

**Platform Ecology Studies Funded by
the Minerals Management Service's
Environmental Studies Program:
An Annotated Bibliography**

January 2000

Abstract

There are a total of 27 oil and gas platforms located off the coast of southern California. A number of these facilities are nearing the end of their economic life and decisions must be made regarding their disposition. The potential conversion of California oil and gas platforms to artificial reefs is an issue that continues to stimulate debate and discussion among commercial and recreational fishermen, the scientific community, industry, environmental groups, State and Federal agencies, and the general public in California. Scientific questions persist about the utility of California platforms as artificial reefs and their ecological value. A Select Scientific Advisory Committee on Decommissioning was recently formed by the University of California Marine Council to address this issue. In addition, an Interagency Decommissioning Working Group composed of Federal, State and local government agencies has also been formed to address a wide range of technical, environmental and disposition issues associated with decommissioning offshore oil and gas platforms and associated onshore facilities. This annotated bibliography was prepared to serve as a reference source for these groups as well as other interested parties. The bibliography identifies and describes platform ecology research and related natural reef research that have been funded by the Minerals Management Service's Environmental Studies Program in the Pacific OCS Region and the Gulf of Mexico OCS Region.

Table of Contents

	Page
Abstract	i
Pacific OCS Region	1
Completed Studies	
<i>I. Effects of OCS oil and gas production platforms on rocky reef fishes and fisheries (1992)</i>	1
<i>II. Annotated Bibliography: Fisheries species and oil/gas platforms offshore California (1987)</i>	4
<i>III. Ecology of oil/gas platforms offshore California (1987)</i>	7
<i>IV. An historical perspective of the commercial and sport fisheries offshore California through 1985 (1989)</i>	10
<i>V. Disturbance of deep-water reef communities by exploratory oil and gas operations in the Santa Maria Basin and Santa Barbara Channel (1995)</i>	13
<i>VI. Effect of offshore oil platform structures on the distribution patterns of commercially important benthic crustaceans, with emphasis on the rock crab (1999)</i>	16
On-going Studies	
<i>I. Ecological consequences of alternative abandonment strategies for POCS offshore facilities and implications for policy development</i>	21
<i>II. Survey of invertebrate and algal communities on offshore oil and gas platforms in southern California</i>	23
<i>III. Social and economic adaptations by fish harvesters in the Santa Barbara Channel-Santa Maria Basin area, California</i>	25
<i>IV. The ecological role of natural reefs and oil and gas production platforms on rocky reef fishes in southern California, Final Interim Report</i>	26
<i>V. The political economy of the rigs-to-reef option for decommissioning of offshore oil and gas structures</i>	27
<i>VI. Early development of fouling communities on offshore oil platforms</i>	28

Gulf of Mexico Region	29
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Completed Studies

<i>I. Study of the effects of oil and gas activities on reef fish populations in the Gulf of Mexico OCS area (1982)</i>	29
<i>II. An analysis of recreational and commercial fishing use at 164 major offshore petroleum structures in the central Gulf of Mexico (1983)</i>	30
<i>III. Adaptive environmental assessment: A planning scheme for rigs-to-reefs (1984)</i>	30
<i>IV. The ecology of petroleum platforms in the northwestern Gulf of Mexico: A community profile (1982)</i>	30
<i>V. Characterization and trends in recreational and commercial fishing from the Florida Panhandle (1997)</i>	31
<i>VI. Cumulative ecological significance of the oil and gas structures of the Gulf of Mexico: Information search, synthesis, and ecological modeling; Phase I, Final Report (1998)</i>	31
<i>VII. Cumulative ecological significance of the oil and gas structures of the Gulf of Mexico: A Gulf of Mexico fisheries habitat suitability model -- Phase II, Model Description (1998)</i>	32
<i>VIII. Ecological investigations of petroleum production platforms in the central Gulf of Mexico (1981)</i>	32
<i>IX. Mariculture associated with oil and gas structures: A Compendium (1996)</i>	33
<i>X. Petroleum structures as artificial reefs: A Compendium (1989)</i>	33

On-going Studies

<i>I. Estimation of fisheries impacts due to underwater explosions used to sever and salvage petroleum platforms</i>	34
<i>II. The postlarval and juvenile fish nursery ground/refugia function of offshore oil and gas platforms</i>	34
<i>III. Sea turtle behavior relative to offshore structures in the Western and Central Gulf of Mexico</i>	35
<i>IV. Seasonal and spatial variation in the biomass and size frequency distribution of fish associated with oil and gas platforms in the Northern Gulf of Mexico</i>	35

Decommissioning Workshop Proceedings	36
Pacific OCS Region	
<i>I. Decommissioning and removal of oil and gas facilities offshore California: Recent experience and future deepwater challenges (1997)</i>	36
<i>II. Abandonment and removal of offshore oil and gas facilities: Education and information transfer (1994)</i>	36
Gulf of Mexico Region	
<i>I. An international workshop on offshore lease abandonment and platform disposal: Technology, regulation, and environmental effects (1996)</i>	37

Pacific OCS Region

I. Completed Studies

Imamura, E., J. Hyland and J. Campbell. 1992. *Effects of OCS oil and gas production platforms on rocky reef fishes and fisheries*. MMS 92-0021. 84 pp.

Total Cost: \$753,000

Principal Investigators: Alfred Ebeling, Dane Hardin, Jeffrey Hyland, Milton Love, and Robert Spies.

Key Words: fish, fisheries, southern California, Pt. Arguello Field, platforms, platform Hidalgo, Platform Hermosa, Platform Harvest, Outer Continental Shelf, rockfish, *Sebastes*, juveniles, distribution, hook and line, gill net, trophic relationship, prey, feeding, sublethal responses, seeps, oil spill, hard bottom, hard substrate, reefs, pinnacles, remotely operated vehicle (ROV), underwater photography.

Background: The MMS Pacific OCS Region initiated planning for a long-term, platform effects study in 1982 when a conference was conducted to develop recommendations for "A Pacific OCS Environmental Monitoring Program for Oil and Gas Activities." From the conference, emerged a multi-year, phased approach of investigations that included a reconnaissance of benthic habitats in the Santa Maria Basin and western Santa Barbara Channel followed by a five-year monitoring program at Platforms Hidalgo and Julius in the Santa Maria Basin. These studies did not, however, include research on fishes, in part, because the motile habit and variable distribution of the nekton, relative to the benthos, made hypothesis testing for platform effects on fishes more problematical. Due to improvements in sampling equipment and knowledge of the fisheries in the Pt. Arguello area, however, sufficient technology now exists to support definitive experimental designs to address relevant fish and fishery concerns. While a three-year study was originally envisioned by the MMS to address the fishery issues, due to funding constraints, the research scope was modified to this "Pilot Study" which focused on the evaluation of sampling methods, technical approaches, and testing equipment for assessing offshore platform effects to fishes and fisheries in the Pt. Arguello offshore region.

Objectives: In the Pilot Study, investigators collected preliminary data on: 1) the spatial and short-term temporal variability in densities and species composition of fish assemblages on an offshore platform structure, and from a series of eight natural offshore reefs representing different factorial combinations of relief height, water depth, distances from the platform and type of habitat; 2) variations in feeding habits between different species of fish, depths along the platform structure, times of day, type of substrate and relief height; 3) the pathological

and physiological conditions of these or similar fish in relation to chemical body burdens and a known contaminant source; and 4) testing various sampling methods and equipment such that study objectives can be satisfied.

Description: Eight natural-reef sites in the vicinity of Platform Hidalgo were selected and sampled in this study. Four sites were classified as “high relief” (with outcroppings more than 1 m high) and four as “low relief” (with sand, cobble, and lower outcroppings approximately 0.2 - 0.5 m). Sites within each relief category were further distinguished as either “nearfield” (located <3 km from Platform Hidalgo) or “farfield” (>3 km from Platform Hidalgo). Study sites were also grouped into two depth categories: shallow (113-160 m) and deep (195-213 m). Thus, the sampling design among reef sites is a 2³ factorial of relief height, proximity to the platform, and depth, with two levels per factor. Each of the eight factorial combinations of reefs is unreplicated, although within a reef site replicate photosurvey observations were made to increase sampling precision.

Significant Conclusions: The fish assemblage at Platform Hidalgo consisted of far fewer species than assemblages reported for platforms in the Gulf of Mexico and others in southern California. The assemblage consisted primarily of juvenile rockfish (*Sebastes*) species even though adult rockfish are abundant at nearby natural reefs. Among the natural reefs, no statistical differences were found in rockfish population densities or community-level variables due to the effect of relief-height, depth, or proximity to the platform.

Study Results: Pattern recognition techniques and formal hypothesis testing show distinct differences in the fish assemblages between Platform Hidalgo and nearby natural reefs. Platform Hidalgo harbored a large number of midwater rockfishes and few of the more bottom-associated species found over nearby natural reefs. The preliminary data from this Pilot Study suggest that Platform Hidalgo acts as a producer by providing recruitment habitat for pelagic larvae to settle and grow before dispersing as small juveniles.

Three feeding guilds were identified in the Pilot Study. A planktivore guild, comprised of *Sebastes elongatus*, *Sebastes enlomelas*, *Sebastes hopkinsi*, and *Sebastes ovalis*; an epibenthivore guild composed of *Ophiodon elongalus*, *Sebastes miniatus*, *Sebastes paucispinis*, and *Sebastes rubrivinctus*; and a transitional guild represented by *Sebastes flavidus*. The three rockfish feeding guilds differed in their apparent diel activity patterns, as indicated by average day and night catch rates. Both planktivores and epibenthivores appeared to be more active during the day. Conversely, the catch rates for the single transitional feeder species did not differ greatly between day and night. The comparison of fishing methods indicated that gillnetting was less likely to result in everted stomachs than was hook-and-line fishing. Puncturing the fishes' swimbladders further reduced the incidence of everted stomachs.

Several biomarkers of hydrocarbon exposure and sublethal effects were measured in rainbow surfperch *Hypsurus caryi* and rubberlip surfperch *Rhacochilus toxodes* from a shallow natural

petroleum seep and from reference areas in the Santa Barbara Channel. Compounds in bile samples fluorescing at wavelengths of naphthalene were significantly elevated in rainbow surfperch but not the rubberlip surfperch from the seep, and compounds fluorescing at wavelengths of phenanthrene were significantly elevated in both species relative to the comparison areas. Both species from the petroleum seep had significantly greater concentrations of P-450IA1 in hepatic microsomes than those from the reference areas. A variety of histopathological lesions were documented in gills, liver and kidney of both species, however, total lesion scores were not different between the two groups of rubberlip surfperch.

Study Products:

Imamura, E., J. Hyland and J. Campbell. 1992. *Effects of OCS oil and gas production platforms on rocky reef fishes and fisheries*. Vol. I and II, A Final Report for the U.S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Camarillo, CA. Contract No. 14-12-0001-30489.

Love, M., J. Hyland, A. Ebeling, T. Herrlinger, A. Brooks and E. Imamura. *A pilot study of the distribution and abundances of rockfishes in relation to natural environmental factors and an offshore oil and gas production platform off the coast of southern California*. In Press

Hardin, D., D. Heilprin, G. Cailliet and M. Love. *A pilot study of rockfish feeding habits in the Santa Maria Basin, California*. In Review.

Spies, R., J. Stegeman, D. Hinton, B. Woodin, M. Okihiro and D. Shea. *Biomarkers of hydrocarbon exposure and sublethal effects in embiotocid fishes from a natural petroleum seep in the Santa Barbara Channel*. In Review.

MBC Applied Environmental Sciences. 1987. *Annotated Bibliography: Fisheries species and oil/gas platforms offshore California*. MMS 86-0092. 290 pp.

Total Cost: \$341,000

Principal Investigators: M. J. Allen, R. K. Cowen, L. A. de Wit, T. J. Kawling, M. S. Love, C. T. Mitchell, W. L. Stockton

Key Words: age, artificial reef, assemblage, attached epibiota, attraction, behavior, biology, central California, community, contaminant, distribution, ecology, economics, epibiota, feeding, fish, fish assemblages, fishery, fisheries, fouling community, gas platform, groundfish, growth, habitat, ichthyoplankton, larvae, length, life history, mariculture, migration, mortality, movements, mussels, nursery, OCS, oil island, oil platform, population, physiology, productivity, recruitment, reef, regulations, reproduction, seasonality, southern California, spawning, succession, tagging, weight, wetfish.

Background: The Minerals Management Service (MMS) of the U. S. Department of the Interior has jurisdiction over the leasing and development of oil and gas resources of the submerged lands of the Outer Continental Shelf (OCS). Recent lease sales and development activities have resulted in an increased concern for the potential conflict between offshore oil and gas operations and the sport and commercial fisheries off California. There is a considerable body of information on the biology, ecology, and distribution of the more important fisheries species offshore California. There are also some reports and data files on the ecology of the epibiota and fish assemblages of oil/gas platforms off California. However, concise summaries of this information are not available. MMS personnel require such summaries to assess and predict the potential for impacts on these species and to make effective decisions concerning leasing and development plans.

Objectives: The primary objective of this phase of the study was to assemble a comprehensive, annotated bibliography on important fisheries species offshore California and on the ecology of fish and invertebrates which associate with oil and gas platforms offshore California. Corollary objectives of the bibliography were to provide "hard copies" of all citations (arranged alphabetically by author) and annotations and to provide the entire annotated bibliography on magnetic media in such a format that it can be readily expanded, searched, sorted and retrieved.

Description: The annotated bibliography is an appendix to two other documents produced under the same contract: Ecology of Important Species Offshore California (MMS OCS Study 86-0093), and Ecology of Oil/Gas Platforms Offshore California (MMS OCS Study 86-0094). It consists of more than 950 citations and annotations, and includes all references cited in those two documents plus others which were not cited, but were considered to be potentially useful to researchers seeking more detailed or more general information than was included in the contract documents.

The hard-copy bibliography is considered to be of limited usefulness, inasmuch as it is in a fixed format (alphabetical by senior authors' last names) and thus can only be searched effectively by author. The computer-based bibliography was provided to MMS along with a complete Sci-Mate[®] Software System (produced and registered by the Institute for Scientific Information[®], Philadelphia, PA), including "The Searcher", "The Manager", and "The Editor." "The Manager" will allow MMS users to update the bibliography with new citations/annotations, to search entries by author, key words (subjects), species names or dates, and to sort and retrieve selected entries.

Significant Conclusions: The literature search revealed that there is a considerable body of information about the general ecology of most of the 32 target species, more in fact than could be incorporated into the species characterizations produced in this study. As a result, the annotated bibliography is much larger than anticipated but will be very useful for users who require more detailed information than provided in the text. However, if this bibliography is to remain useful, it must be updated on a regular basis.

Because concern for the potential for conflict between the fisheries and oil and gas development of the California OCS has only recently been expressed, little detailed information on this conflict was available. Future studies should directly address this problem and should be conducted by disinterested parties; such studies, whether published in the refereed literature or not, should be entered into the annotated bibliography.

The literature search revealed that there is little published information on the ecology of oil/gas platforms in OCS waters off California. There is a considerable amount of information on the ecology of artificial reefs and platforms in State waters, although the most detailed studies were conducted more than 25 years ago on nearshore platforms. There is little information at present on the ecology of the offshore platforms, and no suitable quantitative information that would allow the determination of whether platforms increase fish productivity or simply attract fish from surrounding areas.

Recommendations for further studies include: 1) a synoptic survey of all existing platforms in California OCS waters, to identify differences in the fish assemblages at different platforms; 2) monitoring studies (of up to 10 years) at representative platforms with the goal of describing interannual changes in the fish assemblages and populations at deep water and northern platforms; 3) feeding studies to determine which species feed on platform-associated prey and the relative importance of this prey in their diet; and 4) tagging studies to determine residence time at, and movement between platforms.

Study Results: The results of this aspect of the study consist of the annotated bibliography described under "DESCRIPTION" above.

Study Products:

MBC Applied Environmental Sciences. 1987. *Ecology of important fisheries species offshore California*. U. S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Los Angeles, CA. MMS Contract No. 14-12-0001-30294.

MBC Applied Environmental Sciences. 1987. *Ecology of oil/gas platforms offshore California*. U. S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Los Angeles, CA. MMS Contract No. 14-12-0001-30294.

MBC Applied Environmental Sciences. 1987. *Annotated bibliography: Fisheries species and oil/gas platforms offshore California*. U. S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Los Angeles, CA. MMS Contract No. 14-120001-30294.

MBC Applied Environmental Sciences. 1987. *A computerized database of important fisheries offshore California*. U. S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Los Angeles, CA. MMS Contract No. 14-12-0001-30294.

MBC Applied Environmental Sciences. 1987. *Ecology of oil/gas platforms offshore California*. MMS 86-0094. 92 pp.

Total Cost: \$341,000

Principal Investigators: M. J. Allen, R. K. Cowen, T. J. Kawling, C. T. Mitchell.

Key Words Artificial reef, assemblage, attached epibiota, attraction, central California, community, ecology, epibiota, fish, fish assemblages, fisheries, feeding, fouling community, gas platform, habitat, mariculture, movements, mussels, OCS, oil island, oil platform, productivity, recruitment, reef, southern California, succession, tagging.

Background The Minerals Management Service (MMS) of the U. S. Department of the Interior has jurisdiction over the leasing and development of oil and gas resources of the submerged lands of the Outer Continental Shelf (OCS). Recent lease sales and development activities have resulted in an increased concern for the potential conflict between offshore oil and gas operations and the sport and commercial fisheries off California. There are some reports and data files on the ecology of the epibiota and fish assemblages of oil/gas platforms off California and the associated recreational fisheries; however, a concise summary of this information is not available. MMS personnel require such a summary to assess and predict the potential for impacts on these species and to make effective decisions concerning leasing and development plans.

Objectives The primary objective of this phase of the study was to summarize information on the ecology of oil/gas platforms off California and the relationship of these platforms to fisheries and mariculture. Secondary objectives were to determine whether there are sufficient data to determine whether platforms merely attract fishes or actually increase their productivity and to recommend studies which would fill the present data gaps in the knowledge of platform fish and invertebrate communities.

Description Information on the ecology of oil/gas platforms off California was summarized from published and unpublished literature as well as personal communications with knowledgeable persons. Existing platforms were described in terms of their physical structure, their location and date of installation; these factors were related to observed differences in the associated faunas. The ecology of the epibiota of the platforms was described, including community development, its productivity, and the invertebrate fauna of the cuttings and detrital pile beneath the platforms. The ecology of fish assemblages found at platforms was described also, including community development, relative abundance of the species, ecological relationships of the species, and movements.

Platform fish assemblages were compared to those at other artificial structures and in nearby natural habitats. The role of the platforms in aggregating fishes and in increasing their productivity was discussed, and a trophic model projecting differences between community

dynamics at offshore and nearshore platforms was presented. The mariculture potential of the platforms was summarized, primarily from personal communications with persons directly involved with such projects. The effects of the platforms on sport and commercial fisheries were also described and compared to known interactions between platforms and fisheries in the Gulf of Mexico. Recommendations for further studies were proposed, along with a generalized plan for conducting these studies.

Significant Conclusions The literature search revealed that there is little published information on the ecology of oil/gas platforms in OCS waters off California. There is a considerable amount of information on the ecology of artificial reefs and platforms in State waters, although the most detailed studies were conducted more than 25 years ago on nearshore platforms. There is little information at present on the ecology of the offshore platforms, and no suitable quantitative information that would allow the determination of whether platforms increase fish productivity or simply attract fish from surrounding areas.

Recommendations for further studies include: 1) a synoptic survey of all existing platforms in California OCS waters, to identify differences in the fish assemblages at different platforms; 2) monitoring studies (of up to 10 years) at representative platforms with the goal of describing interannual changes in the fish assemblages and populations at deep water and northern platforms; 3) feeding studies to determine which species feed on platform-associated prey and the relative importance of this prey in their diet; and 4) tagging studies to determine residence time at, and movement between platforms.

Study Results: At present (1987) there are 28 oil and gas platforms in central and southern California, 19 in Federal OCS waters and 9 in California State waters. Although some platforms have been in place for over 25 years, there is a general lack of data concerning the fish and invertebrate faunas which associate with them, especially at those in OCS waters.

The epibiotic community of the platform is composed primarily of attached mollusks, barnacles, and polychaetes, with bay mussels (*Mytilus edulis*) and California mussels (*Mytilus californianus*) being dominant. The attached epibiota develops over the first two years through a series of successional stages to a more stable community. Most of this filter-feeding epibiota derives its energy from plankton in the passing water mass. As they grow, clumps of mussels and associated biota fall to the bottom and form a debris pile that is used by other organisms for food and cover.

The fish fauna at nearshore, shallow-water depths (less than 45 m) is dominated by surfperches and rockfishes. The major species in this assemblage are about equally divided between those with relatively large mouths (which consume large organisms such as crabs and small fish) and those with relatively small mouths (which graze on small epifauna and planktonic organisms). The platform-associated fauna is generally similar to that of nearby natural reefs and oil islands. However, more species were observed frequently at the platforms than at the other structures. Platforms also lacked species which associate with algae,

presumably because algal growth on platforms is limited. Some species of fish may only be attracted to platforms temporarily, as a point of reference, but other species do feed and reproduce at them.

The fish fauna at platforms in California OCS waters has not been well studied. Qualitative observations indicate that some of the same species associate with the upper 35 m of those structures as at shallow-water platforms; rockfishes probably dominate below that depth.

Although a considerable amount of zoo- and phytoplankton is converted into bivalve biomass at offshore platforms, only one company is currently harvesting mussels from the platforms for commercial sale. The use of platforms for mariculture is not yet financially profitable. Platforms are not fished extensively by sport fishermen, and their presence effectively closes the area to commercial trawling and gill netting.

Study Products:

MBC Applied Environmental Sciences. 1987. *Ecology of important fisheries species offshore California*. U. S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Los Angeles, CA. MMS Contract No. 14-12-0001-30294.

MBC Applied Environmental Sciences. 1987. *Ecology of oil/gas platforms offshore California*. U. S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Los Angeles, CA. MMS Contract No. 14-120001-30294.

MBC Applied Environmental Sciences. 1987. *An annotated bibliography: Fisheries species and oil/gas platforms offshore California*. U. S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Los Angeles, CA. MMS Contract No. 14-12-0001-30294.

MBC Applied Environmental Sciences. 1987. *A computerized database of important fisheries offshore California*. U. S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Los Angeles, CA. MMS Contract No. 14-12-0001-30294.

MBC Applied Environmental Sciences. 1989. *An historical perspective of the commercial and sport fisheries offshore California through 1985.* MMS 89-0073. 43 pp.

Total Cost: \$538,000

Principal Investigators: Leray A. de Wit, Michael Brandman Associates

Key Words: fisheries, marine, California, sport, commercial

Background: The Minerals Management Service (MMS) of the U.S. Department of the Interior has jurisdiction over the leasing and development of oil and gas resources of the submerged lands of the Outer Continental Shelf (OCS). Recent lease sales and development activities have resulted in an increased concern for the potential conflict between offshore oil and gas operations and the sport and commercial fisheries off California. There are numerous reports and data files on the sport and commercial fisheries of California's offshore waters, however, a concise summary of this information is not readily available to MMS and other potential users. MMS personnel require such a summary to assess and predict the potential for impacts to fisheries species and to make effective decisions about leasing and development plans.

Objectives: The primary objective of this phase of the study was to provide an overview of the historical commercial and sport fisheries offshore California. The document will be especially useful as an introduction to the computerized database and software being developed for use on IBM-PC compatible computers. Potential users can utilize this document to determine what fish species, fishing gear, and fisheries are of importance and concern in a particular region. The computer system can then be used to compile and output data for a much smaller area, for example a particular 3nm by 3nm lease block.

Description: Information on commercial and sport fisheries was obtained from published and unpublished literature; personal interviews with numerous fishermen, the University of California Cooperative Extension (UCCE), as well as various regulatory and management agency personnel; and from the (in-progress) computerized database. The resulting summary which is presented is current through 1985 and thus forms the basis for updating the commercial and sport fisheries for the ensuing years.

For the purposes of discussion, California was divided into seven marine regions. The historically important sport and commercial target species and gear types in each were discussed and heavily fished areas within each region were described in greater detail. These regions generally correspond to catch-reporting areas recently established by the California Department of Fish and Game as follow:

Eureka:	The Oregon border to Cape Mendocino
Fort Bragg:	Cape Mendocino to Point Arena

San Francisco:	Point Arena to Point San Pedro
Monterey:	Point San Pedro to Point Sur
Morro Bay:	Point Sur to Point Conception
Santa Barbara:	Point Conception to Point Dume
San Pedro:	Point Dume to the Mexican border.

In addition to describing the fisheries by region, the final report discusses fishing regulations, statewide and by region, and it presents information on under-utilized species and developing fisheries.

Despite the abundance of information (and the costs involved in collecting it) the available data are compromised to some extent. The fishermen who provide the original data to CDF&G may be reluctant to reveal their Fishing "hot-spots" or may be too hurried to provide accurate information on the location of the catch. In addition, some of the data may have been inadvertently altered during manual transcriptions or computer-assisted manipulations.

Study Results: Commercial fishing in California began as early as 1849 and increased steadily from 1916 to 1950; between 1950 and 1985 the total fishery declined, leveling off to an annual average of about 450 million pounds. The party-boat catch (which represents approximately 40% of the total sport catch) in California increased steadily until about 1979 and has decreased since then. The success of both commercial and sport fisheries varied by species from year to year and over the long term according to market price, fishing pressure, and availability of the species; examples of increasing, decreasing, and cyclic trends with time were provided.

Study Products:

MBC Applied Environmental Sciences. 1987. *Ecology of important fisheries species offshore California*. U.S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Los Angeles, CA. MMS Contract No. 14-12-0001-30294, OCS Study MMS 86-0093.

MBC Applied Environmental Sciences. 1987. *An Annotated Bibliography: Fisheries species and oil/gas platforms offshore California*. U.S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Los Angeles, CA. MMS Contract No. 14-12-0001-30294, OCS Study MMS 86-0092.

MBC Applied Environmental Sciences. 1987. *Ecology of oil/gas platforms offshore California*. U.S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Los Angeles, CA. MMS Contract No. 14-12-0001-30294, OCS Study MMS 86-0094.

MBC Applied Environmental Sciences. 1989. *An historical perspective of the commercial and sport fisheries offshore California through 1985*. U.S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Los Angeles, CA. MMS Contract No. 14-12-0001-30294, OCS Study MMS 89-0073.

MEC Analytical Systems, Inc. 1995. *Disturbance of deep-water reef communities by exploratory oil and gas operations in the Santa Maria Basin and Santa Barbara Channel*. MMS 95-0030. 359 pp.

Total Cost: \$654,000

Principal Investigators: Douglas Diener, Andrew Lissner, Suzanne Benech, Noel Davis, and A.J. Field.

Quality Review Board (ORB): Paul Dayton, Roger Green, and Ronald Kolpack.

Key Words: Hard-bottom epifaunal communities, disturbance, recovery, anchor scars, Santa Maria Basin, Santa Barbara Channel, benthic epifauna.

Background: Based mostly on Minerals Management Service (MMS) biosurveys, it is known that deep-water, hard-bottom areas on the Outer Continental Shelf (OCS) are populated by a fascinating diversity of epifaunal invertebrates and numerous fish species. Many of these species are long-lived and slow growing organisms (Lissner et al., 1991). Because of the scarcity, value, and potential sensitivity to disturbances of deep-water, hard-bottom habitat on the OCS, the regulatory agencies, fishing industry, and interested public have expressed concern about the disturbances of offshore oil and gas exploration activities on this habitat. To address these concerns, the MMS organized a two-day workshop in November 1989 that led to the formation of a subcommittee known as the Hard Bottom Committee (HBC). The HBC was given the task of developing guidance to resolve the issues concerning the disturbances of exploratory drilling activities on hard-bottom habitat of the Santa Maria Basin and Santa Barbara Channel.

Objectives: The objectives of the exploratory oil and gas operations disturbances study targeted by the HBC were: (1) to document the extent of physical damage to reef communities from anchoring operations; (2) to quantify the recovery period of reef communities from disturbances due to anchoring events associated with exploration operations; (3) to make recommendations to minimize anchor disturbances to reef communities during exploration activities; (4) to identify and, if possible, quantify disturbances associated with drill muds and cuttings; and (5) to provide information on the composition and natural history of the hard-bottom, benthic communities of the Santa Maria Basin and Santa Barbara Channel.

Description: The study area consisted of a portion of the Pacific OCS off the coast of California between Point Arguello and Santa Barbara. The area of interest lies in water depths between approximately 65 and 400 m (210 and 1,300 ft).

The study consisted of the following five tasks:

Task 1 involved an extensive literature review to obtain existing information on anchoring-related disturbances.

Task 2 involved the development of a logical, carefully documented procedure for selection of the study sites.

Task 3 was to conduct a remotely-operated vehicle (ROV) field survey at the selected sites to assess and document disturbances related to anchoring operations and discharge of drill muds and cuttings on deep-water, reef communities.

Task 4 involved the analysis of sediments collected around the wellsites to determine if drill muds and cuttings were still present.

Task 5 involved the preparation of a report and videotape to summarize the study methodology, results, conclusions, and recommendations.

Significant Conclusions: Hard-bottom habitats can be severely impacted by anchoring operations resulting in physical alteration of the substrate size and amount of exposed hard bottom. Hard-bottom communities will not recover to pre-disturbed conditions where substrate has been altered. A different hard-bottom community more appropriate for the disturbed substrate will develop.

Hard-bottom communities do recover from disturbances depending upon the size and frequency of disturbance, the natural history of the biota, and water depth. Deeper communities appear to recover more slowly than shallow water communities.

Recovery takes years to decades depending upon the complexity of the community. Low relief communities tend to be less diverse than high relief communities.

Since exploratory anchoring operations are infrequent and impact less than 1% of hard-bottom habitat within the mooring system, exclusive of other cumulative impacts, this level of disturbance does not represent a threat to the maintenance of a diverse and abundant epifaunal community.

There was no conclusive evidence for the persistence of drilling muds or cuttings near wellsites investigated for this study.

Study Results: The deep-water (> 65 m (210 ft)) seafloor of the project area was predominantly soft bottom and contained a relatively small portion (< 10%) of hard-bottom substrate.

Of the 274 exploratory wellsites identified in water depths greater than 65 m (210 ft), only 60 were reported on or near hard-bottom substrate. After reviewing all available information, nine wellsites were identified that had a high potential for containing anchoring-related disturbances. Of these nine sites only four provided good evidence for disturbances on hard-bottom communities.

The epifaunal communities were significantly altered in scar areas having fewer species and lower density of organisms. These community changes were largely due to alteration of the physical habitat by anchoring operations.

Anchoring disturbances altered the substrate composition by decreasing substrate size and by increasing or decreasing the amount of exposed, hard-bottom habitat. The physical damage (e.g., crushing) to hard-bottom habitat caused by anchoring operations is long-lasting (e.g., 26 years or greater).

Because hard-bottom epifauna have preferences for relief height, size of substrate, and different tolerances to sediment fluxes, communities will not recover to pre-disturbed conditions where the substrate has been altered. Where the hard-bottom substrate was disturbed by anchoring operations but not crushed or removed, complete recovery of the dominant, hard-bottom invertebrate groups can occur within 26 years. Certain long-lived taxa that are rare on hard-bottom, such as various sponge species, may require longer than 26 years to completely recover. For fast growing opportunistic species recovery was complete within 12 years. Motile species probably recover much faster due to immigration.

Sediment samples collected near wellsites could not be conclusively demonstrated to contain drilling muds or cuttings. Impacts associated with drilling muds and cuttings appear to be less severe than those associated with anchoring impacts.

Study Products:

MEC Analytical Systems, Inc. 1995. *Disturbance of deep-water reef communities by exploratory oil and gas operations in the Santa Maria Basin and Santa Barbara Channel*. Final Report. Prepared for U.S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Camarillo, CA. Contract No. 14-35-0001-30601, OCS Study MMS 95-0030.

Page, Henry M. and J. E. Dugan. 1999. *Effect of offshore oil platform structures on the distribution patterns of commercially important benthic crustaceans, with emphasis on the rock crab*. MMS 99-0018. 24 pp.

Total Cost: \$30,000

Principal Investigators: H.M. Page (UCSB) and Jenifer Dugan (UCSB)

Key Words: Santa Barbara Channel, oil platform, crabs, Cancridae, Majidae, benthos, soft-bottom, mussels, mussel mound

Background: Offshore oil platforms act as artificial reefs which provide habitat for mussels, encrusting bivalves, sea anemones and other invertebrates. These structures are also sites of aggregation and/or production of sport and commercially important fish species. Studies of artificial reefs, in general, have centered on whether they attract or produce sport and commercially important fishes. We tested elements of a conceptual model describing possible interactions between offshore platforms and commercially important crab stocks based on ideas developed for fish populations and fishery refugia.

We hypothesized that the distribution and abundance of highly mobile, commercially important crab species fit into one of four scenarios: 1) “recruitment/emigration” scenario-a platform provides recruitment habitat and individuals that recruit to the platform emigrate at some point to the surrounding environment, contributing to the regional production of a species; the scenario most similar to the production of new biomass hypothesis reviewed in Bohnsack (1989), 2) “recruitment/resident” scenario-platform provides recruitment habitat, but individuals remain in the vicinity of the structure, forming a resident population, 3) “attraction” scenario-individuals that recruited elsewhere are attracted to and aggregate at the platform, and 4) “visitor” scenario-individuals that recruited elsewhere occur temporarily at the platform without aggregation.

Objectives: 1) Test whether commercially important crab species occurred in higher densities beneath a platform compared to adjacent soft bottom, 2) Characterize spatial and temporal patterns of crab recruitment to a platform, including the importance of the platform invertebrate community as potential habitat and source of food for crab, and 3) Evaluate the data in the context of four scenarios described above that reflect different combinations of recruitment, and of distribution and abundance of mobile species around oil platforms.

Description: This study was conducted ~3km offshore of Goleta, California in the Santa Barbara Channel at and in the vicinity of Platform Holly (Mobil, Venoco). To characterize the invertebrate community as potential habitat and source of food for crabs, community thickness was determined on randomly selected conductor pipes monthly at four depths (6, 12, 18, 24m) from August 1995 through August 1996. Faunal litterfall from the conductor pipes to the benthos was measured monthly using 38cm internal diameter plastic circular

hoops with attached 1.4mm mesh bags suspended between pairs of pipes at a depth of 18m from October 1995 through August 1996.

Baited traps were used to evaluate the effect of location (beneath the platform versus soft bottom) and time-of-year on the abundance of adult crabs. Traps were deployed monthly beneath the platform from July, 1995 through August, 1997 and retrieved after a 22 to 24 hour soak time. Traps were deployed on soft bottom every two months -200 m east, south, and west of the platform from October, 1995 through May, 1997. Crabs in the traps were identified to species and sex, measured, and the presence of eggs recorded. Trapping results are expressed as catch per unit effort (CPUE).

Video recordings taken from a manned submersible (Delta) on October 29, 1996 provided qualitative information on bottom topography and semi-quantitative information on the abundance of adult cancrid and majid crabs on the bottom. Crabs in the video within an -2m wide swath along each of the four sides of the structure were counted and identified to genus or species where possible.

To assess potential movement of crabs between the platform and surrounding benthic habitats, all cancrid crabs >95mm were tagged -1cm from the right margin of the epimeral suture with individually labeled yellow T-bar anchor tags (Floy FD-94) and released at the site of capture.

To measure spatial and temporal variation in the recruitment of crabs to the platform, recruitment cages (12 x 30cm cylinders, 12 mm mesh vexar) filled with 5kg of mussel community were deployed at depths of 12, 18, 24, and 64m from March 1996 to September 1997. Cages were retrieved bimonthly and the mussel community removed and searched. Crabs within the cages were identified to species and sex (where possible), and measured. Crabs also were sampled on conductor pipes at three depths (12, 18, 24m) using SCUBA every other month from October 1995 to November 1996 and monthly from December 1996 to July 1997. A 0.82 x 2.46 m (2m²) area was searched by two divers and crabs removed by hand. In addition, crabs concealed within the mussel community at 12m were sampled by removing 5-10kg of mussels at each station into 1.4mm mesh bags. Crabs in the samples were identified to species and sex (where possible) and measured. Crab density was standardized to 5kg wet weight of mussel community, or to area (m²). To measure the growth rate of *C. antennarius* at the platform, crabs were enclosed in cages filled with mussel community. The cages were attached to the platform at a depth of ~9m and the crabs measured monthly.

The effects of independent variables (e.g., depth, time, location) on the dependent variables (e.g., invertebrate community thickness, CPUE) were evaluated using analysis of variance (ANOVA). Tests for differences in the relative abundance of crab species between depths of 9 and 64m were made using a paired t-test by sampling date. A Chi-square test was used to test for significant deviations from a predicted proportion of 0.50 male individuals for each species.

Significant Conclusions: Three species of Cancer (*Cancer antennarius*, *C. anthonyi*, *C. productus*) and the majid crab, *Loxorhynchus grandis*, were caught in traps deployed on the bottom. None of the crab species clearly fit the recruitment/emigration scenario. Although *Cancer antennarius* recruits to the platform, emigration of this species from the platform appears limited. There was no evidence of large scale movement of this crab from the platform into the surrounding soft bottom habitat and a behavioral preference for hard substrate may preclude such movement. *C. anthonyi* most closely fits the attraction scenario with movement between the platform and surrounding habitat. The attraction of primarily female *C. anthonyi* to the platform during the winter and spring months, may involve seasonal changes in habitat use related to reproduction; behavior that has not been invoked previously to explain patterns of aggregation around artificial structures. The distribution and abundance of *C. productus* and *L. grandis* most closely fit the visitor scenario. *C. productus* is present in low densities throughout the year while *L. grandis* is present seasonally. Our results, in the context of these scenarios, reflect interspecific differences in patterns of abundance, recruitment, and behavior, and illustrate the need to consider the responses of individual species to artificial structures such as oil platforms.

Study Results: The invertebrate community on platform conductor pipes varied in thickness with depth and time. Thickness was greatest over time at a depth of 12m (11.0 to 18.1cm) and least at depths of 18 and 24m (3.3 to 7.5cm). Rates of faunal litterfall to the benthos varied over time, ranging from 0.08 to 2.60kg wet weight•trap⁻¹•week⁻¹. Dislodged clumps of *M. galloprovincialis* formed 92.8% of this material.

Video recordings from the submersible showed that the topography of mud soft bottom beneath the platform is covered by a mound of mussel shells and other debris with an estimated height of 3 to 4m. The mound was highest towards the west and north side of the platform. Mud substratum was visible on the east side of the platform.

The mean CPUE of *Cancer antennarius* over time was much higher beneath the platform (1.0 to 7.5 crabs•trap⁻¹) than on surrounding soft bottom (0 to 0.7 crabs•trap⁻¹). The mean CPUE of *C. anthonyi* was also higher at the platform (0 to 16.7 crabs•trap⁻¹) than at the soft bottom stations (0 to 3.0 crabs•trap⁻¹). No effect of location on CPUE was found for *C. productus* and *Loxorhynchus grandis*. A strong effect of time on CPUE was found for *C. anthonyi* and *L. grandis*. For *C. anthonyi*, there was a pattern of generally higher values during the winter and spring (January-May, ≥ 3.0 crabs•trap⁻¹) compared with summer and fall (June-November, ≤ 2.0 crabs•trap⁻¹). *L. grandis* were present only during the fall and winter months. There was no relationship between the monthly mean CPUE of *C. antennarius*, *C. anthonyi*, *C. productus*, or *L. grandis* beneath the platform and monthly faunal litterfall rates measured at the conductor pipes.

The number of cancrid crabs in the video recordings ranged from 0.5 crab•10m⁻² (east, west, and south transects) to 2 crabs•10m⁻² along the north transect. Values for *L. grandis* were variable, ranging from ~0.2 crab•10m⁻² along the east and south transects to 2 crabs•10m⁻²

along the west and north transects.

Seven hundred eighty cancrid crabs were tagged in this study (368 *C. antennarius*, 347 *C. anthonyi*, and 65 *C. productus*). Recapture rates were low for all species at the platform (*C. antennarius*- 1.4%, *C. anthonyi*-0.9%, *C. productus*-3.1%). No tagged individuals were recaptured at the soft bottom stations. 10 tagged *C. anthonyi* were caught in traps set by local fishermen at distances of up to 8km from the platform and up to 1.5 years after initial tagging. No tagged individuals of the other species were reported by fishermen.

All *Cancer* individuals captured in traps on the bottom were adults. At the platform, the proportion of male crabs (number of male crabs/total number of trapped crabs) of *C. antennarius* (0.34), *C. anthonyi* (0.13) and of *C. productus* (0.10) differed significantly from 0.50. At the soft bottom stations, the proportion of male crabs was not significantly different from 0.50 for *C. antennarius* and *C. productus* or biased towards male crabs for *C. anthonyi* (0.76). A trend of more male than female *L. grandis* were trapped at both platform (0.89) and soft bottom (0.85) locations.

Only 1.8% (n=169) and 8.3% (n=12) of female *C. antennarius* were ovigerous beneath the platform and on the structure, respectively. The percent of female *C. anthonyi* that were ovigerous ranged from 0% in Summer and Fall to 28 and 37%, respectively in Winter 1996, and Spring 1997 and was positively correlated with the CPUE of females beneath the platform (excluding the outlying mean value of 15.3 crabs/trap in November 1995).

Only *C. antennarius* recruited onto the platform. Recruitment was clearly seasonal; crabs ≤ 10 mm CW were most abundant during late Spring and Summer. In the recruitment cages, there were no differences in the densities of crabs ≤ 10 mm CW with depth. In addition, only *C. antennarius* were observed in visual surveys on the platform. There was no effect of time or depth (12, 18 and 24m) on crab density which, for grouped data, averaged $0.8 \text{ crab} \cdot \text{m}^{-2}$. If data from mussel community samples and visual surveys are combined, the density of crabs was dramatically higher at 12m than at 18 or 24m during late Spring and early Summer due to crab recruitment. The rate of growth of *C. antennarius* in cages at the platform was two to three times faster than rates reported previously for this species.

Study Products:

Page, H. M., J. Dugan, D. Dugan, and J. Richards. 1997. *Commercially important crabs and offshore oil and gas platforms*. Platform Decommissioning Workshop, MMS/California State Lands Commission, Ventura, California. (poster).

Page, H. M., J. Dugan, D. Dugan, and J. Richards. 1997. *Distribution of rock and sheep crabs in relation to an offshore platform*. Annual meeting of the Western Society of Naturalists,

Monterey, California.

Page, H. M., J. E. Dugan, D. Dugan, and J. Richards. in press. *Effects of an offshore oil platform on the distribution and abundance of commercially important crab species*. Marine Ecology Progress Series.

Dugan, D. S. in preparation. *An investigation of the population structure and growth rate of the brown rock crab, Cancer antennarius, on an offshore oil platform.*, Masters Thesis, California State Polytechnic University, San Luis Obispo.

Dugan, D. S., J. E. Dugan, and H. M. Page. in preparation. *Population structure and growth rate of the brown rock crab, Cancer antennarius, on an offshore oil platform*. Target-Fishery Bulletin.

II. On-going Studies

Carr, Mark H., G. E. Forrester and M. V. McGinnis. *Ecological consequences of alternative abandonment strategies for POCS offshore facilities and implications for policy development.*

Total Cost: \$ 255,000

Principal Investigators: M.H. Carr (UCSC), G.E. Forrester (UCLA), and M.V. McGinnis (UCSB)

Project Period: FY 1996 - 2000

Background: Several offshore platforms in Federal waters offshore California are nearing the ends of their useful life cycles and may be removed in the next few years. This is already happening in state waters. The MMS has been actively involved with the State of California in workshops and planning for abandonment of facilities. Scientific questions persist about the utility of offshore structures as artificial reefs and the value of these potential artificial reefs to commercial and sports fishing interests within the state. This proposal addresses some of the scientific questions focusing on several platforms which may be removed during the next year or two. Information gained from this research will be coupled with research funded through the MMS and U.S. Geological Service/Biological Resources Division.

Objectives: The objectives of this research proposal are to study four platforms in the Santa Barbara Channel which may be removed in the next year or two. The role these platforms play in providing an artificial reef for various species of fish is to be investigated.

Method: Pre and post platform removal surveys of the fish populations around the platforms and at adjacent natural reefs will be conducted by divers and remote sensing equipment. Species composition and size analyses will be done at the two environments (natural reefs and platforms) with the goal of correlating these parameters with the presence or absence of the platform.

Products: A final report will be prepared with the findings of the research and the implications of platform removal on populations of commercial and sports fish in the Santa Barbara Channel. Peer reviewed publications are expected to be submitted to scientific journals. Final briefings and discussions with MMS, other state and local agencies, and interested fishing industry and oil and gas industry representatives will be done.

Justification: MMS as a regulatory authority must insure that OCS facilities abandonments are conducted within existing regulations and that proposed changes to regulations or abandonment practices must be reviewed for their scientific and operational merits. This information is critical to MMS and other agencies if changes to present abandonment and

removal processes and regulations are to be considered for future facilities.

Current Status of Information: Researchers have completed collecting data on fish assemblages around platforms. The final report is due in December 1999.

Continental Shelf Associates. *Survey of invertebrate and algal communities on offshore oil and gas platforms in southern California.*

Total Costs: \$400,000

Principal Investigators: R. Meek (UCSB) and S. Benech (Benech Associates)

Project Period: FY 1998 - 2000

Background: Data gaps exist with respect to the degree of contribution of invertebrate and algal communities to the general ecology in and around oil and gas platforms in the Pacific OCS Region. Additional information needs must be addressed with respect to comparison of invertebrate species at platforms with those on adjacent natural reefs.

Biological field surveys are being conducted at eight OCS oil and gas platforms in the Santa Barbara Channel and Santa Maria Basin

Objectives: The basic study objectives are to (1) conduct biological field surveys of invertebrate and algal communities at selected oil and gas platforms and adjacent natural reefs in the Santa Barbara Channel and Santa Maria Basin, and (2) describe community structure by determining abundance, density, and distribution of these species. The Santa Barbara Channel and Santa Maria Basin are the geographic focus of the proposed survey, since they represent the most concentrated area of oil and gas operations in the POCS. Results from this study will aid the MMS with issues relating to the decommissioning of oil and gas platforms in the Santa Barbara Channel and Santa Maria Basin. Based on the Region's increased decommissioning activities projected for the near future, this study is vital to the MMS decision-making process.

The specific objectives of the proposed study are as follows:

- (1) determine the abundance, density, and depth distribution/vertical zonation of invertebrate and algal communities on selected oil and gas platforms and adjacent natural reefs in the Santa Barbara Channel and Santa Maria Basin;
- (2) quantify biomass production estimates of invertebrate and algal communities on selected oil and gas platforms and adjacent natural reefs in the Santa Barbara Channel and Santa Maria Basin;
- (3) conduct the proposed research with methodologies similar to or complimentary to those of the ongoing studies being conducted by UCSB (Marine Science Institute); and
- (4) make recommendations (based on the study results) to MMS regarding invertebrate and algal communities on selected oil and gas platforms with respect to future decommissioning

activities in the Santa Barbara Channel and Santa Maria Basin and the importance of these organisms to general ecology of the region and local area.

Importance to MMS: In the near future, the MMS will require information provided by the study to address issues and make decisions on possible decommissioning and removal of oil and gas platforms in the Santa Barbara Channel and Santa Maria Basin, especially those in deepwater. The study addresses the above with comprehensive surveys of invertebrates and algal communities associated with oil and gas platforms and adjacent natural reefs.

Endter-Wada, Joanna and R. Little. *Social and economic adaptations by fish harvesters in the Santa Barbara Channel-Santa Maria Basin area, California.*

Total Cost: \$336,000

Principal Investigators: Joanna Endter-Wada (U. of Utah) and Ron Little (U. of Utah)

Project Period: FY 1995-1999

Background: The OCSLA 1978 (1802 (2) (b)) mandates balancing "...orderly energy resource development with protection of the human, marine, and coastal environments". However, the human environment in areas adjacent to existing OCS development in the Pacific Region needs further study. This lack of attention to the local human environment has been repeatedly brought to MMS' attention by various levels of local government, public interest groups, and groups opposed to OCS development. Commercial fish harvesting in the area has a regional symbolic value far beyond its locally important economic contribution.

Objectives: The objectives of this research are to aid MMS in assessing the actual or potential impacts of OCS gas and oil activities on the social organization of fish harvesters, the lives of fishing families and the economics of fish harvesting.

Methods: This procurement will provide an analysis of the social composition and the social and economic adaptations of commercial fish harvesters in the Santa Barbara Channel-Santa Maria Basin area for three time samples during the period, ca. 1960-1990. The research will be centered upon the commercial fish harvesters working out of the ports of Morro Bay, Port San Luis, Santa Barbara, Ventura, and Channel Islands.

Products: Final Report

Importance to MMS: Commercial fish harvesters in the Santa Barbara Channel-Santa Maria Basin area comprise a major user group of offshore marine resources and a competitor for OCS space. Knowledge of the social and economic adaptations of local commercial fish harvesters in the recent period, and the impact of OCS development on them and their enterprises, will support current operations in the area. This information will also be critical for the future development of active leases in the area.

Love, Milton S., M. Nishimoto, D. Schroeder, A. Gharrett and A. Gray. 1998. *The ecological role of natural reefs and oil and gas production platforms on rocky reef fishes in southern California, Final Interim Report.* U.S. Dept. of Interior, U.S. Geological Survey, Biological Resources Division. USGS/BRD/CR-1999-0007. 226 pp.

Total Cost: \$2,200,000

Principal Investigators: M.S. Love (UCSB) and Anthony Gharrett (U. of Alaska-Fairbanks)

Project Period: FY 1995 - 2000

Background: This Phase II project builds upon the results of a pilot project (MMS Contract No. 30489) that was conducted during 1990 in the Santa Maria Basin. The Final Report for the pilot project was completed in June 1993.

Objectives: The goal of the project is to evaluate the effects of an OCS oil and gas development and production platform on the abundance, species composition, and movements of fishes that inhabit natural, deep-water reefs adjacent to a platform. Important questions that need to be addressed because they relate to achieving the goal include: Do fish assemblages associated with reefs vary temporally, and/or spatially with proximity to platforms? If changes do occur, are they associated (1) directly with physical (i.e., sedimentological) changes to the reefs, (2) indirectly with changes in the availability of prey species on the reefs as altered by platform discharges, or (3) indirectly because of the availability of new prey and/or shelter beneath the platform?

Products: Final Report, Journal Papers

Justification: Southern California trawl and set line fishermen continue to complain that areas adjacent to oil and gas production activities lose their fishing productivity. Study results will provide answers to the direct and indirect effects of OCS oil and gas production platform operations on rocky reef fisheries (commercial and recreational). Additionally, the study will supply supportive information important for many post-lease decisions, including environmental assessments, environmental impact statements, and other environmental documents associated with plans of exploration, development and production. The effects of OCS production platform operations on rocky reef fish and fisheries continue to be a major unresolved issue among the California fishing industry, resources agencies, and the public.

Current Status of Information: Spring 1998 field surveys have been completed and an interim technical report has been published. Additional field surveys are being discussed because of the need for greater statistical power and the need to compare additional platform sites. A one-year extension to the ongoing project has been developed and will be funded by BRD.

McGinnis, Michael V. and L. M. Fernandez. *The political economy of the rigs-to-reef option for decommissioning of offshore oil and gas structures.*

Total Cost: \$115,000

Principal Investigators: M.V. McGinnis (UCSB) and L.M. Fernandez (UCSB)

Project Period: FY1999-2000

Background: Decommissioning of OCS oil and gas platforms in the Pacific Region is a relatively new challenge. Options other than complete removal have not been fully explored. The MMS and California State Lands Commission sponsored Decommissioning Workshop and follow-up interagency meetings identified a number of policy issues that should be examined. Studies should be undertaken as the next step in the process. For example, a growing body of literature examines the recreational and other uses of active and decommissioned offshore platforms as artificial reef sites. However, most of this literature has focused on areas other than the Pacific OCS. Research commenced in April 1999 and is proceeding on schedule.

Objectives: This study involves 1) examining the costs and benefits of decommissioning alternatives for offshore platforms, 2) evaluating state rigs-to-reef programs on the basis of three criteria: effectiveness of the statutory basis of the program, allocation of the costs and benefits of decommissioning options, and 3) the role of ecological restoration in a rigs-to-reef programs.

Methods: This study uses a number of social science methods including case studies, analysis of archival data, elite interviews, and policy analysis.

Importance to MMS: The study illustrates the alternatives available for converting OCS platforms to some other use as part of an economically rational, environmentally beneficial decommissioning strategy. The study supports the Region's interests in decommissioning.

Page, Henry M. and J. E. Dugan. *Early development of fouling communities on offshore oil platforms.*

Total Cost: \$198,000

Principal Investigators: H.M. Page (UCSB) and J.E. Dugan (UCSB)

Project Period: FY 1999-2001

Background: The intertidal and subtidal portions of offshore oil platforms provide hard attachment sites for a diverse community of invertebrates. Development of this "fouling community" can be very extensive with several factors affecting the rate of accumulation. The accumulation can increase the weight load on platform surface members and the frictional drag on the structure, necessitating periodic and costly removal. Furthermore, the dislodging of community members (faunal litterfall) creates hard substrate which may affect community development and provide food and habitat for benthic organisms. Research commenced in April 1999 and is proceeding on schedule.

Objectives: This study characterizes the recruitment and growth of invertebrates onto recently cleaned support members of two platforms, tests the effect of several non-biological factors on community development, evaluates the importance of early colonizers on recruitment of later species, and determines the relationship between the fouling community and rates of faunal litterfall.

Methods: This study uses a number of well established techniques for determining the rates of accumulation and removal of biomass on platforms.

Importance to MMS: The information on the composition and rate of growth of biomass on platforms is useful to structural engineers in order to calculate the forces imposed on the structure from the marine environment. Also, this information would be useful in developing requirements for marine growth removal. Finally, characterization of the process from a clean platform to a functioning ecosystem helps us to understand the value of platforms as marine habitat.

Gulf of Mexico Region

I. Completed Studies

Continental Shelf Associates. 1982. *Study of the effects of oil and gas activities on reef fish populations in the Gulf of Mexico OCS area.* BLM Contract AA551-CT9-36. 223 pp.

The objectives of this study were 1) to compare reef fish populations associated with natural hard bottom areas with those associated with offshore oil and gas production structures and 2) to develop fish population censusing methods which were applicable in water depths beyond conventional scuba depth limits. The study was a three-phase effort with each phase designed to meet specific objectives. Planning and design for each subsequent phase depended upon the results of the preceding phase. Phase I involved an evaluation of potential study sites. Equipment and sampling methodology were evaluated during Phase II. Data for standing stock estimates of fish species associated with four oil and gas production platforms and one natural hard bottom area were collected during Phase III.

During Phase I, 25 sites were surveyed, described, and classified. Shallow water hard bottom sites (<35-m depth) consisted of relatively small, low-relief outcrop features, many of which have not been previously described. The hard substrate was generally covered by thick growths of ascidians, bryozoans, and hydroids. Atlantic spadefish, grey triggerfish, red snapper, sheepshead, and tomtate predominated.

Shallow water platforms were covered by an epibiotal assemblage numerically dominated by barnacles, bryozoans, hydroids, and encrusting sponges. The platforms supported large populations of Atlantic spadefish, blue runner, greater amberjack, red snapper, and sheepshead.

Deep water hard bottom sites (>35-m depth) consisted of large, high-relief outcrop features rising above the nepheloid layer and typically supported coral, crustacean, fish, and sponge species with tropical affinities. The intrusion of numerous tropical fish species into typically temperate communities was the principal faunal characteristic distinguishing deep water hard bottom and platform sites from those located in shallow water.

In Phase II, two types of remotely operated vehicles (ROVs) and several visual and remote photographic fish censusing techniques were tested. The mobility offered by the tethered, free-swimming type of ROV was judged a distinct advantage over other remote censusing methods tested. Statistical analysis revealed no significant difference ($F=0.26$; $P<0.92$) in fish abundance estimates between the type of ROV employed.

Standing stock estimates of reef fish species were quantitatively assessed and compared from the remotely collected data gathered during Phase III. Fish distribution patterns were highly variable over both space and time, thus rendering accurate comparisons between platforms and hard bottom areas impossible with the short-term data collected. Twenty-five species were identified from videotapes made by the ROVs. Total standing stock and standing stock per species were correlated with total submerged platform surface area using linear regression and curve fitting equations. A high correlation between overall fish abundance and the availability of habitat area was indicated ($r^2=0.79$, linear; $r^2=0.93$, exponential). Correlations were very high for the smaller territorial reef fishes, while no correlations were found for the larger transient species. No fishes were observed more than a few meters above the hard bottom site. Offshore structures appeared to be responsible for expanding the normal hard bottom distribution of fish populations vertically in the water column.

Statistical analyses of the quantitative data from remotely controlled television systems indicated that the sampling design accurately sampled the fish populations present above the nepheloid layer. Observations of the remote sensor quantitatively corresponded with qualitative *in situ* observations and literature reports. This correspondence supports our conclusions that remote sensors and ROVs can accurately census deep water (>100 m) fish populations.

Ditton, R., B. J. Auyong. 1983. *An analysis of recreational and commercial fishing use at 164 major offshore petroleum structures in the central Gulf of Mexico*. New Orleans, LA: Proceedings of the 4th Annual Gulf of Mexico Information Transfer Meeting. 7 pp.

A survey of 164 reporting sources from offshore petroleum structures by oil and gas company personnel yielded data on overall use patterns, spatial use patterns, temporal use patterns and user group differences.

Ellison, R., A. J. Roelle. 1984. *Adaptive environmental assessment: A planning scheme for rigs-to-reefs*. New Orleans, LA: Proceedings of the 4th Annual Gulf of Mexico Information Transfer Meeting. MMS 84-0026. 4 pp.

Development of a computer simulation model for predicting environmental impact of offshore oil and gas drilling and its potential for simulating artificial reefs is discussed.

Gallaway, B. J., G. S. Lewbel. 1982. *The ecology of petroleum platforms in the northwestern Gulf of Mexico: A community profile*. Library of Congress #82-600568. 92 pp.

Platform installation, distribution and types reviewed. Description of biofouling community components, habitat structure and zonation, and growth and succession as well as recreational

and fishery uses of platforms are presented. Thirty-six pages of color plates are included.

Gettleston, David. 1997. *Characterization and trends in recreational and commercial fishing from the Florida Panhandle*. MMS 97-0020.

The Outer Continental Shelf (OCS) of the Florida Panhandle is of interest to the OCS gas and oil industry. This interest and the potential for any conflicts or adverse impacts requires knowledge of both recreational and commercial fishing from the Florida Panhandle area. This information will help to ensure that decisions regarding development of offshore mineral resources will be compatible with the fishing industry of the Florida Panhandle. The study objectives consist of analyses and interpretations of available data (1983-1993) pertaining to recreational and commercial fishing that originated from the Florida Panhandle but was performed anywhere within Federal waters of the Gulf of Mexico but originated from the Florida Panhandle area. The investigation will also describe fishing trends and identify any relationship(s) between offshore recreational and commercial fishing from the northeastern Gulf of Mexico and OCS gas and oil development.

LGL Ecological Research Associates, Inc. and Science Applications International Corporation. 1998. *Cumulative ecological significance of the oil and gas structures of the Gulf of Mexico: Information search, synthesis, and ecological modeling; Phase I, Final Report*. MMS 97-0036. vii + 130 pp.

Bibliographic searches were made of eight databases for information and data describing the environmental characteristics and biota of the Gulf of Mexico. Nearly 400 references were obtained describing the biota, but fewer than half contained adequate information to characterize the life history of target species. The level of detail obtained, while informative, was not particularly useful for the modeling exercise. The environmental data yielded by the searches yielded much more useful information for modeling purposes, namely mapped coverages depicting environmental gradients. These coverages, along with the biological catch data contained in several extant biological databases are enabling the preparation of Habitat Suitability Index (HSI) models for selected key species. A significant finding of Phase I is that petroleum platform habitat is but a small fraction of the total reef habitat found in the central and western Gulf. However, the total numbers of red snapper estimated to occupy petroleum platforms correspond favorably to the Gulf of Mexico Fisheries Management Council's estimate of the total red snapper stock. Possible implications are that the total stock may be much larger than previously thought, or that platforms may be far more important than their area would imply, or that one or both the stock estimates are in error.

LGL Ecological Research Associates, Inc. 1998. *Cumulative ecological significance of the oil and gas structures of the Gulf of Mexico: A Gulf of Mexico fisheries habitat suitability*

model -- Phase II, Model Description. MMS 97-0044. vii + 109 pp.

Bibliographic searches were made of eight databases for information and data describing the environmental characteristics and biota of the Gulf of Mexico. Nearly 400 references were obtained describing the biota, but fewer than half contained adequate information to characterize the life history of target species. The level of detail obtained, while informative, was not particularly useful for the modeling exercise. The environmental data yielded by the searches yielded much more useful information for modeling purposes, namely mapped coverages depicting environmental gradients. These coverages, along with the biological catch data contained in several extant biological databases are enabling the preparation of Habitat Suitability Index (HSI) models for selected key species. A significant finding of Phase I is that petroleum platform habitat is but a small fraction of the total reef habitat found in the central and western Gulf. However, the total numbers of red snapper estimated to occupy petroleum platforms correspond favorably to the Gulf of Mexico Fisheries Management Council's estimate of the total red snapper stock. Possible implications are that the total stock may be much larger than previously thought, or that platforms may be far more important than their area would imply, or that one or both the stock estimates are in error.

LGL Ecological Research Associates. 1981. *Ecological investigations of petroleum production platforms in the central Gulf of Mexico. BLM Contract AA 551-CT8-17. 210 pp.*

Surveys of biofouling macroepibiota and fishes were made in June 1978 at four production platforms offshore Louisiana and were supplemented by limited observations made at an additional 15 platforms in August and September of 1978. Biofouling communities of nearshore platforms were dominated by barnacles in terms of biomass, whereas the communities on offshore platforms were dominated by bivalves. Primary production was largely restricted to surface zones of nearshore platforms but at some offshore platforms primary producers were abundant to depths of 30 m.

Platform habitats offshore Louisiana were classified into three zones using depth and faunal characteristics--Coastal (shore to 27-m bottom contour), Offshore (37 to 64 m) and Blue Water (> 64 m). A transitional area between the Coastal and Offshore Zones was considered to have been represented between the 27- and 37-m depth contours. Platforms in the Coastal Zone were dominated by barnacles and shorefishes. Bivalves and shorefishes were abundant at platforms in the Offshore Zone but were supplemented by a rich Caribbean fauna. The Caribbean fauna was dominant at platforms in the Blue Water Zone.

Taxonomic findings of significance include documentation of the presence of four species of oysters (*Crassostrea virginica*, *Ostrea equestris*, *Lopha frons*, and *Hyotissa thomasi*) on Louisiana platforms and the occurrence of two other bivalves (*Pinna carnea*, *Kellia suborbicularis*) new to the area. Species represented on production platforms that had formerly been recorded only from natural banks of the northern Gulf included the sea urchin,

Eucidaris tribuloides, and the spiny lobster, *Panulirus* sp.

Results of this study, as well as those from many previous studies, document that structures concentrate large numbers of epibiota and fishes which would not be as abundantly represented in the same area in the absence of structures. In contrast to some previous studies, produced water discharges were observed to have a detrimental effect on platform macroepibiota. The magnitude and significance of this effect have yet to be well defined.

Reggio, Villere. 1996. *Mariculture associated with oil and gas structures: A Compendium*. MMS 96-0050. 32 pp.

Increased interest in the use of offshore oil and gas platforms for growing coastal and pelagic fish and shellfish for commercial markets led MMS to sponsor a forum on this topic. This report encompasses the views, opinions, constraints, limitations, possibilities, and proposals from representatives of the public and private sectors with interest and concern for fishery development in the Gulf of Mexico.

Reggio, Villere. 1989. *Petroleum structures as artificial reefs: A Compendium*. MMS 89-0021. 176 pp.

Interest in the use of oil and gas structures for artificial reefs has increased significantly in the past 10 years, especially after passage of the National Fishing Enhancement Act of 1984 and publication of the National Artificial Reef Plan in late 1985. Consequently, the Minerals Management Service offered to play a major role in planning, organizing, and chairing a special session on Rigs-to-Reefs at the Fourth International Conference on Artificial Habitats for Fisheries held November 2-6, 1987, in Miami, Florida. Realizing that the legal, technical, social, economic, and biological ramifications of converting offshore structures to permitted artificial reefs were of keen interest to artificial reef developers, fisheries administrators, scientists, and fishermen, we attempted to organize a session that offered a broad view of Rigs-to-Reefs concerns and potentials. Practical information and expert opinion from a broad spectrum representing government, industry, academia, environmental groups, and the private sector were presented and are included in these proceedings in varying formats made available by the authors or session moderators. It is our hope that a complete and separate compendium devoted strictly to the proceedings from the special Rigs-to-Reefs session will facilitate dissemination and use of this information by those interested in the conversion of petroleum structures for fisheries enhancement and development.

II. On-going Studies

Gitschlag, Gregg. *Estimation of fisheries impacts due to underwater explosions used to sever and salvage petroleum platforms.*

The Gulf of Mexico Fishery Management Council (FMC) is very concerned over the declining stocks of reef fish, especially red snapper in the Gulf of Mexico. At least 100 platforms per year are removed from the Gulf of Mexico; the majority from the Central Planning Area. Eighty percent of all removals must use explosive charges placed 5 m below the seafloor to sever the well caissons and jacket pilings. In a letter dated May 9, 1991, to Mr. J. Rogers Percy, the FMC urged the MMS Gulf of Mexico OCS Region to require the oil and gas industry hold in abeyance explosive removal of offshore structures with three or more supports. Although there is no doubt that the use of explosives during platform removals kills fish, anecdotal accounts of fish mortalities at removals range from "a few fish" to estimates in the thousands.

This Interagency Agreement between MMS and NOAA/NMFS was signed in June 1992 and examines the specific severity of the effect of explosive platform removals on fish stocks when compared to other fish harvesting methods in the Gulf of Mexico. Both historic, annual, and projected data concerning stock assessments, commercial and sport harvest, and shrimp bycatch will be provided by the FMC.

Shaw, Richard. *The postlarval and juvenile fish nursery ground/refugia function of offshore oil and gas platforms.*

The placement of offshore oil and gas structures in the northern Gulf of Mexico (GOM) has undoubtedly had an impact on the marine environment and its inhabitants. It is the goal of this study contract to gain insight into a critical OCS question: What is the role offshore platforms play as nursery grounds or refugia for postlarval and juvenile fish, which could thereby contribute to and enhance overall fish production in the GOM. Use of light-trap methodology, which is capable of sampling large numbers of late stage postlarval and juvenile fishes in structurally complex environs, will provide foundational information. Combined with a statistically-rigorous sampling design and program, this study will begin the across shelf characterization of the early life stages of the fish community utilizing offshore oil and gas platform habitat in the central GOM.

Thompson, Nancy. *Sea turtle behavior relative to offshore structures in the Western and Central Gulf of Mexico.*

This study is being conducted in the Western and Central Gulf Planning Areas; its objectives include: (1) obtaining data on patterns of diurnal activity, habitat usage, preference, and fidelity; (2) investigating possible interrelationships between habitat preference, the ocean environment, and oil and gas activities; (3) explaining correlations that may be found and to characterize features of the habitat that appear to be important to sea turtles; and (4) determining seasonal variability in patterns of behavior. Methods include capturing, tagging, and tracking loggerhead (and, if possible, Kemp's ridley) sea turtles using a combination of radio, acoustic, and retransmitted LORAN (RTL) tags.

Wilson, Charles A. *Seasonal and spatial variation in the biomass and size frequency distribution of fish associated with oil and gas platforms in the Northern Gulf of Mexico.*

The placement of offshore oil and gas structures in the northern Gulf of Mexico has undoubtedly had an impact on the marine environment and its inhabitants. It is the goal of this study contract to gain insight into a critical OCS question: What is the effect of habitat modifications caused by the installation, operation, and subsequent removal of the numerous oil and gas structures, on the regional fish populations in the northern Gulf of Mexico. Use of a stationary array of dual-beam hydroacoustic equipment will allow measurement of near-field temporal changes in the size frequency and biomass of fishes, define the near field area of influence of the structures, and document behavior of fishes associated with the three platforms, and permit determination of the effects of SCUBA divers and a ROV on fish densities.

Workshop Proceedings

I. Pacific OCS Region

Proceedings: *Public Workshop - Decommissioning and removal of oil and gas facilities offshore California: Recent experience and future deepwater challenges. Ventura, California, September 23-25, 1997. MMS 98-0023. 270 pp.*

This proceedings volume includes papers prepared for a workshop to review recent experience and future deepwater challenges associated with removing oil and gas facilities offshore California. Included in the volume are several plenary speeches and a series of papers on decommissioning topics covered during the technical, environmental and disposition sessions of the workshop. Also included are a summary of the issues and recommendations that were developed by each of the session chairs, position papers that were prepared by environmental groups, the oil and gas industry, and recreational and commercial fishermen, the transcripts of an interagency panel discussion with the public, and an appendix describing the regulatory framework and environmental review process for the decommissioning of oil and gas facilities.

Summary of Workshop Proceedings - *Abandonment and removal of offshore oil and gas facilities: Education and information transfer. March 22, 1994. MMS Contract 14-35-0001-30-471. 28 pp.*

This proceedings volume includes papers prepared for a one-day workshop that was held in Santa Barbara, California to provide the public with an introduction to the decommissioning process and disseminate information regarding the outlook for decommissioning of oil and gas facilities located offshore California. Also included were brief discussions of decommissioning procedures, regulatory requirements, and environmental and socioeconomic considerations.

II. Gulf of Mexico Region

Proceedings: *An international workshop on offshore lease abandonment and platform disposal: Technology, regulation, and environmental effects.* New Orleans, Louisiana, April 1996. MMS Contract 14-35-0001-30794. 312 pp.

This proceedings volume includes papers prepared for an international workshop on lease abandonment and platform disposal. The workshop was held April 15, 16 and 17, 1996, in New Orleans, Louisiana. Included in the volume are several plenary speeches and issue papers prepared by six working groups, who discussed: Abandoning Wells; Abandoning Pipelines; Removing Facilities; Site Clearance; Habitat Management, Maintenance, and Planning; and Regulation and Policy. Also included are an Introduction, an Afterward, and as Appendix C, the complete report of the National Research Council Marine Board's "An Assessment of Techniques for Removing Fixed Offshore Structures", around which much discussion at the workshop was organized.