfish	1	<0.1
Shortbelly rockfish	1	<0.1
Speckled rockfish YOY	1	<0.1
Swordspine rockfish	1	<0.1
Treefish YOY	1	<0.1
Total	4,590	
Minimum number of species	27	
Total rockfish YOY	2,276	
Total rockfishes	3,952	

Rockfish YOY comprised 49.6% of all fishes surveyed
All rockfishes comprised 86.1% of all fishes surveyed

Table 5 (continued)

PLATFORM EDITH (Surveyed 2005–2009)

Species	Number	Density
Blacksmith YOY	10,982	548.0
Jack mackerel	722	32.2
Blacksmith	368	18.3
Squarespot rockfish YOY	357	11.2
Unidentified fishes	223	6.7
Unidentified rockfish YOY	212	6.1
Halfbanded rockfish	161	7.7
California sheephead	69	3.0
Garibaldi	54	2.5
Unidentified rockfish	43	1.2
Kelp rockfish YOY	35	1.0
Sebastomus YOY	27	0.9
Sharpnose seaperch	21	0.6
Painted greenling	20	0.8
Squarespot rockfish	19	0.6
Kelp rockfish	17	0.6
Cabezon	16	0.5
White seaperch	15	0.5
Painted greenling YOY	14	0.5
Senorita	13	0.6
Honeycomb rockfish YOY	4	0.1
Sharpchin rockfish	4	0.2
Pile perch	3	0.1
Unidentified *Sebastomus*	2	<0.1
Treefish YOY	2	<0.1
Flag rockfish YOY	1	<0.1
Honeycomb rockfish	1	<0.1
Kelp bass	1	<0.1
Widow rockfish YOY	1	<0.1
Wolf-eel	1	<0.1
Total	13,408	
Minimum number of species	21	
Total rockfish YOY	639	
Total rockfishes	886	

Rockfish YOY comprised 4.8% of all fishes surveyed
All rockfishes comprised 6.6% of all fishes surveyed

PLATFORM ELLY (Surveyed 2005–2009)

Species	Number	Density
Squarespot rockfish	7,920	243.5
Blacksmith YOY	2,584	136.3
Squarespot rockfish YOY	2,372	76.1
Unidentified rockfish YOY	1,970	62.7
Widow rockfish	151	4.5
Halfmoon	65	3.5
Blacksmith	55	1.9
Halfbanded rockfish	48	1.8
Sebastomus YOY	36	1.5
Bluebanded ronquil	35	1.0
Cabezon	33	1.3
Painted greenling	27	1.0
Widow rockfish YOY	21	0.7
California sheephead	20	1.0
Sharpnose seaperch	11	0.4
Kelp rockfish	10	0.4
Garibaldi	7	0.4
Unidentified fishes	6	0.2
Blue rockfish YOY	5	0.2
Shortbelly rockfish YOY	5	0.2
Gopher rockfish	4	0.1
Unidentified rockfish	4	0.1
Blue rockfish	3	<0.1
Painted greenling YOY	3	<0.1
Starry rockfish YOY	3	<0.1
Copper rockfish	2	<0.1
Lingcod	2	<0.1
Opaleye	2	<0.1
Sebastomus sp.	2	<0.1
Bocaccio	1	<0.1
Bocaccio YOY	1	<0.1
Grass rockfish	1	<0.1
Halfbanded rockfish YOY	1	<0.1
Olive rockfish	1	<0.1
Pile perch	1	<0.1
Rosy rockfish YOY	1	<0.1
Starry rockfish	1	<0.1
Yelloweye rockfish YOY	1	<0.1
Total	15,415	
Minimum number of species	27	
Total rockfish YOY	4,416	
Total rockfishes	12,564	

Rockfish YOY comprised 28.6% of all fishes surveyed
All rockfishes comprised 81.5% of all fishes surveyed

Table 5 (continued)

PLATFORM ELLEN (Surveyed 2005–2009)

Species	Number	Density
Squarespot rockfish YOY	9,140	206.5
Squarespot rockfish	4,440	102.0
Blacksmith YOY	2,505	192.4
Unidentified rockfish YOY	2,184	56.5
Widow rockfish	2,102	55.4
Widow rockfish YOY	502	13.2
Unidentified fishes	452	10.5
Blacksmith	288	9.2
Kelp rockfish	70	1.7
Sebastomus YOY	65	1.5
Bocaccio	62	1.6
Jack mackerel	55	1.3
Unidentified rockfish	52	1.3
Cabezon	40	1.0
California sheephead	38	1.0
Painted greenling	17	0.4
Sharpnose seaperch	14	0.4
Painted greenling YOY	10	0.2
Bocaccio YOY	7	0.2
Blue rockfish	6	0.2
Garibaldi	6	0.2
Copper rockfish	5	0.1
Halfmoon	5	0.3
Gopher rockfish	3	<0.1
Starry rockfish YOY	3	<0.1
Halfbanded rockfish	2	<0.1
Pile perch	2	<0.1
Lingcod	1	<0.1
Northern anchovy	1	<0.1
Rock wrasse	1	<0.1
Unidentified surfperch	1	<0.1
Treefish YOY	1	<0.1
Unidentified sculpin	1	<0.1
Total	22,081	
Minimum number of species	22	
Total rockfish YOY	11,902	
Total rockfishes	18,592	

Rockfish YOY comprised 53.9% of all fishes surveyed
All rockfishes comprised 84.2% of all fishes surveyed

PLATFORM EUREKA (Surveyed 2005–2009)

Species	Number	Density
Squarespot rockfish	12,128	92.0
Squarespot rockfish YOY	5,875	47.4
Unidentified rockfish YOY	4,585	32.8
Blacksmith YOY	838	9.6
Widow rockfish	762	4.7
Blacksmith	604	7.0
Unidentified rockfish	566	4.0
Jack mackerel	530	6.4
Speckled rockfish	392	2.5
Speckled rockfish YOY	252	1.8
Sebastomus sp.	179	1.2
Blue rockfish	167	1.4
Widow rockfish YOY	157	1.1
Bocaccio YOY	100	0.7
Bank rockfish	91	0.6
Copper rockfish	82	0.7
Kelp rockfish	75	0.7
Rosy rockfish	68	0.5
Dwarf-red rockfish YOY	62	0.4
Pinkrose rockfish	61	0.4
Greenblotched rockfish	58	0.4
Flag rockfish	55	0.4
Dwarf-red rockfish	54	0.4
Pygmy rockfish	42	0.3
Unidentified fishes	30	0.3
Bocaccio	29	0.2
Cabezon	25	0.2
Greenspotted rockfish	24	0.1
Starry rockfish	24	0.2
Garibaldi	23	0.2
California sheephead	22	0.2
Painted greenling	21	0.2
Honeycomb rockfish	19	0.1
Starry rockfish YOY	17	0.1
Bank rockfish YOY	15	<0.1
Darkblotched rockfish	15	<0.1
Sebastomus YOY	15	<0.1
Gopher rockfish	13	<0.1
Shortbelly rockfish YOY	13	<0.1
Freckled rockfish	10	<0.1
Painted greenling YOY	7	<0.1
Swordspine rockfish	7	<0.1
Flag rockfish YOY	6	<0.1
Blue rockfish YOY	4	<0.1
Blackeye goby	3	<0.1
Grass rockfish	3	<0.1
Rosethorn rockfish	3	<0.1
Sharpchin rockfish	2	<0.1
Vermilion rockfish	2	<0.1
Blackgill rockfish	1	<0.1
Halfbanded rockfish YOY	1	<0.1
Kelp rockfish YOY	1	<0.1
Popeye Catalufa	1	<0.1
Treefish	1	<0.1
Yelloweye rockfish	1	<0.1
Total	28,141	
Minimum number of species	40	
Total rockfish YOY	11,103	
Total rockfishes	26,037	

Rockfish YOY comprised 39.5% of all fishes surveyed
All rockfishes comprised 92.5% of all fishes surveyed

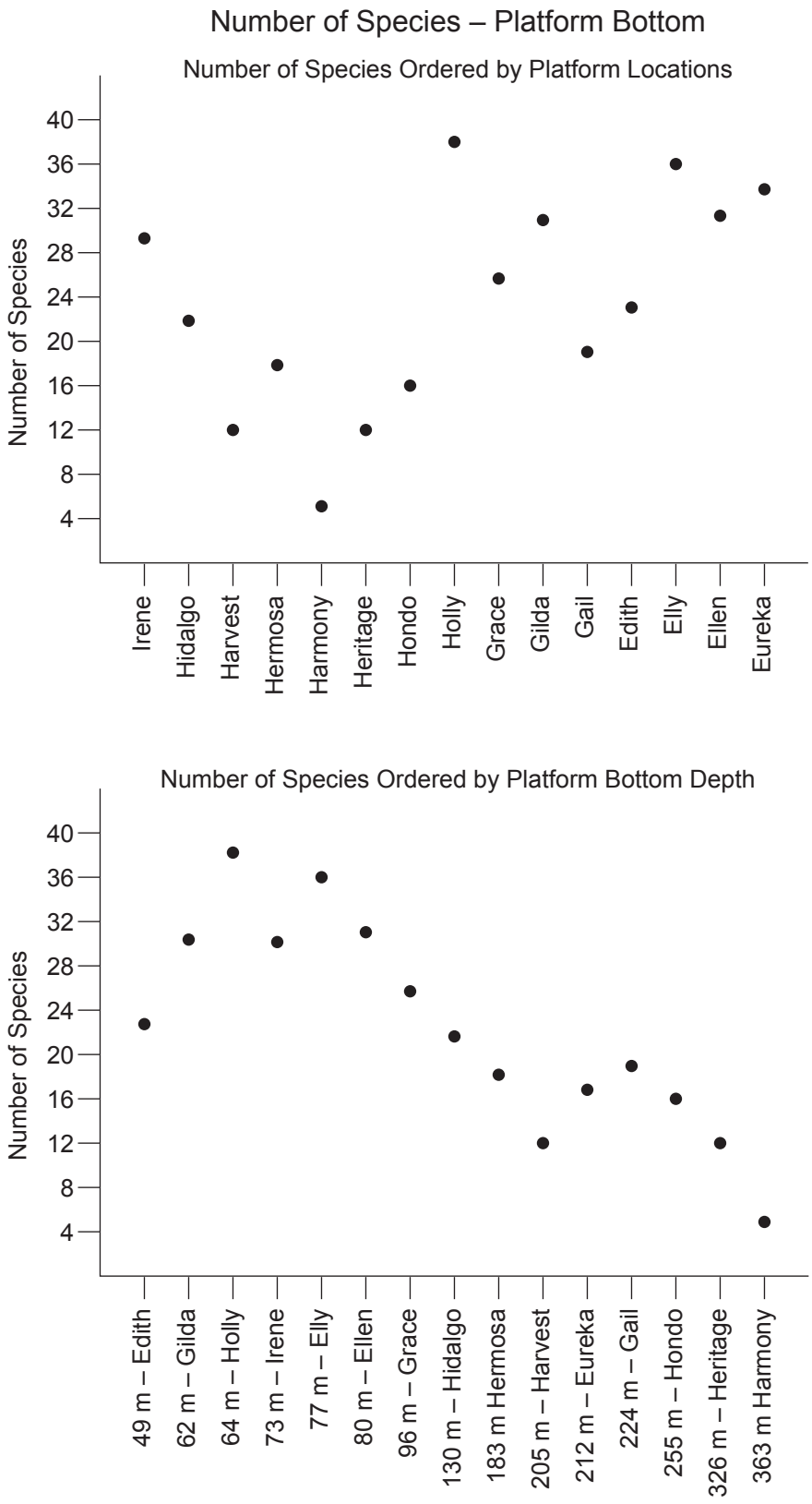

Figure 8. Number of species observed at bottoms of platforms, 2004–2009. Platforms are listed first from northernmost to southernmost and then from shallowest to deepes

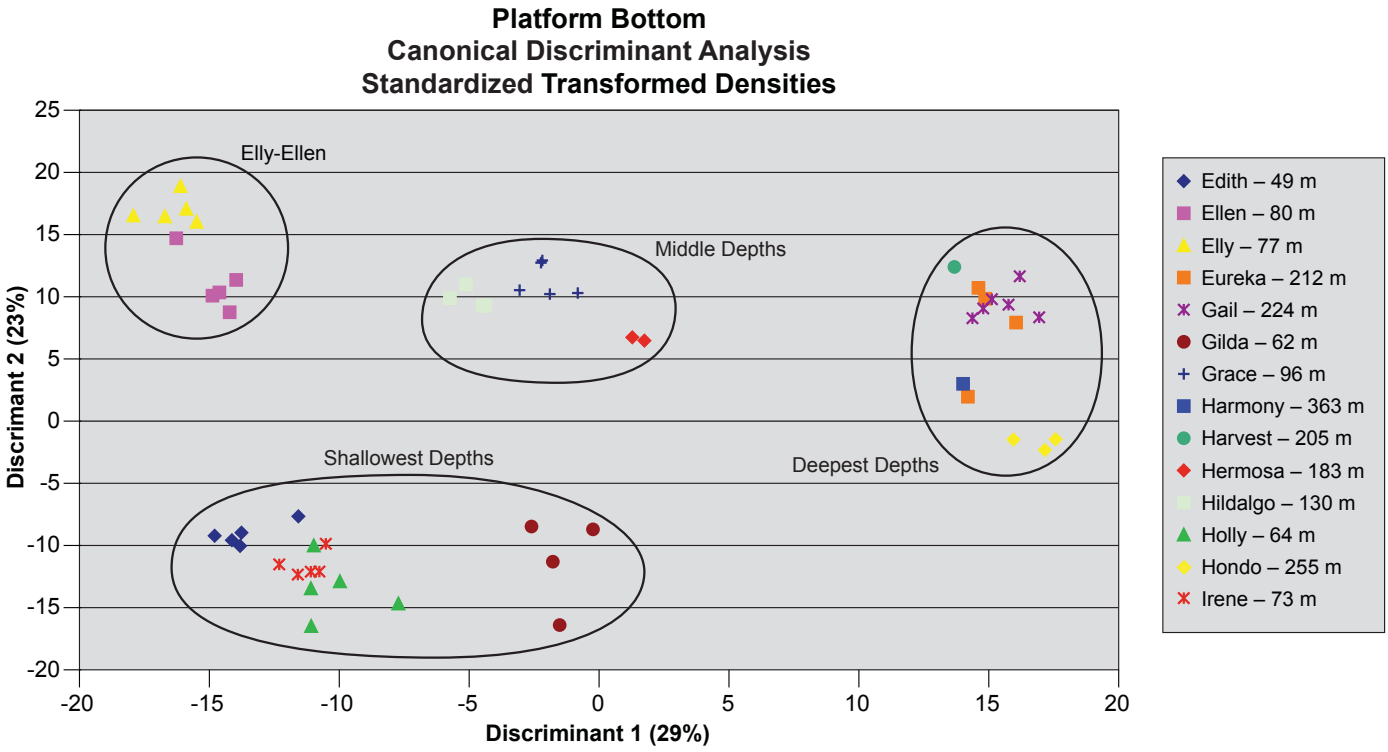

Figure 9. A canonical discriminant analysis of platform bottom fish assemblages, by year, 2004–2009.

At each platform, the bottom fish assemblage was similar over the survey period (Figure 9). Bottom depth was a major factor in structuring bottom fish assemblages; the platforms formed three or perhaps four groups (Figure 9). Of particular note was the close similarity in the species assemblages of Elly and Ellen, platforms that lie within a few hundred meters of each other. We observed three recurrent groups of fishes that tended to be found together; these were 1) shallow- and 2) deep-bottom assemblages, and 3) one that was composed of both shallow and mid-depth taxa (Figures 10–11). In both numbers and densities, rockfishes comprised the vast majority of species (Figure 11, Table 6), although sea perches, blackeye goby, cabezon, and several hexagrammids (e.g., lingcod and painted greenling) were also characteristic of some platforms.

Platform Shell Mounds

We observed between 9 (Hermosa, Harvest, and Harmony) and 30 (Holly) fish species around platform shell mounds (Figure 12, Table 7). As with the platform bottom assemblages, two peaks in taxa number were observed, one in moderate depths and another in deeper waters.

We observed little change in species assemblages at any platform over the survey period (Figure 13). Similar to that living in the platform bottom habitat, the shell mound species composition were driven by bottom depth (Figures 13–15). Also similar to the platform bottom assemblages, there were three recurrent groups of species, a shallow and a deep one, and one shared by shallow and middle-depth bottom species. Rockfishes were again the dominant taxonomic group, although other bottom dwellers, including poachers, various flatfishes, and combfishes were also typical. There was considerable overlap of characteristic species with the bottom habitats; these included the YOY of several rockfish species, adults of a number of rockfishes, spotted scorpionfish, and lingcod. However, also typical of shell mounds (and less abundant at platform bottoms) were species characteristic of lower relief. These included bluebarred ronquil, cowcod YOY, longspine and shortspine combfishes, poachers, and Dover sole.

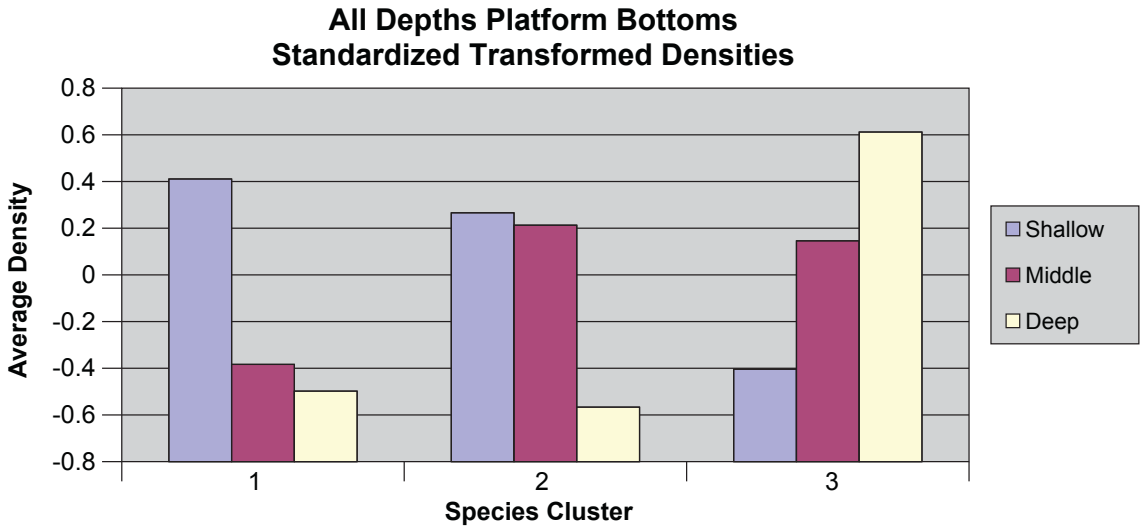

Figure 10. A comparison of densities of the three bottom species clusters shown in Figure 11.

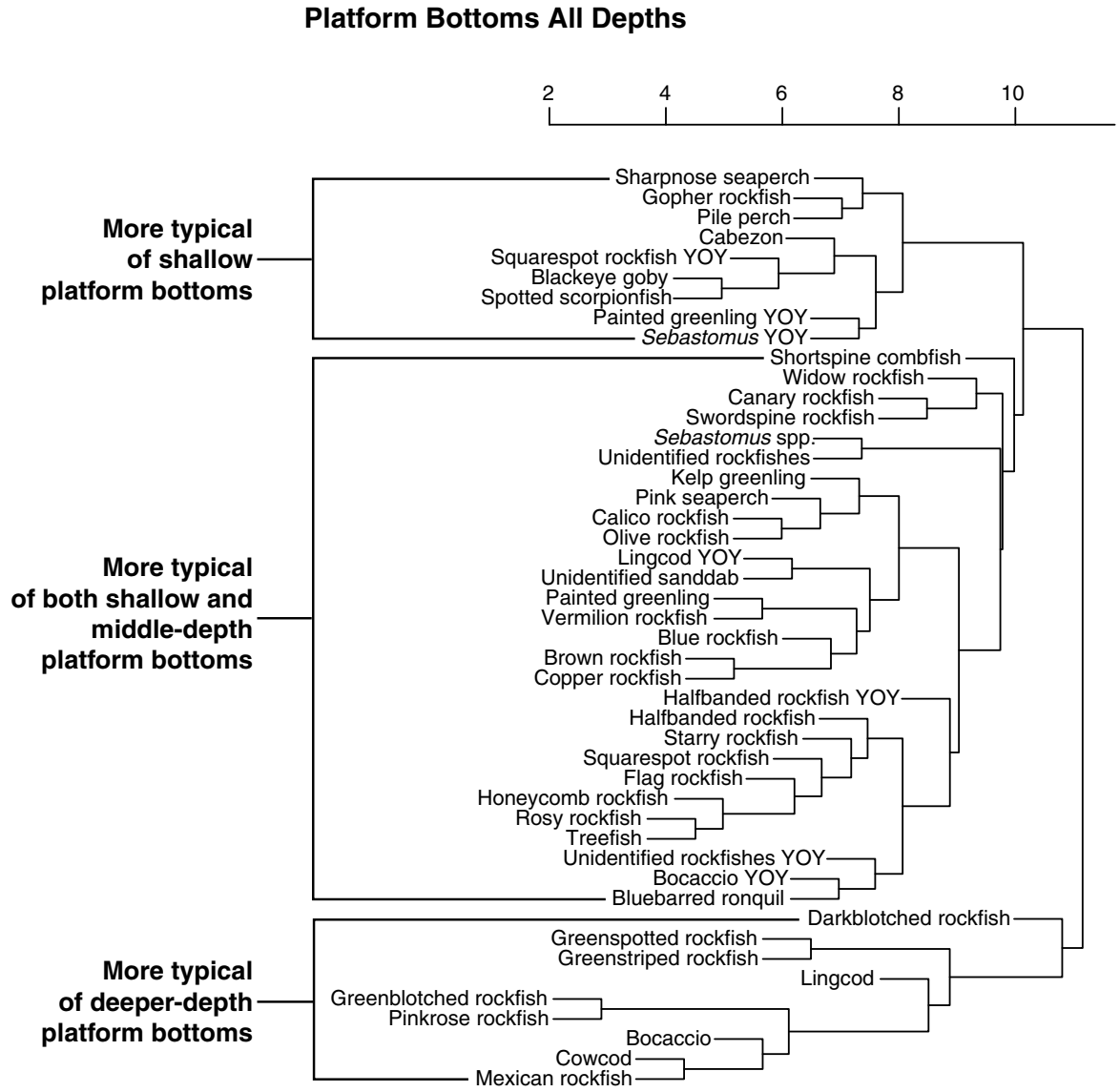

Figure 11. A cluster analysis of the characteristic species of platform bottoms, 2004–2009.

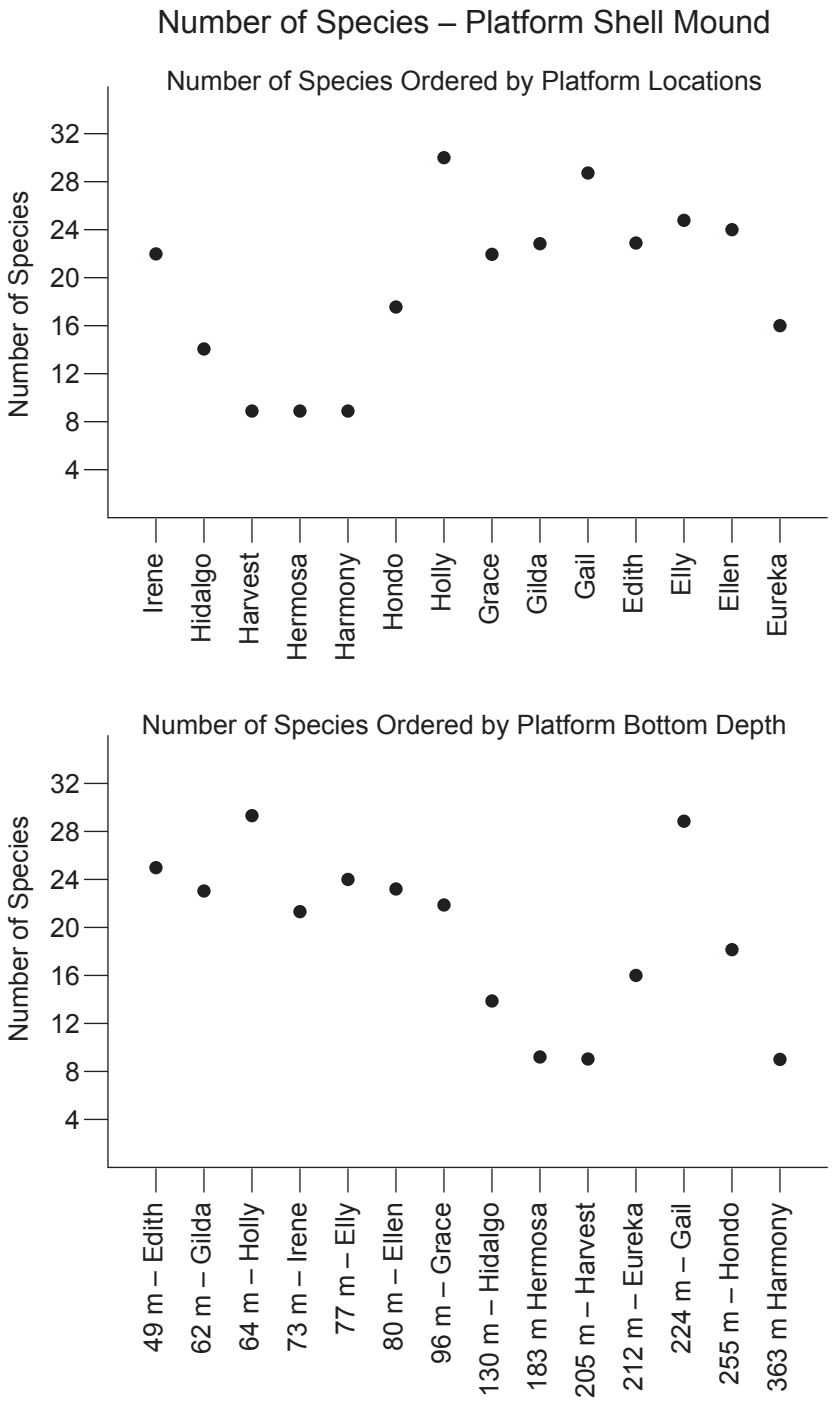

Figure 12. Number of species observed on shell mounds of platforms, 2004–2009. Platforms are listed first from northern most to southernmost and then from shallowest to deepest.

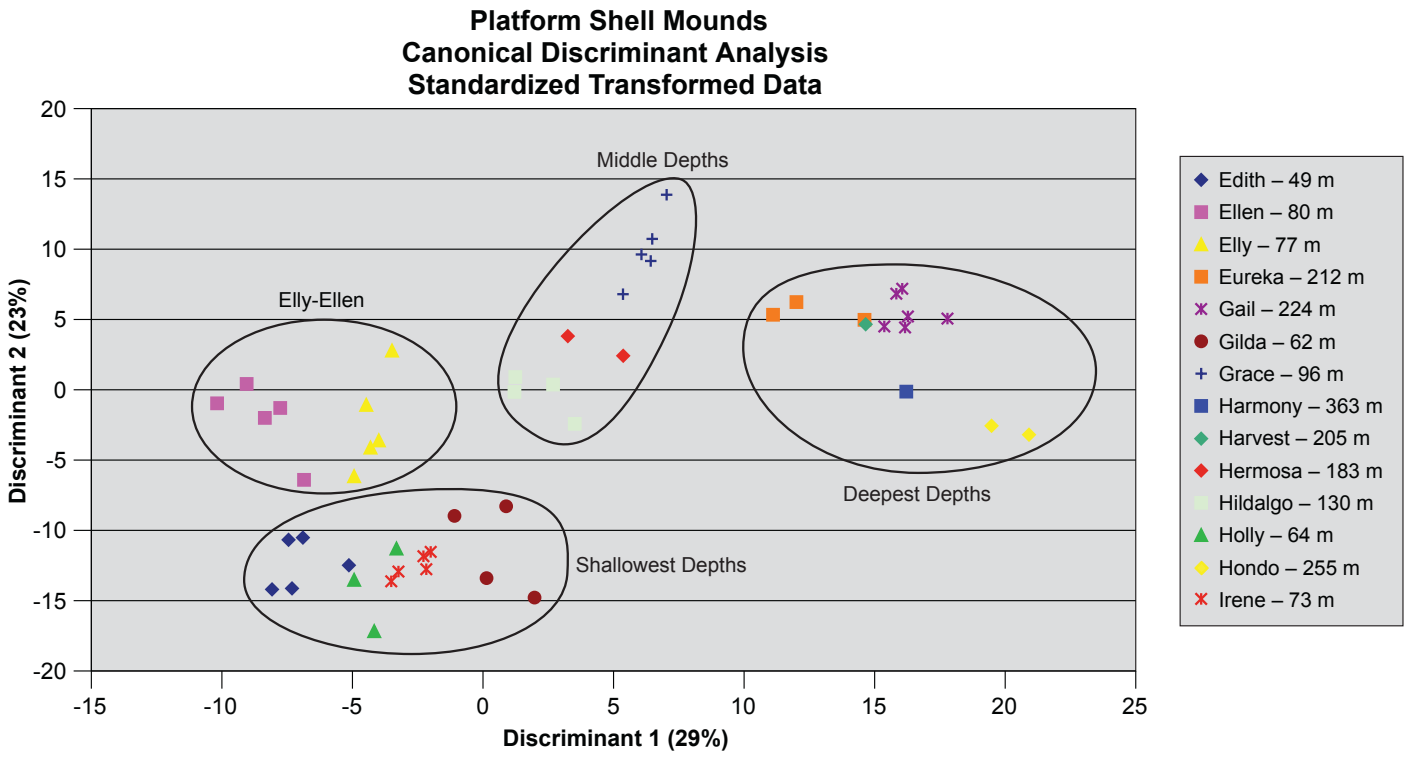

Figure 13. A canonical discriminant analysis of platform midwater fish assemblages, by year, 2004–2009.

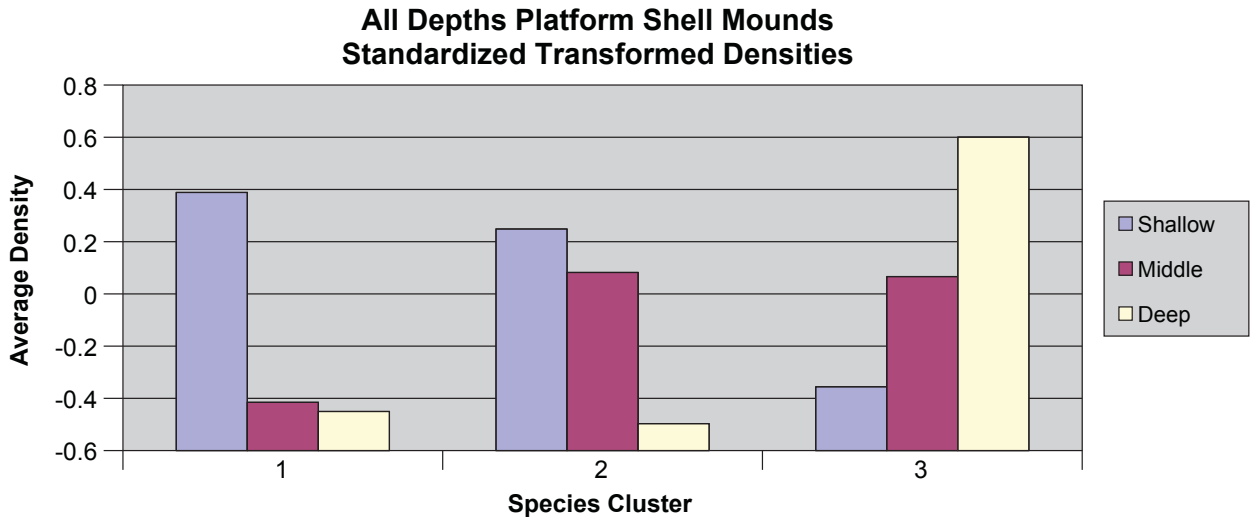

Figure 14. A comparison of densities of the three shell mound species clusters shown in Figure 15.

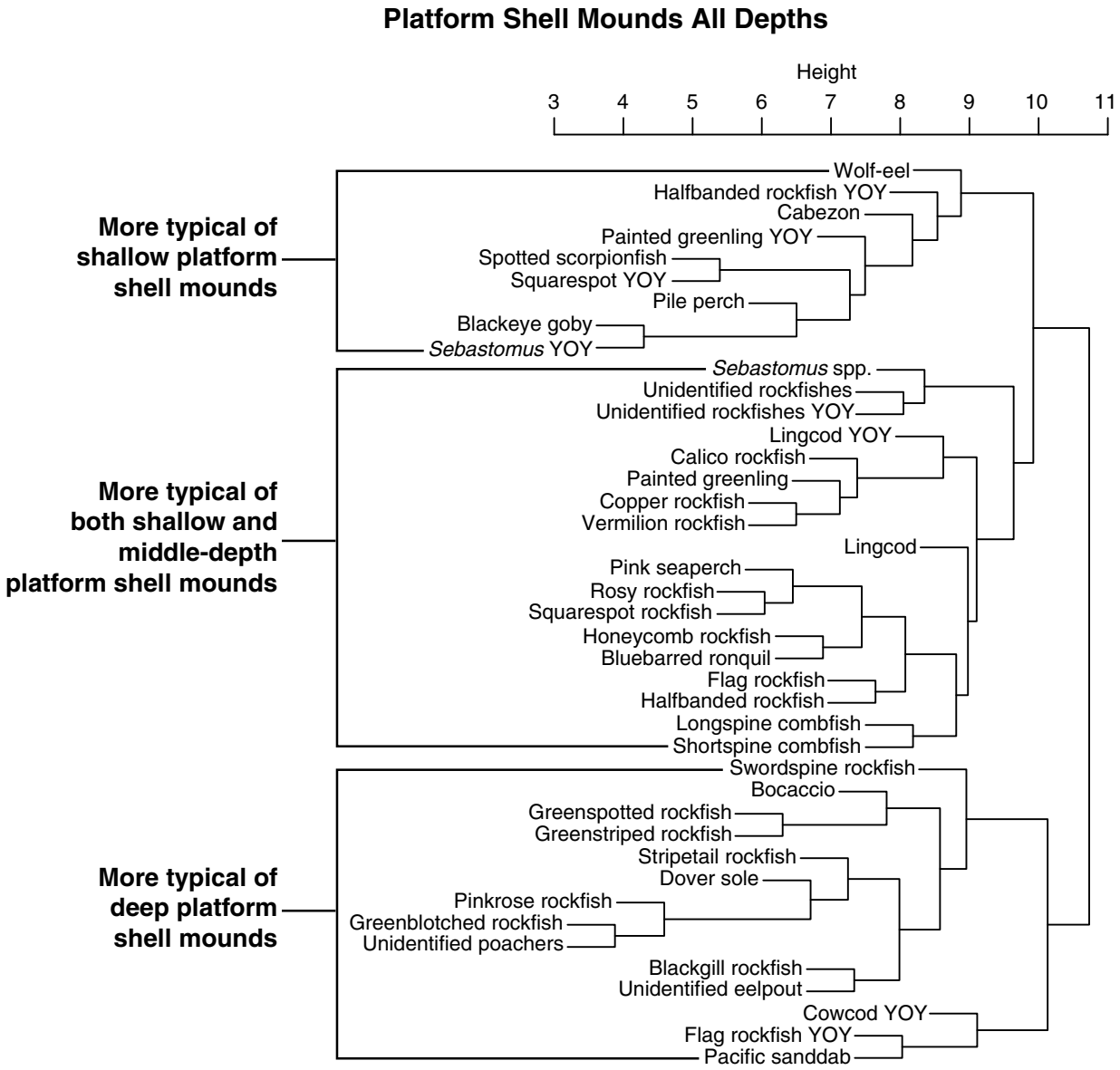

Figure 15. A cluster analysis of the characteristic species of platform shell mounds, 2004–2009.

Table 6. Numbers and densities (average number per 100 m2) of fish species observed at the bottoms of platforms, 2004–2009. 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 IRENE (Surveyed 2004–2006, 2008, 2009)

Species	Number	Density
Halfbanded rockfish YOY	2,031	98.0
Copper rockfish	605	29.2
Shortbelly rockfish	600	28.9
Halfbanded rockfish	588	28.4
Unidentified rockfish YOY	523	25.2
Squarespot rockfish YOY	504	24.3
Vermilion rockfish	368	17.8
Painted greenling	244	11.8
Squarespot rockfish	136	6.6
Lingcod YOY	117	5.6
Calico rockfish	116	5.6
Sebastomus sp.	115	5.6
Brown rockfish	97	4.7.8
Unidentified rockfish	38	1.8
Sebastomus YOY	34	1.6
Pile perch	26	1.3
Unidentified ronquil	21	1.0
Blue rockfish	19	0.9
Canary rockfish	17	0.8
Lingcod	11	0.5
Unidentified sanddab	11	0.5
Copper rockfish YOY	10	0.5
Widow rockfish YOY	10	0.5
Flag rockfish	8	0.4
Starry rockfish YOY	8	0.4
Olive rockfish	4	0.2
Rubberlip seaperch	4	0.2
Unidentified fishes	4	0.2
Vermilion rockfish YOY	4	0.2
Blackeye goby	3	0.1
Yelloweye rockfish YOY	3	0.1
Yellowtail rockfish	3	0.1
Kelp greenling	2	0.1
Painted greenling YOY	2	0.1
Bocaccio YOY	1	<0.1
Flag rockfish YOY	1	<0.1
Greenspotted rockfish	1	<0.1
Rosy rockfish	1	<0.1
Shortbelly rockfish YOY	1	<0.1
Starry rockfish	1	<0.1
Unidentified surfperch	1	<0.1
Swordspine rockfish	1	<0.1
Treefish	1	<0.1
Widow rockfish	1	<0.1
Wolf-eel	1	<0.1
Yelloweye rockfish	1	<0.1
Yellowtail rockfish YOY	1	<0.1
Total	6,299	
Minimum number of species	30	
Total rockfish YOY	3,131	
Total rockfishes	5,852	

Rockfish YOY comprised 49.7% of all fishes surveyed
All rockfishes comprised 92.9% of all fishes surveyed

Platform HIDALGO (Surveyed 2004–2006, 2009)

Species	Number	Density
Halfbanded rockfish	3,278	155.2
Greenspotted rockfish	340	16.1
Vermilion rockfish	239	11.3
Sebastomus sp.	154	7.3
Flag rockfish	95	4.5
Canary rockfish	94	4.5
Painted greenling	81	3.8
Pygmy rockfish	79	3.7
Squarespot rockfish	53	2.5
Unidentified rockfish	52	2.5
Greenstriped rockfish	45	2.1
Unidentified rockfish YOY	37	1.8
Widow rockfish YOY	28	1.3
Lingcod	26	1.2
Lingcod YOY	25	1.2
Swordspine rockfish	13	0.6
Widow rockfish	12	0.6
Cowcod	10	0.5
Rosy rockfish	10	0.5
Greenblotched rockfish	9	0.4
Cowcod YOY	7	0.3
Painted greenling YOY	7	0.3
Bocaccio	4	0.2
Greenspotted rockfish YOY	3	0.1
Sebastomus YOY	3	0.1
Starry rockfish	3	0.1
Flag rockfish YOY	2	<0.1
Greenstriped rockfish YOY	2	<0.1
Shortspine combfish	2	<0.1
Unidentified fishes	2	<0.1
Kelp greenling	1	<0.1
Shortbelly rockfish YOY	1	<0.1
Swordspine rockfish YOY	1	<0.1
Wolf-eel	1	<0.1
Yelloweye rockfish	1	<0.1
Yelloweye rockfish YOY	1	<0.1
Total	4,721	
Minimum number of species	22	
Total rockfish YOY	92	
Total rockfishes	4,576	

Rockfish YOY comprised 1.9% of all fishes surveyed
All rockfishes comprised 96.9% of all fishes surveyed

Table 6 (continued)

Platform HARVEST (Surveyed 2004)

Species	Number	Density
Halfbanded rockfish	216	34.1
Stripetail rockfish	96	15.2
Greenstriped rockfish	41	6.5
Sebastomus sp.	19	3.0
Greenspotted rockfish	8	1.3
Pinkrose rockfish	8	1.3
Flag rockfish	7	1.1
Sharpchin rockfish	6	1.0
Lingcod	4	0.6
Greenblotched rockfish	3	0.5
Unidentified rockfish	3	0.5
Starry rockfish	2	0.3
Shortspine combfish	1	0.2
Yelloweye rockfish	1	0.2
Total	415	
Minimum number of species	12	
Total rockfish YOY	0	
Total rockfishes	410	

Rockfish YOY comprised 0% of all fishes surveyed
All rockfishes comprised 98.8% of all fishes surveyed

Platform HERMOSA (Surveyed 2004, 2006)

Species	Number	Density
Halfbanded rockfish	12,123	1,035.5
Sebastomus sp.	17	1.5
Greenspotted rockfish	10	0.9
Flag rockfish	7	0.6
Stripetail rockfish	5	0.4
Unidentified rockfish	5	0.4
Sebastomus YOY	3	0.3
Rosy rockfish	2	0.2
Squarespot rockfish	2	0.2
Vermilion rockfish	2	0.2
California smoothtongue	1	<0.1
Cowcod YOY	1	<0.1
Darkblotched rockfish	1	<0.1
Greenstriped rockfish	1	<0.1
Lingcod	1	<0.1
Longspine combfish	1	<0.1
Painted greenling	1	<0.1
Sharpchin rockfish	1	<0.1
Shortbelly rockfish	1	<0.1
Starry rockfish	1	<0.1
Unidentified fishes	1	<0.1
Widow rockfish YOY	1	<0.1
Total	12,188	
Minimum number of species	18	
Total rockfish YOY	5	
Total rockfishes	12,183	

Rockfish YOY comprised <0.1% of all fishes surveyed
All rockfishes comprised >99.9% of all fishes surveyed

Platform HARMONY (Surveyed 2004)

Species	Number	Density
Unidentified thornyheads	48	5.5
Blackgill rockfish	24	2.9
Darkblotched rockfish	20	2.4
Splitnose rockfish	15	1.8
Unidentified rockfish	9	1.1
Aurora rockfish	4	0.5
Total	118	
Minimum number of species	5	
Total rockfish YOY	0	
Total rockfishes	72	

Rockfish YOY comprised 0% of all fishes surveyed
All rockfishes comprised 61.0% of all fishes surveyed

Platform HERITAGE (Surveyed 2008)

Species	Number	Density
Splitnose rockfish	18	2.2
Pinkrose rockfish	4	0.5
Bank rockfish	3	0.4
Blackgill rockfish	3	0.4
Unidentified rockfish	3	0.4
Blacktail snailfish	2	0.3
Unidentified fishes	2	0.3
Unidentified witch-eel	2	0.3
Bank rockfish YOY	1	0.1
Bearded eelpout	1	0.1
Unidentified cusk-eel	1	0.1
Flag rockfish	1	0.1
Greenblotched rockfish	1	0.1
Sebastomus sp.	1	0.1
Spotted cusk-eel	1	0.1
Unidentified sculpin	1	0.1
Total	45	
Minimum number of species	12	
Total rockfish YOY	1	
Total rockfishes	35	

Rockfish YOY comprised 2.2% of all fishes surveyed
All rockfishes comprised 77.8% of all fishes surveyed

Table 6 (continued)

Platform HONDO (Surveyed 2004, 2006, 2008)

Species	Number	Density
Northern anchovy	1,572	236.5
Stripetail rockfish	230	14.0
Bank rockfish	72	4.4
Pinkrose rockfish	52	3.5
Greenblotched rockfish	34	2.2
Darkblotched rockfish	28	2.1
Sebastomus sp.	25	1.7
Shortbelly rockfish	19	2.6
Splitnose rockfish	10	1.2
Unidentified rockfish	7	0.4
Sharpchin rockfish	4	0.3
Flag rockfish	3	0.2
Unidentified poachers	3	0.5
Blackgill rockfish	2	0.1
Unidentified fishes	2	0.1
Bank rockfish YOY	1	<0.1
Cowcod	1	<0.1
Dover sole	1	<0.1
Unidentified flatfish	1	<0.1
Painted greenling	1	<0.1
Unidentified eelpout	1	<0.1
Total	2,069	
Minimum number of species	16	
Total rockfish YOY	1	
Total rockfish	488	

Rockfish YOY comprised <0.01% of all fishes surveyed
All rockfishes comprised 23.6% of all fishes surveyed

Platform (Surveyed 2004–2008)

Species	Number	Density
Calico rockfish	1,570	94.2
Halfbanded rockfish	257	15.7
Unidentified rockfish YOY	239	14.1
Rosy rockfish	137	8.4
Vermilion rockfish	108	6.4
Copper rockfish	84	5.0
Squarespot rockfish	84	5.1
Blackeye goby	72	4.4
Painted greenling	59	3.6
Brown rockfish	42	2.5
Canary rockfish	34	2.0
Unidentified ronquil	29	1.7
Olive rockfish	22	1.3
Pink seaperch	21	1.2
Halfbanded rockfish YOY	20	1.2
Unidentified sanddabs	20	1.2
Squarespot rockfish YOY	18	1.1
Widow rockfish YOY	18	1.1
Pile perch	17	1.1
Flag rockfish	16	0.9
Honeycomb rockfish	16	0.9
Kelp greenling	13	0.8
Bluebanded ronquil	13	0.8
Bocaccio YOY	11	0.7
Sebastomus sp.	11	1.9
Unidentified rockfish	11	0.8
Vermilion rockfish YOY	10	0.6
Pacific sanddab	9	1.7
Treefish	9	0.5
Sebastomus YOY	8	0.5
Gopher rockfish	7	0.4
Lingcod	5	0.3
Sharpnose seaperch	5	0.3
Shortspine combfish	5	0.6
Starry rockfish	5	0.3
Blue rockfish	4	0.2
Kelp rockfish	4	0.2
Rubberlip seaperch	4	0.2
Starry rockfish YOY	4	0.2
Widow rockfish	4	0.2
Bull sculpin	3	0.2
Unidentified flatfish	3	0.2
Lingcod YOY	3	0.4
Painted greenling YOY	3	0.2
Yellowtail rockfish	3	0.2
Calico rockfish YOY	2	0.1
Copper rockfish YOY	2	0.1
Spotted scorpionfish	2	0.1
Yelloweye rockfish YOY	2	0.1
Brown rockfish YOY	1	0.2
California lizardfish	1	0.2
Chilipepper	1	<0.1
Honeycomb rockfish YOY	1	<0.1
Longspine combfish	1	<0.1
Rosy rockfish YOY	1	<0.1
Unidentified fish	1	<0.1
Yelloweye rockfish	1	<0.1
Total	3,056	
Minimum number of species	38	
Total rockfish YOY	337	
Total rockfishes	2,767	

Rockfish YOY comprised 11.0% of all fishes surveyed
All rockfishes comprised 90.5% of all fishes surveyed

Table 6 (continued)

Platform GRACE (Surveyed 2004–2005, 2007–2009)

Species	Number	Density
Halfbanded rockfish	13,100	579.1
Squarespot rockfish	535	23.7
Vermilion rockfish	443	19.6
Widow rockfish	433	19.1
Widow rockfish YOY	381	16.8
Unidentified rockfish YOY	168	7.4
Flag rockfish	90	4.0
Lingcod	40	1.8
Bocaccio	39	1.7
Painted greenling	28	1.2
Rosy rockfish	25	1.1
Blue rockfish	22	1.0
Calico rockfish	17	0.8
Unidentified sanddab	17	0.8
Pink seaperch	16	0.7
Sebastomus sp.	15	0.7
Greenspotted rockfish	14	0.6
Copper rockfish	13	0.6
Lingcod YOY	12	0.5
Unidentified rockfish	10	0.4
Shortspine combfish	9	0.4
Treefish	4	0.2
Bocaccio YOY	3	0.1
Canary rockfish	3	0.1
Greenstriped rockfish	3	0.1
Olive rockfish	3	0.1
Squarespot rockfish YOY	3	0.1
Unidentified fishes	3	0.1
Yellowtail rockfish	3	0.1
Kelp greenling	2	<0.1
Sebastomus sp. YOY	2	<0.1
Starry rockfish	2	<0.1
Unidentified combfish	1	<0.1
Shortbelly rockfish	1	<0.1
Swordspine rockfish	1	<0.1
Treefish YOY	1	<0.1
Total	15,462	
Minimum number of species	25	
Total rockfish YOY	558	
Total rockfishes	15,334	

Rockfish YOY comprised 3.6% of all fishes surveyed
All rockfishes comprised 99.2% of all fishes surveyed

Platform GILDA (Surveyed 2004, 2007–2009)

Species	Number	Density
Halfbanded rockfish	6,231	399.2
Vermilion rockfish	735	47.1
Calico rockfish	383	24.5
Painted rockfish	132	8.5
Lingcod YOY	48	3.1
Vermilion rockfish YOY	45	2.9
Copper rockfish	36	2.3
Brown rockfish	34	2.2
Unidentified flatfish	17	1.1
Pink seaperch	16	1.0
Rosy rockfish	16	1.0
Pile perch	15	<0.1
Flag rockfish	12	<0.1
Unidentified rockfish	10	<0.1
Lingcod	9	<0.1
Olive rockfish	8	<0.1
Bocaccio	7	<0.1
Canary rockfish	6	<0.1
Unidentified ronquil	6	<0.1
Cabezon	5	<0.1
Kelp rockfish	5	<0.1
Unidentified sanddab	5	<0.1
Shortspine combfish	4	<0.1
Unidentified fishes	4	<0.1
Kelp greenling	3	<0.1
Squarespot rockfish	3	<0.1
Starry rockfish	3	<0.1
Copper rockfish YOY	2	<0.1
Sebastomus sp.	2	<0.1
Treefish	2	<0.1
Blacksmith	1	<0.1
Bocaccio YOY	1	<0.1
Brown rockfish YOY	1	<0.1
California halibut	1	<0.1
Chilipepper YOY	1	<0.1
Gopher rockfish	1	<0.1
Greenspotted rockfish	1	<0.1
Spotted scorpionfish	1	<0.1
Bluebanded ronquil	1	<0.1
Unidentified surfperch	1	<0.1
Treefish YOY	1	<0.1
Unidentified sculpin	1	<0.1
Widow rockfish	1	<0.1
Yelloweye rockfish	1	<0.1
Total	7,818	
Minimum number of species	31	
Total rockfish YOY	51	
Total rockfishes	7,596	

Rockfish YOY comprised 0.4% of all fishes surveyed
All rockfishes comprised 97.2% of all fishes surveyed

Table 6 (continued)

Platform GAIL (Surveyed 2004–2009)

Species	Number	Density
Bocaccio	899	25.0
Pinkrose rockfish	402	11.2
Greenblotched rockfish	241	6.7
Lingcod	138	3.8
Cowcod	104	2.9
Sebastomus sp.	102	2.8
Mexican rockfish	93	2.6
Greenspotted rockfish	60	1.7
Greenstriped rockfish	30	0.8
Flag rockfish	12	0.3
Unidentified rockfish	7	0.2
Unidentified fishes	4	0.1
Spotted ratfish	3	<0.1
Widow rockfish	3	<0.1
Pink rockfish	2	<0.1
Unidentified ronquil	2	<0.1
Bocaccio YOY	1	<0.1
Chilipepper	1	<0.1
Unidentified flatfish	1	<0.1
Lingcod YOY	1	<0.1
Painted greenling	1	<0.1
Redbanded rockfish	1	<0.1
Rosethorn rockfish	1	<0.1
Vermilion rockfish	1	<0.1
Total	2,110	
Minimum number of species	18	
Total rockfish YOY	2	
Total rockfishes	1,960	

Rockfish YOY comprised 0.1% of all fishes surveyed
All rockfishes comprised 92.9% of all fishes surveyed

Platform EDITH (Surveyed 2005–2009)

Species	Number	Density
Squarespot rockfish YOY	19,448	907.4
Shortbelly rockfish YOY	8,327	384.7
Blackeye goby	854	40.5
Sebastomus YOY	567	26.5
Unidentified rockfish YOY	440	20.3
Spotted scorpionfish	320	14.9
Squarespot rockfish	206	9.5
Painted greenling	55	2.6
Pile perch	37	1.8
Cabezon	33	1.6
Sebastomus sp.	20	0.9
White seaperch	18	0.8
Lingcod	14	0.7
Painted greenling YOY	11	0.5
Rosy rockfish	11	0.5
Bocaccio YOY	5	0.2
Kelp rockfish	5	0.2
California sheephead	5	0.2
Copper rockfish	4	0.2
Sharpnose seaperch	4	0.2
Gopher rockfish	3	0.1
Honeycomb rockfish	3	0.1
Unidentified fishes	3	0.1
Brown rockfish	2	<0.1
Deepwater blenny	1	<0.1
Flag rockfish	1	<0.1
Honeycomb rockfish	1	<0.1
Rubberlip seaperch	1	<0.1
Unidentified surfperch	1	<0.1
Widow rockfish YOY	1	<0.1
Total	30,401	
Minimum number of species	23	
Total rockfish YOY	28,791	
Total rockfishes	29,044	

Rockfish YOY comprised 94.7% of all fishes surveyed
All rockfishes comprised 95.5% of all fishes surveyed

Platform ELLY (Surveyed 2005–2006, 2008–2009)

Species	Number	Density
Halfbanded rockfish	3,573	202.9
Unidentified rockfish YOY	3,128	177.6
Squarespot rockfish	2,314	131.4
Squarespot rockfish YOY	906	51.5
Shortbelly rockfish YOY	584	33.2
Rosy rockfish	533	30.3
Calico rockfish	487	27.7
Flag rockfish	327	18.6
Honeycomb rockfish	292	16.6
Sebastomus sp.	217	12.3
Vermilion rockfish	139	7.9
Painted greenling	85	4.8
Lingcod	83	4.7
Unidentified rockfish	80	4.5
Bocaccio	52	3.0
Treefish	46	2.6
Starry rockfish	16	0.9
Cabezon	9	0.5
Bocaccio YOY	8	0.5
Gopher rockfish	8	0.5
Olive rockfish	8	0.5
Bluebanded ronquil	8	0.5
Greenspotted rockfish	6	0.3
Pile perch	6	0.3
Unidentified fishes	6	0.3
Halfbanded rockfish YOY	5	0.3
Pink seaperch	5	0.3
Copper rockfish	4	0.2
Blue rockfish	3	0.2
Sharpnose seaperch	3	0.2
Yelloweye rockfish	3	0.2
Freckled rockfish	2	0.1
Greenblotched rockfish	2	0.1
Shortbelly rockfish	2	0.1
Speckled rockfish	2	0.1
Unidentified surfperch	2	0.1
Bank rockfish	1	<0.1
Cowcod YOY	1	<0.1
Flag rockfish YOY	1	<0.1
Kelp greenling	1	<0.1

Table 6 (continued)

Rosy rockfish YOY	1	<0.1
Shortspine combfish	1	<0.1
Widow rockfish	1	<0.1
Wolf-eel	1	<0.1
Yelloweye rockfish YOY	1	<0.1
Yellowtail rockfish	1	<0.1
Total	12,964	
Minimum number of species	36	
Total rockfish YOY	4,635	
Total rockfishes	12,754	

Rockfish YOY comprised 35.8% of all fishes surveyed
All rockfishes comprised 98.4% of all fishes surveyed

Platform ELLEN (Surveyed 2005–2009)

Species	Number	Density
Halfbanded rockfish	13,530	540.0
Squarespot rockfish	1,952	78.4
Halfbanded rockfish YOY	599	24.6
Unidentified rockfish YOY	548	22.5
Honeycomb rockfish	473	19.4
Shortbelly rockfish YOY	347	14.2
Squarespot rockfish YOY	268	11.0
Vermilion rockfish	201	8.1
Flag rockfish	177	7.1
Rosy rockfish	176	7.2
Calico rockfish	95	3.9
Painted greenling	91	3.7
Sebastomus sp.	85	3.4
Lingcod	44	1.8
Bocaccio	33	1.3
Starry rockfish	28	1.2
Treefish	24	1.0
Widow rockfish	23	0.9
Cabezon	14	0.6
Copper rockfish	14	0.6
Freckled rockfish	14	0.6
Bocaccio YOY	11	0.5
Bluebanded ronquil	11	0.5
Unidentified rockfish	11	0.4
Pink seaperch	10	0.4
Pile seaperch	7	0.3
Blue rockfish	5	0.2
Shortbelly rockfish	5	0.2
Spotted scorpionfish	4	0.2
Unidentified surfperch	4	0.2
Kelp rockfish	3	0.1
Starry rockfish YOY	3	0.1
Swordspine rockfish	3	0.1
Canary rockfish	2	<0.1
Olive rockfish	2	<0.1
Sharpnose seaperch	2	<0.1
Widow rockfish YOY	2	<0.1
Wolf-eel	2	<0.1
Blackeye goby	1	<0.1
Brown rockfish	1	<0.1
Unidentified combfish	1	<0.1
Flag rockfish YOY	1	<0.1
Greenblotched rockfish`	1	<0.1
Lingcod YOY	1	<0.1
Sebastomus YOY	1	<0.1
Threadfin bass	1	<0.1
Unidentified ronquil	1	<0.1
Total	18,832	
Minimum number of species	33	
Total rockfish YOY	1,780	
Total rockfishes	18,638	

Rockfish YOY comprised 9.5% of all fishes surveyed
All rockfishes completed 99.0% of all fishes surveyed

Platform EUREKA (Surveyed 2005, 2007, 2009)

Species	Number	Density
Pinkrose rockfish	214	12.7
Greenblotched rockfish	82	4.9
Sebastomus sp.	29	1.7
Vermilion rockfish	28	1.7
Bocaccio	23	1.4
Widow rockfish	15	0.9
Lingcod	10	0.6
Cowcod	8	0.5
Greenspotted rockfish	7	0.4
Flag rockfish	6	0.4
Bank rockfish	5	0.3
Unidentified rockfish	4	0.2
Speckled rockfish	2	0.1
Unidentified ronquil	2	0.1
Cabezon	1	<0.1
Dover sole	1	<0.1
Rosethorn rockfish	1	<0.1
Sebastomus YOY	1	<0.1
Squarespot rockfish	1	<0.1
Swordspine rockfish	1	<0.1
Total	441	
Minimum number of species	17	
Total rockfish YOY	1	
Total rockfishes	427	

Rockfish YOY comprised 0.2% of all fishes surveyed
All rockfishes comprised 96.8% of all fishes surveyed

Table 7. Numbers and densities (average number per 100 m2) of fish species observed on the shell mounds of platforms, 2004–2009. 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 Irene (Surveyed 2004–2006, 2008–2009)

Species	Number	Density
Halfbanded rockfish YOY	1,771	114.0
Halfbanded rockfish	510	30.4
Painted greenling	165	6.1
Lingcod YOY	151	7.3
Sebastomus sp.	70	3.0
Unidentified rockfish YOY	47	1.8
Copper rockfish	36	1.1
Shortbelly rockfish	32	2.1
Northern anchovy	30	1.3
Unidentified ronquil	30	0.8
Lingcod	28	1.0
Sebastomus YOY	28	0.9
Blackeye goby	27	1.0
Squarespot rockfish YOY	21	0.8
Calico rockfish	15	0.5
Canary rockfish	15	0.5
Vermilion rockfish	13	0.5
Unidentified sanddab	12	0.5
Copper rockfish YOY	9	0.3
Unidentified rockfish	9	0.4
Yellowtail rockfish	8	0.2
Flag rockfish	7	0.3
Painted greenling YOY	7	0.4
Pile perch	7	0.3
Squarespot rockfish	7	0.1
Unidentified fishes	7	0.3
Unidentified flatfish	4	0.2
Starry rockfish YOY	3	0.1
Pinkrose rockfish	2	<0.1
Brown rockfish	1	<0.1
Greenblotched rockfish	1	<0.1
Rosy rockfish	1	<0.1
Rubberlip seaperch	1	<0.1
Tiger rockfish	1	<0.1
Total	3,076	
Minimum number of species	24	
Total rockfish YOY	1,879	
Total rockfishes	2,607	

Rockfish YOY comprised 61.1% of all fishes surveyed
All rockfishes comprised 84.8% of all fishes surveyed

Platform Hidalgo (Surveyed 2004–2006, 2009)

Species	Number	Density
Halfbanded rockfish	76	2.5
Greenstriped rockfish	37	1.4
Painted greenling	27	1.1
Unidentified fishes	23	0.9
Lingcod YOY	19	0.8
Lingcod	14	0.6
Unidentified combfish	12	0.5
Cowcod YOY	8	0.2
Sebastomus sp.	7	0.3
Rockfish YOY	7	0.3
Pacific sanddab	6	0.2
Greenspotted rockfish	5	0.2
Shortspine combfish	5	0.2
Rosy rockfish	4	0.2
Unidentified rockfish	4	0.2
Dover sole	3	0.1
Swordspine rockfish	3	0.1
Greenblotched rockfish	2	<0.1
Greenspotted rockfish YOY	2	<0.1
Halfbanded rockfish YOY	2	<0.1
Sebastomus YOY	2	<0.1
Squarespot rockfish	2	<0.1
Flag rockfish	1	<0.1
Flag rockfish YOY	1	<0.1
Unidentified flatfish	1	<0.1
Greenstriped rockfish YOY	1	<0.1
Swordspine rockfish YOY	1	<0.1
Unidentified sanddab	1	<0.1
Total	276	
Minimum number of species	18	
Total rockfish YOY	24	
Total rockfishes	165	

Rockfish YOY comprised 8.7% of all fishes surveyed
All rockfishes comprised 59.8% of all fishes surveyed

Platform Harvest (Surveyed 2004)

Species	Number	Density
Halfbanded rockfish	595	26.8
Stripetail rockfish	441	19.9
Greenstriped rockfish	16	0.7
Sebastomus sp.	9	0.4
Unidentified ronquil	4	0.2
Shortspine combfish	3	0.1
Unidentified rockfish	3	0.1
Lingcod	2	<0.1
Unidentified fishes	2	<0.1
Flag rockfish	1	<0.1
Greenblotched rockfish	1	<0.1
Lingcod YOY	1	<0.1
Unidentified poacher	1	<0.1
Total	1,079	
Minimum number of species	9	
Total rockfish YOY	0	
Total rockfishes	1,066	

Rockfish YOY comprised 0% of all fishes surveyed
All rockfishes comprised 98.8% of all fishes surveyed.

Table 7 (continued)

Platform Hermosa (Surveyed 2004, 2006)

Species	Number	Density
Halfbanded rockfish	8,696	370.7
Stripetail rockfish	6	0.2
Sebastomus sp.	5	0.4
Unidentified fishes	3	0.2
Bocaccio YOY	2	<0.1
Cowcod YOY	2	0.1
Flag rockfish	2	0.2
Greenstriped rockfish	2	0.2
Sebastomus YOY	2	<0.1
Unidentified combfish	1	<0.1
Flag rockfish YOY	1	<0.1
Greenspotted rockfish	1	<0.1
Painted greenling	1	<0.1
Shortspine combfish	1	<0.1
Unidentifiable rockfish	1	<0.1
Total	8,726	
Minimum number of species	9	
Total rockfish YOY	7	
Total rockfishes	8,720	

Rockfish YOY comprised 0.1% of all fishes surveyed
All rockfishes comprised 99.9% of all fishes surveyed

Platform Harmony (Surveyed 2004)

Species	Number	Density
Unidentified eelpout	43	1.9
Splitnose rockfish	20	0.9
Unidentified thornyheads	9	0.4
Blackgill rockfish	4	0.2
Aurora rockfish	3	0.1
Unidentified fishes	2	<0.1
Unidentified catshark	1	<0.1
Dover sole	1	<0.1
Sharpchin rockfish	1	<0.1
Stripetail rockfish	1	<0.1
Unidentified rockfish	1	<0.1
Total	86	
Minimum number of species	9	
Total rockfish YOY	0	
Total rockfishes	30	

Rockfish YOY comprised 0% of all fishes surveyed
All rockfishes comprised 34.9% of all fishes surveyed

Platform Hondo

Species	Number	Density
Stripetail rockfish	319	15.2
Darkblotched rockfish	24	1.2
Unidentified poachers	23	1.1
Greenblotched rockfish	13	0.8
Bank rockfish	10	0.8
Sebastomus sp.	8	0.5
Pinkrose rockfish	7	0.5
Splitnose rockfish	7	0.4
Blackgill rockfish	6	0.3
Shortbelly rockfish	6	0.3
Unidentified rockfish	6	0.4
Unidentified eelpout	5	0.2
Unidentified flatfish	4	0.3
Sharpchin rockfish	4	0.2
Bearded eelpout	2	<0.1
Blackgill rockfish YOY	2	<0.1
Bluebarred prickleback	2	<0.1
Dover sole	2	<0.1
Unidentified sanddab	2	<0.1
Blackbelly eelpout	1	<0.1
Blacktail snailfish	1	<0.1
Cowcod	1	<0.1
Flag rockfish	1	<0.1
Sebastomus YOY	1	<0.1
Unidentified fishes	1	<0.1
Unidentified rockfish YOY	1	<0.1
Unidentified ronquil	1	<0.1
Total	460	
Minimum number of species	19	
Total rockfish YOY	4	
Total rockfishes	416	

Rockfish YOY comprised 0.8% of all fishes surveyed
All rockfishes comprised 80.6% of all fishes surveyed

Table 7 (continued)

Platform Holly (Surveyed 2005–2006, 2008)

Species	Number	Density
Calico rockfish	383	24.1
Halfbanded rockfish	69	9.6
Blackeye goby	33	1.6
Rosy rockfish	27	1.4
Vermilion rockfish	23	1.3
Copper rockfish	19	1.1
Squarespot rockfish	19	0.8
Painted greenling	16	0.9
Unidentified ronquil	14	1.4
Unidentified sanddab	14	0.8
Brown rockfish	12	0.7
Pink seaperch	10	0.6
Pacific sanddab	7	0.5
Pile perch	7	0.3
Bluebanded ronquil	7	0.3
Honeycomb rockfish	6	0.2
Longspine combfish	6	0.4
Sebastomus sp.	5	1.8
Flag rockfish	4	0.7
Kelp greenling	4	0.2
Lingcod YOY	4	2.3
Shortspine combfish	4	0.2
Lingcod	3	0.1
Bull sculpin	2	0.1
Canary rockfish	2	0.1
Squarespot rockfish YOY	2	1.2
Unidentified surfperch	2	0.1
Unidentified rockfish	2	0.1
Brown rockfish YOY	1	<0.1
Calico rockfish YOY	1	<0.1
California lizardfish	1	<0.1
Chilipepper	1	<0.1
Flag rockfish YOY	1	<0.1
Unidentified flatfish	1	<0.1
Unidentified Icelinus	1	<0.1
Rosy rockfish YOY	1	<0.1
Spotted scorpionfish	1	<0.1
Starry flounder	1	<0.1
Treefish	1	<0.1
Unidentified fishes	1	<0.1
Wolf-eel	1	<0.1
Yellowtail rockfish	1	<0.1
Total	720	
Minimum number of species	30	
Total rockfish YOY	6	
Total rockfishes	580	

Rockfish YOY comprised 0.8% of all fishes surveyed
All rockfishes comprised 80.6% of all fishes surveyed

Platform Grace (Surveyed 2004–2005, 2007–2009)

Species	Number	Density
Halfbanded rockfish	657	23.3
Squarespot rockfish	114	4.4
Unidentified rockfish YOY	111	2.4
Unidentified sanddabs	51	1.8
Shortspine combfish	39	1.4
Pink seaperch	33	1.2
Lingcod	26	0.8
Greenstriped rockfish	24	0.8
Flag rockfish	23	0.7
Lingcod YOY	23	0.8
Longspine combfish	22	0.7
Vermilion rockfish	15	0.4
Greenspotted rockfish	13	0.4
Painted greenling	12	0.4
Rosy rockfish	8	0.3
Sebastomus sp.	8	0.3
Unidentified fishes	8	0.3
Blue rockfish	5	0.1
Bocaccio	5	0.2
Unidentified rockfish	5	0.2
Unidentified combfish	4	0.1
Sebastomus YOY	4	0.1
Unidentified flatfish	3	0.1
Greenspotted rockfish YOY	2	<0.1
Bocaccio YOY	1	<0.1
Cabezon	1	<0.1
Copper rockfish	1	<0.1
Flag rockfish YOY	1	<0.1
Greenblotched rockfish	1	<0.1
Shortbelly rockfish	1	<0.1
Spotted ratfish	1	<0.1
Bluebanded ronquil	1	<0.1
Swordspine rockfish	1	<0.1
Widow rockfish YOY	1	<0.1
Total	1,225	
Minimum number of species	25	
Total rockfish YOY	120	
Total rockfishes	1,001	

Rockfish YOY comprised 9.8% of all fishes surveyed
All rockfishes comprised 81.7% of all fishes surveyed

Table 7 (continued)

Platform Gilda (Surveyed 2004, 2007–2009)

Species	Number	Density
Halfbanded rockfish	10,069	469.0
Calico rockfish	85	4.3
Lingcod YOY	70	4.0
Painted greenling	57	3.5
Widow rockfish	46	2.1
Vermilion rockfish	38	2.0
Lingcod	16	0.9
Pacific sanddab	15	0.8
Pink seaperch	13	0.7
Unidentified sanddab	13	0.8
Flag rockfish	11	0.6
Rosy rockfish	11	0.6
Copper rockfish	10	0.5
Pile perch	10	0.6
Vermilion rockfish YOY	8	0.5
Shortspine combfish	7	0.4
Unidentified flatfish	6	0.3
Spotted scorpionfish	6	0.4
Olive rockfish	3	0.1
Blackeye goby	2	0.1
Unidentified combfish	2	0.1
Longspine combfish	2	0.1
Squarespot rockfish	2	0.1
Unidentified fishes	2	0.1
Unidentified rockfish	2	<0.1
Wolf-eel	2	0.1
Cabezon	1	<0.1
California halibut	1	<0.1
Rubberlip seaperch	1	<0.1
Unidentified surfperch	1	<0.1
Unidentified ronquil	1	<0.1
Total	10,513	
Minimum number of species	24	
Total rockfish YOY	8	
Total rockfishes	10,298	

Rockfish YOY comprised 0.1% of all fishes surveyed
All rockfishes comprised 98.0% of all fishes surveyed

Platform Gail (Surveyed 2004–2009)

Species	Number	Density
Greenstriped rockfish	169	9.8
Pinkrose rockfish	149	4.6
Stripetail rockfish	76	1.3
Greenblotched rockfish	41	1.4
Lingcod	26	0.6
Shortspine combfish	24	0.3
Bocaccio	21	0.5
Unidentified poacher	19	0.5
Unidentified flatfish	14	0.3
Dover sole	10	0.2
Flag rockfish	10	0.3
Greenspotted rockfish	8	0.3
Sebastomus sp.	8	0.3
Unidentified combfish	7	0.1
Blackgill rockfish	6	0.4
Unidentified fishes	6	0.3
Unidentified rockfish	6	0.1
Darkblotched rockfish	4	<0.1
Unidentified sculpin	4	<0.1
Cowcod YOY	3	<0.1
Pacific sanddab	3	<0.1
Sharpchin rockfish	2	<0.1
Swordspine rockfish	2	<0.1
Bluebarred prickleback	1	<0.1
Cowcod	1	<0.1
Darkblotched rockfish YOY	1	<0.1
English sole	1	<0.1
Halfbanded rockfish	1	<0.1
Mexican rockfish	1	<0.1
Redbanded rockfish	1	<0.1
Squarespot rockfish	1	<0.1
Starry rockfish	1	<0.1
Unidentified eelpout	1	<0.1
Unidentified rockfish YOY	1	<0.1
Unidentified ronquil	1	<0.1
Total	630	
Minimum number of species	29	
Total rockfish YOY	5	
Total rockfishes	513	

Rockfish YOY comprised 0.8% of all fishes surveyed
All rockfishes comprised 81.4% of all fishes surveyed

Table 7 (continued)

Platform Edith (Surveyed 2005–2009)

Species	Number	Density
Squarespot rockfish YOY	3,721	166.0
Blackeye goby	1,939	83.9
Spotted scorpionfish	901	37.1
Sebastomus YOY	608	24.8
Shortbelly rockfish	88	4.2
Halfbanded rockfish YOY	70	3.1
Wolf-eel	60	2.7
Unidentified rockfish YOY	38	1.5
Pile perch	32	1.4
Painted greenling	22	0.9
Squarespot rockfish	15	0.6
Unidentified fishes	13	0.6
Cabezon	11	0.5
Painted greenling YOY	11	0.5
Sharpnose seaperch	4	0.2
Unidentified surfperch	4	0.2
White seaperch	4	0.2
Honeycomb rockfish	3	0.1
Lingcod	3	0.1
Vermilion rockfish	3	0.1
Blue rockfish	2	<0.1
Deepwater blenny	2	<0.1
Sebastomus sp.	2	<0.1
Bluebanded ronquil	2	<0.1
Unidentified sanddab	2	<0.1
Blacksmith YOY	1	<0.1
Bocaccio YOY	1	<0.1
Brown rockfish YOY	1	<0.1
Calico rockfish	1	<0.1
Calico rockfish YOY	1	<0.1
Honeycomb rockfish YOY	1	<0.1
Olive rockfish	1	<0.1
Senorita	1	<0.1
Unidentified rockfish	1	<0.1
Unidentified ronquil	1	<0.1
Total	7,570	
Minimum number of species	25	
Total rockfish YOY	4,529	
Total rockfishes	4,557	

Rockfish YOY comprised 59.8% of all fishes surveyed
All rockfishes comprised 60.2% of all fishes surveyed

Platform Elly (Surveyed 2005–2006, 2008–2009)

Species	Number	Density
Halfbanded rockfish	3,580	143.0
Rockfish YOY	696	32.2
Halfbanded rockfish YOY	163	7.6
Shortbelly rockfish YOY	108	5.0
Squarespot rockfish	104	4.9
Rosy rockfish	96	4.1
Pink seaperch	72	3.0
Squarespot rockfish YOY	64	3.1
Widow rockfish YOY	60	2.8
Lingcod	53	2.2
Calico rockfish	49	2.0
Painted rockfish	47	2.1
Sebastomus sp.	39	1.8
Honeycomb rockfish	37	1.6
Unidentified rockfish	34	1.6
Shortbelly rockfish	32	1.6
Unidentified sanddab	21	0.9
Blackeye goby	11	0.4
Flag rockfish	9	0.3
Shortspine combfish	7	0.3
Unidentified ronquil	7	0.3
Unidentified fishes	5	0.2
Cabezon	3	0.2
Pile perch	3	0.1
Bluebanded ronquil	3	0.2
Wolf-eel	3	0.1
Sharpnose seaperch	2	<0.1
Starry rockfish	2	<0.1
Bocaccio	1	<0.1
Unidentified combfish	1	<0.1
Cowcod	1	<0.1
Cowcod YOY	1	<0.1
Unidentified flatfish	1	<0.1
Greenspotted rockfish	1	<0.1
Lingcod YOY	1	<0.1
Pygmy rockfish	1	<0.1
Sebastomus YOY	1	<0.1
Stripetail rockfish	1	<0.1
Total	5,320	
Minimum number of species	25	
Total rockfish YOY	1,093	
Total rockfishes	5,080	

Rockfish YOY comprised 21.5% of all fishes surveyed
All rockfishes comprised 95.5% of all fishes surveyed

Table 7 (continued)

Platform Ellen (Surveyed 2005–2009)

Species	Number	Density
Halfbanded rockfish	3,401	92.5
Honeycomb rockfish	225	7.5
Squarespot rockfish	172	4.6
Unidentified sanddab	144	4.0
Rosy rockfish	105	3.5
Squarespot rockfish YOY	69	2.2
Painted greenling	50	1.6
Flag rockfish	42	1.2
Calico rockfish	38	1.2
Pink seaperch	38	1.1
Sebastomus sp.	38	1.2
Lingcod	36	1.1
Bluebanded ronquil	28	0.9
Blackeye goby	24	0.7
Halfbanded rockfish YOY	24	0.8
Unidentified surfperch	20	0.5
Unidentified rockfish YOY	16	0.5
Shortspine combfish	13	0.4
Unidentified fishes	12	0.4
Cabezon	9	0.3
Sebastomus YOY	7	0.2
Unidentified flatfish	6	0.2
Lingcod YOY	6	0.2
Spotted scorpionfish	6	0.2
Unidentified ronquil	6	0.1
Swordspine rockfish	4	0.1
Unidentified combfish	3	<0.1
Unidentified rockfish	3	0.1
Vermilion rockfish	3	0.1
White seaperch	3	0.1
Cowcod YOY	2	<0.1
Flag rockfish YOY	2	<0.1
Freckled rockfish	2	<0.1
Greenspotted rockfish	2	<0.1
Pacific electric ray	2	<0.1
Pile perch	2	<0.1
Wolf-eel	2	<0.1
California lizardfish	1	<0.1
Copper rockfish	1	<0.1
Starry rockfish	1	<0.1
Total	4,568	
Minimum number of species	27	
Total rockfish YOY	120	
Total rockfishes	4,157	

Rockfish YOY comprised 2.6% of all fishes surveyed
All rockfishes comprised 91.0% of all fishes surveyed

Platform Eureka (Surveyed 2005, 2007, 2009)

Species	Number	Density
Pinkrose rockfish	87	3.8
Shortspine combfish	17	0.8
Greenstriped rockfish	15	0.7
Sebastomus sp.	13	0.6
Dover sole	11	0.5
Greenblotched rockfish	8	0.4
Unidentified prickleback	8	0.3
Unidentified combfishes	7	0.3
Rosethorn rockfish	4	0.2
Unidentified poacher	3	0.1
Swordspine rockfish	3	0.1
Unidentified fishes	3	0.1
Unidentified eelpout	3	0.1
Pinkrose rockfish YOY	2	<0.1
Blackgill rockfish	1	<0.1
Cabezon	1	<0.1
Darkblotched rockfish	1	<0.1
Unidentified flatfish	1	<0.1
Greenspotted rockfish	1	<0.1
Stripetail rockfish	1	<0.1
Unidentified rockfish	1	<0.1
Total	191	
Minimum number of species	16	
Total rockfish YOY	1	
Total rockfishes	137	

Rockfish YOY comprised 0.5% of all fishes surveyed
All rockfishes comprised 71.7% of all fishes surveyed

A comparison of Platform and Natural Site Fish Assemblages

Because the composition of platform bottom and shell mound fish assemblages are driven by bottom depth (Figures 9, 13), we compared platform habitats and natural sites within the three depth regimes (≤83 m, 84–136 m, ≥137 m) that characterize the natural habitat assemblages along much of the continental shelf of the southern California Bight (Love et al. 2009).

Platform Midwaters and Natural Sites

The midwater fish assemblages of the shallow water platforms tended to be somewhat different from that occurring in reef habitat of shallow water natural sites (Figures 16–18). More typical midwater platform species included the YOY of painted greenling, *Sebastomus* sp., and blacksmith, along with juveniles and adults of such species as blacksmith, pile perch, senorita, sheephead, and sharpnose seaperch. Natural site fishes were characterized by species more typical of complex, high relief (gopher, starry, vermilion rockfishes, treefish) and soft-seafloor, low-relief dwellers (e.g., shortspine combfish and pink seaperch). Similar to shallower waters, midwater platform assemblages of middle-depth platforms were also different from middle-depth natural sites (Figures 19–21). Around middle depth platforms, the YOY of a number of species (e.g., bocaccio, starry and squarespot rockfishes, and painted greenling) were important, as were painted greenling and copper and widow rockfishes. None of these species were very abundant over middle depth natural sites. Instead, there were a wide variety of high-relief species (e.g., bocaccio, cowcod, greenspotted, pygmy, and squarespot rockfish), as well as lingcod. In addition, such soft bottom taxa as flatfishes and poachers were commonly observed. The midwater structure of deeper platforms was also quite different from deep natural sites (Figures 22–24). Midwater assemblages were similar to those around both shallow and middle depth platforms, while the natural site assemblage were characterized by deeper-welling rockfishes, spotted ratfish, Dover sole, flatfishes, and poachers.

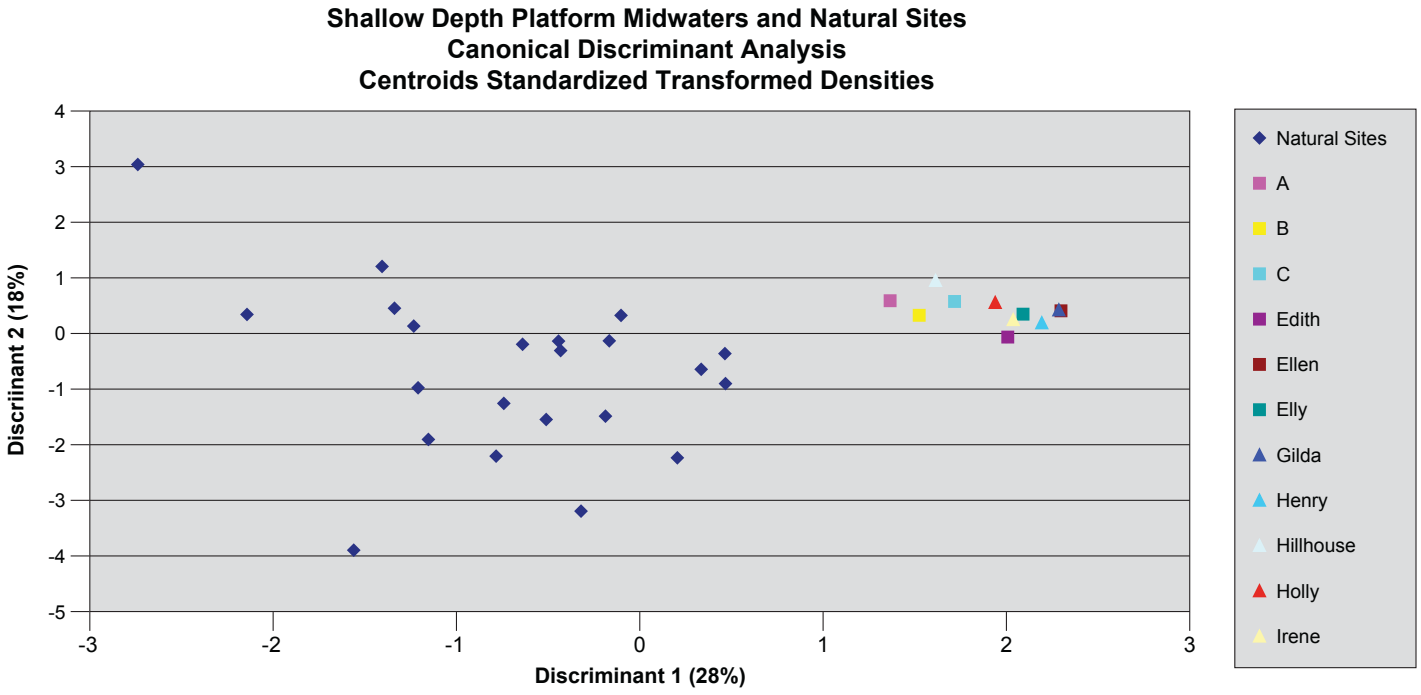

Figure 16. A canonical discriminant analysis comparing the midwater fish assemblages of shallow depth platforms (≤83 m) with shallow natural sites. Data is based on centroids of surveys conducted in 2004–2009.

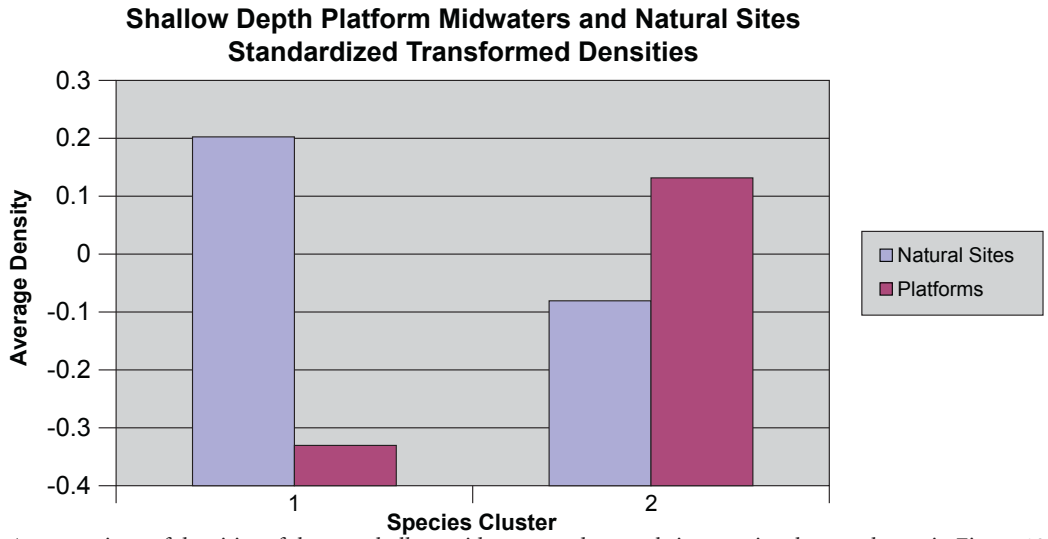

Figure 17. A comparison of densities of the two shallow midwaters and natural sites species clusters shown in Figure 18.

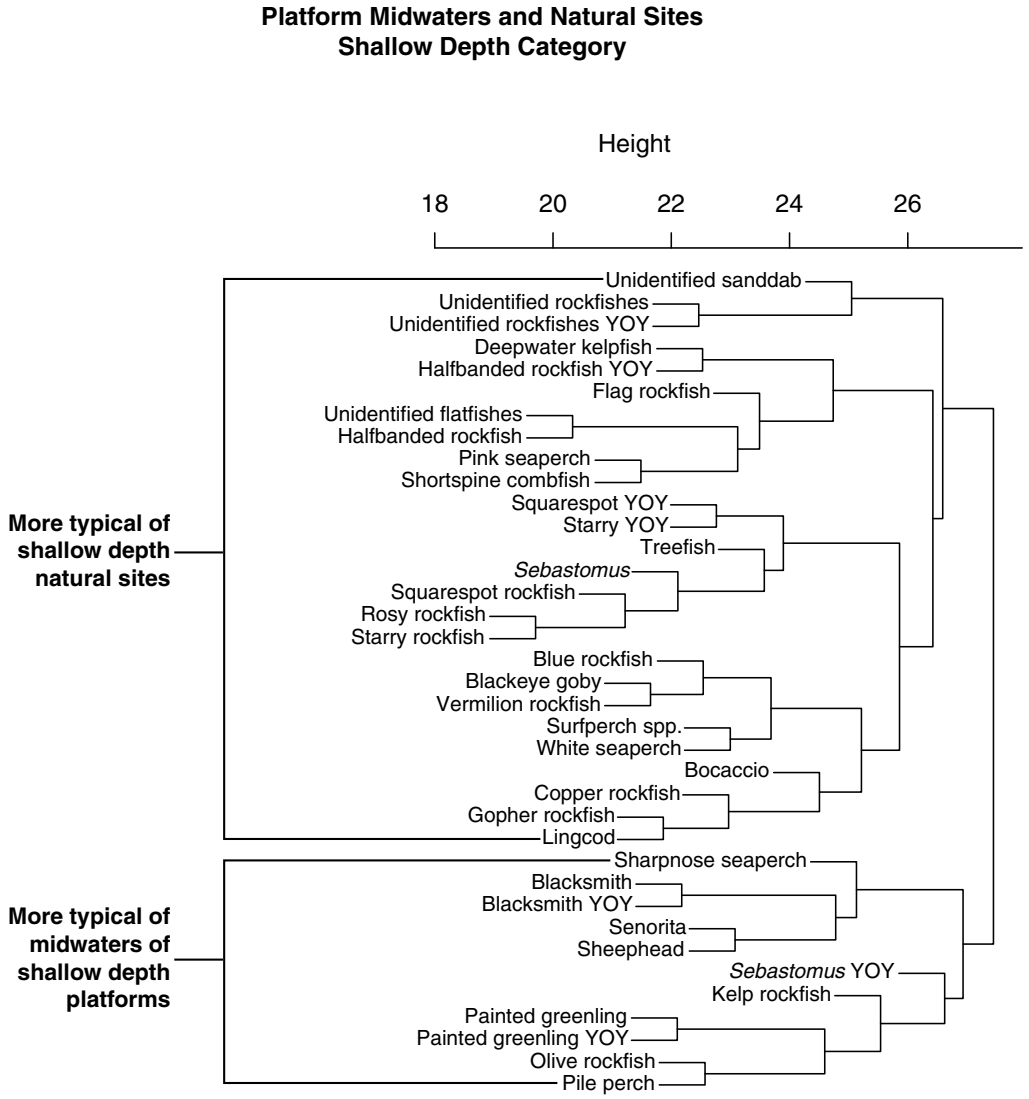

Figure 18. A cluster analysis of the characteristic species of platform midwaters of shallow depth platforms (≤83 m) and shallow natural sites. Data is based on surveys conducted in 2004–2009.

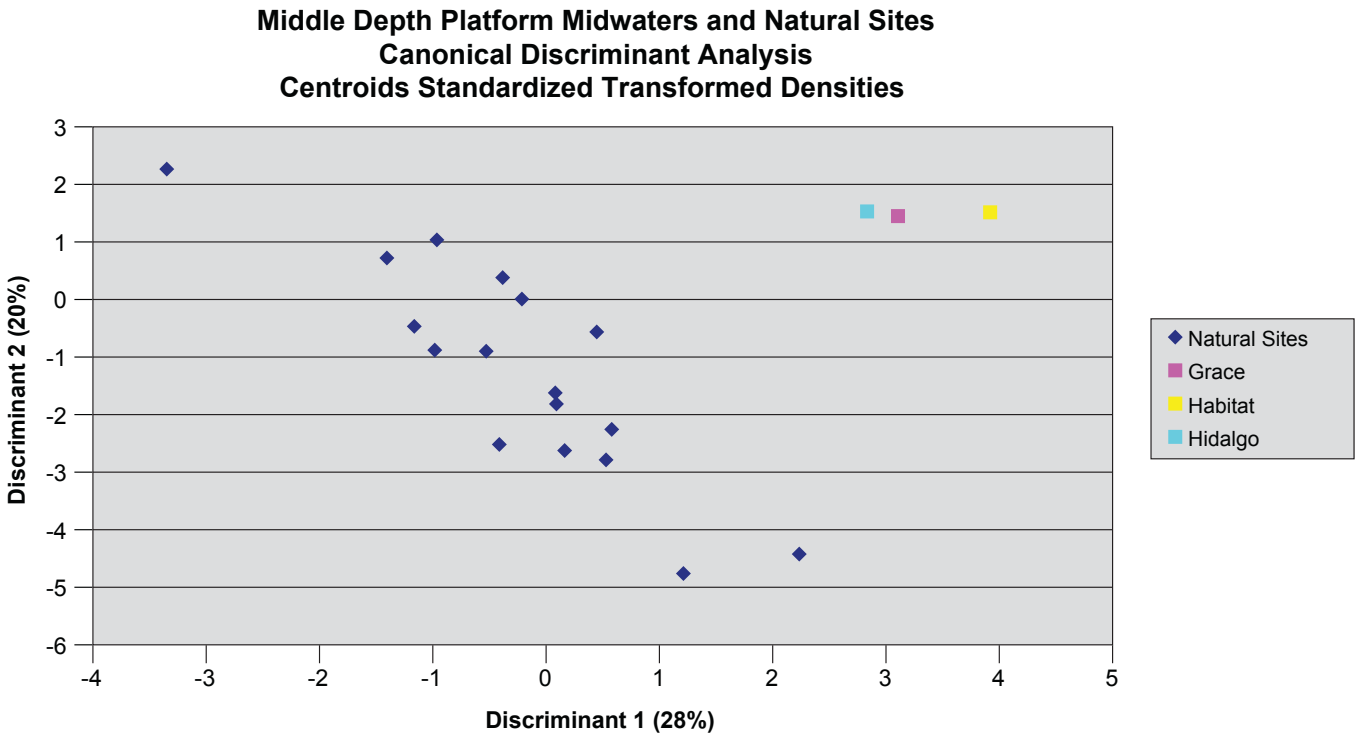

Figure 19. A canonical discriminant analysis comparing the midwater fish assemblages of middle depth platforms (84–136 m) with middle depth natural sites. Data is based on centroids of surveys conducted in 2004–2009.

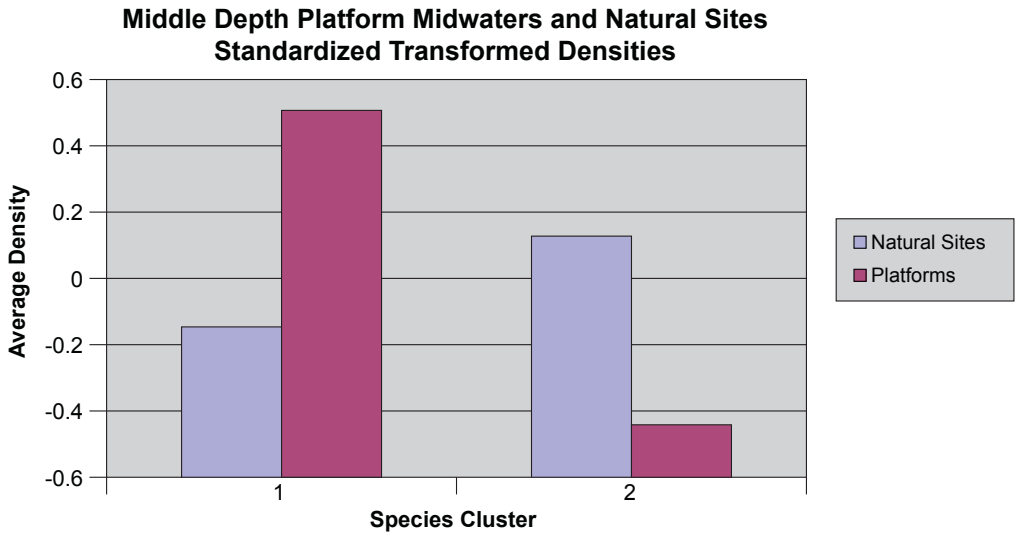

Figure 20. A comparison of densities of the two middle depth midwater and natural sites species clusters shown in Figure 21.

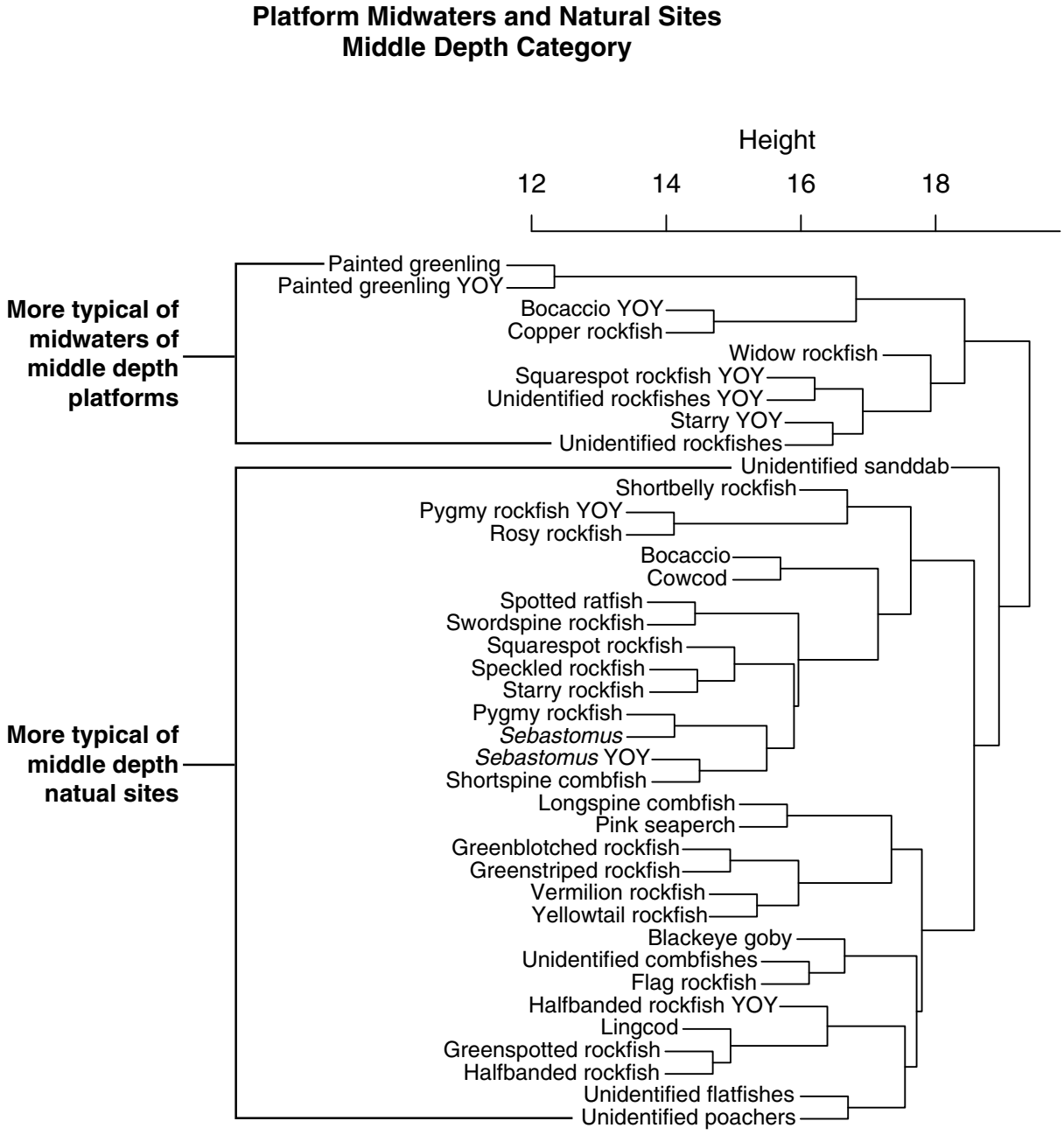

Figure 21. A cluster analysis of the characteristic species of platform midwaters of middle depth platforms (84–136 m) and middle depth natural sites. Data is based on surveys conducted in 2004–2009.

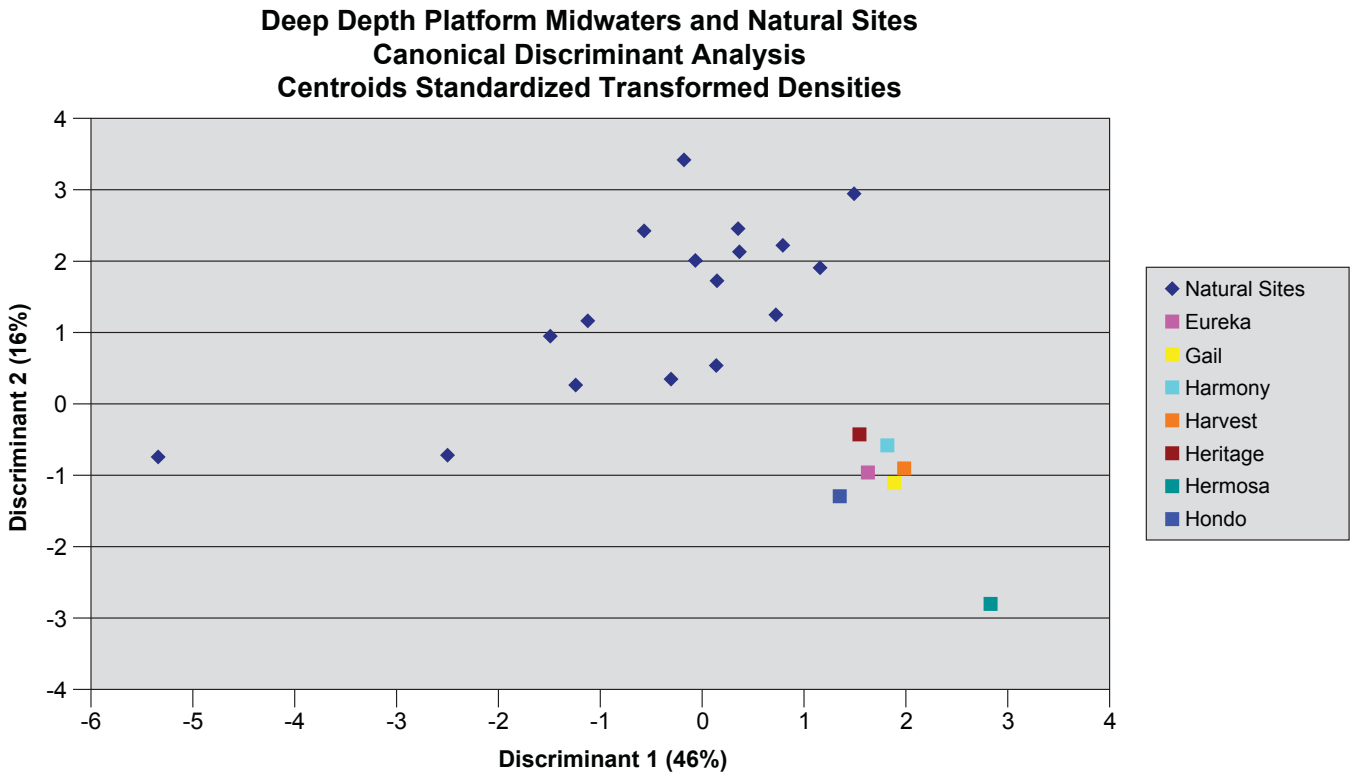

Figure 22. A canonical discriminant analysis comparing the midwater fish assemblages of deep depth platforms (≥137 m) with deep depth natural sites. Data is based on centroids of surveys conducted in 2004–2009.

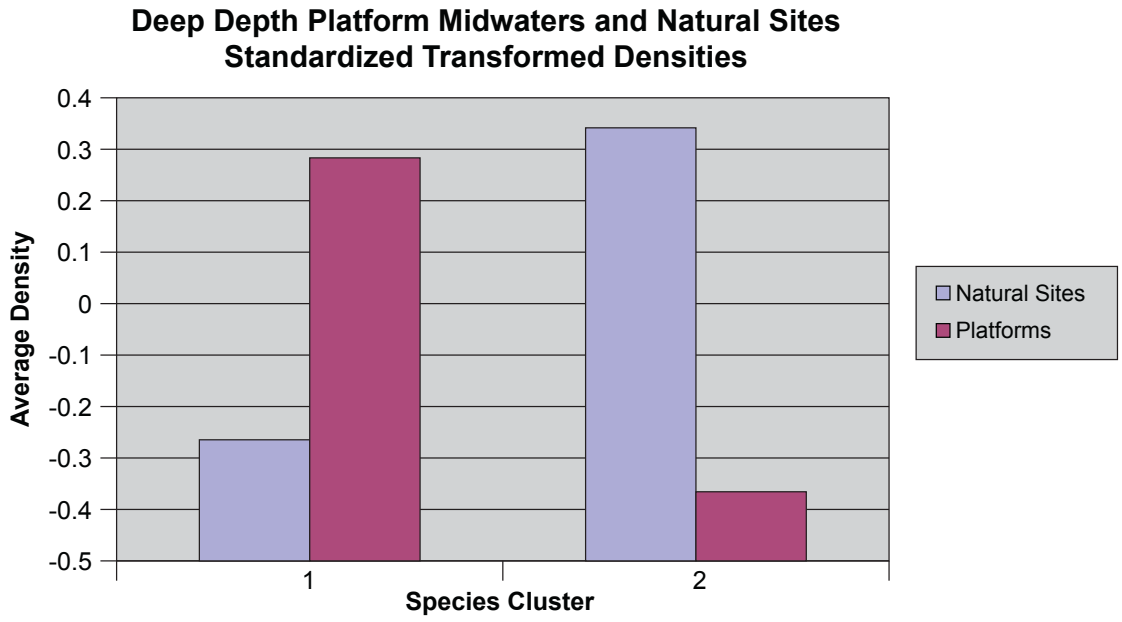

Figure 23. A comparison of densities of the two deep depth midwater and natural sites species clusters shown in Figure 24.

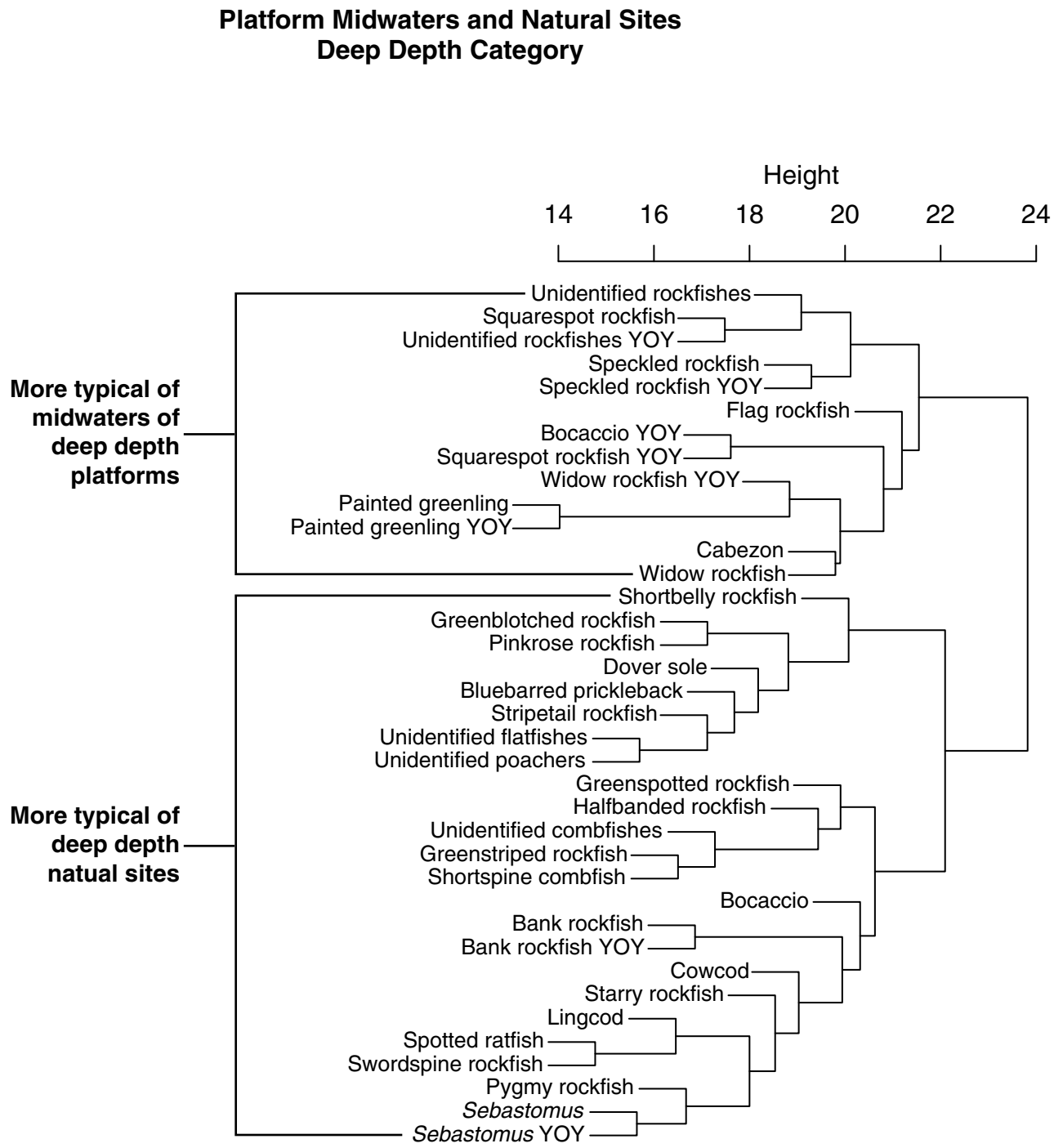

Figure 24. A cluster analysis of the characteristic species of platform midwaters of deep depth platforms (≥137 m) and deep depth natural sites. Data is based on surveys conducted in 2004–2009.

Platform Bottoms and Natural Sites

Most of the shallow-water platforms supported fish assemblages that were at least somewhat different from natural sites (Figures 25–27). Of the six shallow water platforms, only Edith harbored a fish assemblage that was very similar to natural sites. Elly and Ellen shared similar assemblages, as did Gilda and Irene, while platform Holly stood alone. While a very wide range of species characterized platform bottoms, few were as important to natural sites (Figures 26–27). In general, the differences we observed reflected higher species densities around platforms rather than absences of these from natural sites (Table 4). In the middle depth range, the bottom fish assemblages of both Grace and Hidalgo were quite different from each other and from the natural sites (Figures 28–30). In these habitats, there were two suites of species; one composed of taxa most characteristic of both bottoms and natural sites and the other of platform bottoms alone (Figures 29–30). By comparison to shallower platforms, and with the exception of Gail, the deeper bottom platform assemblages tended to be more similar to natural sites (Figures 31–33). The primary difference in species assemblages between Gail and both the other platforms and the natural sites was the much higher densities of a range of shelter-oriented, often economically important species, such as cowcod, bocaccio, and green-blotched, pinkrose, and greenspotted rockfishes (Table 6).

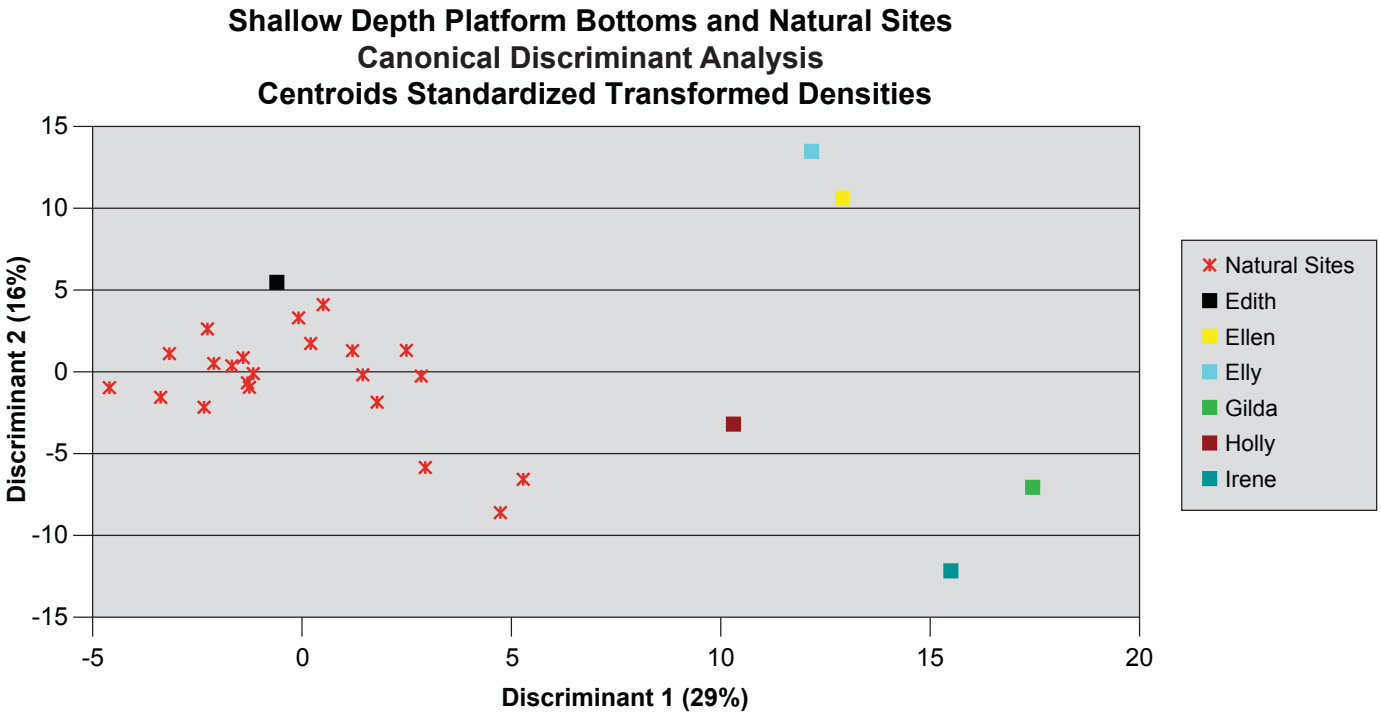

Figure 25. A canonical discriminant analysis comparing the bottom fish assemblages of shallow depth platforms (≤83 m) with shallow natural sites. Data is based on centroids of surveys conducted in 2004–2009.

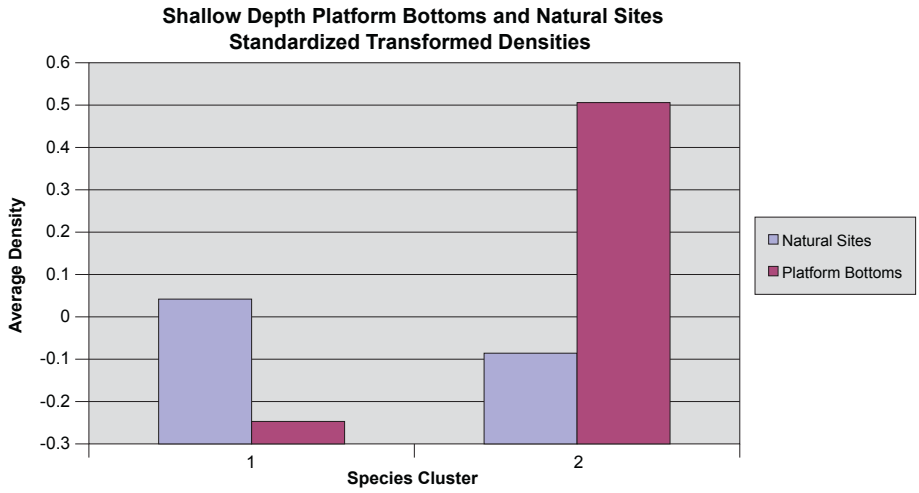

Figure 26. A comparison of densities of the two shallow depth platform bottom and natural sites species clusters shown in Figure 27.

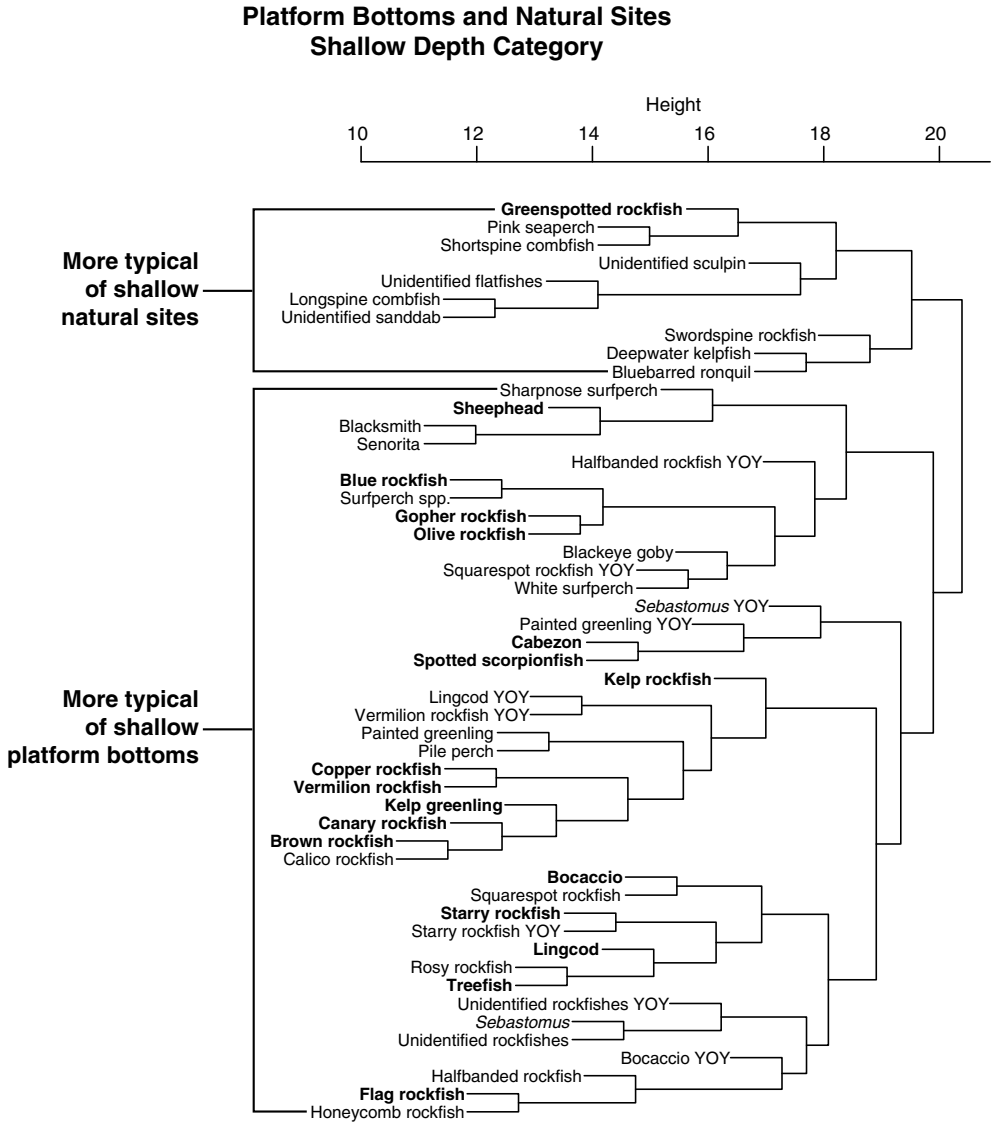

Figure 27. A cluster analysis of the characteristic species of platform bottoms of shallow depth platforms (≤83 m) and shallow natural sites. Data is based on surveys conducted in 2004–2009. Economically important species are in bold.

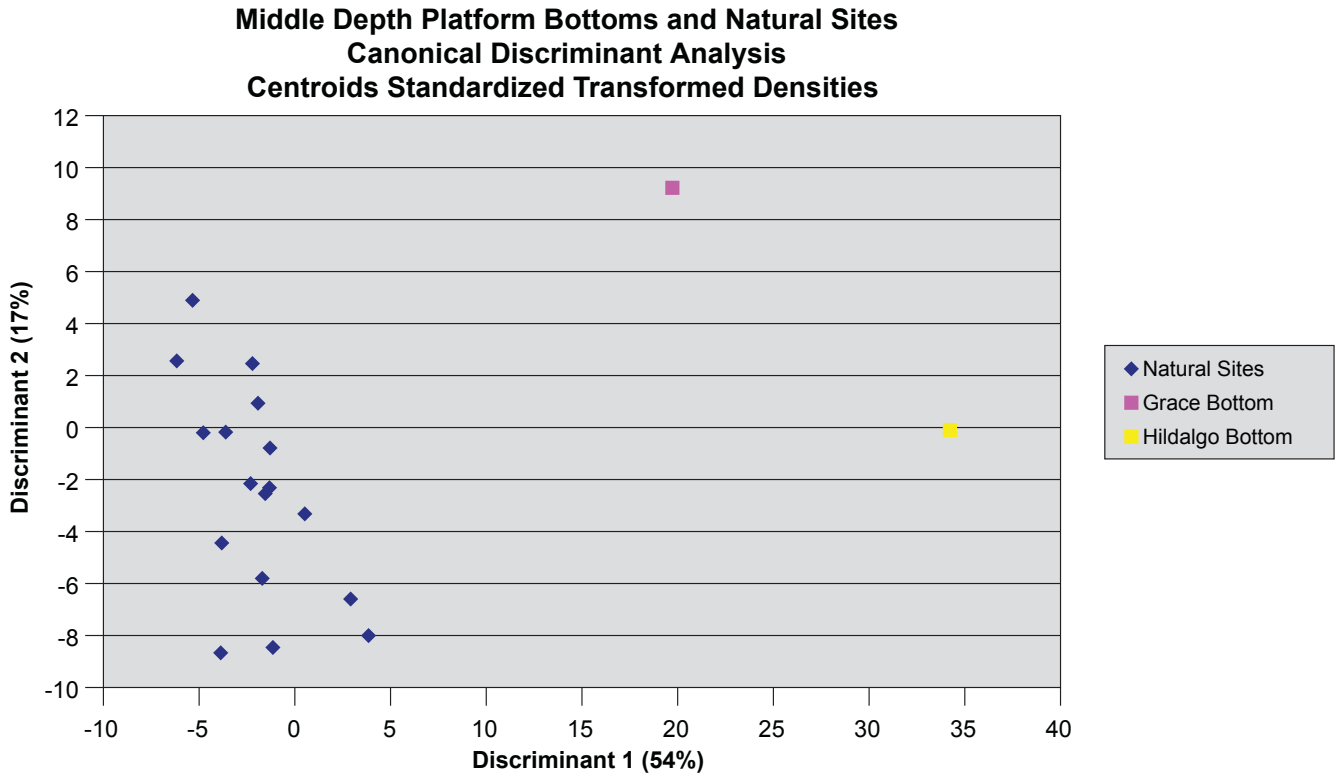

Figure 28. A canonical discriminant analysis comparing the bottom fish assemblages of middle depth platforms (84–136 m) with-middle depth natural sites. Data is based on centroids of surveys conducted in 2004–2009.

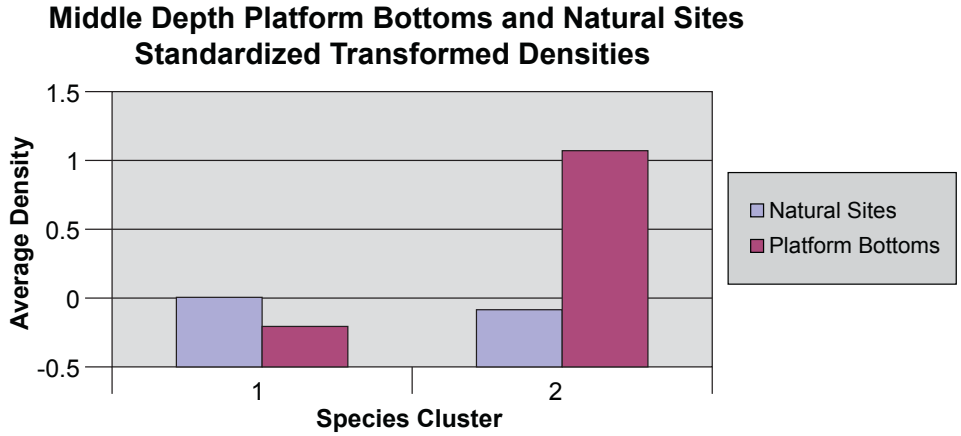

Figure 29. A comparison of densities of the two middle depth platform bottom and natural sites species clusters shown in Figure 30.

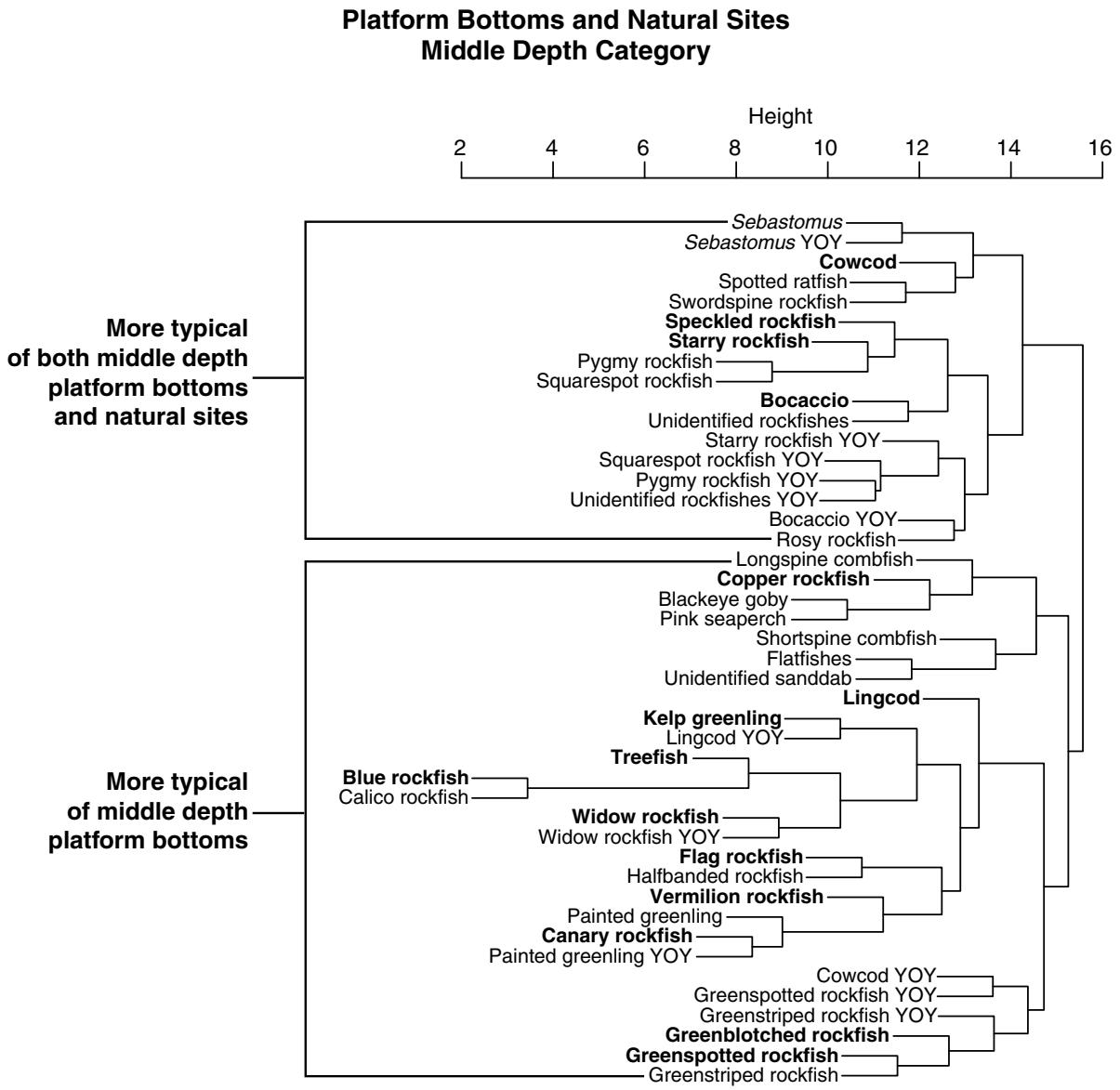

Figure 30. A cluster analysis of the characteristic species of platform bottoms of middle depth platforms (84–136 m) and middle depth natural sites. Data is based on surveys conducted in 2004–2009. Economically important species are in bold.

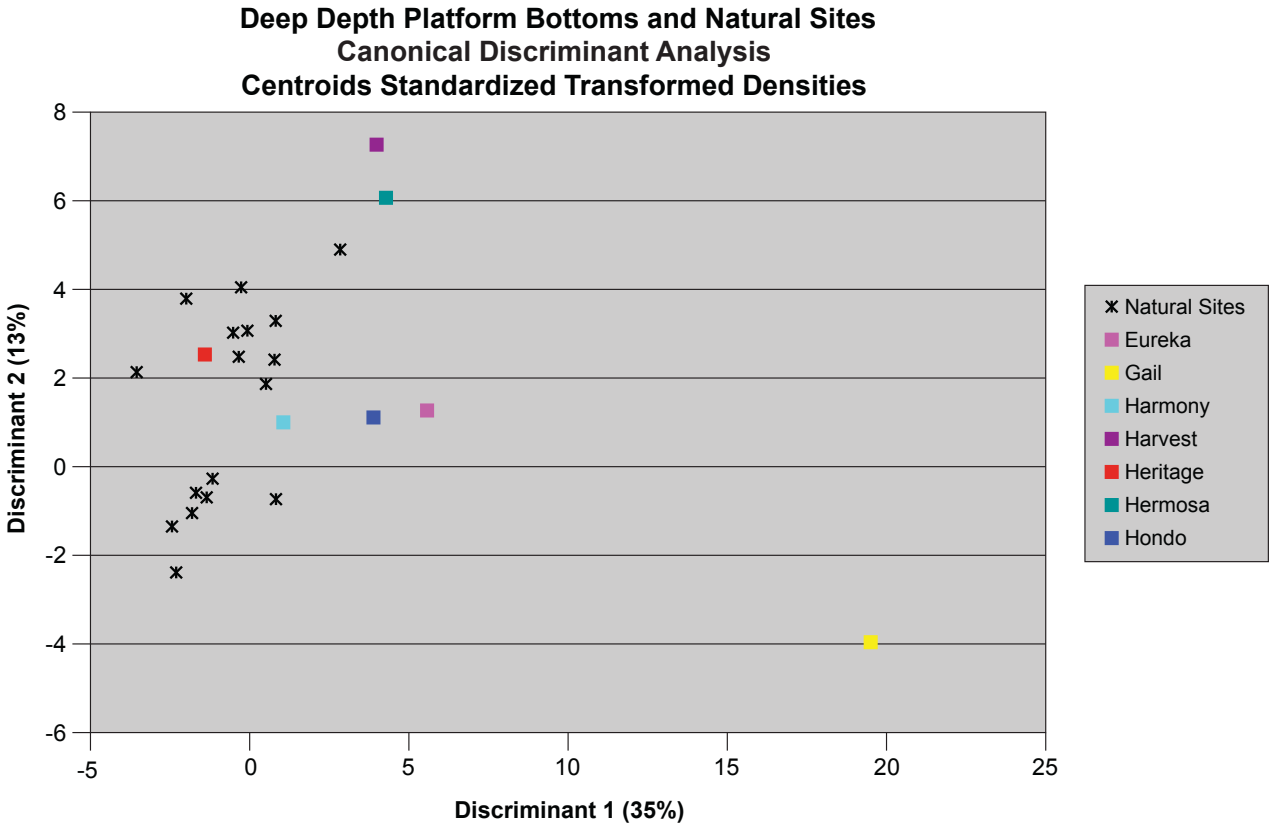

Figure 31. A canonical discriminant analysis comparing the bottom fish assemblages of deep depth platforms (≥137 m) with deep depth natural sites. Data is based on centroids of surveys conducted in 2004–2009.

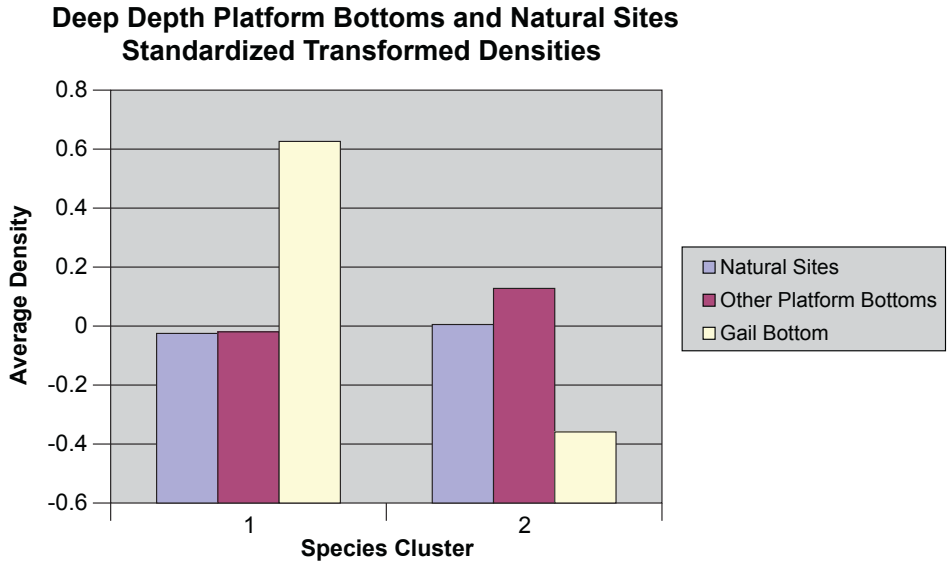

Figure 32. A comparison of densities of the two deep depth platform bottom and natural sites species clusters shown in Figure 33.

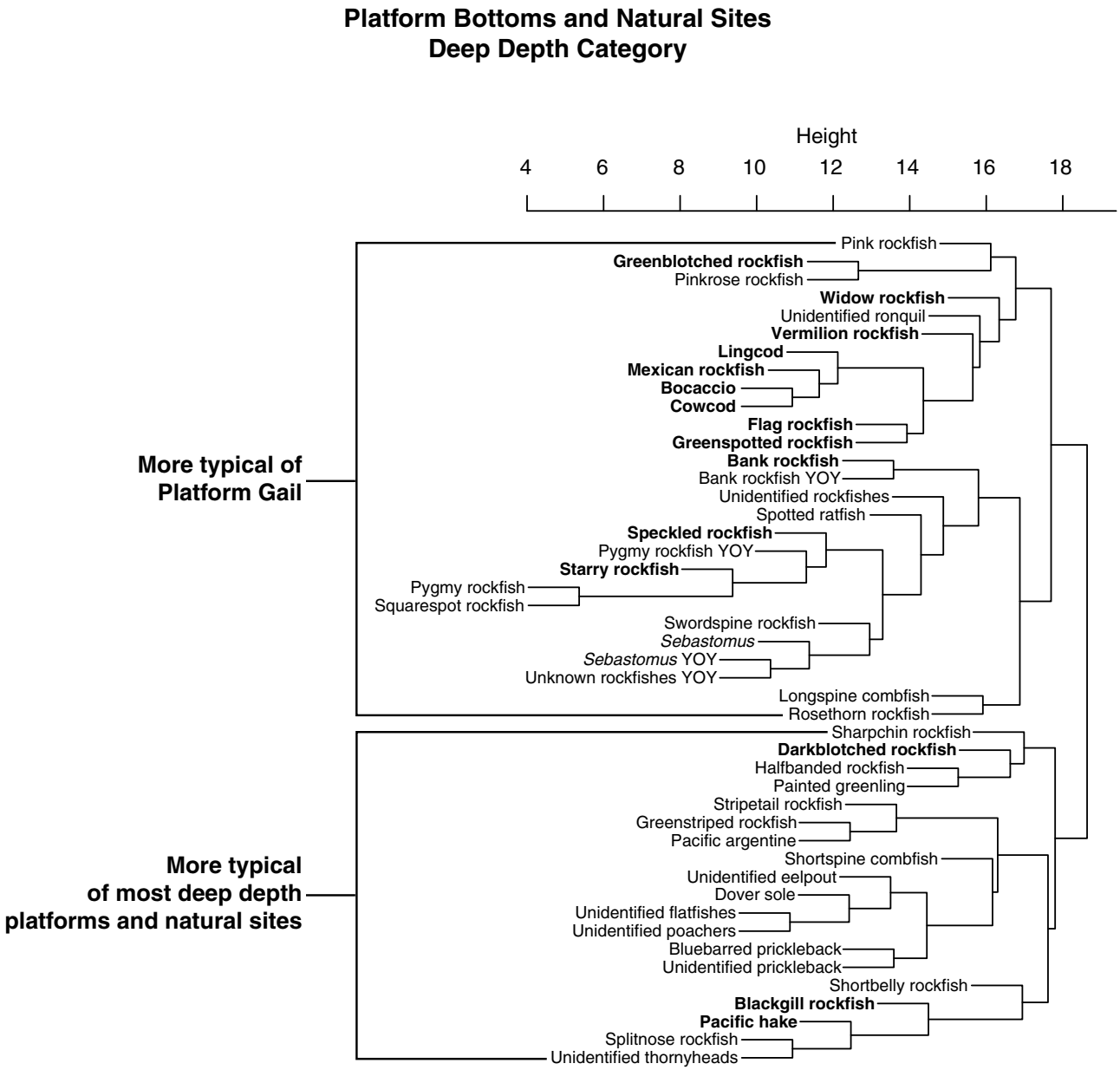

Figure 33. A cluster analysis of the characteristic species of platform bottoms of deep depth platforms (≥137 m) and deep depth-natural sites. Data is based on surveys conducted in 2004–2009. Economically important species are in bold.

Platform Shell Mounds and Natural Sites

The shell mound assemblages of most shallow platforms were quite similar to one another (Figure 34). The exception was Platform Edith (Figure 34) whose assemblage more closely resembled some natural sites. Those species more typical of shell mounds tended to be taxa (e.g., calico rockfish, ronquils, flatfishes, pink seaperch) that associate with lower-relief habitats, while those more abundant on natural sites (e.g., treefish, rosy, squarespot, starry rockfishes, blacksmith, senorita, and sheephead) characteristically live over higher relief (Figures 35–36). In middle depth shell mounds, the assemblages around Grace and Hidalgo were very similar and these were quite different from natural sites (Figures 37–39). These differences were driven by at least two factors. First, there were substantial differences in what species recruited to each habitat from the plankton as YOYs (Figure 39). For instance, starry, squarespot, and pygmy rockfish YOY were characteristic of natural sites, while the YOYs of lingcod, flag and greenspotted rockfish, and cowcod were found more often on shell mounds. Similar to the shallow water assemblage, we found that much of the middle depth assemblage was composed of species favoring low relief (e.g., greenstriped rockfish, combfishes, and Pacific sanddab), while higher-relief taxa (e.g., cowcod, speckled, pygmy, and rosy rockfishes) characterized natural sites. In the deepest stratum, shell mound and natural reef assemblages were more similar with each other than in shallower waters (Figures 40–42), although two platforms (i.e., Gail and Hondo) harbored a somewhat different assemblage.

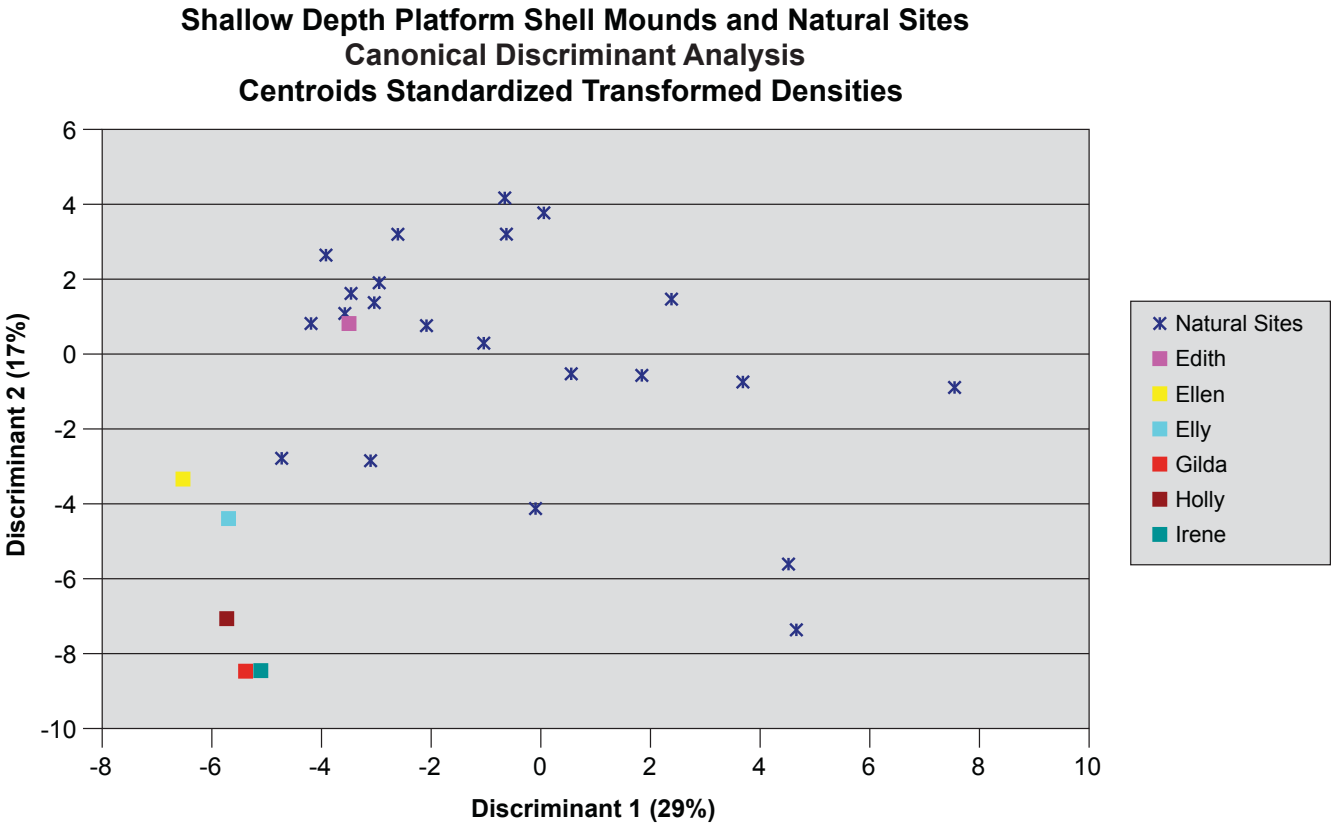

Figure 34. A canonical discriminant analysis comparing the shell mound fish assemblages of shallow depth platforms (≤83 m) with shallow natural sites. Data is based on centroids of surveys conducted in 2004–2009.

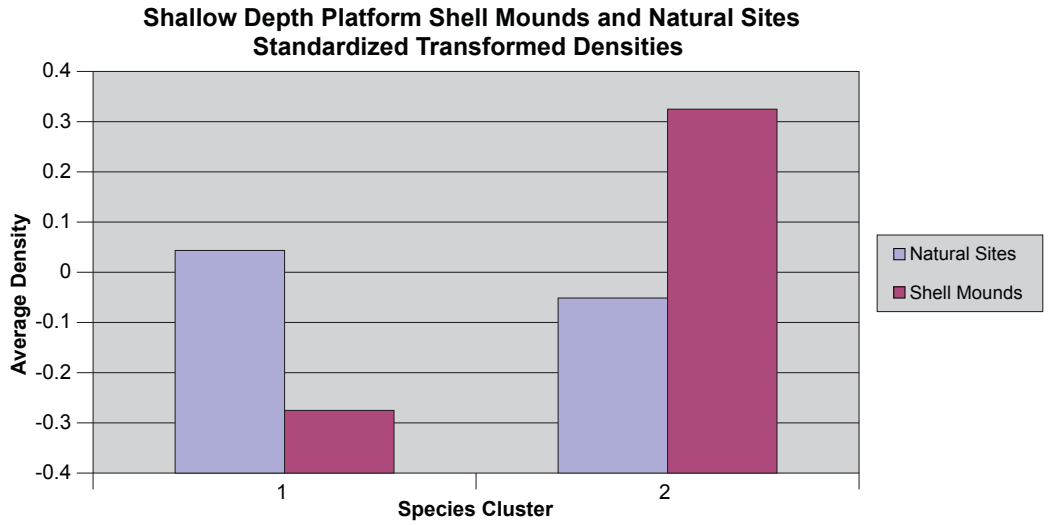

Figure 35. A comparison of densities of the two shallow depth platform shell mound and natural sites species clusters shown in Figure 36.

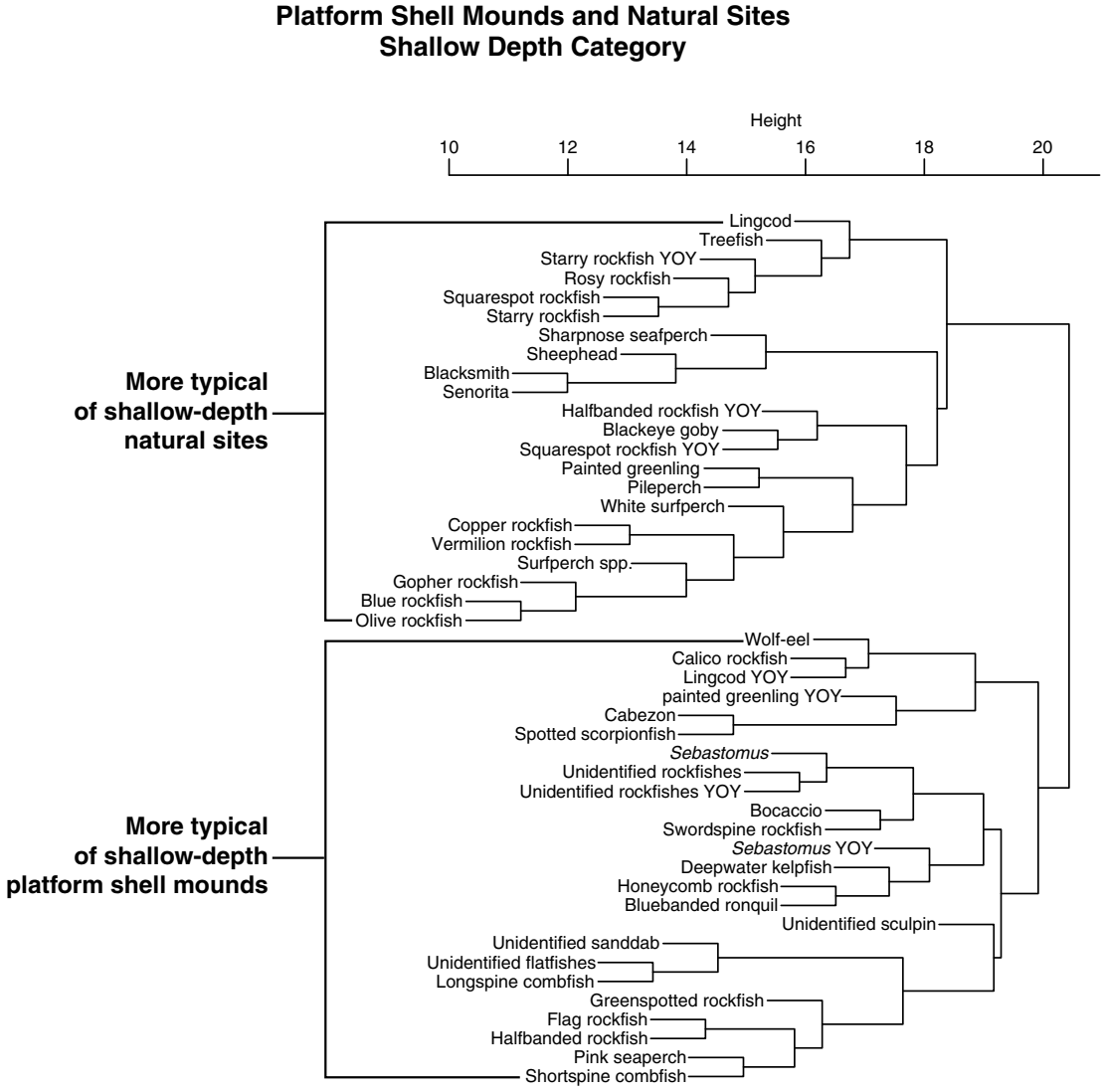

Figure 36. A cluster analysis of the characteristic species of platform shell mounds of shallow depth platforms (≤83 m) and shallow natural sites. Data is based on surveys conducted in 2004–2009.

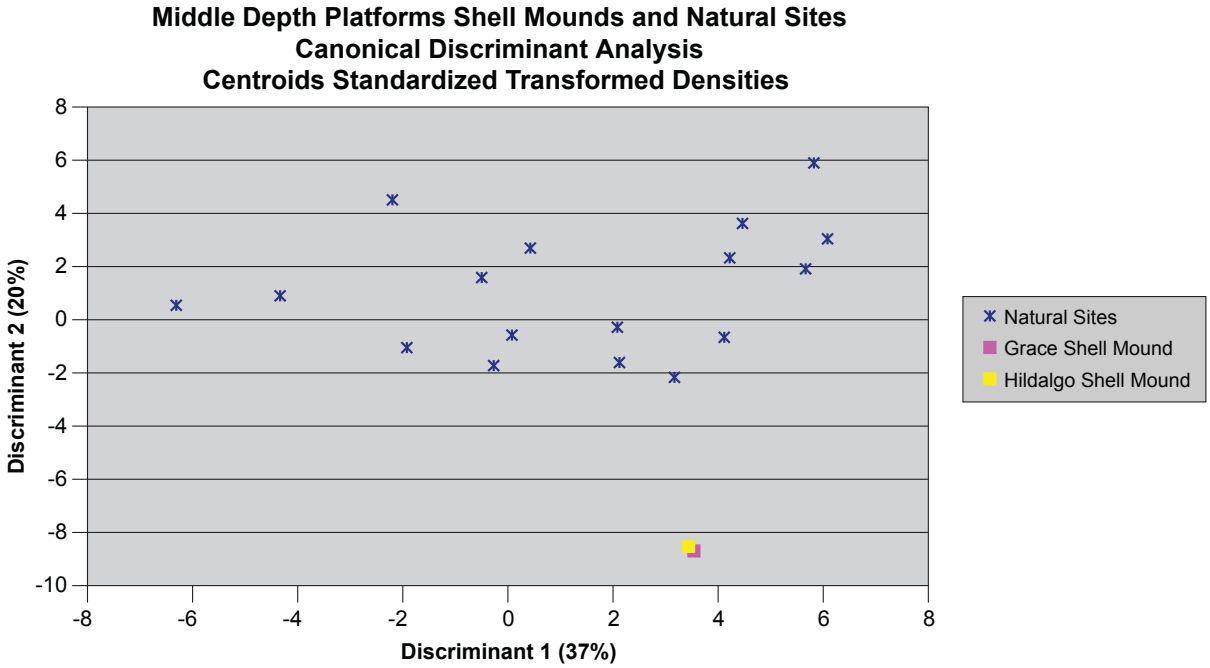

Figure 37. A canonical discriminant analysis comparing the shell mound fish assemblages of middle depthplatforms (84–136 m) with middle depth natural sites. Data is based on centroids of surveys conducted in 2004–2009.

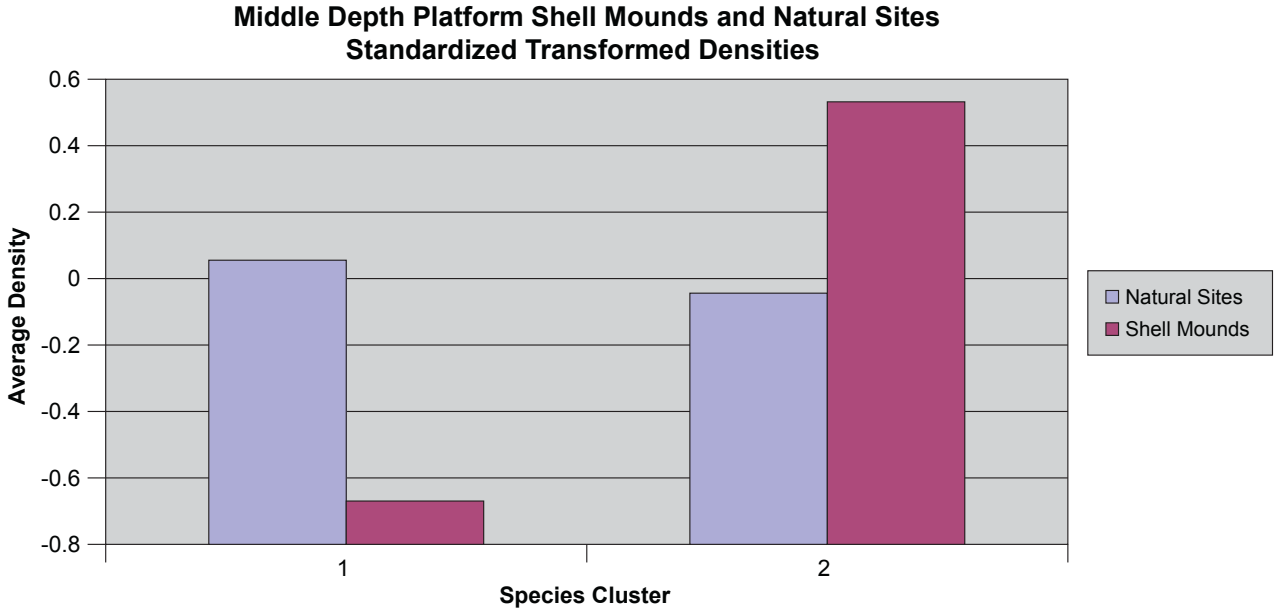

Figure 38. A comparison of densities of the two middle depth platform shell mound and natural sites species clusters shown in Figure 39.

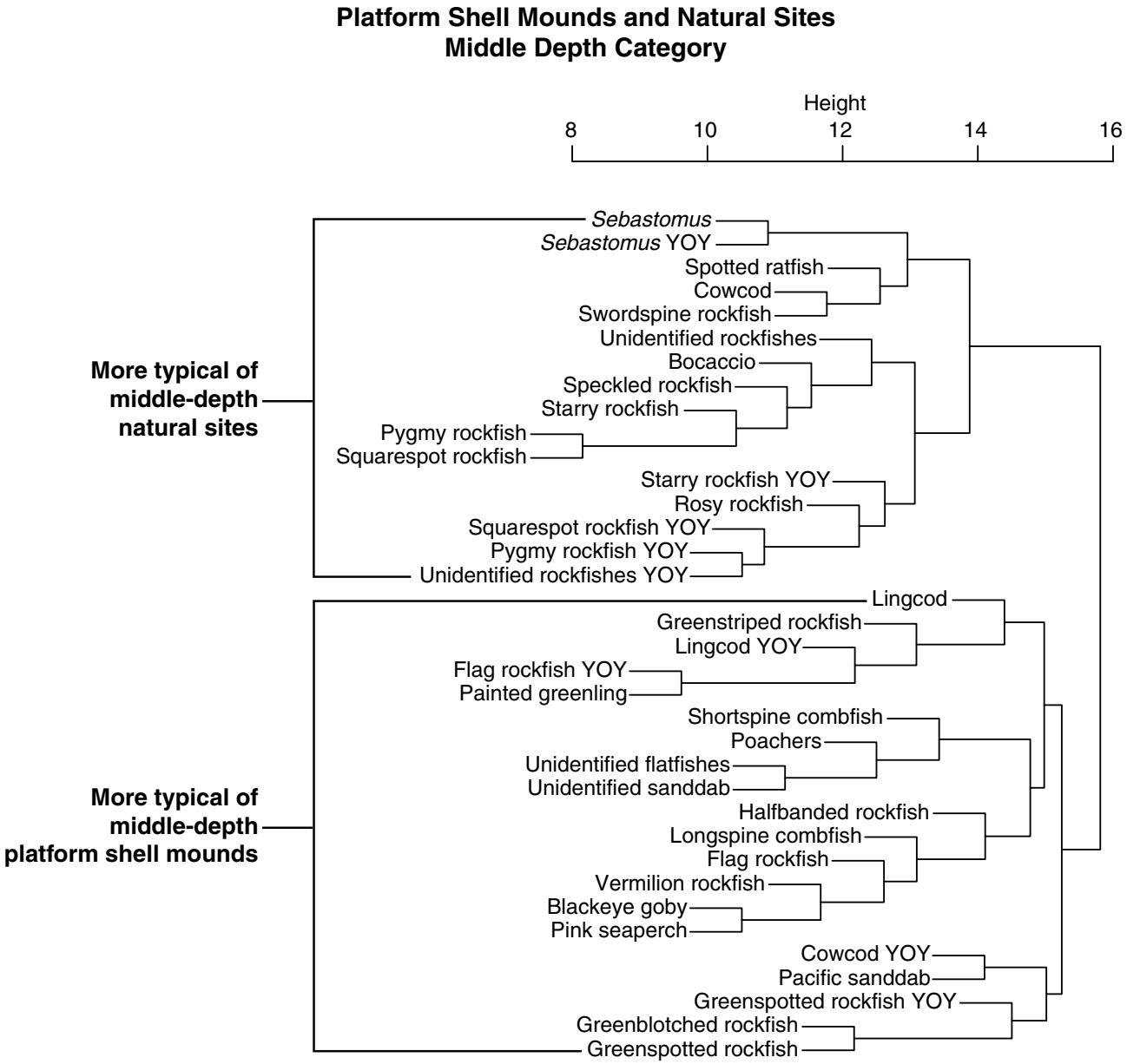

Figure 39. A cluster analysis of the characteristic species of platform shell mounds of middle depth platforms (84–136 m) and middle depth natural sites. Data is based on surveys conducted in 2004–2009.

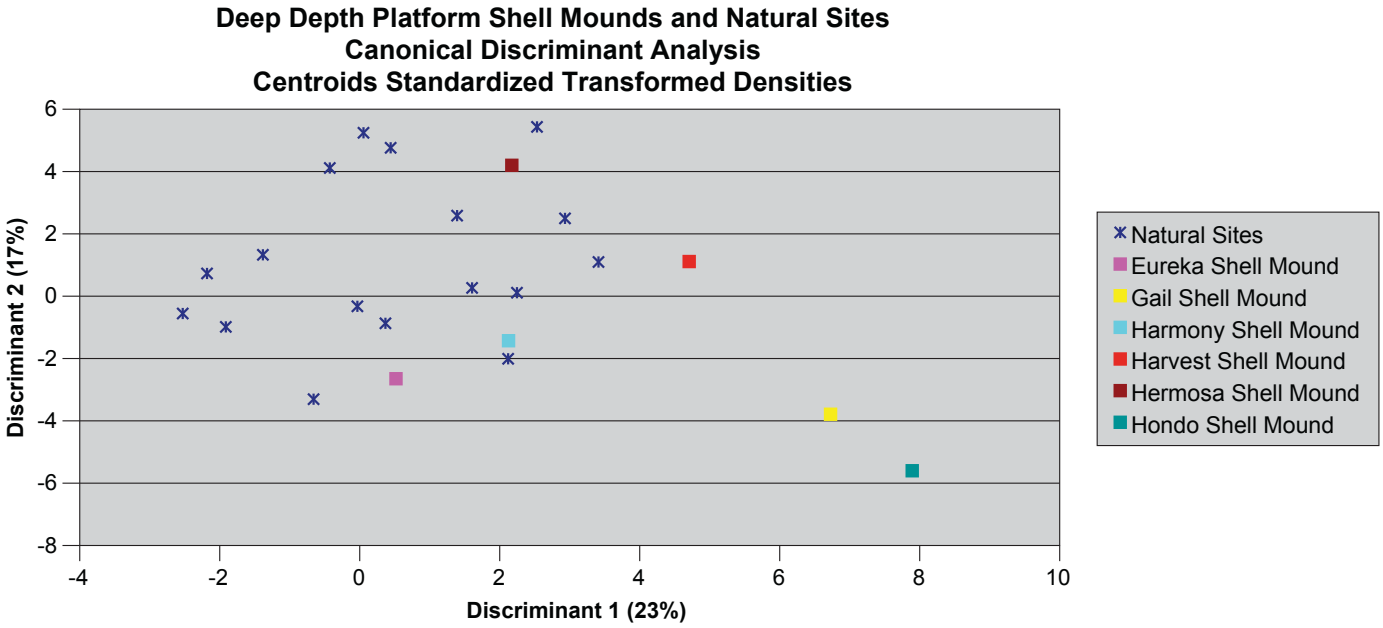

Figure 40. A canonical discriminant analysis comparing the shell mound fish assemblages of deep depth platforms (137 m) with deep depth natural sites. Data is based on centroids of surveys conducted in 2004–2009.

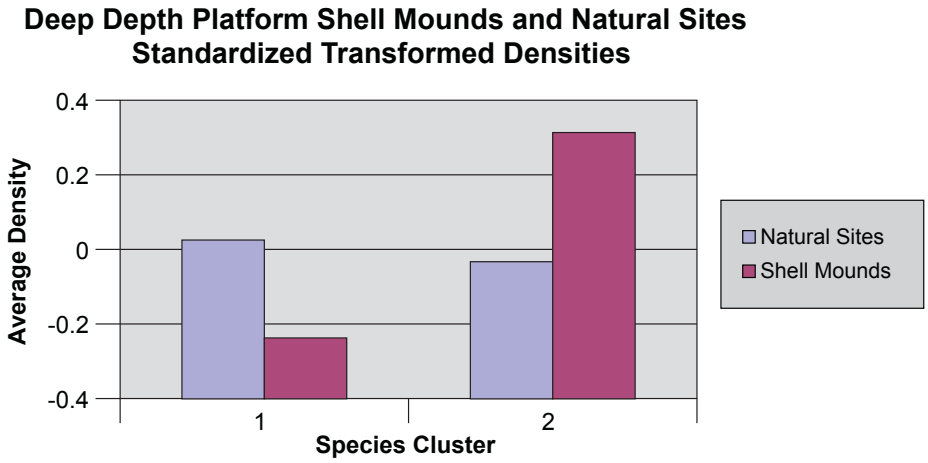

Figure 41. A comparison of densities of the two deep depth platform shell mound and natural sites speciesclusters shown in Figure 42.

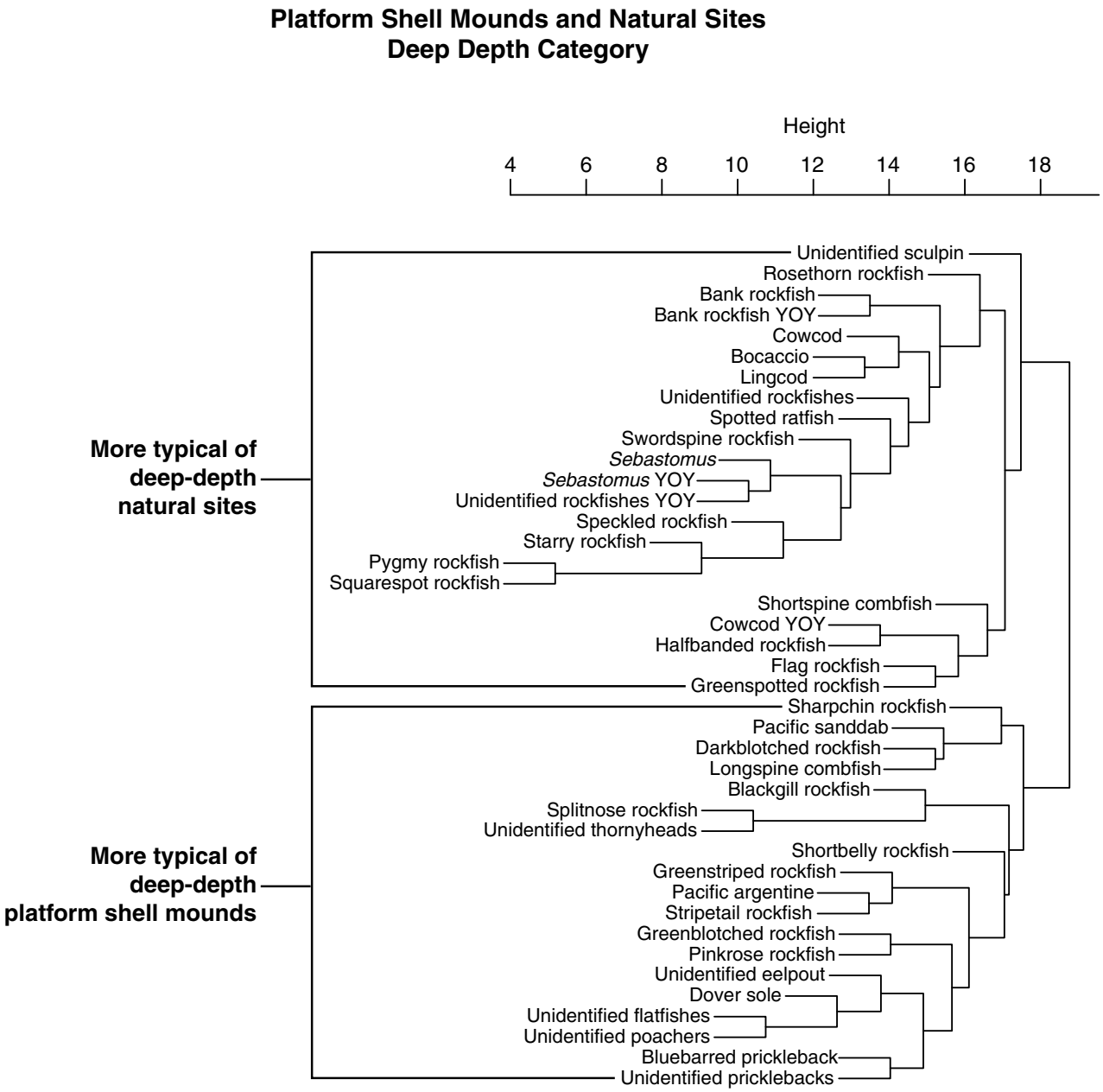

Figure 42. A cluster analysis of the characteristic species of platform shell mounds of deep depth platforms (>137 m) and deep depth natural sites. Data is based on surveys conducted in 2004–2009.

We compared the species assemblages at Platform Hidalgo with that of nearby North Reef (Table 8), using data from 2005, 2006, and 2009. The platform and reef were always sampled on the same day, are both in the same water mass and about the same water depth (Hildalgo, 130 m; North Reef, 97 m). Analyses yielded four fish assemblages, midwater, bottom, shell mound, and reef (Figure 43), although there was considerable between-habitat sharing of species (Figures 44–45). In particular, a suite of both high-relief and low-relief species were typical of both Hidalgo bottom and North Reef. The density of YOY rockfishes was higher at Hidalgo than at North Reef in each of the three years (Figure 46). In 2009, densities of these YOY were 38 times higher at Hidalgo.

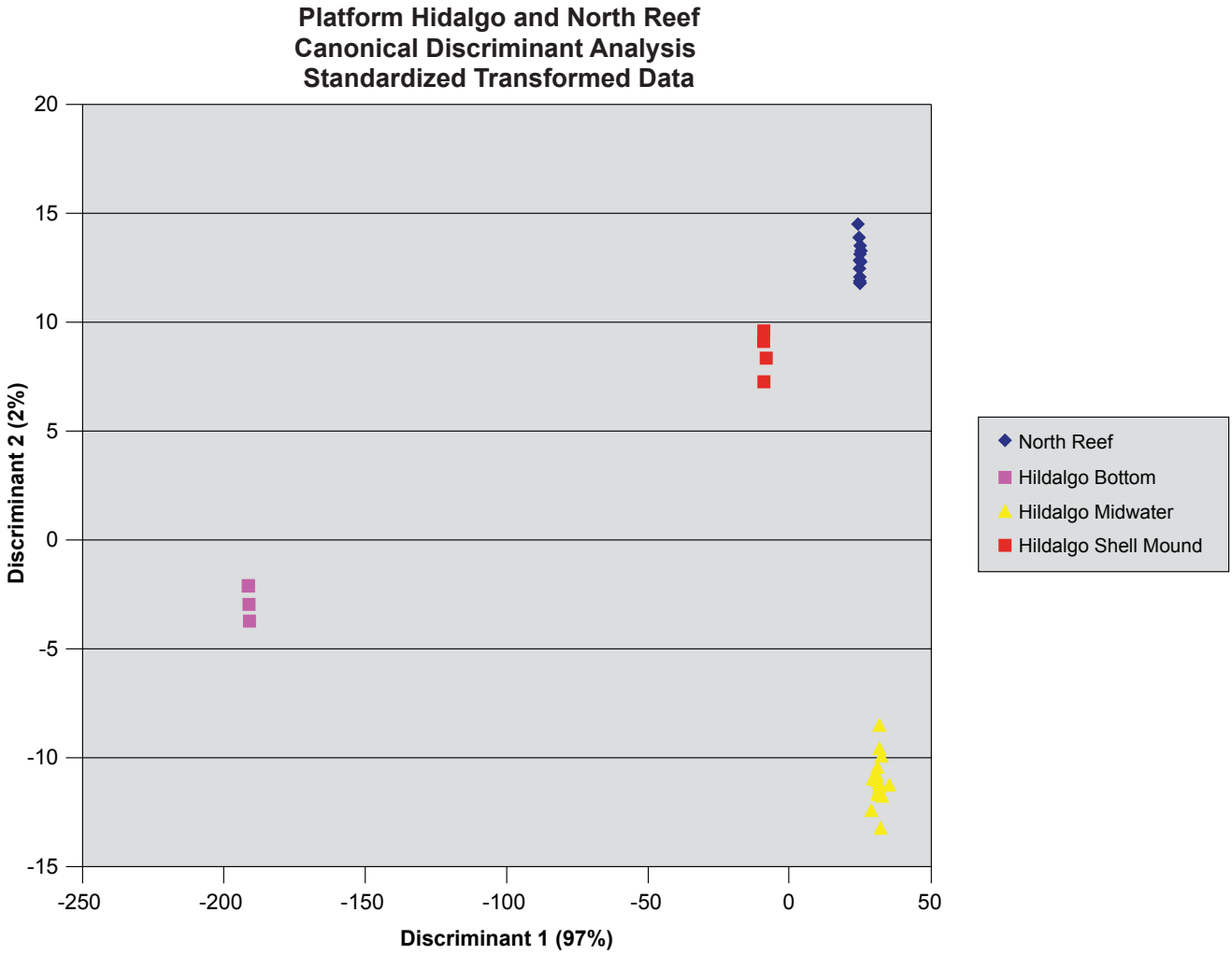

Figure 43. A canonical discriminant analysis comparing the midwaters, bottom, and shell mound fish assemblages of Platform Hidalgo with the fish assemblage of North Reef, 2005, 2006, and 2009.

Table 8. Numbers and densities (average number per 100 m^2) of fish species observed at North Reef 2005–2006 and 2008–2009.

Species	Number	Density
Pygmy rockfish	596	5.9
Squarespot rockfish	589	5.5
Vermilion rockfish	422	5.3
Halfbanded rockfish	387	4.0
Unidentified rockfish YOY	343	4.5
Pygmy rockfish YOY	340	4.2
Greenspotted rockfish	291	3.3
Sebastomus spp.	180	2.0
Yellowtail rockfish	101	1.2
Shortspine combfish	99	1.2
Blackeye goby	97	1.1
Starry rockfish	93	1.1
Greenstriped rockfish	45	0.5
Sebastomus YOY	45	0.5
Speckled rockfish	41	0.4
Greenblotched rockfish	38	0.5
Pink seaperch	38	0.4
Bocaccio	30	0.4
Unidentified rockfishes	26	0.3
Flag rockfish	24	0.3
Swordspine rockfish	22	0.2
Unidentified fishes	20	0.2
Widow rockfish	16	0.2
Starry rockfish YOY	13	0.2
Rosy rockfish	11	0.1
Cowcod	10	0.1
Unidentified combfishes	9	0.1
Longspine combfish	9	0.1
Pinkrose rockfish	8	<0.1
Canary rockfish	7	<0.1
Lingcod	6	<0.1
Unidentified flatfishes	5	<0.1
Longnose skate	2	<0.1
Pink rockfish	2	<0.1
Rosethorn rockfish	2	<0.1
Squarespot rockfish YOY	2	<0.1
Widow rockfish YOY	2	<0.1
Unidentified cusk-eel	1	<0.1
English sole	1	<0.1
Greenspotted rockfish YOY	1	<0.1
Greenstriped rockfish YOY	1	<0.1
Kelp greenling	1	<0.1
Lingcod YOY	1	<0.1
Olive rockfish	1	<0.1
Painted greenling	1	<0.1
Red brotula	1	<0.1
Shortbelly rockfish	1	<0.1
Unidentified ronquil	1	<0.1
Tiger rockfish	1	<0.1
Yelloweye rockfish	1	<0.1
Total	3,984	
Minimum number of species	37	
Total rockfish YOY	747	
Total rockfishes	3,692	
Rockfish YOY comprised 18.8% of all fishes surveyed		
All rockfishes comprised 92.7% of all fishes surveyed		

Discussion

This research confirms and expands the observations we have previously reported upon (summarized in Love et al. 2003). The fish assemblages of California oil and gas platforms are quite diverse and not easily summarized. Nevertheless it is clear that:

1) There are three fish assemblages around each platform (midwaters, bottom, shell mound);
2) Within each of these assemblages, midwater assemblages tend to be similar across platforms, while there are substantial differences among those found at bottoms and shell mounds. Assemblages at any platform changed little over the course of the study;
3) In general, the assemblages of platforms and natural sites are different, and these differences are mainly based on variability in species' densities;
4) All of the platforms we surveyed serve as nursery grounds for a variety of rockfishes and other taxa and, in general, platform habitats harbor higher densities of young fishes than do many natural sites.
5) The bottoms of some platforms harbor higher densities of larger, and economically important, fishes than do most or all natural sites.

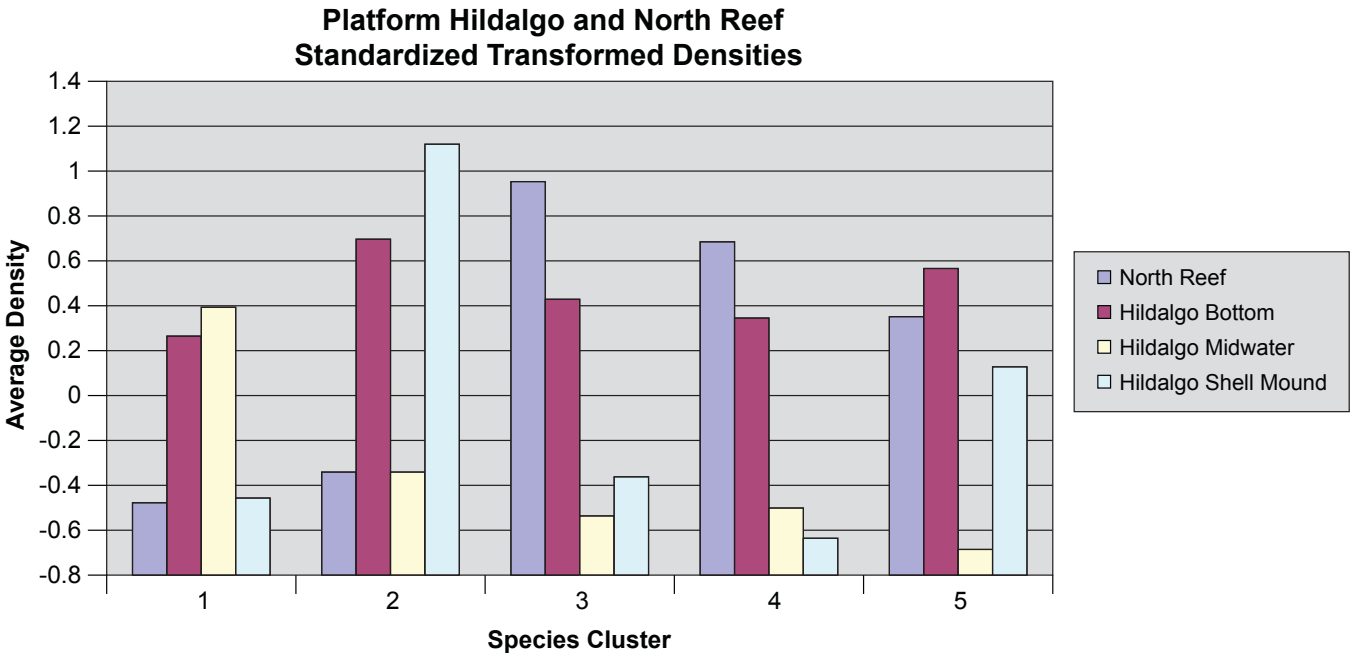

Figure 44. A comparison of densities of the five Platform Hidalgo midwaters, bottom, and shell mound and North Reef species clusters shown in Figure 45.

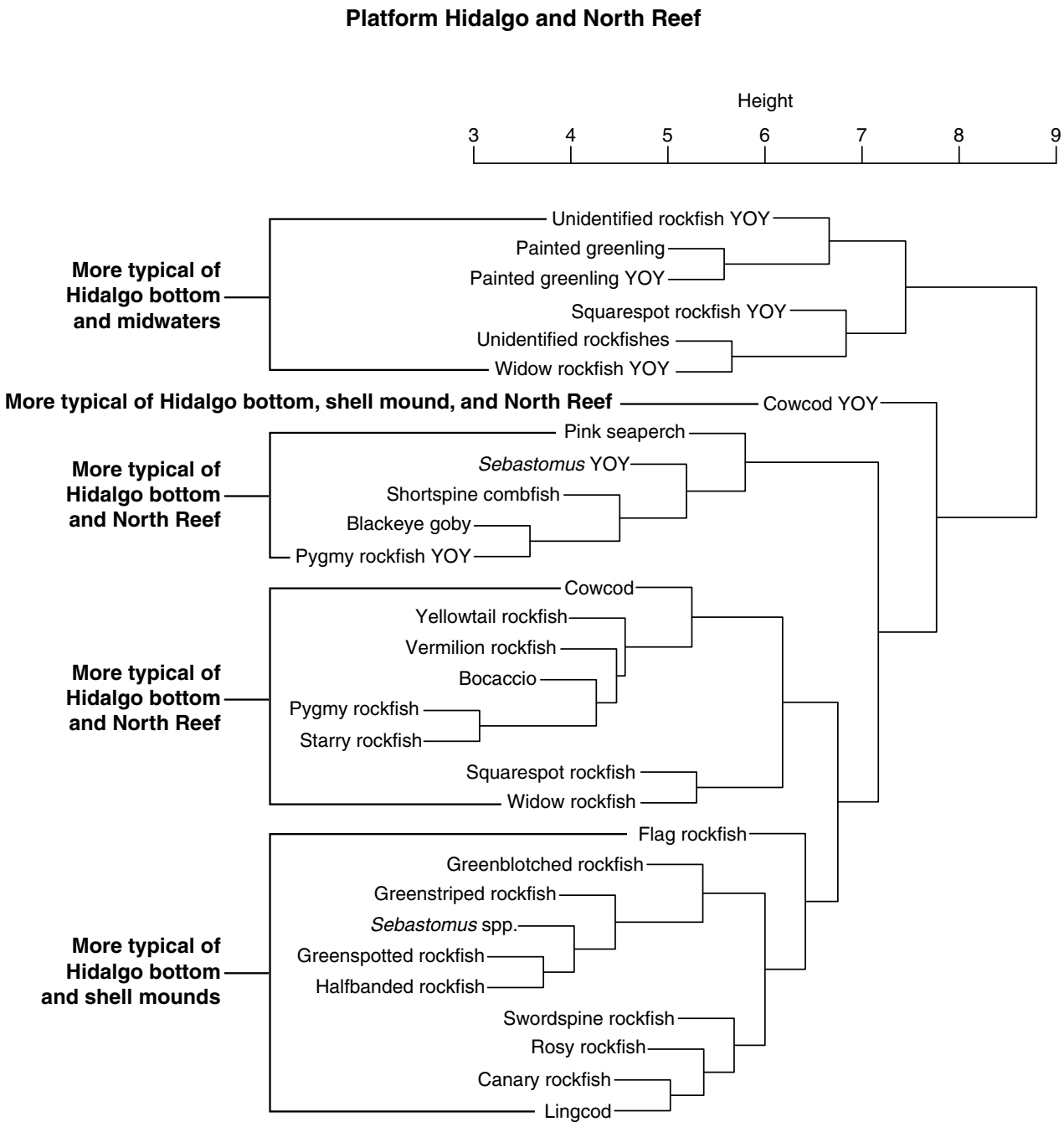

Figure 45. A cluster analysis of the characteristic species of midwaters, bottom, and shell mound of Platform Hidalgo and North Reef. Data is based on surveys conducted in 2005, 2006, and 2009.

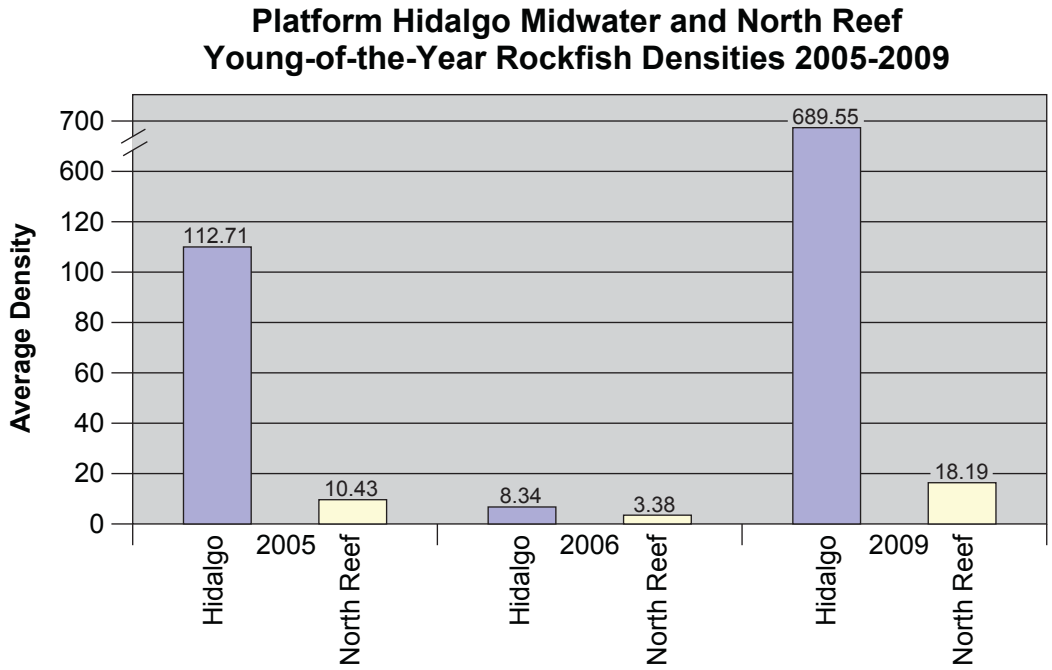

Figure 46. Densities of young-of-the-year rockfishes at Platform Hidalgo midwaters and North Reef, 2005, 2006, and 2009.

A range of juvenile and adult fishes inhabits platform midwaters, although this assemblage has much in common among all of the platforms surveyed. Typical species whose juveniles recruit to platforms include bocaccio, flag, shortbelly, squarespot, and widow rockfishes, and also of such taxa as blacksmith, garibaldi, and painted greenling. Depending on platform, this assemblage also contains the adults of a number of nearshore reef species (e.g., cabezon, garibaldi, kelp bass, painted greenling, pile perch, and sheephead). With the exception of an occasional school of jackmackerel, we did not observe large number of pelagic species in this habitat. The more northerly platforms, particularly those north of Point Conception, harbor fewer nearshore species and thus contain a lower overall number of taxa. Because juvenile recruitment is driven by oceanographic conditions, it is not surprising that rockfish recruitment is highly variable between years and platforms (Figure 47a, b). The role that habitat complexity plays in influencing midwater assemblages is discussed in Task 2.

The bottom assemblages are quite variable among platforms and the compositions of these assemblages are driven both by platform architecture and bottom depth. As noted by Love and York (2006), those platforms that have a bottom cross beam that is undercut to form a "crevice" (e.g., Gail, Hidalgo, Irene) have higher densities of shelter-seeking fishes (e.g., bocaccio, flag and canary rockfishes, cowcod) than do those structures (e.g., Hermosa and Harvest) whose cross beams are either buried in mussel shells or deeply undercut (forming a wide gap). These latter platforms tend to have bottoms that are dominated by such species as halfbanded rockfish, a schooling mobile taxa that is not limited to complex habitats. Bottom depth is also an important determinant of species composition as the three species clusters that we observed around platform bottoms (linked to depth) are similar to those that occur over natural sites within the southern California Bight (Love et al. 2009). Interestingly, the peaks in species richness that we observed in platforms situated in about 60–80 m also occurred at natural sites throughout the southern California Bight (Love et al. 2009).

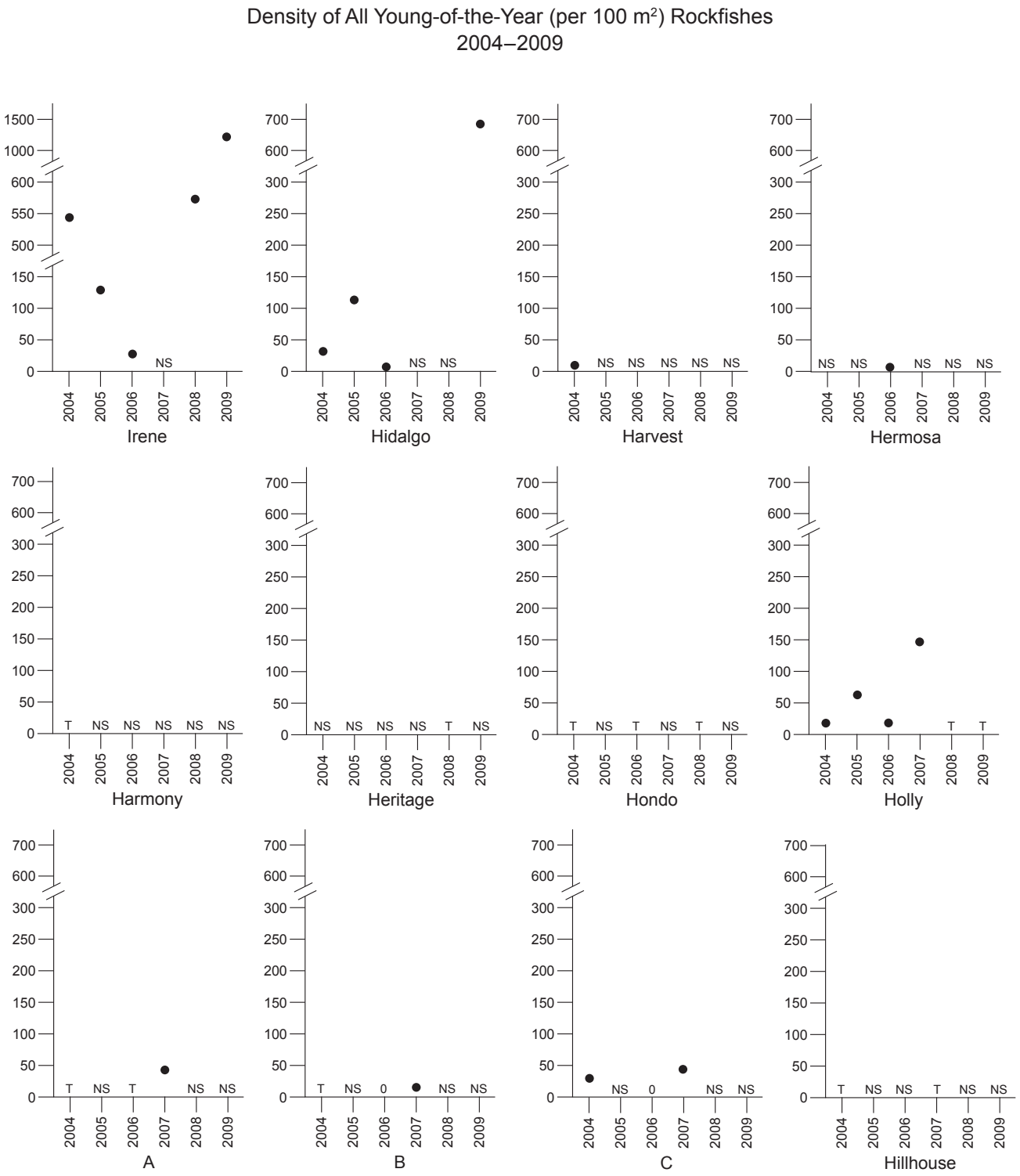

Figure 47a. Densities of young-of-the-year rockfishes in the midwaters of all platforms, by year. NS = platform not sampled and T = trace.

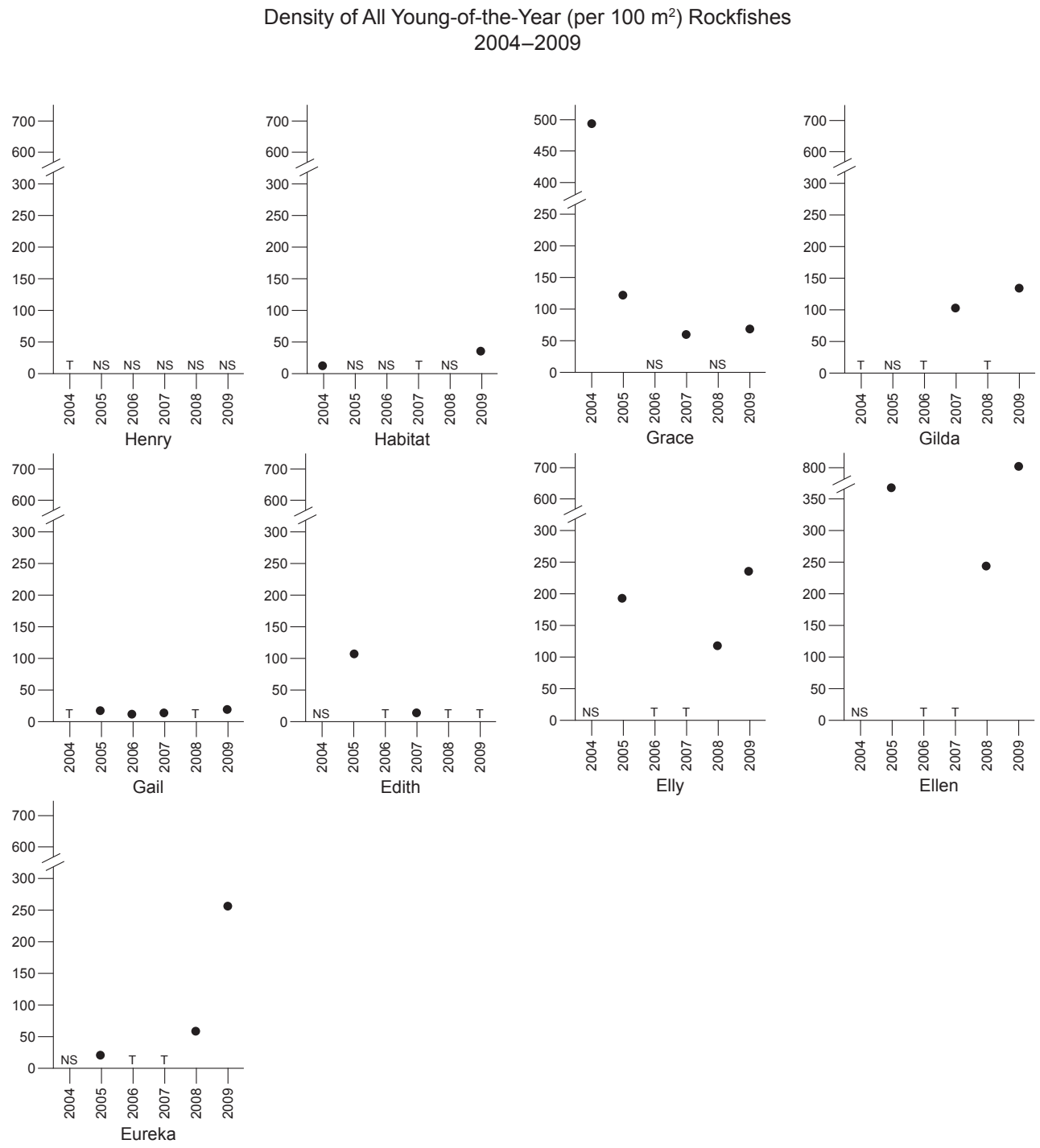

Figure 47b. Densities of young-of-the-year rockfishes in the midwaters of all platforms, by year. NS = platform not sampled and T = trace.

Although platform bottoms often harbor large numbers of adults, the YOYs of a number of taxa are also found there. Some of these young juveniles (e.g., bocaccio, painted greenling, and squarespot rockfish) also occupy the platform midwaters and these individuals may have first recruited to the shallow portions of the platform before moving to the bottom. However, the YOYs of other fishes (e.g., lingcod and halfbanded rockfish) are only rarely found in platform midwaters and these may recruit from the plankton directly to the bottom.

In contrast to the robust and sometimes complex habitat that platform bottoms provide, the shell mounds are of only moderate relief and complexity. Because of this, most of the dominant shell mound species are those that are adapted to living over relatively low relief. Typical species include the young of larger taxa, such as cowcod and lingcod, along with a range of diminutive species, including painted greenling, pink seaperch, and a variety of poachers, combfishes, and rockfishes. With only a few exceptions, these are small, solitary, and often benthic fishes. Exceptions are a few schooling taxa, such as halfbanded rockfish, that are often found in groups of hundreds or even thousands. This pattern appears to break down somewhat in deeper waters, where some larger rockfishes, such as greenblotched, greenspotted, and pinkrose, occupy both the platform bottoms and shell mounds. These species may be more "generalist" in their habitat needs and may move more freely from bottom to shell mound.

The species assemblages at every platform were relatively stable throughout the survey period. That is, the overall interannual variability within an assemblage was low (Figures 5, 9, 13). This is not to say that densities of all of the species in an assemblage were identical from year to year. Clearly, for instance, some habitats, particularly midwater ones, are subject to great interannual variation in rockfish recruitment. However, despite these periodic influxes, each assemblage at every platform has a suite of "typical" species that do not appear to appreciably vary from year to year.

Generally, all three of the platform species assemblages are different from those at natural sites. Importantly, these distinctions are due more to differences in species' densities rather than to the presence or absence of certain taxa (Table 4). That is, there are relatively few species that are present in large numbers at either a platform or natural site and are completely absent from the other. What might promote these differences? First, as noted in our previous surveys (Love et al. 2003), there are generally higher densities of juvenile fishes (particularly YOY fishes) at many platforms than at most natural sites (Figure 48). For instance, most of the top 20 sites with highest YOY rockfish densities measured either in a single year or averaged over the six-year survey, were at platforms (Table 9). These high densities occurred not only in platform midwaters but also at bottoms and occasionally shell mounds (Table 9). And, as noted previously, even reefs that are in close proximity to platforms (e.g., North Reef and Hidalgo) almost invariably have lower densities of YOY rockfishes (see Figure 46). The enhanced nursery function exhibited by platforms is due to several factors. First, during its pelagic stage, a juvenile rockfish is more likely to encounter a platform (extending from sea floor to surface) than the deep natural reefs we surveyed. Second, with a few exceptions, platform midwaters and shell mounds, in particular, tend to harbor relatively few large fishes and thus predation rates on YOYs are likely low (Love and Schroeder 2006).

Most of the fishes that we observed living around platforms and natural sites were relatively small, primarily 15 cm or less in length (Figure 48). These were both juveniles of a variety of taxa (e.g., bocaccio, lingcod, widow rockfish) and dwarf species (e.g., painted greenling, squarespot and halfbanded rockfishes). Larger fishes (25 cm and above) were less common (Figures 48, 49) and these were most often found around platform bottoms (Figure 49). In addition, and supporting observations from earlier surveys (Love et al. 2003), some platform bottoms (e.g., Gail and Irene), harbor higher densities of species of economic importance (both juveniles and adults) than do most, or all, natural sites (Figures 27, 30, 33). It is likely that these high densities are due to a combination of several factors. First, and as documented by Love and York (2006) and Love et al. (2006), many economically important rockfishes (e.g., cowcod, bocaccio, and cop-

Table 9. Locations with the highest densities of young-of-the-year rockfishes (YOY) for A) a single year and B) averaged over all years. Density in number of fish per 100 m^2.

A) ROCKFISH YOY		B) ALL ROCKFISH YOY	
Platform	Density	Platform	Density
Edith, Bottom, 2005	2,821	Edith Bottom	1,116
Edith, Bottom, 2009	1,570	Irene Midwater	450
Irene Midwater, 2009	1,191	Ellen Midwater	314
Elly Bottom, 2005	836	Wolf Rock	224
Ellen Midwater, 2009	814	Elly Bottom	211
Hidalgo Midwater, 2009	690	Hidalgo Midwater	210
Edith Bottom, 2007	597	Grace Midwater	170
Irene Midwater, 2008	572	Edith Shell Mound	167
Irene Midwater, 2004	538	Anacapa Passage	132
Irene Bottom, 2009	514	Elly Midwater	115
Edith Shell Mound 2005	510	Gull Island	114
Grace Midwater 2004	484	Irene Bottom	108
Edith Bottom, 2006	396	Irene Shell Mound	84
Ellen Midwater, 2005	379	Eureka Midwater	83
Anacapa Passage, 2009	368	Ellen Bottom	73
Anacapa Passage, 2005	341	Gilda Midwater	56
Edith Shell Mound, 2009	333	Holly Midwater	52
Irene Shell Mound, 2009	277	Short Banks	51
Eureka Midwater, 2009	268	Northwest Edith Reef	49
Ellen Midwater, 2008	246	Northeast Anacapa	45

per rockfish) are primarily found over complex substrata and mostly occupy crevices and other sheltering sites. Platforms that have bottom cross beams that are undercut to form a narrow gap (e.g., Irene and Gail) have higher densities of these species than those that do not (e.g., Hermosa and Harvest). As demonstrated in Task II, a unique complexity in the midwaters of one platform produced a midwater species assemblage similar to that found on the bottom. Thus, the importance of structural complexity to this suite of species should not be under estimated. Second, many, or perhaps most, platforms act as *de facto* marine reserves, as fishing pressure at these structures is likely lower than at natural sites. Fishing pressure appears to be lower for at least two reasons. First, some platforms are sited well away from coastal ports, in areas that are often exposed to wind, and thus are difficult to access. Of perhaps more importance is the perceived reluctance of many platform operators, in a post-9/11 world, to have vessels close to their structures.

The shell mounds surrounding California platforms are a unique feature of these structures. They are created by the dislodgement (through wave action and platform cleaning) of attached invertebrates from the upper parts of a jacket. Composed primarily of living and dead mussels, and associated marine life, they

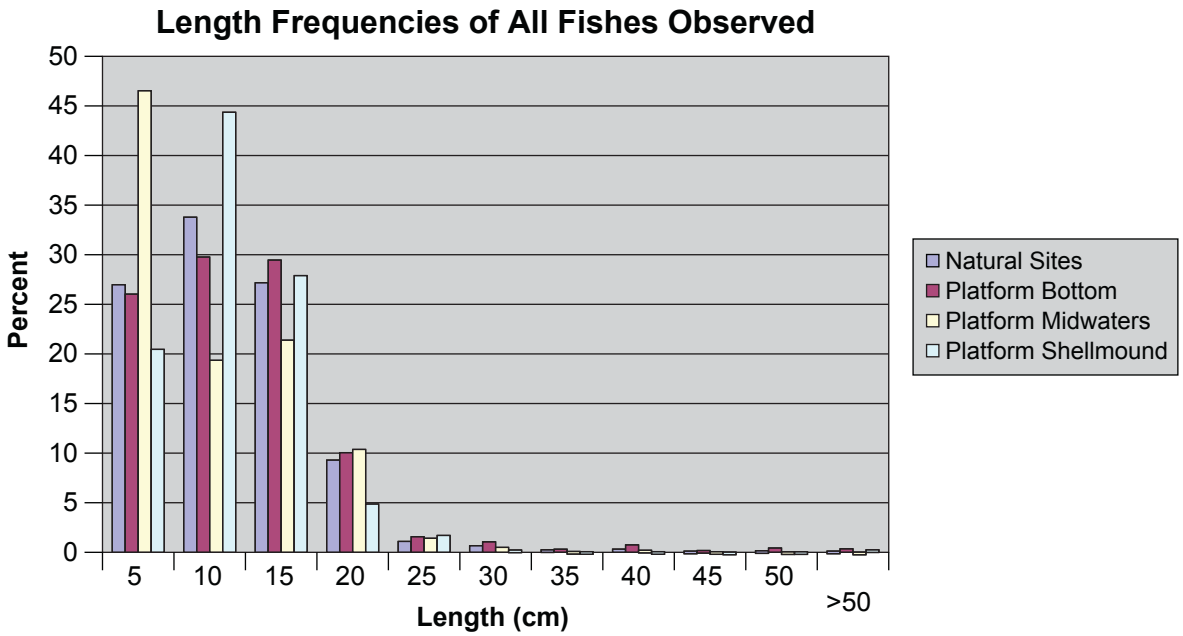

Figure 48. A length frequency histogram of all fishes observed at platform midwaters, bottom, and shell mounds.

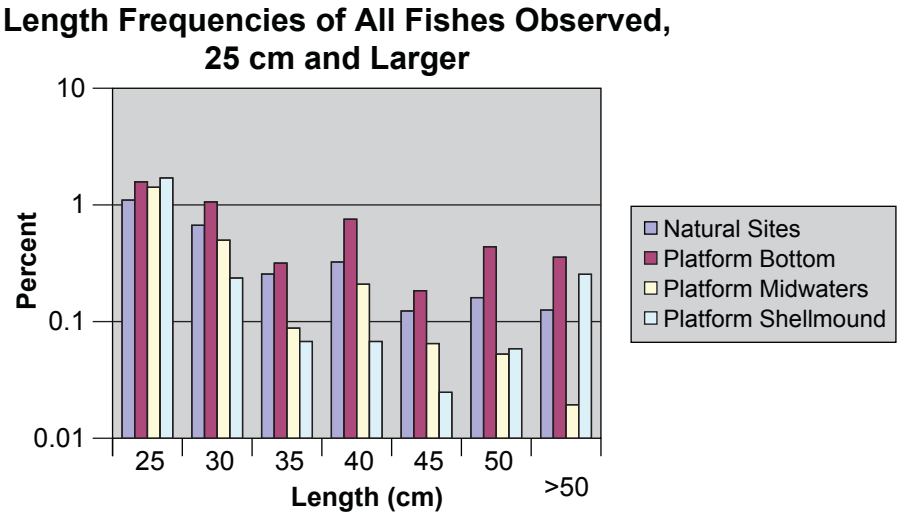

Figure 49. A length frequency histogram of all fishes larger than 25 cm observed at platform midwaters, bottom, and shell mounds. Note that the percent observed on the y-axis is on a log scale.

form an extensive web of low, but rugose, sea floor. The relatively small crevices created by mussel shells deter large numbers of many high-relief species (such as copper and vermilion rockfishes, and adult cowcod) from venturing onto these areas. Rather, most shell mound species are either the juveniles of larger species, whose juvenile stages require small sheltering sites (e.g. cowcod, see Love and Yoklavich 2008), or somewhat generalist species that live over 1) soft sea floors, 2) the ecotones between soft and low-relief hard bottom, and 3) low-relief reefs. While shell mound assemblages in shallow and middle depth waters tend to be different from those of natural sites of the same depths (Figures 34 and 37), deep depth shell mound assemblages more closely resemble those at natural sites (Figure 40).

This is likely because, as noted in Love et al. (2009b), reefs in the deeper waters of California tend to be low relief and thus more like shell mounds.

Acknowledgements

We thank S. Clark, S. Liles, M. Edwards, M. McCrea, and A. Scarborough for their support. Research was conducted aboard the submersible *Delta*, piloted by C. Ijames and J. Lilly, with assistance of the crew of the R/V *Velero*.

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Task 2: A Comparison of Fish Assemblages in the Midwaters of Two California Oil and Gas Platforms

Milton S. Love and William H. Lenarz

Abstract

Between 2005 and 2008, using the manned research submersible Delta, we compared the midwater fish assemblages of two southern California platforms, Gail and Eureka. Platform Gail is a typical California platform, with rounded crossbeams and pilings, while the midwater jacket of Eureka, studded with fascicles of pilings and bowl-shaped piling guides, is much more complex. While the assemblages of both platforms were dominated by rockfishes (Sebastes), there were also significant differences. Compared to Gail, Eureka harbored 1) higher densities both of all species combined and of most species held in common, 2) far more mature individuals of most species, 3) greater species richness, and 4) much higher densities of species that live over complex high relief. We propose that from a fish's perspective, the complex midwater jacket of Eureka, with its many sheltering sites, mimics rugose natural reefs. This research both re-enforces the conclusion that many reef species have quite specific habitat requirements and that the platform decommissioning process must examine each platform individually.

Introduction

In general, there are two distinct fish assemblages living around the jackets (pilings and crossbeams) of deeper-water California oil and gas platforms (with bottom depths >100 m). First, subadult and adult fishes of a number of benthic species (primarily rockfishes, genus *Sebastes*) inhabit the platform jacket-sea floor complex (Love et al. 2000). Many of these species associate with the bottom crossbeam, particularly where that crossbeam has been undercut leaving a long crevice (Love and York 2006). The midwaters (at depths below about 40 m) around most California platforms serve primarily as nursery grounds for rockfishes. The adults of those benthic species adapted to resting on or sheltering in complex habitat are rarely observed in the platform midwaters (Love et al. 2000).

The midwater structures of most California platforms are similarly configured. The platform jacket is a framework of rounded steel crossbeams and tubular vertical sleeves. The main pilings are driven through

Table 1. Depth (m) and perimeter length (m) of cross beams surveyed and number of years survey, platforms Gail and Eureka, 2005-2008.

EUREKA			GAIL		
Depth	Perimeter Length	Years Surveyed	Depth	Perimeter Length	Years Surveyed
59	194	3	49	189	4
79	206	3	70	203	3
101	218	3	93	217	4
123	230	4	116	232	3
144	243	4	141	246	4
165	254	4	166	264	3
190	268	4	195	283	4

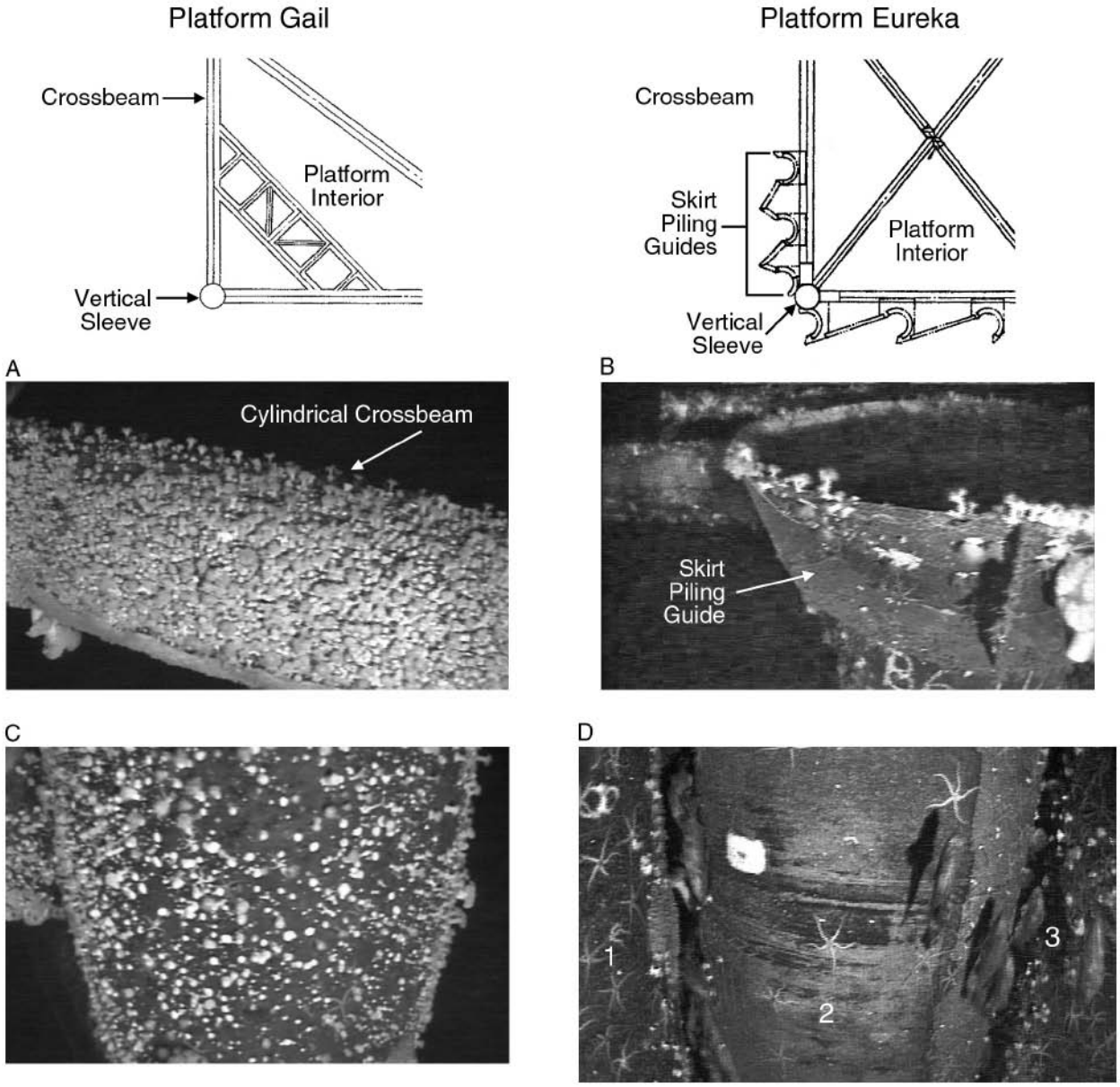

Figure 1. Physical characteristics of the midwater jackets of Platforms Gail and Eureka. Crossbeams (1A) and pilings (1C) of Plat form Gail are cylindrical and lack structural complexity. Crossbeams of Platform Eureka have bowl-shaped skirt piling guides (view from outside a piling guide looking inwards toward a crossbeam in rear (1B) and the pilings (1D) are in groups of three (pilings labeled 1, 2, 3) creating a series of crevices. Adult widow rockfish, *Sebastes entomelas* are pictured in Figure 1D.

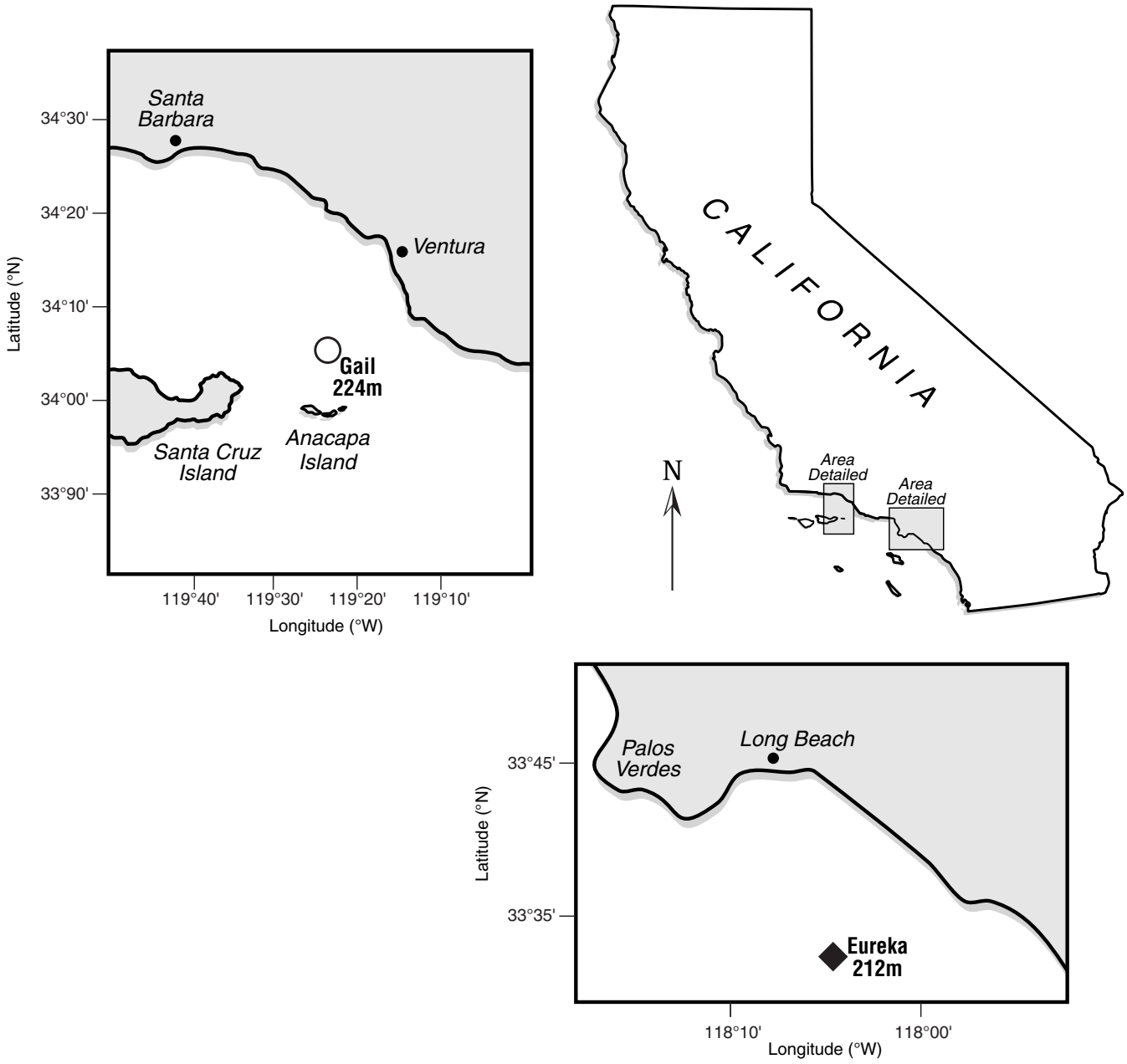

Figure 2. Location and bottom depths of Platforms Gail (open circle) and Eureka (closed diamond).

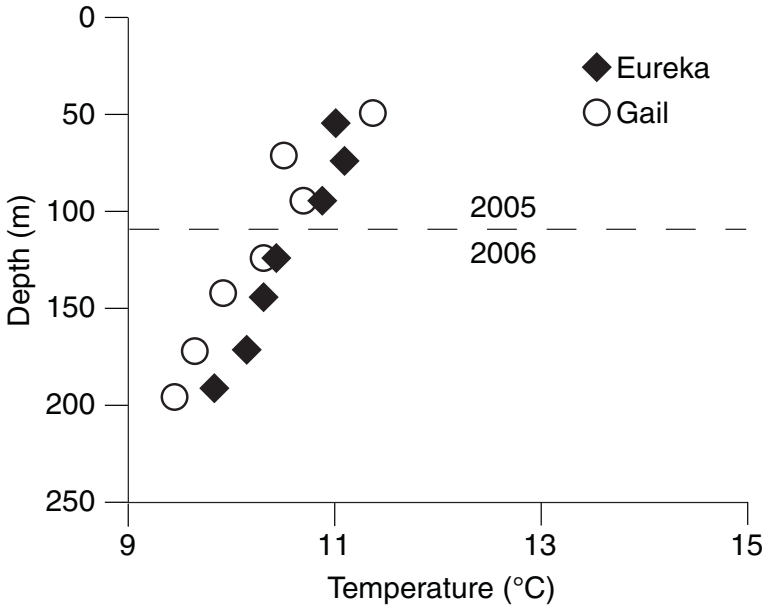

Figure 3. Ambient water temperatures during fish surveys of the midwaters of platforms Gail and Eureka during 2005 (shallow waters) and 2006 (deeper depths). Faulty data from the ctd of the *Delta* research submersible precluded temperature data from the complete water column during either year.

these sleeves, which are located at the corners and sometimes at widely spaced intervals between the corners of the jacket (Figure 1a, c). While the jacket is covered with sessile invertebrates (e.g., mussels, sea stars, sea anemones), most of these organisms are small and do not form significant vertical relief.

Platform Eureka is structurally unique among California platforms. Instead of pilings driven through the vertical sleeves, it has a series of relatively narrow "skirt pilings" that are attached to the outside of the jacket. The skirt pilings are in fascicles of three with a relatively narrow space between each. To guide these pilings into the sea floor, large circular guides were constructed at each crossbeam directly above each piling's location (Figure 1b, d). Thus, compared to a typical California platform, these skirt pilings and guides add a great deal of vertical and horizontal relief to the jacket midwaters.

In this study, we compare the midwater fish assemblages of Platform Eureka with that of Platform Gail, a more typically configured platform. These two platforms are similar in a number of respects. They were constructed at about the same time, Eureka in 1984 and Gail in 1987. Both platforms are about 13 km from shore and stand in similar depths: Gail in 224 m, Eureka in 212 m. Both have nine midwater crossbeams and these crossbeams are situated at comparable depths (Table 1). Although Eureka is found about 118 km to the southeast of Gail (Figure 2), both platforms are in the southern California Bight and are bathed by waters of similar temperatures (Figure 3). Lastly, the dominant natural reef species in the two areas are comparable (Ebeling et al. 1980; Stephens et al. 1984; Love et al. 2009).

Methods

Fish Surveys

We surveyed fishes in the midwaters of platforms Eureka and Gail (Figure 2) annually between 2005 and 2008 during September or October. In each year, the two platforms were surveyed within three days of each other. We used the *Delta* research submersible, a 4.6-meter, 2-person vessel, operated by Delta Oceano-

Table 2. Common and scientific names of fishes mentioned in the text.

Bank rockfish	*Sebastes rufus*
Blackgill rockfish	*Sebastes melanostomus*
Blacksmith	*Chromis punctipinnis*
Blue rockfish	*Sebastes mystinus*
Bocaccio	*Sebastes paucispinis*
Cabezon	*Scorpaenichthys marmoratus*
California sheephead	*Semicossyphus pulcher*
Copper rockfish	*Sebastes caurinus*
Darkblotched rockfish	*Sebastes crameri*
Dwarf-red rockfish	*Sebastes rufianus*
Flag rockfish	*Sebastes rubrivinctus*
Freckled rockfish	*Sebastes lentiginosus*
Garibaldi	*Hypsypops rubicundus*
Gopher rockfish	*Sebastes carnatus*
Greenblotched rockfish	*Sebastes rosenblatti*
Greenspotted rockfish	*Sebastes chlorostictus*
Greenstriped rockfish	*Sebastes elongatus*
Halfbanded rockfish	*Sebastes semicinctus*
Honeycomb rockfish	*Sebastes umbrosus*
Kelp bass	*Paralabrax clathratus*
Kelp greenling	*Hexagrammos decagrammus*
Kelp rockfish	*Sebastes atrovirens*
Lingcod	*Ophiodon elongatus*
Northern anchovy	*Engraulis mordax*
Opaleye	*Girella nigricans*
Pacific hake	*Merluccius productus*
Painted greenling	*Oxylebius pictus*
Pinkrose rockfish	*Sebastes simulator*
Popeye catalufa	*Pristigenys serrula*
Pygmy rockfish	*Sebastes wilsoni*
Rosethorn rockfish	*Sebastes helvomaculatus*
Rosy rockfish	*Sebastes rosaceus*
Sharpchin rockfish	*Sebastes zacentrus*
Shortbelly rockfish	*Sebastes jordani*
Speckled rockfish	*Sebastes ovalis*
Squarespot rockfish	*Sebastes hopkinsi*
Starry rockfish	*Sebastes constellatus*
Swordspine rockfish	*Sebastes ensifer*
Treefish	*Sebastes serriceps*
Vermilion rockfish	*Sebastes miniatus*
Widow rockfish	*Sebastes entomelas*
Yelloweye rockfish	*Sebastes ruberrimus*

Table 3. Total numbers and average densities (fish per 100 m2) of all fishes observed at the crossbeams of platforms Eureka (depths = 59, 79, 101, 123, 144, 165, and 190 m) and Gail (depths = 49, 70, 93, 116, 141, 166, and 195 m), 2005-2008. Starred species were observed at only one of the two platforms.

PLATFORM EUREKA			PLATFORM GAIL		
Species	Number	Average Density	Species	Number	Average Density
Squarespot rockfish	9893	101.3	Squarespot rockfish	1118	11.1
Unidentified rockfishes1	1448	15.7	Bocaccio	1031	10.0
Widow rockfish	794	5.7	Unidentified rockfishes1	403	3.7
*Speckled rockfish	584	4.9	Widow rockfish	220	2.1
Unidentified *Sebastomus*[2]	137	1.6	Painted greenling	73	0.7
*Blue rockfish	135	1.1	Flag rockfish	45	0.5
Bocaccio	72	0.7	Unidentified *Sebastomus*[2]	33	0.3
Copper rockfish	62	0.7	Pinkrose rockfish	16	0.1
Pinkrose rockfish	53	0.4	Unidentified fishes	13	0.1
*Rosy rockfish	50	0.4	Cabezon	6	0.1
Greenblotched rockfish	46	0.3	Darkblotched rockfish	6	0.1
Flag rockfish	39	0.4	*Pacific hake	3	<0.1
Unidentified fishes	34	0.3	Copper rockfish	2	<0.1
*Starry rockfish	32	0.2	Sharpchin rockfish	2	<0.1
*Pygmy rockfish	30	0.3	*Unidentified sculpin	1	<0.1
Bank rockfish	29	0.2	Gopher rockfish	1	<0.1
*Kelp rockfish	26	0.3	*Kelp greenling		<0.1
Dwarf-red rockfish	20	0.2	Greenspotted rockfish	1	<0.1
Greenspotted rockfish	19	0.1	Swordspine rockfish	1	<0.1
Cabezon	17	0.1	Bank rockfish	1	<0.1
Darkblotched rockfish	15	0.1	*Northern Anchovy	1	<0.1
Shortbelly rockfish	13	0.1	Greenblotched rockfish	1	<0.1
Painted greenling	12	0.1	Shortbelly rockfish	1	<0.1
*Freckled rockfish	10	0.1	Average Total Density		28.7
*Honeycomb rockfish	9	0.1			
*Blacksmith	8	0.1			
Swordspine rockfish	7	0.1			
Gopher rockfish	4	<0.1			
*Rosethorn rockfish	3	<0.1			
Sharpchin rockfish	2	<0.1			
*Vermilion rockfish	2	<0.1			
*Blackgill rockfish	1	<0.1			
*Popeye catalufa	1	<0.1			
*Treefish	1	<0.1			
*Yelloweye rockfish	1	<0.1			
Average Total Density		135.9			
Minimum Number of Species	32			20	
Total Number of Fishes Observed		13,609			2,980

[1]Primarily young-of-the-year rockfishes

[2]Potentially freckled, greenblotched, greenspotted, honeycomb, pinkrose, rosy, starry, or swordspine rockfishes.

graphics of Oxnard, California. In the platform midwater, we conducted surveys along each of the platform's horizontal beams, located at 20 to 30 m intervals between near-surface waters and the bottom. We conducted belt transects around the horizontal beams at a distance of approximately 2 m from the platform, while the submersible maintained a speed of about 0.5 knots.

Submersible surveys were conducted during daylight hours between one hour after sunrise and two hours before sunset. During each transect, the researcher made observations from a viewing port on the starboard side of the submersible. An externally mounted hi-8 mm video camera with associated lights

Table 4. Results of ANOVAS based on fish densities around the midwater cross beams of platforms Eureka and Gail, 2005-2008 with platform, depth, and year as factors. Because not all cross beams were surveyed at each platform in each year, we present two separate analyses. Figure 1A includes data from 2005, 2007, and 2008, from four midwater depths, 50-59, 90-101, 140-141, and 190-192 m. Figure 1B includes data from 2005, 2006, and 2007 and includes surveys of cross beams at 116-123, 141-144, 165-166, and 190-195 m. ** = significant at 99% level, * = significant at 95% level, ns = non significant.

1A

Species	Platform	Depth	Year	Platform x Depth	Platform x Year	Depth x Year
Squarespot rockfish	**	**	ns	ns	ns	ns
Bocaccio	ns	ns	ns	ns	ns	ns
Widow rockfish	*	ns	ns	*	ns	ns
Speckled rockfish	**	**	ns	**	ns	ns
Pinkrose rockfish	ns	**	ns	ns	ns	ns
Blue rockfish	**	**	ns	**	ns	ns
Copper rockfish	**	**	ns	**	ns	ns
Painted greenling	*	*	ns	ns	ns	ns
Flag rockfish	ns	*	ns	ns	ns	ns
Bank rockfish	**	**	ns	*	ns	ns

1B

Species	Platform	Depth	Year	Platform x Depth	Platform x Year	Depth x Year
Squarespot rockfish	**	**	ns	ns	ns	ns
Bocaccio	ns	*	ns	ns	ns	ns
Widow rockfish	**	ns	*	ns	ns	ns
Speckled rockfish	**	ns	ns	ns	ns	ns
Pinkrose rockfish	*	**	*	ns	ns	ns
Greenblotched rf	**	**	ns	*	ns	ns
Bank rockfish	**	*	*	ns	ns	ns
Darkblotched rf	ns	*	ns	ns	ns	ns
Flag rockfish	ns	ns	ns	ns	ns	ns
Starry rockfish	**	ns	ns	ns	ns	ns

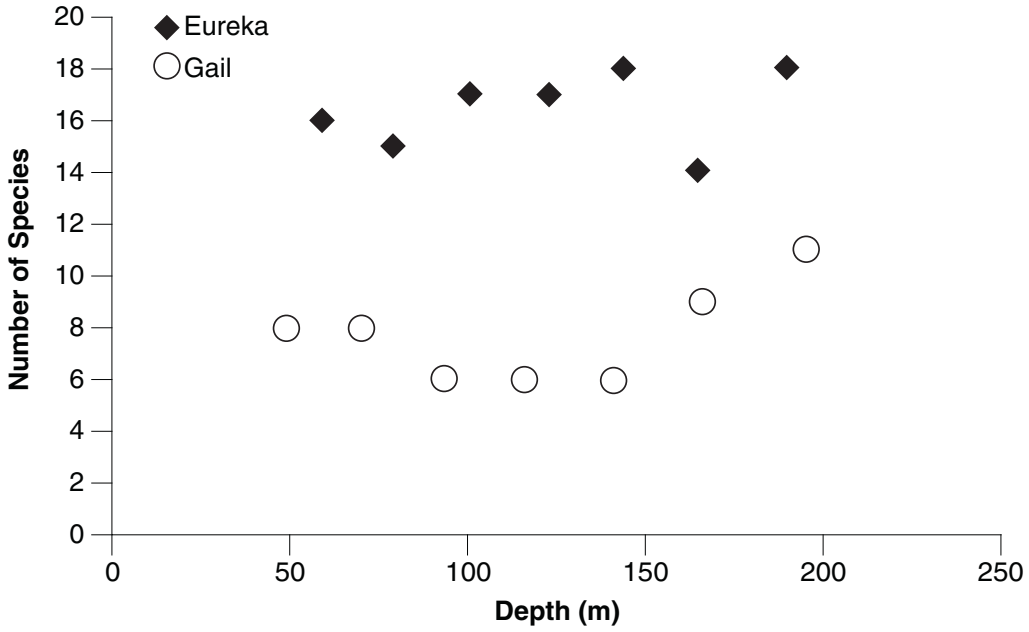

Figure 4. The number of species observed at each cross beam, platforms Gail and Eureka, summarized for 2005-2008.

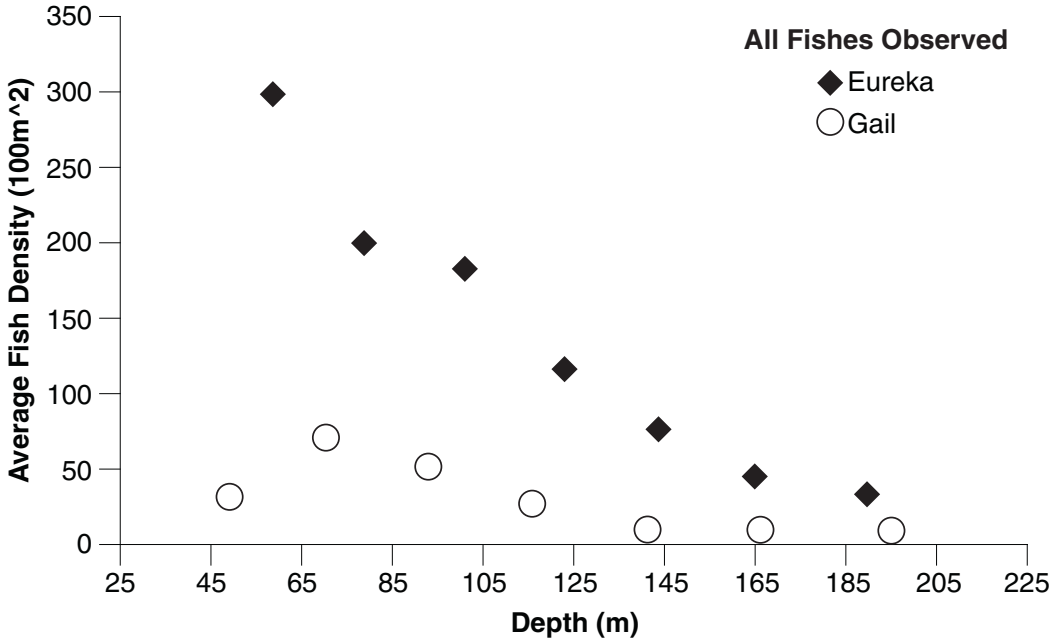

Figure 5. Average densities of fishes surveyed at each crossbeam, platforms Gail and Eureka, for 2005-2008.

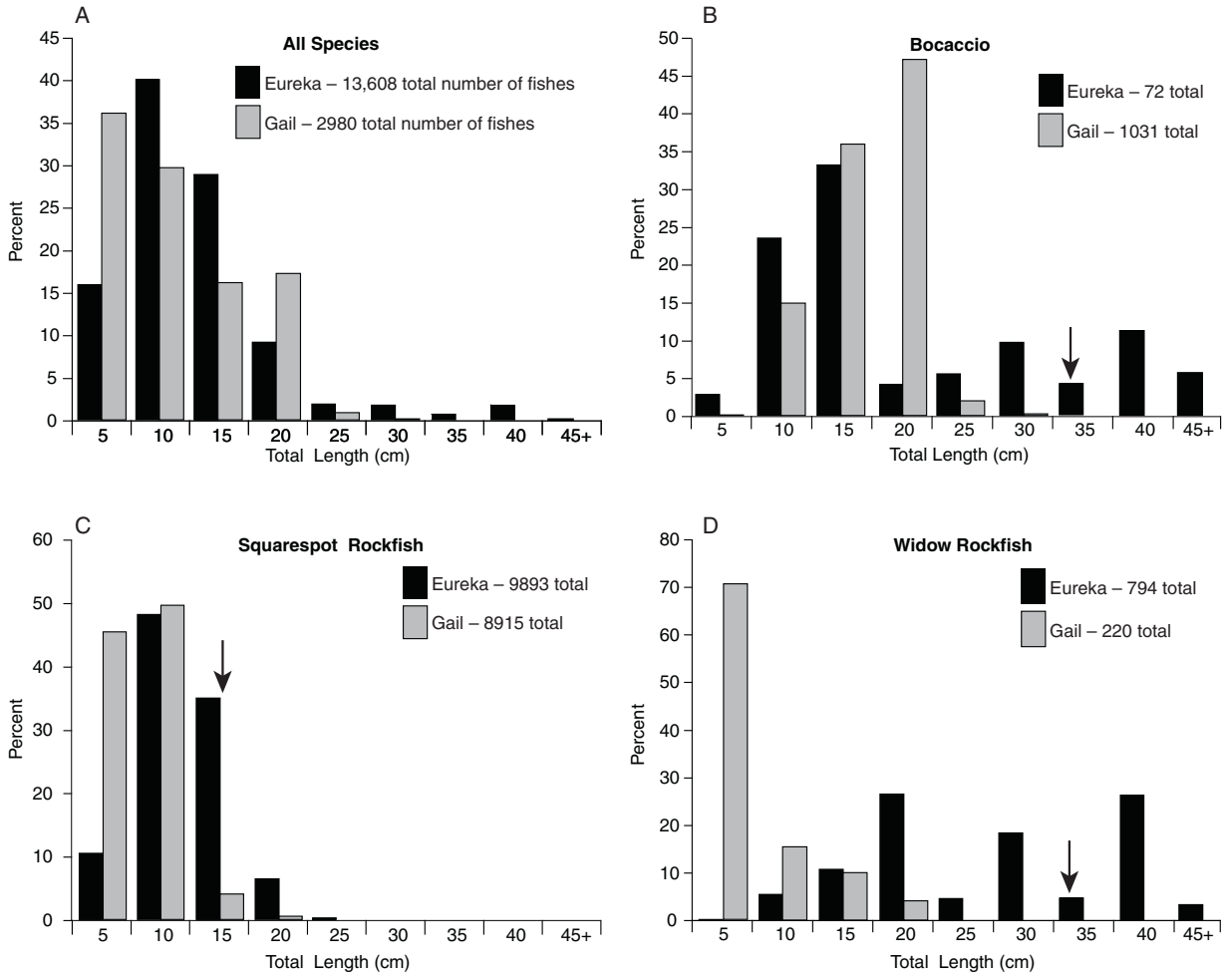

Figure 6. Size frequencies of all species, bocaccio, squarespot and widow rockfishes, observed at the midwater crossbeams of plat forms Gail and Eureka, 2005-2008. Vertical arrows denote length at 50% maturity (from Love et al. 2002).

filmed the same viewing fields as seen by the observer. Images recorded by the camera were laid down on tape. The observer identified, counted and estimated the lengths of all fishes and verbally recorded those data on the videotape. All fishes within two meters of the submersible were counted. Fish lengths were estimated using a pair of parallel lasers mounted on either side of the external video camera. The projected reference points were 20 cm apart and were visible both to the observer and in the video camera image. Many years of experience along the Pacific Coast have shown that if the *Delta* is moving at a constant and slow rate of speed, as in these surveys, there is very little obvious effect on most fishes, particularly rockfishes. Certainly, we noticed virtually no movement from most of the fishes in this study as the research submersible passed

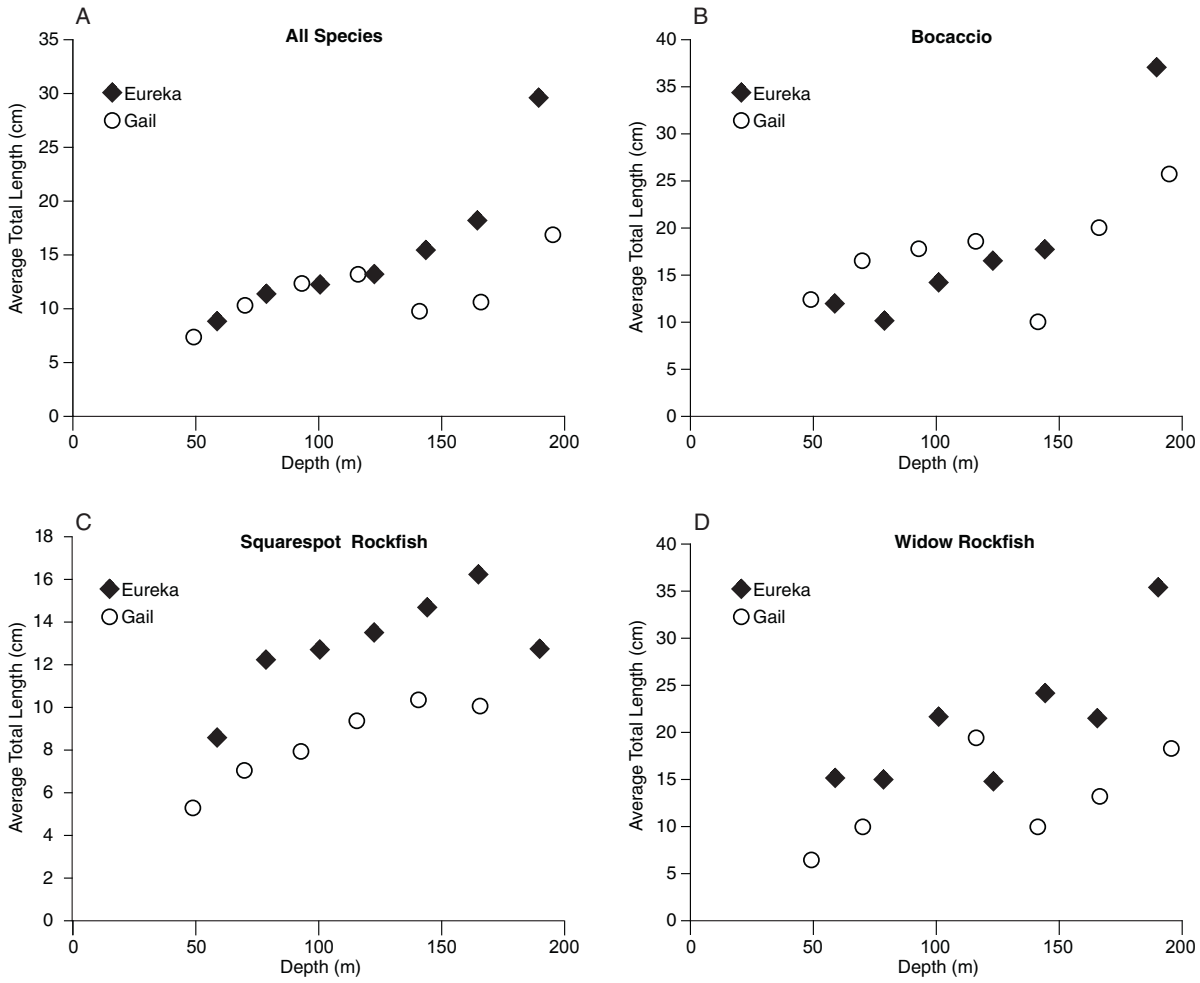

Figure 7. The relationships between depth and average length for all species, and for bocaccio, squarespot and widow rockfishes, platforms Gail and Eureka, 2005-2008.

by. Unless hidden in complex substrate, fishes as small as about 5 cm in length are readily visible within two meters of the submersible.

Data analyses

We used a root-root ($x^{0.25}$) transformation of species densities before performing ANOVAS. Anderson and Yoklavich (2007) worked with similar data and found that the root-root transformation normalized species densities. We used the aov procedure of the statistical package R version 2.8.1 (R-Development Core Team, 2008) to perform balanced factorial ANOVAs of the transformed data for the most common 10 taxa (defined as those with highest combined densities) in two groups of three years (2005, 2007, 2008 and 2005, 2006, 2007). We used two groups of years because we did not sample each crossbeam in each year. Thus, in some instances, a crossbeam was surveyed at one platform but its comparable beam was not surveyed in the other. ANOVAs were conducted on data from those crossbeams surveyed at both platforms in the same year. We used platform, depth, and year as factors. We assumed that the three-way interaction was non-significant

and used it as the error term. Four depths were sampled at each platform during each year of a year group resulting in 24 observations. There was some overlap in the two sets of ANOVAs as two depths, two years, and seven species were held in common. Of the 240 observations used in one group of ANOVAs, 56 were also used in the other group.

Results

We observed 13,609 fishes of at least 32 species at Platform Eureka and 2,980 fishes of at least 20 species at Platform Gail (Tables 2, 3). Total average fish density was much higher at Eureka (135.9 individuals per 100 m^2) than at Gail (28.7 individuals per 100 m^2). Rockfishes (genus Sebastes) dominated both assemblages, comprising 99.5% and 96.7% of all fishes observed at Eureka and Gail, respectively. A minimum of 28 rockfish species (28 species at Eureka and 14 at Gail) inhabited the platform midwaters. Those species with highest densities at Eureka included squarespot, widow, speckled, and blue rockfishes, while squarespot and widow rockfishes and bocaccio dominated the midwaters of Gail (Table 3). Fifteen species were unique to Eureka and four species were found only at Gail. Of the species shared by the two structures, the densities of almost all species were higher at Eureka, sometimes by a factor of 10 or more. The number of species around the crossbeams varied with depth (ranging from 6-11 at Gail, and 14-18 at Eureka) and tended to be highest around the deeper members (Figure 4). Between the two platforms, species numbers were higher at all depths at Eureka and usually 2-3 times that of Gail.

For a majority of the common species, there was a significant difference in densities both between platforms and among depth (Table 4). There were insignificant year effects for almost all of the tests, no significant platform-year and depth-year interactions, but the platform-depth interaction often was significant in the first group of tests (Table 4). At both platforms, and with only once exception, fish densities were highest in shallow waters and progressively declined with depth (Figure 5). Fish densities were much higher at all of the crossbeams at Platform Eureka compared to those at Gail as even the lowest density at Eureka (in 190 m) was almost equal to the highest observed at Gail (in 70 m). Very few fish of any species were observed around Gail's deepest three crossbeams (Figure 5).

Most of the fishes that we observed were small, usually 20 cm TL or less long and only one fish larger than 30 cm was observed around Gail (Figure 6a) compared to several hundred fish, ranging to over 45 cm, at Eureka. Similarly, very few adult fishes lived around Gail. As an example, Gail harbored almost no adults of the three species that were relatively abundant at both platforms (e.g., bocaccio, squarespot, and widow rockfishes) (Figure 6b–d). Substantial numbers of mature individuals of all of these species were present at Eureka (Figure 6b–d). Most of the fish at Gail were young-of-the-year (YOY) rockfishes, primarily bocaccio, squarespot, and widow rockfishes (Figure 6b–d). YOY rockfishes were also a major part of Eureka's fish assemblage, but comprised somewhat less of the total individuals observed.

Fish sizes tended to increase with depth (Figure 7a). The average size of fish was similar between the platforms until a depth of about 150 m, when fish size increased abruptly at Eureka. Of the three most abundant species, bocaccio was similar sized throughout most of the depths, although fish in 200 m were much larger at Eureka (Figure 7b). Both squarespot and widow rockfishes generally were larger at each depth at Eureka (Figure 7c, d).

Discussion

There is a substantial body of research clearly demonstrating that at relatively local scales reef fish assemblages are structured by such habitat characteristics as bottom depth, relief, and sea floor composition (Lecchini and Tsuchiya 2008; Anderson and Yoklavich 2007). Among deeper-water Pacific Coast reefs, many species differentially associate either with high relief, such as boulders (e.g., squarespot and rosy rockfishes), or low relief, which is often a mixture of cobble and mud (e.g., halfbanded and greenstriped rockfishes)

(Anderson and Yoklavich 2007; Love et al. 2009). At an even finer scale, within high relief the presence of caves, crevices, and other reef complexity also has a significant effect on species composition (Caselle et al. 2002; Love and York 2006; Love et al. 2006a). Indeed, there are a number of rockfish species, such as bocaccio, pinkrose, and copper rockfishes that, although not limited to complex habitat, are far more abundant there (Love and York 2006; Love et al. 2006a). In addition, habitat requirements may change as fish mature. For instance, newly recruited young-of-the-year cowcod (*Sebastes levis*) live primarily among cobbles and proceed to move into complex, high relief as they mature (Love and Yoklavich 2008).

At both platforms, the characteristic fish species we observed in the midwaters are those whose primary habitat is hard substrate reefs. More specifically, in most instances these species are those taxa oriented to complex, high relief habitats. These species include blue, speckled, copper, pinkrose, and rosy rockfishes, and bocaccio (Anderson and Yoklavich 2007; Love et al. 2009). Conspicuously rare or absent from the midwaters of either platform, and from the midwaters of any California platform, are such species as greenstriped, halfbanded, and stripetail rockfishes (Love et al. 2000; Love et al. 2003; Nishimoto et al. 2008), all of which live along mud-rock interfaces and inhabit comparable depths, are abundant in the southern California Bight, and are found on the shell mounds surrounding some platforms (Love et al. 2000; Love et al. 2009).

We observed major differences between the midwater fish assemblages at platforms Gail and Eureka. Specifically, Platform Eureka exhibited: 1) higher overall fish densities and higher densities of most of the species held in common; 2) the presence of larger individuals of a number of species; 3) greater species richness, reflecting an assemblage containing more taxa typical of high-relief reefs. Off California, both species density and species richness are higher around high-relief reefs than over low relief rocks or on soft substrates (Yoklavich et al. 2002; Love et al. 2009). Thus, in all of these respects, compared to Gail the midwater fish assemblage of Platform Eureka more closely resembles the high relief natural reefs of the Southern California Bight.

There were a few similarities in midwater species assemblage patterns. For instance, at both platforms, overall species densities declined with depth. This was also observed on natural reefs in the southern California Bight, where overall fish densities peaked at depths of about 100 m (Love et al. 2009). On natural reefs, changes in fish densities primarily reflect the depths at which most rockfishes recruit and this, in turn, reflects the availability of zooplankton prey. The general tendency among many species to be larger with depth reflects both a decrease in the abundances of young fishes and a gradual movement of juvenile fishes into deeper waters as they mature (Love et al. 2009).

What is the source of the fishes we observed at the two platforms? It is likely that the vast majority of fishes living in platform midwaters recruit from the plankton as pelagic juveniles. During both this and a number of scuba-based studies we have observed YOYs of many species (e.g., blue, copper, flag, squarespot, and widow rockfishes, bocaccio, and painted greenling) recruiting to platform midwaters. Many of these species also recruit from the plankton to relatively shallow-water natural reefs (Love et al. 2002) and it would be expected that they would react similarly to shallow portions of platforms. A relatively small number of fishes might also have recruited to the platform bottom and swum up the jacket into the midwaters. However, few species recruit to the relatively deep waters at the bottoms of Eureka and Gail, although it is possible that some individuals of such deeper-water taxa as greenblotched, bank, and pinkrose rockfishes could have recruited there and moved into shallower waters along the skirt pilings and vertical sleeves (Love et al. 2009).

Regardless of their shape, dimensions, and location, the midwaters of almost all California oil and gas platforms will, depending on variable annual oceanographic conditions, harbor very high densities of YOY rockfishes (Love et al. 2003; Love et al. 2006b; Nishimoto et al. 2008). Why then are YOYs sometimes present in extremely high densities in these habitats with little shelter? First, the YOYs of some species, such as gopher, copper, and black-and-yellow rockfishes, will hide amongst mussels and anemones. On natural reefs, these species often hide in the kelp or other algae (Love et al. 2002). YOYs of such species as blue and

olive rockfishes and bocaccio form large schools and, at least when small, depend on these for protection, rather than on hiding in crevices. It appears that, as all of these species grow, the need for discrete sheltering sites increases, a need that cannot be filled in the midwaters of Gail and most platforms. Two species, grass and kelp rockfishes, are exceptions to this pattern. Both species recruit as YOYs to the midwaters of platforms and, often lying on or orienting to jacket members, will remain at the crossbeams through adulthood (Martin 2009). In contrast, the presence of large fishes of a number of species demonstrates that many of the fishes that recruit to the midwaters of Eureka remain there as they mature and become adults.

Ultimately, the fishes living in the depths studied utilize the two structures in different ways. At Gail, the crossbeams function as a nursery ground for most species and young fishes remain in the midwaters for a few months to perhaps a year at which point a few species, such as bocaccio and probably flag rockfish, migrate down the jacket and take up residence at the bottom of the platform (Love et al. 2006b). Other species, such as widow rockfish, do not live at the bottom of Gail and thus must migrate away. In general, most of the species of rockfishes that recruit to California platforms as YOYs remain there for at most a few years. If the platform rests in relatively shallow waters, some of these species migrate to the sea floor and take up residence there. As an example, the bottom of Platform Irene, located in central California, harbors high densities of copper rockfish that recruit to the platform midwaters as YOYs. If a platform resides at a depth inappropriate for the adults of a species, they may move to natural reefs. For instance, young bocaccio tagged by the California Department of Fish and Game at platforms sited in about 60 m left after about one year and were recaptured years later on a number of natural reefs as much as 148 km away (Hartmann 1987).

From a fish's perspective, the crossbeams and vertical sleeves of most platforms appear to be rounded structures lacking substantial rugosity and sheltering sites. Because the thick invertebrate covering provides refuge for only the smallest of fishes, sheltering sites in the midwaters of a typical platform occur only where horizontal crossbeams meet vertical sleeves. We have long noted that, on a typical platform, these junctions are often the only places where somewhat larger rockfishes congregate. We should note that the high densities of fishes along Eureka's crossbeams occur only in the narrow spaces formed between the skirt pilings and, in particular, in the vicinity of the bowl-shaped piling guides. Interestingly, the large schools of squarespot, speckled, and widow rockfishes do not form within the bowls, but rather behind them, where the guides meet the crossbeams.

All platforms have finite economic lives and all will eventually be decommissioned. Decommissioned platforms can be totally or partially removed or left in place (Schroeder and Love 2004). One of the issues that will likely be addressed in the decommissioning process is the role that a platform plays as fish habitat. However, although there are substantial similarities among many platforms, the fish assemblages of California oil and gas platforms do not lend themselves to clean generalizations. It is clear that the shallowest waters of many platforms, to depths of about 30 m, harbor typical nearshore reef species, such as kelp bass, opaleye, garibaldi, painted greenling, sheephead, and YOY rockfishes. This is particularly true of the relatively nearshore platforms off Long Beach and those in the southeastern part of the Santa Barbara Channel (Love et al. 2003; Martin 2009). However, more northerly structures have fewer of these temperate reef species and in these midwaters only YOY rockfishes are usually abundant (Love et al. 2003). Around most offshore platforms, in waters below 30 m and down to the sea floor, juvenile rockfishes dominate the midwater assemblage (with the exception of Platform Eureka, which is inhabited by high densities of both juvenile and adult fishes). By comparison, the sea floor-jacket bottom habitat assemblage off deeper water structures is comprised primarily of larger rockfishes and lingcod and the shell mounds surrounding each platform harbor juveniles of various taxa and a number dwarf rockfishes and other benthic species (Love et al. 2000; Love et al. 2003). In these two sea floor habitats, bottom depth drives the species assemblages. All of this complexity reinforces the need to evaluate every platform on a case-by-case basis (Schroeder and Love 2004).

Acknowledgments

We thank M. Edwards, S. Liles, D. M. Schroeder, M. Nishimoto, A. Scarborough, M. McCrea, and S. Clark for their support. Research was conducted aboard the submersible Delta, piloted by C. Ijames and J. Lilly, with assistance of the crew of the R/V Velero.

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