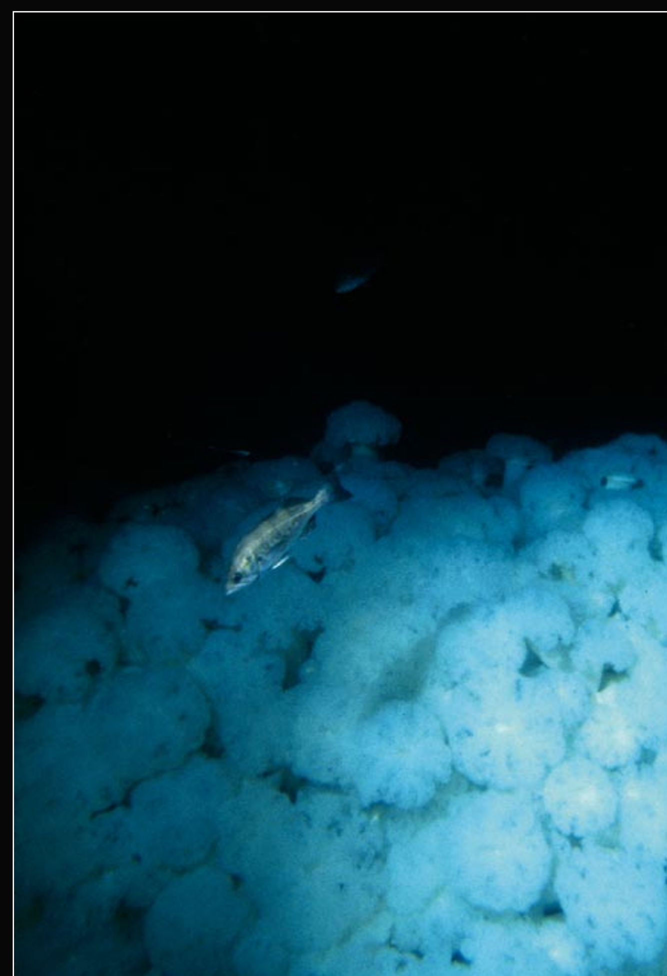


EXECUTIVE SUMMARY

Information Needed

Production of oil and gas from offshore platforms has been a continual activity along the California coast since 1958. There are 26 oil and gas platforms off California, 23 in federal waters (greater than 3 miles from shore) and 3 in state waters. The platforms are located between 1.2 to 10.5 miles from shore and at depths ranging from 11 to 363 m (35–1,198 ft.). Crossbeams and diagonal beams occur about every 30 m (100 ft.), from near the surface to the seafloor. The beams extend both around the perimeter of the jacket and reach inside and across the platform. The beams and vertical pilings (forming the jacket) and the conductors on all platforms are very heavily encrusted with invertebrates and provide important habitat for fishes. The seafloor surrounding a platform is littered with mussel shells. This "shell mound" (also called "mussel mound" or "shell hash") is created when living mussels, and other invertebrates, are dislodged and fall to the seafloor during platform cleaning or storms.

Once an industrial decision is made to cease oil and gas production, managers must decide what to do with the structure, a process known as *decommissioning*. Platform decommissioning can take a number of forms, from leaving much, or all, of the structure in place to complete removal. Along with the platform operator, many federal and state agencies are involved in the decommissioning process. All oil and gas platforms have finite economic lives and by the beginning of the twenty-first century, seven platforms in southern California had been decommissioned and a number of others appeared to be nearing the end of their economic lives.

Management decisions regarding the decommissioning of an oil and gas platform are based on both biological and socioeconomic information. This study addressed the need for resource information and better understanding of how offshore oil/gas platforms contributed to the fish populations and fishery productivity in the Santa Maria Basin and Santa Barbara Channel. Prior to our studies, there was almost no biological information on Pacific Coast platform fish assemblages. This necessary research involved broad scale sampling at numerous oil/gas platforms and natural reefs. Research objectives included 1) characterizing the fish assemblages around platforms and natural reefs, 2) examining how oceanography affects patterns of recruitment and community structure of reef fishes, and 3) describing the spatial and temporal patterns of fish diversity, abundance and size distribution among habitat types (e. g., platforms and natural outcrops).

Research Summary

Between 1995 and 2001, we studied oil and gas platforms sited over a wide range of bottom depths, ranging between 29 and 224 m (95 and 739 ft.) and sited from north of Point Arguello, central California to off Long Beach, southern California. However, most of the platform research occurred in the Santa Barbara Channel and Santa Maria Basin. The Santa Barbara Channel and Santa Maria Basin are situated in a dynamic marine transition zone between the regional flow patterns of central and southern California. The Santa Barbara Channel is about 100 km long by about 50 km wide (60 x 20 miles) and is bordered on the south by the Northern Channel Islands (San Miguel, Santa Rosa, Santa Cruz, and Anacapa). This area is bathed in a complex hydrographic system of currents and water masses. Generally, cool coastal waters from the California Current enter the Santa Barbara Channel through its west entrance at Point Conception. Warm waters from the Southern California Bight flow in the opposite direction into the channel through its eastern entrance. Surface waters are substantially warmer in the Bight than north of Point Conception due to less wind-induced vertical mixing, the solar heating of surface waters, and currents of subtropical waters entering from the south. The convergence of different water masses in the Santa Barbara Channel results in relatively large scale differences in physical parameters (e.g., temperature, salinity, oxygen, and nutrient concentrations) and biotic assemblages (e. g., flora and fauna).

Scuba surveys were conducted at shallow depths and submersible surveys, using the research submarine *Delta*, at greater depths. We also surveyed shallow-water and deeper-water rock outcrops, many in the vicinity of platforms. Nine nearshore, shallow-water rock outcrops, seven on the mainland and two at Anacapa Island, were monitored annually from 1995 to 2000. These natural outcrops are geographically distributed across the Santa Barbara Channel providing opportunities for spatial comparisons. In addition, we surveyed over 80 deeper-water outcrops, in waters between 30 and 360 m (100

Opposite: Juvenile widow rockfish in platform midwater. (Photograph by Lovelab, UC Santa Barbara) and 1,180 ft.) deep, located throughout the Southern California Bight and off Points Conception and Arguello. These sites included a wide range of such habitats as banks, ridges, and carbonate reefs, ranging in size from a few kilometers in length to less than a hectare in area. On these features, we focussed on hard bottom macrohabitats, including kelp beds, boulder and cobble fields, and bedrock outcrops. Most of these deeper-water sites were visited once, a few were surveyed during as many as four years and one outcrop, North Reef, near Platform Hidalgo, was sampled annually.

Most of our oil and gas platform surveys were conducted at nine structures (Platforms Irene, Hidalgo, Harvest, Hermosa, Holly, Gilda, Grace, Gina, and Gail) located in the Santa Barbara Channel and Santa Maria Basin. Between 1995 and 2000, we conducted annual surveys on the shallow portions of these nine platforms. The shallowest of the nine platforms, Gina, was surveyed from surface to bottom depths using scuba techniques. Deep-water surveys conducted between 1995 and 2001, using the research submersible, *Delta*, studied the same platforms excluding the bottom of Gilda and all of Gina. In 1998, one submersible survey was conducted around Platform Edith, located off Long Beach. In 2000 partial submersible surveys were completed around Platforms C, B, A, Hillhouse, Henry, Houchin, Hogan, and Habitat.

Patterns in Shallow-Water Habitats

Regional and local processes influenced patterns of outcrop fish assemblages in shallow waters. At regional spatial scales, outcrop fish abundance patterns often shifted abruptly as oceanographic patterns changed, roughly defining a cool-temperate assemblage in the western Santa Barbara Channel, and a warm-temperate assemblage in the eastern Santa Barbara Channel. This distinctive spatial pattern was observed in both oil and gas platform and natural outcrop habitats. In shallow waters, there was greater variability in platform species assemblages and population dynamics compared to natural outcrop assemblages, and this was most likely caused by the greater sensitivity of platform habitats to changing oceanographic conditions. Local processes that affected fish distribution and abundance were related to habitat features, where depth, relief height, and presence of giant kelp all played important roles. On platform habitat, we found that the majority of newly settled rockfish juveniles resided at depths greater than 26 m (86 ft.), although there were differences among species.

Characterization of the Deepwater Platform Fish Assemblages

With the exception of the shallow-water Platform Gina, all of the platforms we surveyed were characterized by three distinct fish assemblages: midwater, bottom, and shell mound. Rockfishes, totaling 42 species, dominated these habitats. Fish densities at most platforms were highest in the midwater habitat reflecting the depth preferences of young-of-the-year rockfishes. Young-of-the-year rockfishes represented the most abundant size classes in platform midwaters. Platform midwaters were nursery grounds for rockfishes as well as for a few other species, including cabezon and painted greenling. The young-of-the-year of at least 16 rockfish species inhabited these waters. Settlement success was affected by oceanographic conditions. Densities of young-of-the-year varied greatly between years and platforms. Young-of-the-year rockfish densities often varied by an order of magnitude or greater among survey years and platforms. From 1996 through 1998, rockfish settlement was generally higher around the platforms north of Point Conception as compared to platforms in the Santa Barbara Channel. This finding is reflective of the generally colder, more biologically productive waters in central California during the 1980s and much of the 1990s. Colder waters in 1999 were associated with relatively high levels of rockfish recruitment at all platforms surveyed. In 2000 and 2001, juvenile rockfish recruitment at platforms in the Santa Barbara Channel remained higher than pre-1999 levels, possibly reflecting the oceanographic regime shift to cooler temperatures that may be occurring in southern California.

Subadult and adult rockfishes and several other species dominated the bottom habitats of platforms. The bottom habitat of some platforms is also important nursery habitat as, in some instances, young-of-the-year rockfishes were observed in very large numbers. In general, more than 90% of all the fishes around platform bottoms were rockfishes. Bottom depth strongly influenced the number of species, species diversity, and density of fishes living around platform bases. This is distinctly different than the pattern observed in platform midwaters. The platform base provides habitat for not only fishes but also their prey and predators.

Shell mounds supported a rich and diverse fish assemblage. As at other platform habitats, rockfishes comprised the vast majority of the fishes. The many small sheltering sites created by mussels, anemones, and other invertebrates on the shell mounds created a habitat occupied by small fishes. Many of these fishes were the young-of-the-year and older juveniles of such species as lingcod and copper, flag, greenblotched, and pinkrose rockfishes and cowcod. The adults of these species also inhabited the platform bottom.

Platform versus Reef Fish Assemblages

We compared the species composition of the fish assemblages at Platform Hidalgo and at North Reef, an outcrop located about 1,000 m (3,300 ft.) from the platform. The assemblages were quite similar, both were dominated by rockfishes. In general, the distinctions between the platform and outcrop assemblages were based on differences in species densities, rather than species' presence or absence. Most species were more abundant at Platform Hidalgo. Halfbanded, greenspotted, flag, greenstriped, and canary rockfishes, and all three life stages of lingcod (young-of-the-year, immature, adult) and painted greenling had higher densities around the platform. Five species (pink seaperch, shortspine combfish, pygmy, squarespot, and yellowtail rockfishes) were more abundant at the outcrop. Young-of-the-year rockfishes were found at both Platform Hidalgo (primarily in the midwaters) and at North Reef. Young-of-the-year rockfish densities were higher at the platform than at the outcrop in each of the five years studied. In several years, their densities were more than 100 times greater at Platform Hidalgo compared to North Reef.

Rockfishes numerically dominated the fish assemblages at almost all of the platform and hard seafloor habitats in our study. Overall species richness was greater at the natural outcrops (94) than at the platforms (85). There was a high degree of overlap in species between platforms and outcrops and differences were primarily due to generally higher densities, of more species, at platforms. In general, canary, copper, flag, greenblotched, greenspotted, greenstriped, halfbanded, vermilion rockfishes, bocaccio, cowcod, and widow rockfish young-of-the-year, painted greenling and all life history stages of lingcod were more abundant at platforms than at all or most of the outcrops studied. Yellowtail rockfish and the dwarf species pygmy, squarespot, and swordspine rockfishes were more abundant on natural outcrops.

Findings

Our research demonstrates that some platforms may be important to regional fish production. The higher densities of rockfishes and lingcod at platforms compared to natural outcrops, particularly of larger fishes, support the hypothesis that platforms act as de facto marine refuges. High fishing pressure on most rocky outcrops in central and southern California has led to many habitats almost devoid of large fishes. Fishing pressure around most platforms has been minimal. In some locations, platforms may provide much or all of the adult fishes of some heavily fished species and thus contribute disproportionately to those species' larval production.

Platforms usually harbored higher densities of young-of-the-year rockfishes than natural outcrops and thus may be functionally more important as nurseries. Platforms may be more optimal habitat for juvenile fishes for several reasons. First, because as structure they physically occupy more of the water column than do most natural outcrops; presettlement juvenile or larval fishes, transported in the midwater, are more likely to encounter these tall structures than the relatively low-lying natural rock outcrops. Second, because there are few large fishes in the midwater habitat, predation on young fishes is probably lower. Third, the offshore position and extreme height of platforms may provide greater delivery rates of planktonic food for young fishes. Most of the natural outcrops we found that had high densities of young-of-the-year rockfishes were similar to platforms as they were very high relief structures that thrust their way well into the water column.

Our research, and reviews of existing literature, strongly implies that platforms, like natural outcrops, both produce and attract fishes, depending on species, site, season, and ocean conditions. Platform fish assemblages around many of the deeper and more offshore platforms probably reflect recruitment of larval and pelagic juvenile fishes from both near and distant maternal sources, not from attraction of juvenile or adult fishes from natural outcrops. Annual tracking observations of strong year classes of both flag rockfish and bocaccio imply that fishes may live their entire benthic lives around a single platform. A pilot study showed that young-of-the-year blue rockfish grew faster at a platform than at a natural outcrop indicating that juvenile fishes at platforms are at least as healthy as those around natural outcrops.

Management Applications

In this report, we discuss the ecological and political issues that surround platform decommissioning in California, including the ecological consequences of the four platform decommissioning alternatives: (1) Complete Removal, (2) Partial Removal and Toppling, and (3) Leave-in-Place.

Complete Removal: In complete removal, operators may haul the platform to shore (for recycling, reuse, or disposal) or it can be towed to another site and reefed.

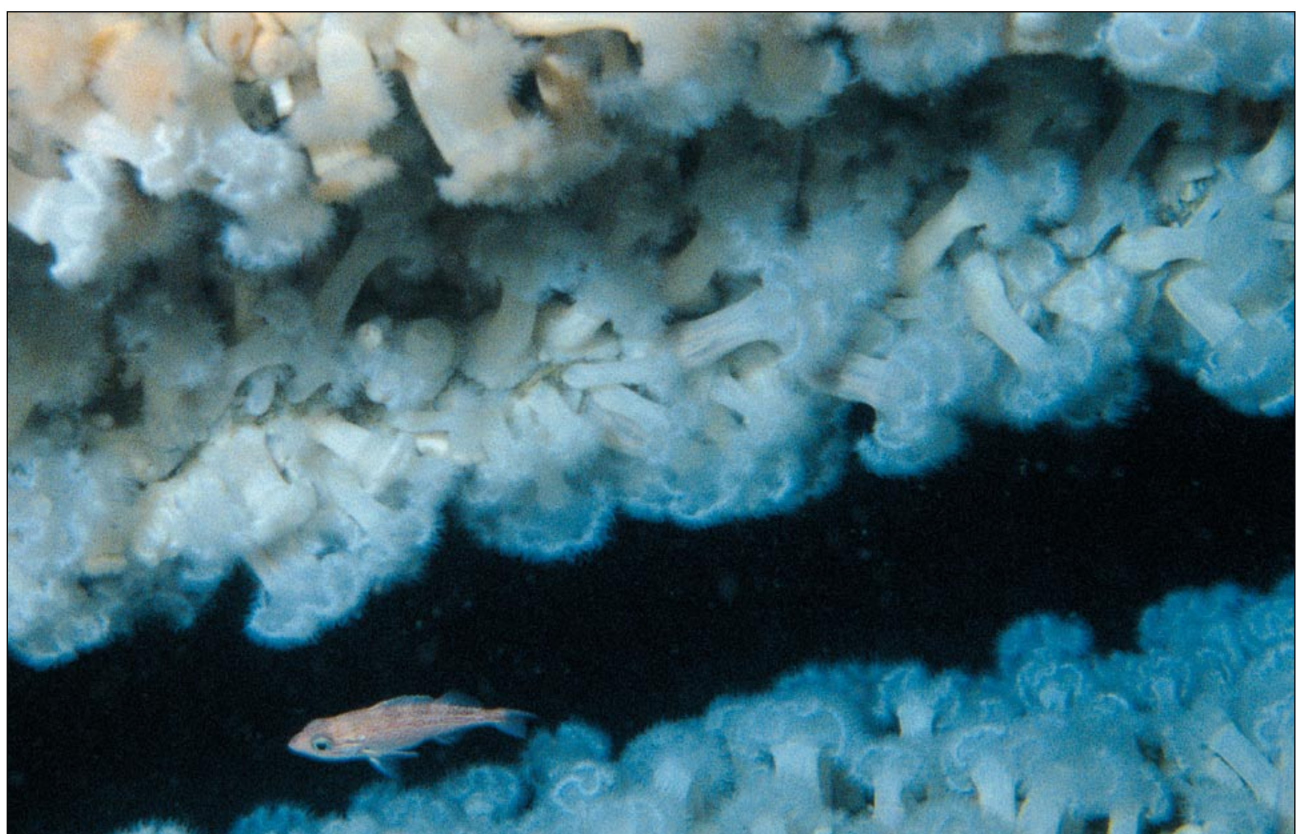
A typical full-removal project begins with well abandonment in which the well bores are filled with cement. The topsides, which contain the crew quarters and the oil and gas processing equipment, are cut from the jacket and removed and the conductors are removed with explosives. Finally, the piles that hold the jacket to the seabed are severed with explosives and the jacket is removed.

Completely removing a platform for disposal on land will kill all attached invertebrates. If some of the platform structure is hauled to a reef area and replaced in the water, some of these animals may survive, depending on water depth and the length of time the structure is exposed to the air. The explosives used to separate the conductor and jacket from the seafloor kill large numbers of fishes. In a study in the Gulf of Mexico, explosives were placed 5 m (15 ft.) below the seafloor to sever the well conductors, platform anchor pilings and support legs, of a platform in about 30 m (100 ft.) of water. All of the fishes on or near the bottom and most of the adult fishes around the entire platform suffered lethal concussions. Marine mammals and sea turtles may also be indirectly killed by damage to the auditory system.

The use of explosives to remove or topple a platform may also complicate fishery-rebuilding programs. Cowcod, a species declared overfished by NOAA Fisheries, provides an example. This species is the subject of a federal rebuilding plan that severely limits catches. In 2001, this was 2.4 metric tons or about 600 fish. Based on our research, there are at least 75 adult cowcod on Platform Gail. If explosives are used to remove Gail, all of these fish will be killed. The loss of at least 75 adult cowcod may be sufficiently large to complicate the rebuilding plan.

Partial Removal and Toppling: Under both partial removal and toppling the topsides are removed. In partial removal, the jacket is severed to a predetermined depth below the surface and the remaining subsurface structure is left standing. In toppling, the conductors and piles are severed with explosives and the jacket is pulled over and allowed to settle to the seafloor. In both partial removal and toppling, conductors need not be completely removed. Retaining conductors would add habitat complexity to a reefed platform.

While the immediate mortality impact to attached invertebrates of partial removal is greater than leaving the platform structure in place, mortality risks to both fishes and invertebrates are much lower than in both toppling and total removal. Partial removal causes fewer deaths than does toppling for two reasons. First, because partial removal does not require explosives (as does toppling), there is relatively little fish, marine mammal, sea turtle, and motile invertebrate (such as crab) mortality. In addition, when a platform is partially removed, vertebrate and invertebrate assemblages associated with the remaining structure are likely to be minimally affected. In contrast, when a platform is toppled, the jacket falls to the seafloor, and, depending on bottom depth, many, if not most of the attached invertebrates die.



MARY NISHIMOTO

*Whitespeckled rockfish and white anemones (*Metridium *sp.).*

Both partial removal and toppling would produce reefs with somewhat different fish assemblages than those around intact platforms. With the shallower parts of the platform gone, it is likely that partial removal would result in fewer nearshore reef fishes, such as seaperches, basses, and damselfishes. However, young-of-the-year rockfishes of many species recruit in large numbers to natural outcrops that have crests in about 30 m (100 ft.) of water or deeper. Thus, it is possible that partial removal would result in little or no reduction in young-of-the-year recruitment for many rockfish species. The pelagic stage of some rockfish species, particularly copper, gopher, black-and-yellow and kelp, may recruit only to the shallowest portions of the platform. For these species, both partial removal and toppling would probably decrease juvenile recruitment, depending on the uppermost depth of the remaining structure. Young-of-the-year rockfishes, which make up the bulk of the fish populations in the platform midwater habitat, would probably be less abundant around a toppled platform compared to a partially removed one. Because most California platforms reside in fairly deep water, toppled platforms might reside at depths below much rockfish juvenile settlement. Thus, toppling might result in lowered species composition and fish density. However, depending on the characteristics of the platform, a toppled structure, with twisted and deformed pilings and beams, might have more benthic complexity than one that is partially removed. This might increase the number of such crevice dwelling fishes as pygmy rockfishes.

It is difficult to catch fishes that live inside the vertically standing platform jacket. Our observations demonstrate that many of the rockfishes living at the platform bottom, such as cowcod, bocaccio, flag, greenspotted, and greenblotched rockfishes, dwell in the crevices formed by the bottom-most crossbeam and the seafloor. To a certain extent, these fishes are protected from fishing gear by the vertical mass of the platform, a safeguard that would persist if the platform were partially removed, particularly if the conductors remained in place. It would be much easier to fish over a toppled platform, as more of the substrate would be exposed to fishing gear.

Coast Guard regulations do not require a minimum depth below the ocean surface to which a decommissioned platform must be reduced. The decision on how much of the jacket and conductors is left in place is based on both a Coast Guard assessment and the willingness of the liability holder to pay for the navigational aids required by the Coast Guard. As mussels become rare below about 30 m (100 ft.) on most platforms, the mistaken assumption that all partially removed platforms must be cut to 24–30 m (80–100 ft.) below the surface has led some to conclude that this will inevitably lead to a severe reduction in the amount of mussels that fall to the bottom and, thus, to a change in or end to, the shell mound community. This is not necessarily the case.

Leave-in-Place: A platform could be left in its original location at the time of decommissioning. The topsides would be stripped of oil and gas processing equipment, cleaned, and navigational aids installed. If a platform were left in place, the effect on platform sea life would be minimal.

Pacific Coast Platforms

In this report we have also included a brief summary of information on all of the Pacific Coast platforms (Appendix 1), densities of all fishes observed at each platform during scuba and submersible surveys (Appendix 2 and Appendix 3, respectively), and a list of the 20 most important sites, both platforms and natural outcrops, for the most abundant species in our deepwater study (Appendix 4).

Research Needs

Our research demonstrates that additional biological information is needed in the decommissioning process. These information needs fall into three categories: (1) A comparison of the ecological performance of fishes living at oil platforms and on natural outcrops, (2) A definition of the spatial distribution of economically important species (of all life history stages) within the region of interest and a definition of the connectivity of habitats within this region, and (3) An understanding of how habitat modification of the platform environment (e.g., removal of upper portion or addition of bottom structure) changes associated assemblages of marine life at offshore platforms.

Major questions remaining to be addressed include:

What Fishes Live Around Platforms and Nearby Natural Reefs?

In order to assess the relative importance of a platform to its region, it is essential to conduct basic surveys not only around the platform, but also at nearby reefs. A majority of platforms have not been surveyed.

How Does Fish Production around Platforms Compare to that at Natural Outcrops?

It is possible to compare fish production between habitats by examining (1) fish growth rates, (2) mortality rates, and (3) reproductive output. A pilot study compared the growth rates of young-of-the-year blue rockfish at Platform Gilda and Naples Reef and another examining young-of-the-year mortality rates is planned. Additional work is needed to determine larval dispersal patterns and differences in densities at various study sites. For example, we now have enough data to study the relative larval production per hectare of cowcod and bocaccio at Platform Gail versus that on natural outcrops.

What Is the Relative Contribution of Platforms in Supplying Hard Substrate and Fishes to the Region?

This research would put in perspective the relative contribution of platforms in supplying hard substrate and reef fishes to their environment.

First, this requires knowledge of the rocky outcrops in the vicinity of each platform; this is derived from seafloor mapping. Once the mapping is complete, visual surveys of the outcrops, using a research submersible, will determine the fish assemblages and species densities in these habitats. Knowing the areal extent of both natural and platforms habitats and the densities of each species in both of these habitats, it is then possible to assess the total contribution of each platform to the fish populations and hard substrate in that region.

How Long Do Fishes Reside at Oil/Gas Offshore Platforms?

It is unclear how long fishes are resident to platforms. For instance, does the large number of fishes, particularly such species as the overfished bocaccio and cowcod, remain around the platforms for extended periods? Knowledge of the residence time of these species would allow us to more accurately determine if platforms form optimal habitat for these species.

What are the Effects of Platform Retention or Removal on Fish Populations within a Region?

As an example, what effect would platform retention or removal have on young-of-the-year fish recruitment? Would the young rockfishes that settle out at a platform survive in the absence of that platform? Our surveys demonstrate that planktonic juvenile fishes, particularly rockfishes, often settle to platforms in substantial numbers. If that platform did not exist, would these young fishes have been transported to natural outcrops? Knowing how long it would take rockfish larvae to reach suitable natural outcrops, and what percent of these larvae would likely die before reaching these outcrops, will give a sense of the importance of a platform as a nursery ground.

Similarly, using a synthesis of oceanographic information, it is possible to model the fate of larvae produced by fishes living at a platform.

How Does Habitat Modification of the Platform Environment (e.g., Removal of Upper Portion or Addition of Bottom Structure) Change Associated Assemblages of Marine Life?

All decommissioning options except leave-in-place involve modification of the current physical structure of offshore platforms. Is it possible to increase fish diversity and density by altering the seafloor or the platform itself? For instance, it would be useful to add complexity, in the form of quarry rock or other structure, to the shell mound around a platform, and follow the changes in fish assemblages.

Descriptive information such as depth distribution and life history information is also useful in determining how decommissioning options affect the environment. Experimental research, using a BACI design or similar approach, can aid in predicting how the biotic community will respond to such structural changes.