ECOLOGICAL CONSEQUENCES OF ALTERNATIVE DECOMMISSIONING STRATEGIES FOR POCS OFFSHORE FACILITIES: PRELIMINARY RESULTS

Mark H. Carr[1] and Graham E. Forrester[2]

[1] Dept. of Biology, University of California, Santa Cruz, CA 95064
(831) 459-3958, FAX (831) 459-4882, E-mail: carr@biology.ucsc.edu
[2] Dept. of Biology, University of California, Los Angeles, CA 90095-1606

INTRODUCTION

Several offshore oil and gas production facilities in the Pacific Outer Continental Shelf (POCS) region are nearing the end of, or have ended, their economic lives. Present legislation requires complete removal of decommissioned platforms. However, alternative decommissioning options including partial removal in place, or relocation as marine artificial reefs, have been implemented in other areas of the country. The removal of four offshore platforms in the Santa Barbara Channel during the summer of 1995 created interest by some user groups in pursuing such alternatives on the West Coast (MMS-SCEI Abandonment Workshop 1994). Critical to formulation of appropriate decommissioning policy is an understanding of the ecological, economic and social consequences of different decommissioning options and identification of the mechanisms by which such information is incorporated, or not, into legislation and public policy.

Perhaps the most important ecological consequence of abandoning POCS facilities is a potential change in regional fish production (the biomass of fish accrued per year), which may in turn influence yields to fisheries. Hard substratum reefs represent a small fraction of the available offshore habitat in California, but are sites of high fish production. Limited information suggests that these offshore structures can support large numbers of fishes that associate with hard substrata, and may therefore function as “artificial reefs” (Carlisle et. al. 1964; Turner et. al. 1969; Bascom et. al. 1976; Mearns and Moore 1976; Love and Westphal 1990; Love et. al. 1994). Indeed, throughout the Gulf of Mexico OCS region, where the amount of natural hard substrate is very limited, oil platforms contribute substantially (ca. 28%; Gallaway 1984) to local and regional abundance of “reef” habitat and the abundance of reef associated fishes (Gallaway and Lewbel 1982; Continental Shelf Associates, Inc. 1982; Stanley and Wilson 1991; Scarborough Bull and Kendall 1994). However, prior to the suite of studies presently being conducted in the Santa Barbara Channel, only one study (Love et. al. 1994) provided quantitative estimates of species composition and abundance of fishes at a single platform near the Santa Barbara Channel.

Central to understanding the ecological role of anthropogenic structures on regional fish production is knowledge of their relationship with fish assemblages on natural reefs (Carr and Hixon 1997). It is difficult to conclude to what extent species associated with a structure influence regional production without distinguishing local production from the redistribution of individuals (i.e., “attraction”) from natural habitat. Also critical to the development of decommissioning is understanding how both the local environment (i.e., oceanographic conditions and proximity to natural reef habitat) and structural characteristics of decommissioned structures influence the kinds and numbers of species associated with it. To provide more detailed quantitative information on the ecological role of OCS production facilities, we initiated a multi-year study on the species, numbers, distribution and movement of reef fishes at six production platforms and three nearby natural reefs in the Santa Barbara Channel.

Our multi-year investigation of the ecological role of offshore structures has three primary objectives. One objective of this study has been to quantify the species and sizes of fishes associated with platforms and natural reefs. Such information is required to determine what species and life stages might be influenced by the various decommissioning options. Do fish recruit to each habitat type from the plankton (as larvae) or migrate on to one habitat type from the other as older stages (benthic juveniles and adults)? Comparison of fishes between platforms and natural reefs provides information on what stages use the two habitat types. Patterns of fish sizes over time can also provide information on how long fish associate with each habitat type and how well they grow and survive. Such information is critical to understanding the relative value of natural reefs and platforms as fish habitat.

Several of the various options for platform decommissioning alter the vertical height of the remaining structure (e.g., “topping,” “toppling,” moving to different water depths). To estimate the potential consequences of these options, it is necessary to determine how species are distributed from the surface to the bottom of the platforms. Also, information on the size of fish at each depth can indicate patterns of recruitment and how the vertical distribution of fishes changes as they grow. Therefore, a second objective of our study has been to quantify the vertical distribution of fishes, by species and size.

Fundamental to understanding the net contribution of local populations to regional production is information on the size-specific rate of migration of fishes among local, reef-associated populations. In the context of platform decommissioning, knowledge of the net direction and rate of transfer of biomass between platforms and natural reefs is crucial. For example if fish recruit to natural reefs and eventually migrate to platforms, accumulation of fish biomass on platforms would be incorrectly attributed to production at the platform habitat. Conversely, if platforms provide recruitment habitat for fish that eventually migrate to natural reefs, the contribution of platforms to regional production may be grossly underestimated by simply measuring production in the two habitats. Movement information is also important to determine whether the loss of fish at a site is due to emigration rather than mortality. Therefore, a third objective has involved a tagging study to determine how much and what direction fish move (from platforms to reefs or vice versa), the rate of that movement, and net direction of exchange. Because this entire study is ongoing, we present here only a qualitative description of some of the preliminary results obtained to date.

STUDY AREA AND METHODS

During the three summers of 1995 to 1997, we quantified attributes of the fish assemblages associated with six production platforms (Hogan, Houchin, Henry, A, B, and C) and five nearby natural reefs (Carpinteria, three-spot, horseshoe, 4-mile, and crotch reefs). All six platforms and nearby reefs are located along the northern mainland side of the Santa Barbara Channel just offshore of the town of Summerland. Shallow (< 33 m) portions of six the production platforms and three shallow natural reefs (Carpinteria, three-spot, and horseshoe), were sampled monthly from May through October (peak periods of recruitment of most reef fishes) using diver surveys. Surveys conducted by divers on production platforms and shallow natural reefs involve estimates of the density and size of individuals of each species along 2 m wide x 2 m tall belt transects at predetermined locations and depths. Survey patterns included a descent along one corner leg of a platform, then swimming around and beneath half of the platform at each of three depth categories (10 m, 20 m, and 30 to 40 m) where major horizontal structures exist, and ascending up a second corner leg. A second diver samples the same transects using an underwater video system. The video system (equipped with parallel lasers for estimating fish length) is used to increase the sample size of fish lengths and provide a standard for comparing density estimates with ROV video at greater depths. Two pairs of divers each sampled one-half of a platform, providing vertical surveys of all four corner legs and horizontal transects throughout the entire platform at each of the three depths sampled. Three platforms were sampled each day such that all six platforms were sampled in a two-day period during each of the six sampling periods each year. Monthly surveys on natural reefs also included quantification of habitat variables (e.g., substratum type and relief, epibenthic cover, density and size of macroalgae, temperature, and visibility) that might explain patterns of species abundance. Four 30 m belt transects were sampled at each natural reef. Each transect consisted of three samples in the surface, mid-depth, and bottom portion of the water column sampling within a 2 m wide x 2 m tall volume.

Deeper (> 33 m) portions of the six platforms and two deep natural reefs (4-mile and crotch) were surveyed 2 to 3 times each year (June, August, October) with a remotely operated vehicle (ROV) outfitted with a video camera and paired lasers in cooperation with the Marine Technology Program at the Santa Barbara City College. The ROV was used to estimate fish size and density along belt transects of similar dimensions and spatial patterns (excluding samples beneath the platforms) as that of the diver surveys. During ROV sampling, an observer logged the depth and location of transects and identified fish species.

To estimate rates and direction of fish movement between production platforms and natural reefs, we tagged fishes at each of four natural reefs during 1996 and 1997. This work was conducted in conjunction with the Channel Islands National Marine Sanctuary and volunteers from the University and the local sport fishing community. Fish were caught by hook and line, identified, measured, tagged with standard Floy tags, and immediately released. When necessary, their swim bladders were vented to enable fish to return to the bottom. Floy tags are similar in design to garment tags, with a number, name and phone number. This allowed fishers to call and inform us of where and when they caught each fish. Tags were color coded by the reef/platform on which they were tagged and released.

RESULTS AND IMPLICATIONS

Analysis of the combined diver and ROV surveys for the three-year sampling period is ongoing. Preliminary results suggest that the species composition of fishes encountered on platforms and natural reefs differed both with respect to the presence/absence and relative abundance of some species in each habitat. Some species were only encountered on the natural reefs whereas others were only observed on the platforms (Table 1). However, most species occurred in both habitat types. Particularly notable were the several species of surfperches and kelp-associated species only seen at the natural reefs, and the young recruits of many rockfish species that were only seen at platforms. Many of the species observed at both habitat types differed in their relative abundance on platforms and natural reefs (Table 2). Some of these economically or recreationally important species were far more abundant on natural reefs (e.g., barred sand bass, kelp rockfish), whereas others were more abundant on platforms. These results suggest that the removal of platforms will likely affect some species much more than others, and some species will likely be influenced little by the various decommissioning options (i.e., those species never observed near platforms).

The abundance of many species varied markedly with depth along platforms. Often these depth-related differences

Table 1. Comparison of species occurrence throughout all depths of the five natural reefs and the six study platforms. Species occurrence (presence/absence) is based on diver and ROV observations combined across all three years of sampling (1995 to 1997). Species encountered at only one habitat type are emphasized by a bold "X".

FAMILY	COMMON NAME	SCIENTIFIC NAME	NATURAL REEFS	PLATFORMS
ANCHOVY	northern anchovy	*Engraulis mordax*		**X**
BARRACUDA	California barracuda	*Sphyraena argentea*	**X**	
BASS	kelp / calico bass	*Paralabrax clathratus*	X	X
BASS	sand bass	*Paralabrax nebulifer*	X	X
BASS	giant sea bass	*Stereolepis gigas*	**X**	
CROAKER	white seabass	*Cynoscion nobilis*	**X**	
CROAKER	white croaker	*Genyomemus lineatus*	**X**	
DAMSELFISH	blacksmith	*Chromis punctipinnis*	X	X
DAMSELFISH	garibaldi	*Hypsypops rubicundus*	X	X
GOBY	blackeye goby	*Coryphopterus nicholsii*	X	X
GOBY	kelp goby	*Lethops connectens*	**X**	
GREENLING	kelp greenling	*Hexagrammus decagrammus*		**X**
GREENLING	lingcod	*Ophiodon elongatus*	X	X
GREENLING	painted greenling	*Oxylebius pictus*	X	X
GRUNT	sargo	*Anisotremus davidsonii*	**X**	
HERRING	pacific sardine	*Sardinops sagax*	X	X
JACK	jackmackeral	*Trachurus symmetricus*	X	X
KELPFISH	giant kelpfish	*Heterostichus rostratus*	**X**	
ROCKFISH	unid. young-of-year		X	X
ROCKFISH	scorpionfish	*Scorpaena guttata*	X	X
ROCKFISH	kelp	*Sebastes atrovirens*	X	X
ROCKFISH	brown	*Sebastes auriculatus*	X	X
ROCKFISH	gopher	*Sebastes carnatus*	X	X
ROCKFISH	copper	*Sebastes caurinus*	X	X
ROCKFISH	greenspotted	*Sebastes chlorostictus*	**X**	
ROCKFISH	black and yellow	*Sebastes chrysomelas*	X	X
ROCKFISH	starry	*Sebastes constellatus*	**X**	
ROCKFISH	calico	*Sebastes dallii*	X	X
ROCKFISH	widow	*Sebastes entomelas*	X	X
ROCKFISH	squarespot	*Sebastes hopkinsi*	X	X
ROCKFISH	vermilion	*Sebastes miniatus*	X	X
ROCKFISH	blue	*Sebastes mystinus*	X	X
ROCKFISH	bocaccio Y-O-Y	*Sebastes paucispinis*	X	X
ROCKFISH	grass	*Sebastes rastrelliger*		**X**
ROCKFISH	rosy	*Sebastes rosaceus*		**X**
ROCKFISH	yellow eye	*Sebastes ruberrimus*		**X**
ROCKFISH	flag	*Sebastes rubrivinctus*	X	X
ROCKFISH	stripetail Y-O-Y	*Sebastes saxicola*		**X**
ROCKFISH	halfbanded Y-O-Y	*Sebastes semicinctus*	X	X
ROCKFISH	olive	*Sebastes serranoides*	X	X
ROCKFISH	treefish	*Sebastes serriceps*	X	X
SCULPIN	cabezon	*Scorpaenichthys marmoratus*	X	X
SEA CHUB	opaleye	*Girella nigricans*	X	X
SEA CHUB	halfmoon	*Medialuna californiensis*	X	X
SHARK, CAT	swell shark	*Cephaloscyllium ventriosum*	**X**	
SHARK, DOGFISH	spiny dogfish	*Squalus acanthias*	**X**	
SHARK, REQUIEM	leopard shark	*Triakis semifasciata*	**X**	
SILVERSIDE	jacksmelt	*Atherinopsis californiensis*	X	X
SURFPERCH	kelp surfperch	*Brachyistius frenatus*	**X**	
SURFPERCH	pile surfperch	*Damalichthys vacca*	X	X
SURFPERCH	black surfperch	*Embiotoca jacksoni*	**X**	
SURFPERCH	rainbow surfperch	*Hypsurus caryi*	**X**	
SURFPERCH	sharpnose surfperch	*Phanerodon atripes*		**X**
SURFPERCH	white surfperch	*Phanerodon furcatus*	**X**	
SURFPERCH	rubberlip surfperch	*Rhacochilus toxotes*	X	X
SURFPERCH	pink surfperch	*Zalembius rosaceus*	X	X
WOLF-EEL	wolf-eef	*Anarrhichthys ocellatus*		**X**
WRASSE	rock wrasse	*Halichoeres semicinctus*	**X**	
WRASSE	seaorita	*Oxyjulis californica*	X	X
WRASSE	California sheephead	*Semicossyphus pulcher*	X	X

Table 2. Relative concentration of economically important species between production platforms and nearby natural reefs. Data are from diver and ROV surveys combined across all three sampling years. Presented is the proportionate density (fish per 100 m³ water volume sampled) between habitats.

Species	Natural Reefs (%)	Platforms (%)
barred sand bass	99.9	0.1
kelp bass	92.6	7.4
California sheephead	82.9	17.1
lingcod	26.7	73.3
cabezon	14.3	85.7
rubberlip surfperch	62.6	37.4
pile surfperch	55.7	44.3
gopher rockfish	67.5	32.5
kelp rockfish	27.9	72.1
brown rockfish	11.3	88.7
copper rockfish	4.8	95.2
vermilion rockfish	0.4	99.6
total benthic rockfish	8.7	91.3
olive rockfish	49.8	50.2
bocaccio	14.3	85.7
blue rockfish	1.4	98.6
total mid-water rockfish	27.3	72.7

were also related to the age/size of individuals. For example, the young of many shallow dwelling rockfish occurred only at the shallower depths sampled, whereas older stages (juveniles and adults) occurred more frequently at greater depths. These results suggest that removing the upper portion of platforms may reduce recruitment of some species to the platforms. In contrast, both the young and older stages of other species (many rockfishes including olives, widows, boccacios) occurred at depth, suggesting that recruitment and adult abundance of these species may not be reduced by the removal of the upper portions of platforms.

To date, we have tagged 500 fish and recaptured 50. This high return rate (10%) is attributable to the excellent cooperation by sport fishers that have called us with information on the fish that they caught. Of the fish recaught, 75% were caught where they were tagged, suggesting that many of the species tagged (mostly rockfishes) remain on the reefs where they were tagged. Of course, it is not clear how much movement occurs by the many fish that were not recaptured, but we hope to continue to collect information on those individuals in the future. Some species contributed greatly to the individuals that do move; particularly barred sand bass and kelp/calico bass. That kelp bass move more helps to explain why we see many adults on reefs, but no young recruits. These data strongly suggest that a species like this is attracted to platforms, having recruited as young elsewhere, rather than recruiting to and remaining on the platforms.

LITERATURE CITED

Bascom, W., A. J. Mearns and M. D. Moore. 1976. A biological survey of oil platforms in the Santa Barbara Channel. Journal of Petroleum Technology, pp. 1280-1284.

Carlisle, J. G. Jr., C. H. Turner and E. E. Ebert. 1964. Artificial habitat in the marine environment. California Department of Fish and Game, Fish Bulletin No. 124.

Carr, M. H. and M. A. Hixon. 1997. Artificial reefs: the importance of comparisons with natural reefs. Fisheries 22(4):28-33.

Continental Shelf Associates, Inc. 1982. Study of the effect of oil and gas activities on reef fish populations in the Gulf of Mexico OCS area. OCS Rep./MMS82-010, United States Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. 210 pp.

Gallaway, B. J. 1984. Assessment of platform effects on snapper populations and fisheries. Pages 130-137 *in* Proceedings of the Fifth Annual Gulf of Mexico Information Transfer Meeting, New Orleans, Nov. 27-29, 1984. OCS Study/MMS85-0008, United States Department of the Interior, Minerals Management Service, Metarie, LA.

Gallaway, B. J. and G. S. Lewbel. 1982. The ecology of petroleum platforms in the northwestern Gulf of Mexico: A community profile. Open-file Rep. 82-03, United States Fish and Wildlife Service, Office of Biological Service, Washington, DC. 91 pp.

Love, M. S. and W. Westphal. 1990. Composition of fishes taken by a sportfishing party vessel around oil platforms and adjacent natural reefs near Santa Barbara, California. Fishery Bulletin, 88:599-605.

Love, M. S., J. Hyland, A. Ebeling, T. Herrlinger, A. Brooks, and E. Imamura. 1994. 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. Bulletin of Marine Science 55:1062-1085.

Mearns, A. J. and M. Moore. 1976. Biological study of oil platforms Hilda and Hazel, Santa Barbara Channel, California. A Final Report to the Institute of Marine Resources, Scripps Institution of Oceanography, University of California, San Diego, CA. 79 pp.

Minerals Management Service/California State Lands Commission Workshop. 1994. Abandonment and Removal of Offshore Oil and Gas Facilities: Education and Information Transfer. March 22.

Scarborough Bull, A. and J. J. Kendall, Jr. 1994. An indication of the process: offshore platforms as artificial reefs in the Gulf of Mexico. Bulletin of Marine Science 55:1086-1098.

Stanley, D. R. and C. A. Wilson. 1991. Factors affecting the abundance of selected fishes near oil and gas platforms in the northern Gulf of Mexico. Fishery Bulletin 89:149-159.

Turner, C. F., E. E. Ebert and R. R. Given. 1969. Man-made reef ecology. California Department of Fish and Game, Fish Bulletin No. 146. 221 pp.