TECHNICAL SUMMARY

Study Title: Benthic Invertebrate Communities on Shell Mounds Surrounding Oil and Gas Platforms in the Santa Barbara Channel and Santa Maria Basin
Report Title: Megabenthic Invertebrates on Shell Mounds Under Oil and Gas Platforms off California
Contract Number: 1435-MO-08-AR-12693
Sponsoring OCS Region: Pacific
Applicable Planning Area: Central and Southern California
Fiscal Years of Project Funding: FY2004-FY2006
Completion Date of Report: September 2008
Principal Investigators: Jeffrey H. R. Goddard & Milton S. Love
Key Words: Oil platforms, OCS platforms, shell mounds, California, decommissioning, platform decommissioning, video transects, megabenthic invertebrates, structure-forming invertebrates, non-native species, community composition, asteroid echinoderms, spawning aggregations, food subsidy, sea stars, *Asterina miniata*, *Metridium farcimen*, *Pleurobranchaea californica*, *Pisaster*, *Stylasterias forreri*, *Watersipora subtorquata*.

Background and Objectives:

Twenty-seven oil and gas platforms are located off the California coast, in waters up to 365 m deep. When a platform becomes uneconomical to operate for its original use, it faces decommissioning, a complex process involving state and federal agencies and requiring extensive environmental review. During their working lives, platforms accumulate a wealth of benthic and pelagic biota, which may include economically important species, species of conservation importance, and even non-native species. Therefore, the environmental review required by decommissioning must consider the ecological impacts on the region of altering or removing each platform and its associated biota as called for by the various decommissioning options. The latter range from complete removal of a platform, to partial removal, to toppling, and finally, no removal.

The fishes associated with platforms off California have been extensively studied and documented, and the platforms have been found to provide important habitat for the juveniles and adults of many species, including some overexploited, economically valuable species of rockfish. Although there has long been interest in the platforms as sites of aquaculture of bivalves such as mussels and rock scallops (with at least one commercial venture), interest in the benthic invertebrate biota associated with the platforms has generally lagged behind that of the fishes. This has changed recently, owing to (1) an increasing recognition of the functional significance - beyond the usual predator/prey relationships - of many sessile invertebrates of the types found on the platforms to fishes, and (2) because the platforms support a large biomass of sessile species, some of which might provide sustainable sources of marine natural products difficult or ecologically harmful to obtain in significant quantities from natural reefs.

Shell mounds are a unique biogenic feature of offshore oil platforms. Formed by the wave- or maintenance-induced dislodgement of mussels, barnacles and other fouling organisms growing on the upper reaches of the platforms, these mounds cover large circular or oval areas around the base of each platform, rise more than 5 meters in height, and provide islands of hard, calcareous substrate for organisms in an otherwise mostly soft bottom habitat. The fishes associated with

shell mounds have been quantitatively investigated and described, as part of the comprehensive studies of platform fishes. A few studies have examined invertebrate communities on shallow water (<50 meters deep) shell mounds. These have reported unusually high densities of sea stars, which prey largely on the shelled and other fouling organisms falling from the shallow water portions of the platforms. However, relatively little is known about the invertebrate communities on mussel mounds under platforms in deeper waters, including those on the Pacific outer continental shelf (Pacific OCS). Even less is known about the ecological importance of these invertebrates to the associated fish assemblages and as potentially important spawning sites and sources of larvae for distant and more widespread populations. Thus, the overall goals of this study were to identify and quantify the invertebrate fauna on deepwater shell mounds, compare important elements of the fauna to those found on neighboring soft sediments and natural reefs, and investigate elements of their potential ecological and conservation importance.

Description:

We investigated the invertebrate fauna on deepwater shell mounds and their ecological importance through four tasks.

Task One:

Identify megabenthic invertebrates on shell mounds associated with OCS platforms off California and determine their densities and depth distribution.

Task Two:

Compare shell mound invertebrate species richness and community composition among platforms, and test for differences in community structure by year, depth, geographic location, and age of platform.

Task Three:

Investigate the relationship between the density of large, structure-forming invertebrates and fishes commonly associated with shell mounds.

Task Four:

Compare sea star densities on shell mounds with those on natural reefs.

Significant Results

Task 1: In this study we utilized archived videotapes of transects conducted between 1997 and 2005 on the shell mounds under 15 platforms, in waters 49 to 365 m deep, in the Santa Maria Basin, Santa Barbara Channel, and San Pedro Bay. We counted all recognizable invertebrates in quadrats randomly selected from these transects.

Asteroid echinoderms, or sea stars, the large sea anemone, *Metridium*, the large side-gilled slug *Pleurobranchaea californica*, and rock crabs *Cancer* spp. dominated the deepwater shell mound megafauna, accounting for more than 90 % of the total number of individuals counted. In addition, spot prawns, *Pandalus platyceros* and the sea urchin *Allocentrotus fragilis* were abundant at a few shell mounds, and large masses (> 50 cm high) of one non-mytilid, non-native species, the foliose bryozoan *Watersipora subtorquata*, was observed under Platform Gilda. Ophiuroids, whose density was estimated qualitatively, were also abundant on some shell mounds. Like neighboring soft sediment communities, echinoderms were the most abundant megabenthic taxon on the shell mounds. However in contrast to the numerical dominance of echinoid echinoderms on the soft sediments, sea stars comprised 77 % of the total number of organisms counted on the shell mounds.

Excluding ophiuroids, the sea star *Asterina miniata* attained the highest densities, reaching nearly 10 individuals per m^2 under Platform Elly and averaging 4.1 per m^2 on the seven shell mounds occurring in less than 100 m of water. This species had a wide depth distribution, but was most abundant above 100 m.

Except for the ophiuroids and *Metridium*, both of which are suspension feeders, the dominant taxa were all carnivorous or omnivorous predators or scavengers, dependent primarily on the food subsidy of mussels and other fouling organisms growing on the upper reaches of each platform. As demonstrated previously for shallow water shell mounds, once this subsidy is cut off (e.g., by any of decommissioning options resulting in no platform structure in shallow water), the shell mounds will become increasingly covered by sediments, and their community composition will shift toward a higher proportion of omnivorous, suspension and deposit feeding species.

The white-plumed anemone *Metridium farcimen* was the only large, structure-forming, sessile invertebrate prevalent on the shell mounds. It occurred on shell hash and artificial substrates on all shell mounds but reached its highest densities (> 0.3 per m^2) on the shell mounds in greater than 90 m of water. Other structure forming, sessile invertebrates included vase and foliose sponges, gorgonians and crinoids (feather stars), each of which occurred at low density (< 0.03 per m^2) on only a few shell mounds each. Where they occurred, sponges and crinoids were prevalent on shell hash, while gorgonians were restricted to rock, platform structures, and platform debris, possibly indicating avoidance of settlement by the larvae of this taxon on the relatively small, calcareous components of the shell matrix. Brittle stars were dense (> 40 per m^2) on four shell mounds, but their relatively small size and slender arms (which are retractable into the shell hash) do not contribute the same large-scale structure to the shell mounds as the above organisms. The clumps of the bryozoan *Watersipora* observed at Platform Gilda added three-dimensional structure to that shell mound, but almost certainly originated mostly, if not entirely, from the upper reaches of the platform. *Metridium* was orders of magnitude denser on the shell mounds than reported from natural reefs and banks, the sponges and crinoids orders of magnitude less dense, and gorgonians were either less or more dense on the shell mounds, depending on the natural reefs studied. Gorgonians, however, were not observed on shell hash, but only on rock and artificial hard substrata.

The relative lack of large sessile structure-forming taxa on the shell mounds other than *Metridium* may be due to avoidance by the larval stages of these species of settling on the relatively small, calcareous components of the shell hash, but might also result from high rates of predation on the post-metamorphic and juveniles stages by the abundant predatory sea stars. Regardless of the cause of their scarcity and low species richness, the lack of these structure-forming species - which typically shelter a wide variety of both sessile and mobile macro invertebrates and fishes - probably results in significantly reduced overall biodiversity on the shell mounds compared to natural reefs. These components of the shell mound benthic community could be enhanced in classic artificial reef style by the addition of hard substrata. Because they are suspension feeders not as dependent as the mobile species on the food subsidy of shellfish growing on the platforms, enhancement of the large, structure-forming organisms would occur on the shell mound regardless of the presence or absence of a standing platform, and indeed, on a large scale could be accomplished by the platform decommissioning option that calls for toppling entire platforms. Given the large dimensions but relatively simple design of the platform jackets (the legs and crossbeams supporting both the topside structures and oil

and gas conductors), huge amounts of artificial secondary structure and surface area could be added to toppled platforms, providing sites for settlement and growth of *Metridium* at all depths, gorgonians in at least shallow waters, and perhaps large sponges and crinoids and other taxa, such as black corals (Antipaththaria) in deeper waters. Separate from the growth of this biotic structure, the physically enhanced, toppled jackets would likely also provide many more spatial refuges for mobile invertebrates and fishes than exist on standing, unmodified platforms.

Task 2: For the seven platforms sampled at least five times each, depth appeared to be the most important variable explaining the total number of megabenthic invertebrate taxa observed on each shell mound, with the number of taxa increasing over the depth range (64 to 225 m) spanned by these platforms. The influence of geographic location was also noteworthy, with lower numbers of taxa tending to occur under shell mounds in San Pedro Bay than in either the Santa Maria Basin or Santa Barbara Channel.

Ordination of the species density data for all years at all platforms showed that each platform had a distinctive community composition, with the shell mound at Platform Hidalgo having the most temporally variable community composition. Of the three environmental factors examined, depth was found to be the most important determinate of community structure, a result consistent with previous studies on natural reefs in the region. Geographic location was also important in distinguishing between shell mound communities from the Santa Maria Basin and San Pedro Bay, at the western and eastern ends of the study region.

Task 3: Few taxa of large, structure-forming invertebrates were observed on the shell mounds, and consisted of (in order of overall density): the large anemone *Metridium*, clumps of the foliose bryozoan *Watersipora* (observed only under Platform Gilda), the crinoid echinoderm *Florometra*, sea pens, including *Ptilosarcus*, gorgonians, and vase and foliose sponges. Except for *Metridium*, which occurred on all shell mounds, each of these taxa occurred on only three or fewer shell mounds. Sea pens, primarily of the family Virgulariidae, were restricted to soft sediments, while the gorgonians were observed only on hard substrates including rock, pipelines or platform debris such as tires. Large *Metridium* were common on the shell matrix, pipelines and platform debris.

By comparing a similarity matrix based on the densities of 12 of the most abundant shell mound fishes with each of the possible matrices based on the densities of the four most common structure-forming invertebrates (plus ophiuroids, which added texture, if not structure, to some of the shell mounds), we found that fishes from shallower water shell mounds were most highly correlated with ophiuroids and gorgonians, and more highly correlated with gorgonians alone than ophiuroids alone. Fishes from deeper water shell mounds were most highly correlated with large *Metridium* and sea pens, and fairly highly correlated with large *Metridium* alone.

Guided by the above general correlations, we found that the densities of painted greenling and four species of rockfish were correlated with the densities of particular structure-forming invertebrates. Both painted greenling and vermilion rockfish were significantly correlated with gorgonians, probably reflecting the association of all three species with rocky substrata, rather than a direct relationship between the fish and gorgonians themselves.

The density of greenblotched rockfish was correlated with the density of sea pens and the sea urchin *Allocentrotus*, both of which are typically associated with soft sediments, but were observed in this study in mixed shell mound/soft sediment habitat. The young of these rockfish may utilize the structure provided by sea pens and *Allocentrotus*, perhaps as spatial refuges from predation or as feeding sites.

The density of pinkrose rockfish was correlated with the density of sea pens, and greenstriped rockfish were significantly correlated with the density of large *Metridium*, the most abundant structure-forming invertebrate on the shell mounds. While a functional relationship cannot necessarily be inferred from these correlations, they suggest that some fishes may be partitioning, as habitat, the few structure-forming invertebrates found on shell mounds.

Task 4: For this task we compared the density of sea stars on the shell mounds with those reported from rocky reefs at similar depths in the same region by the Biological California offshore Monitoring Program (CAMP). Asteroid echinoderms were at least an order of magnitude denser on the shell mounds, a result consistent with earlier studies on shell mounds in shallower waters.

Given the scarcity of hard bottom habitat on the outer continental shelf, and its relatively low densities of sea stars, the denser populations of sea stars found on deepwater shell mounds may be important to the region as spawning aggregations and sources of larvae, especially if the geographically more extensive, shallow water populations of the same species continue to be impacted by the microbial wasting disease first observed in the Santa Barbara Channel in the late 1990's. If the wasting disease is related to long-term warming trends in surface waters, deepwater shell mounds might provide a cold-water refuge from the disease. However, it should be emphasized that any lasting reproductive contribution by shell mound sea stars, whatever its magnitude, depends on the continued transfer of live mussels, barnacles, and other fouling organisms – the prey of most of the sea stars – from the upper reaches of the platforms to the shell mounds. Any platform decommissioning option resulting in the loss of platform structure in shallow water would cut this food subsidy, eventually resulting in significantly reduced densities and reproductive output by the predatory sea stars.

An additional possible, but largely unexplored, consequence of high asteroid density on the shell mounds might be an increased susceptibility to disease outbreaks, should the shell mound populations become exposed to infectious agents. Depending on the vectors and agents involved, this may be less likely on deeper shell mounds compared to shallow ones. One species of particular concern is the ciliate *Orchitophyra stellarum* a parasitic castrator introduced from the north Atlantic Ocean. This parasite apparently has a wide range of host and has been found in *Pisaster ochraceus* from British Columbia.