CALIFORNIA DEPARTMENT OF FISH AND GAME
Nearshore Sport Fish Habitat Enhancement Program

A REPORT OF BIOLOGICAL OBSERVATIONS AT PACIFIC BEACH ARTIFICIAL REEF, OCEANSIDE ARTIFICIAL REEF, AND SANTA MONICA BAY ARTIFICIAL REEF

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Introduction

In fall 1987, the Nearshore Sport Fish Habitat Enhancement Program (NSHEP) of the California Department of Fish and Game constructed three quarry rock reefs in southern California (Figure 1): the Pacific Beach Artificial Reef (PBAR), the Oceanside Artificial Reef (OAR), and the Santa Monica Bay Artificial Reef (SMBAR). They were designed to (1) provide shelter, forage, nesting, and nursery areas for fishes and invertebrates; (2) offer rocky substrate for the attachment and growth of marine plants, particularly giant kelp (*Macrocystis* sp.); and (3) act as "developmental" reefs for investigating the effect of reef location, depth, height, and rock size on the successional development of the associated biotic communities.

The PBAR and OAR were completed in September and October, respectively, and were designed with similar configurations (Figure 2). Each reef was constructed of 10,000 tons of quarry rock arranged over 128 acres in twenty-four modules. Four pairs of modules were constructed along each of three depth contours: shallow (42 ft), mid-depth (57 ft), and deep (72 ft).

The SMBAR was completed in October and was constructed of 20,000 tons of quarry rock (Figure 3). Twenty-four pairs of modules were built along the same depth contours as those at PBAR and OAR. Details of reef design and construction are discussed in the Artificial Reef Plan for Sport Fish Enhancement (Wilson *et al.* 1990).

The three reefs were surveyed by the Department to fulfill permit conditions as established by the California Coastal Commission. Last fall, the biotic communities of each reef were observed. Due to the young age of the reefs and the rapid successional change still occurring in the associated biotic communities (Carlisle *et al.* 1964; Turner *et al.* 1969; Carter *et al.* 1985; Matthews 1985; Solonsky 1985; Ambrose and Swarbrick 1989; Anderson *et al.* 1989; Hueckel and Buckley 1989; and Wilson *et al.* 1990), only qualitative surveys were conducted.

This report summarizes the results of the surveys conducted by California Department of Fish and Game (CDFG) biologists on PBAR, OAR, and SMBAR.

Methods

In October 1990, NSHEP biologist-divers surveyed PBAR, OAR, and SMBAR to evaluate the assemblage of fishes, macroinvertebrates, turf communities (small sessile invertebrates and plants), and macroalgae on randomly selected modules at each depth contour. The 50 ft x 50 ft modules were located by using Loran-C, side-scanning sonar, and echosound. The small size of the modules,

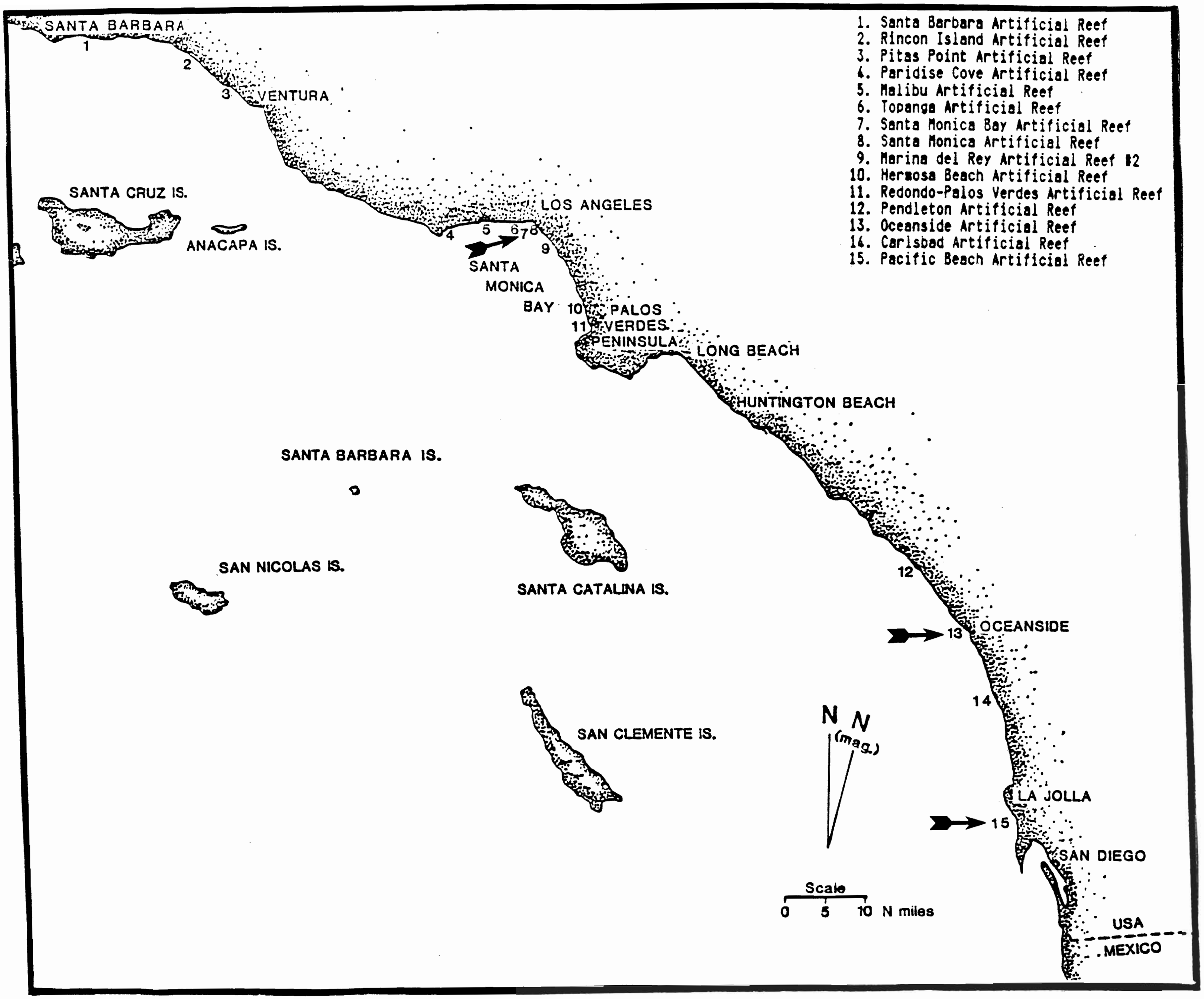

Figure 1. Locations of the developmental artificial fishing reefs in southern California. Pacific Beach Artificial Reef, Oceanside Artificial Reef, and Santa Monica Bay Artificial Reef are indicated. (Source: Wilson et al. 1990)

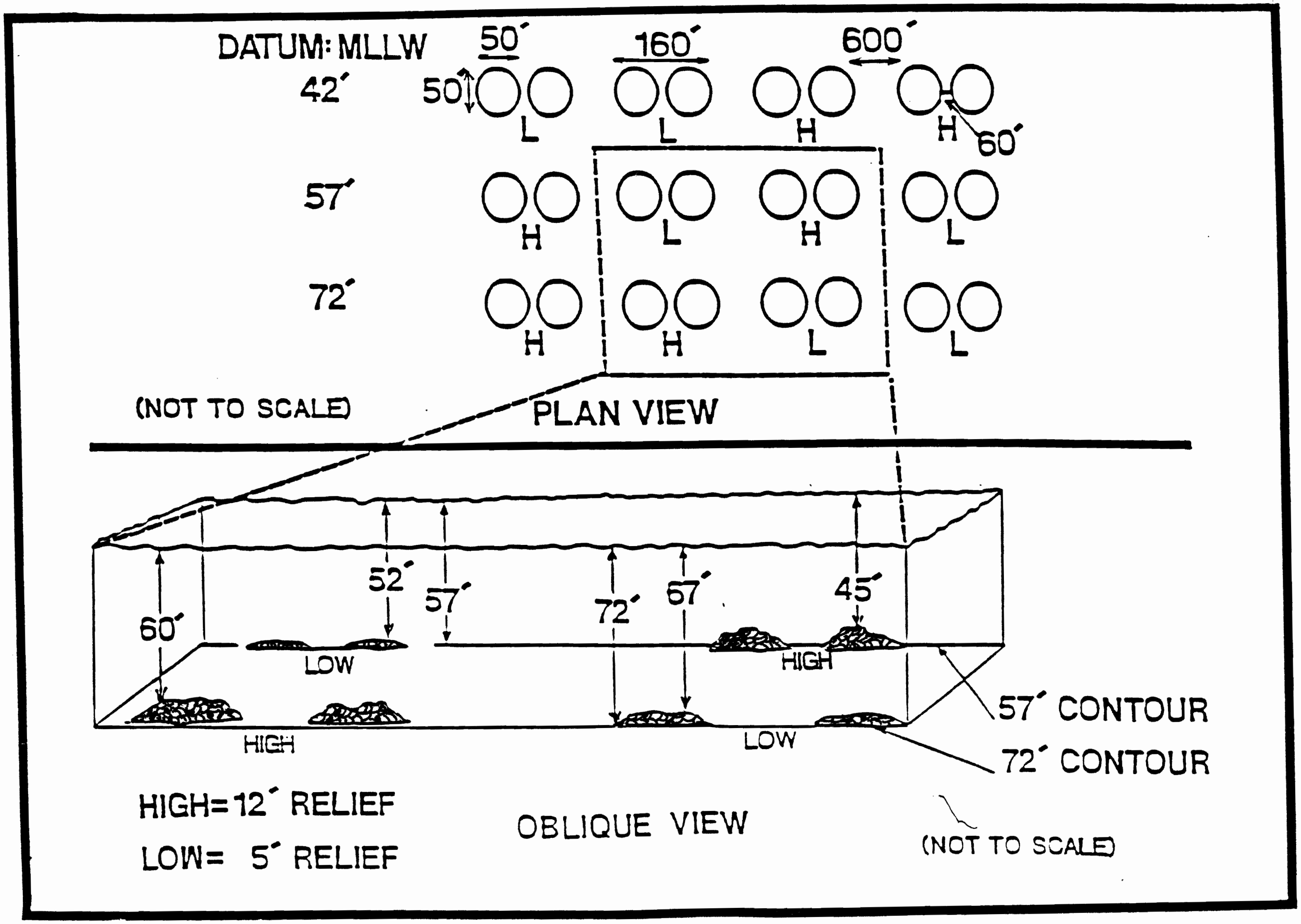

Figure 2. Design of Pacific Beach Artificial Reef and Oceanside Artificial Reef. "H" and "L" represent high and low reef reliefs, respectively.

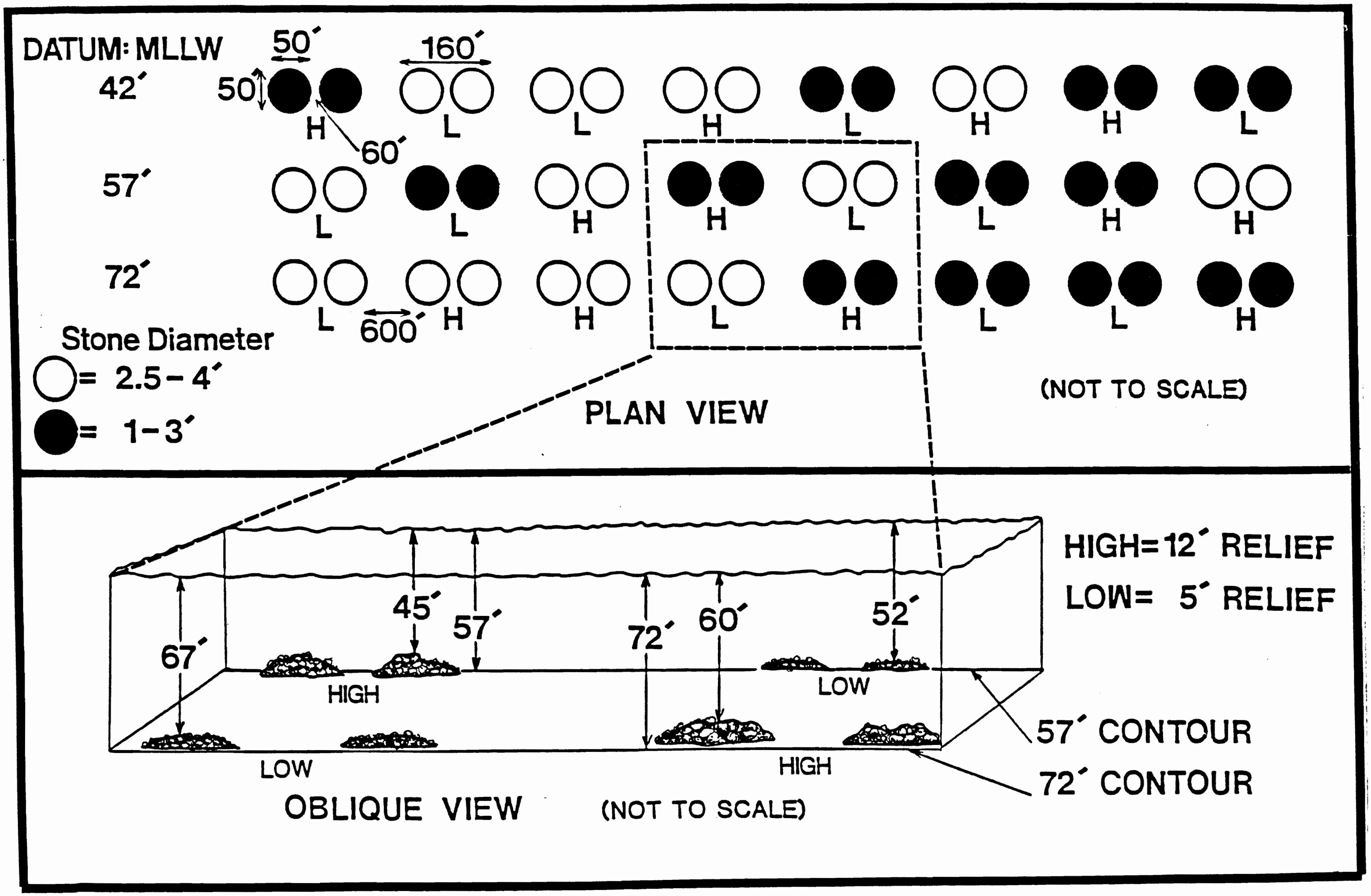

Figure 3. Design of Santa Monica Bay Artificial Reef. "H" and "L" represent high and low reef reliefs, respectively.

coupled with favorable visibility, allowed qualitative observations of the biotic communities to be made.

The quantities of fishes and macroinvertebrates were estimated using four categories: abundant (>50 individuals), common (11-50 individuals), occasional (2-11 individuals), and one (1 individual). Fish size was estimated using two categories: adult (Ad) and subadult (Sad).

The quantities of turf community organisms and macroalgae were estimated using four categories: abundant (>50% cover), common (11-50% cover), occasional (2-11% cover), and rare (≤1% cover). Algae size was estimated using four categories of height: A1 (≤1 in.), A2 (1 in.- 1 ft.), A3 (1 ft. to the subsurface), and A4 (surface canopy).

Physical data included information about module depth and height (relief), water visibility, and sediment. Module depth and height were determined by averaging numerous depth gauge readings taken along the module base and crest (surface), respectively.

Results

Physical Data

Some variability existed among the heights of the modules (Table 1). Although PBAR and OAR were constructed with similar configurations, height among modules at each reef varied between 10 and 14 ft. Modules at SMBAR varied between 8 and 11 ft in height.

The PBAR was surrounded by clean multi-sized sand; grain size varied among modules but no pattern was observed with change in module depth. Scouring around a module base was greatest (3 ft deep) at the shallow module; scouring, if any, was slight at mid-depth and deep modules. Underwater visibility ranged from 30 to 40 ft.

The OAR was surrounded by a combination of sand and cobble (small rocks). Differences in the sediment did exist between the shallow and mid-depth module. The deep module at OAR was not located due to difficulties with the electronic equipment. Fine gray sand surrounded the mid-depth module, and a large amount of cobble was observed at some areas along its inshore base. A mixture of sand and cobble was noted around the entire base of the shallow module. The cobble on both modules was similar to that on southern Oceanside and Carlsbad beaches, which resulted from the recent dredging and construction of Oceanside Harbor. Scouring occurred (1 ft deep) at the shallow module, creating a 3 ft wide band around its base. Scouring was not observed at the mid-depth module. Underwater visibility ranged from 40 to 50 ft.

Table 1. Physical Characteristics of Three Quarry Rock Artificial Reefs in Southern California.

Module	PACIFIC BEACH ARTIFICIAL REEF				OCEANSIDE ARTIFICIAL REEF				SANTA MONICA BAY ARTIFICIAL REEF			
	Substrate Description	Actual Depth	Module Height	Visibility	Substrate Description	Actual Depth	Module Height	Visibility	Substrate Description	Actual Depth	Module Height	Visibility
Shallow Module (42')	Clean, medium-grain sand; deep scour to 3 ft within 3 ft of reef base.	44'	14'	30-40'	Sand/cobble; scoured band (3 ft wide by 1 ft deep) around reef base.	43'	10'	40-50'	Fine gray sand; intermixed with small amount of cobble; scoured to 2 ft within 3 ft of reef base.	43'	10'	40-50'
Mid-Depth Module (57')	Gray, small-grain sand; no scour.	64'	13'	30-40'	Fine gray sand; large amount of rock and cobble along inshore reef base; no scour.	61'	14'	40-50'	Fine gray sand; scoured to 1 ft within 3 ft of reef base.	61'	8'	30-40'
Deep Module (72')	Clean, course sand; scoured to <1 ft within 3 ft of reef base.	72'	10'	30-40'	MODULE NOT LOCATED				Soft, very fine gray sand; no scour; detritus & broken shells abundant.	77'	11'	40-60'

The SMBAR was surrounded by fine gray sand. No apparent change in sand grain size existed with depth. Scouring around the reef base was greatest (2 ft deep) at the shallow module. Slight scouring (1 ft deep) was observed at the mid-depth module; scouring was not apparent at the deep module. Underwater visibility at the reef ranged from 30 to 60 ft.

Biological Data (Biotic Communities)

Fishes

Many of the fish species common on nearshore reefs in southern California (Wilson *et al.* 1990) were observed on each of the modules surveyed (Tables 2, 3, and 4). Blacksmith (*Chromis punctipinnis*) was the most numerous at all three reefs. Adult and subadult (juvenile) blacksmith were observed in abundant numbers at all modules surveyed, particularly on shallow and mid-depth modules at PBAR and OAR. Other fish observed in abundant numbers include kelp bass (*Paralabrax clathratus*), barred sand bass (*P. nebulifer*), sculpin (*Scorpaena gutta*), and halfmoon (*Medialuna californiensis*).

Twenty-one fish species were observed on the modules at PBAR. Fourteen species were on the mid-depth module; thirteen on the shallow and deep modules. Only on the mid-depth module were fish other that blacksmith observed in abundant numbers. Other abundant species were barred sand bass, kelp bass, halfmoon, sheephead (*Semicossyphus pulcher*), rainbow surfperch (*Hypsurus caryi*), white surfperch (*Phanerodon furcatus*), black surfperch (*Embiotica jacksoni*), señorita (*Oxyjulis californica*), jack mackerel (*Trachurus symmetricus*), and pile perch (*Damalichthys vacca*).

Fifteen fish species were observed on the modules at OAR. Adult kelp bass, halfmoon, and blacksmith were abundant on both modules. Adult black surfperch and señorita were also ranked abundant among the ten species observed on the shallow module. On the mid-depth module, adult sculpin were also ranked abundant among the thirteen species present.

Sixteen fish species were observed during surveys at SMBAR. Blacksmith and adult sculpin were abundant on the three modules. Adult barred sand bass and olive rockfish (*Sebastes serranoides*) were also ranked abundant on the mid-depth module. Subadult sheephead were seen occasionally on the shallow module.

Macroinvertebrates

The number of macroinvertebrate species observed at the three reefs ranged from seven to ten (Tables 2, 3, and 4). Only the

Table 2. Observations of Abundance and Size of Organisms Observed on Pacific Beach Artificial Reef, October 1990.

Shallow Module – 42 ft (MLLW)

FISHES	Abundance Estimate°	Size Estimate[1]
Blacksmith	abundant	Ad/SAd
Halfmoon	common	Ad
Black surfperch	common	Ad
Señorita	common	Ad
Rock Wrasse	common	Ad
Kelp Bass	occas.	Ad
Painted greenling	occas.	Ad
Pile perch	occas.	Ad
Black–eyed goby	occas.	Ad
Garibaldi	occas.	Ad
Turbot sp.	one	Ad
Sculpin	one	Ad
Halibut	one	Ad
MACROINVERTEBRATES		**Abundance Estimate°**
Pyura sp.		common
Pisaster giganteus		common
Pisaster brevispinus		occas.
Patiria miniata		occas.
Panulirus interruptus		occas.
Astraea undosa		occas.
Aglaophenia latriostris		occas.
Stronglyocentrotus purpuratus		occas.
TURF COMMUNITY	**Abundance Estimate[2]**	**Size Estimate[3]**
Foliose Red Algae:		
Callophyllis violacea	occas.	A2
Polyneura latissima	occas.	A2
Rhodymenia pacifica	rare	A2
Red Coralline Algae:	occas.	A2
Invertebrates:		
Corynactis sp.	common	–
Pododesmus cepio	common	–
MACROALGAE	**Abundance Estimate[2]**	**Size Estimate[3]**
Pterygophora sp.	common	A3
Macrocystis sp.	occas.	A3

Mid-depth Module – 57 ft (MLLW)

FISHES	Abundance Estimate°	Size Estimate[1]
Blacksmith	abundant	Ad/SAd
White surfperch	abundant	Ad
Sheephead	abundant	Ad
Barred sand bass	abundant	Ad
Kelp bass	abundant	Ad
Rainbow surfperch	abundant	Ad
Señorita	abundant	Ad
Jack mackerel	abundant	Ad
Pile perch	abundant	Ad
Halfmoon	abundant	Ad
Black surfperch	abundant	Ad
Cabezon	common	Ad
Garibaldi	occas.	Ad
Brown rockfish	one	Ad
MACROINVERTEBRATES		**Abundance Estimate°**
Aglaophenia latriostris		abundant
Pisaster giganteus		common
Pisaster brevispinus		occas.
Patiria miniata		occas.
Panulirus interruptus		occas.
Salmacina tribranchiata		occas.
TURF COMMUNITY	**Abundance Estimate°**	**Size Estimate[3]**
Foliose Red Algae:		
Callophyllis violacea	occas.	A2
Gigartina exasperata	occas.	A2
Polyneura latissima	occas.	A2
Gelidium sp.	occas.	A2
Rhodymenia pacifica	occas.	A2
Invertebrates:		
Cryptoarachnidium sp.	abundant	–
Megabalanus sp.	abundant	–
Corynactis sp.	occas.	–
MACROALGAE	**Abundance Estimate°**	**Size Estimate[3]**
Pterygophora sp.	common	A3
Pelagophycus sp.	occas.	A4
Macrocystis sp.	occas.	A3

Deep Module – 72 ft (MLLW)

FISHES	Abundance Estimate°	Size Estimate[1]
Blacksmith	abundant	Ad/SAd
Pile perch	common	Ad
Halfmoon	common	Ad
Rainbow surfperch	occas.	Ad
White surfperch	occas.	Ad
Black surfperch	occas.	Ad
Sheephead	occas.	Ad
Black–eyed goby	occas.	Ad
Painted greenling	occas.	Ad
Brown rockfish	occas.	Ad
Garibaldi	occas.	Ad
Cabezon	one	Ad
Lingcod	one	Ad
MACROINVERTEBRATES		**Abundance Estimate°**
Aglaophenia latriostris		common
Patiria miniata		common
Salmacina tribranchiata		occas.
Panulirus interruptus		occas.
Kelletia kelletii		occas.
Pisaster giganteus		occas.
TURF COMMUNITY	**Abundance Estimate[2]**	**Size Estimate[3]**
Foliose Red Algae:		
Rhodymenia pacifica	occas.	A2
Polyneura latissima	occas.	A2
Invertebrates:		
Cryptoarachnidium sp.	abundant	–
Bugula sp.	common	–
MACROALGAE	**Abundance Estimate[2]**	**Size Estimate[3]**
Macrocystis sp.	occas.	A4/A3
Pelagophycus sp.	occas.	A4
Pterygophora sp.	occas.	A3

° – Abundance estimates for number of fishes and macroinvertebrates are: abundant = >50; common = 11–50; occasional = 2–11; and one = 1.

[1] – Size estimates for fishes are based upon adult (Ad)/subadult (SAd) categories used in CDFG fish studies at Pendleton Artificial Reef.

[2] – Abundance estimates for turf community and macroalgae are: abundant = >50% cover; common = 11–50% cover; occasional = 2–11% cover and rare = <1%.

[3] – Size estimates for algae were based upon four sizes categories: A1 = <1 in; A2 = 1in – 1ft; A3 = 1ft to subsurface; and A4 = surface canopy.

Table 3. Observations of Abundance and Size of Organisms Observed on Oceanside Artificial Reef, October 1990.

Shallow Module – 42 ft (MLLW)			Mid-depth Module – 57 ft (MLLW)			* Deep Module – 72 ft (MLLW)		
FISHES	Abundance Estimate°	Size Estimate[1]	FISHES	Abundance Estimate°	Size Estimate[1]	FISHES	Abundance Estimate°	Size Estimate[1]
Blacksmith	abundant	Ad/SAd	Blacksmith	abundant	Ad/SAd	* MODULE NOT LOCATED		
Halfmoon	abundant	Ad	Sculpin	abundant	Ad			
Kelp bass	abundant	Ad	Kelp bass	abundant	Ad			
Black surfperch	abundant	Ad	Halfmoon	abundant	Ad			
Señorita	abundant	Ad	Barred sand bass	common	Ad			
Sheephead	common	Ad	Rock wrasse	common	Ad			
Pile perch	common	Ad	White surfperch	common	Ad			
Rock wrasse	common	Ad	Black surfperch	common	Ad			
Garibaldi	common	Ad	Sheephead	occas.	Ad			
Garibaldi (juveniles)	occas.	SAd	Garibaldi	occas.	Ad			
Kelp fish	occas.	Ad	Pile perch	occas.	Ad			
			Opaleye	occas.	Ad			
			Black–eyed goby	occas.	Ad			
MACROINVERTEBRATES		Abundance Estimate°	MACROINVERTEBRATES		Abundance Estimate°	MACROINVERTEBRATES		Abundance Estimate°
Aglaophenia latriostris		common	*Hinnites sp.*		common	* MODULE NOT LOCATED		
Styela sp.		common	*Aglaophenia latriostris*		common			
Pisaster brevispinus		common	*Aplysia sp.*		common			
Hinnites sp.		common	*Styela sp.*		occas.			
Panulirus interruptus		common	*Pisaster brevispinus*		occas.			
Aplysia sp.		occas.	*Pisaster giganteus*		occas.			
			Panulirus interruptus		occas.			
TURF COMMUNITY	Abundance Estimate[2]	Size Estimate[3]	TURF COMMUNITY	Abundance Estimate°	Size Estimate[3]	TURF COMMUNITY	Abundance Estimate[2]	Size Estimate[3]
Foliose Red Algae:			Foliose Red Algae:			* MODULE NOT LOCATED		
Rhodymenia pacifica	rare	A2	*Rhodymenia pacifica*	rare	A2			
Red Algae, unid.	rare	A2/A1	Red Algae, unid.	rare	A2/A1			
Invertebrates:			Invertebrates:					
Muricea sp.	common	–	*Cryptoarachnidium sp.*	abundant	–			
Cryptoarachnidium sp.	common	–	*Corynactis sp.*	common	–			
Eudistylia sp.	occas.	–	*Bugula sp.*	common	–			
Corynactis sp.	occas.	–	*Megabalanus sp.*	common	–			
Bugula sp.	occas.	–	Encrusting sponge, unid.	common	–			
Obelia sp.	occas.	–	Encrusting tunicate, unid	common	–			
Megabalanus sp.	occas.	–						
Plumularia sp.	occas.	–						
MACROALGAE	Abundance Estimate[2]	Size Estimate[3]	MACROALGAE	Abundance Estimate°	Size Estimate[3]	MACROALGAE	Abundance Estimate[2]	Size Estimate[3]
Macrocystis sp.	abundant	A4/A3	*Macrocystis sp.*	common	A4/A3	* MODULE NOT LOCATED		
Egregia sp.	occas.	A4	*Pterygophora sp.*	common	A4			
Pterygophora sp.	rare	A4						

° – Abundance estimates for number of fishes and macroinvertebrates are: abundant = >50; common = 11–50; occasional = 2–11; and one = 1.

[1] – Size estimates for fishes are based upon adult (Ad)/subadult (SAd) categories used in CDFG fish studies at Pendleton Artificial Reef.

[2] – Abundance estimates for turf community and macroalgae are: abundant = >50% cover; common = 11–50% cover; occasional = 2–11% cover and rare = <1%.

[3] – Size estimates for algae were based upon four sizes categories: A1 = <1 in; A2 = 1in – 1ft; A3 = 1ft to subsurface; and A4 = surface canopy.

Table 4. Observations of Abundance and Size of Organisms Observed on Santa Monica Bay Artificial Reef, October 1990.

	Shallow Module – 42 ft (MLLW)			Mid-depth Module – 57 ft (MLLW)			Deep Module – 72 ft (MLLW)	
FISHES	Abundance Estimate°	Size Estimate[1]	**FISHES**	Abundance Estimate°	Size Estimate[1]	**FISHES**	Abundance Estimate°	Size Estimate[1]
Blacksmith	abundant	Ad/SAd	Blacksmith	abundant	Ad/SAd	Blacksmith	abundant	Ad/SAd
Sculpin	abundant	Ad	Barred sand bass	abundant	Ad	Sculpin	abundant	Ad
Black Croaker	common	Ad	Sculpin	abundant	Ad	Pile perch	common	Ad
Black surfperch	common	Ad	Olive rockfish	abundant	Ad	Kelp bass	common	Ad
Sargo	common	Ad	Kelp bass	common	Ad	Black surfperch	common	Ad
Kelp bass	common	Ad	Sheephead	common	Ad	Barred sand bass	common	Ad
Barred sand bass	common	Ad	Black–eyed goby	common	Ad	Black–eyed goby	common	Ad
Halfmoon	occas.	Ad	Black surfperch	occas.	Ad	Sheephead	occas.	Ad
Brown rockfish	occas.	Ad	Pile perch	occas.	Ad	Cabezon	occas.	Ad
Black–eyed goby	occas.	Ad	Brown rockfish	one	Ad	Halfmoon	occas.	Ad
Sheephead	occas.	SAd						
Catalina goby	occas.	Ad						
Kelp fish	one	Ad						
MACROINVERTEBRATES		Abundance Estimate°	**MACROINVERTEBRATES**		Abundance Estimate°	**MACROINVERTEBRATES**		Abundance Estimate°
Hinnites sp.		common	*Panulirus interruptus*		common	*Hinnites sp.*		common
Aglaophenia latriostris		common	*Aglaophenia latriostris*		occas.	*Cancer anthonyi*		occas.
Cancer anthonyi		common	*Hinnites sp.*		occas.	*Aglaophenia latriostris*		occas.
Stronglyocentrotus purpuratus		common	*Acanthodoris lutea*		occas.	Encrusting sponge, unid.		occas.
Pisaster giganteus		occas.				*Panulirus interruptus*		occas.
Rock shrimp		occas.						
Panulirus interruptus		occas.						
TURF COMMUNITY	Abundance Estimate[2]	Size Estimate[3]	**TURF COMMUNITY**	Abundance Estimate°	Size Estimate[3]	**TURF COMMUNITY**	Abundance Estimate[2]	Size Estimate[3]
Foliose Red Algae:			Foliose Red Algae:			Foliose Red Algae:		
Gigartina exasperata	common	A2	*Gigartina exasperata*	occas.	A2	*Gigartina exasperata*	rare	A2
Callophyllis violacea	occas.	A2	*Rhodymenia pacifica*	occas.	A2	*Rhodymenia pacifica*	rare	A2
Polyneura latissima	occas.	A2	*Polyneura latissima*	rare	A2	*Polyneura latissima*	rare	A2
Rhodymenia pacifica	rare	A2	*Callophyllis violacea*	rare	A2			
Foliose Brown Algae:								
Pachydictyon coriaceum	occas.	A2						
Invertebrates:			Invertebrates:			Invertebrates:		
Pododesmus cepio	common	–	*Cryptoarachnidium sp.*	abundant	–	*Cryptoarachnidium sp.*	abundant	–
Bugula sp.	common	–	*Megabalanus sp.*	abundant	–	*Bugula sp.*	common	–
Megabalanus sp.	common	–	*Corynactis sp.*	common	–			
Mytilus sp.	common	–	*Pododesmus cepio*	common	–			
Obelia sp.	common	–	*Obelia sp.*	occas.	–			
Eudistylia sp.	common	–	*Eudistylia sp.*	occas.	–			
Serpulorbis sp.	occas.	–	*Bugula sp.*	occas.	–			
Thalamoporella sp.	occas.	–						
MACROALGAE	Abundance Estimate[2]	Size Estimate[3]	**MACROALGAE**	Abundance Estimate°	Size Estimate[3]	**MACROALGAE**	Abundance Estimate[2]	Size Estimate[3]
Macrocystis sp.	occas.	A3	*Pterygophora sp.*	rare	A4			
Pterygophora sp.	rare	A4						

° – Abundance estimates for number of fishes and macroinvertebrates are: abundant = >50; common = 11–50; occasional = 2–11; and one = 1.

[1] – Size estimates for fishes are based upon adult (Ad)/subadult (SAd) categories used in CDFG fish studies at Pendleton Artificial Reef.

[2] – Abundance estimates for turf community and macroalgae are: abundant = >50% cover; common = 11–50% cover; occasional = 2–11% cover and rare = <1%.

[3] – Size estimates for algae were based upon four sizes categories: A1 = <1 in; A2 = 1in – 1ft; A3 = 1ft to subsurface; and A4 = surface canopy.

feather hydroid (*Aglaophenia latriostris*) and spiny lobster (*Panulirus interruptus*) were observed on all modules. The feather hydroid was also the only species ranked abundant.

Ten macroinvertebrate species were observed at PBAR. Eight species were on the shallow module, although none were ranked abundant. Ranked common were *Pyura* sp. and the giant sea star (*Pisaster giganteus*). Six species were on the mid-depth and deep modules; the feather hydroid was ranked abundant on the former and common on the latter.

Seven macroinvertebrate species were observed at OAR. Only the feather hydroid and the rock scallop (*Hinnites* sp.) were ranked common.

Nine macroinvertebrate species were observed at SMBAR. The feather hydroid and the rock scallop were common on the shallow module. Only the spiny lobster was common on the mid-depth module, while the rock scallop was the only species common on the deep module.

<u>Turf Community</u>

In the turf community (Tables 2, 3, and 4), foliose red algae (primarily *Callophyllis violacea*, *Polyneura latissima*, and *Gigartina exasperata*) were observed on all modules, although in small numbers. Only one species of foliose brown algae (*Pachydiction coriaceum*) was observed. It was ranked occasional on the shallow module at SMBAR. The encrusting mud ectoproct (*Cryptoarachnidium* sp.) was the most frequently observed invertebrate, generally more abundant at the deeper modules of each reef.

Foliose red algae were rated occasional on the modules at PBAR. The mud ectoproct was abundant on both the mid-depth and deep modules, but was not observed on the shallow module. Barnacles (*Megabalanus* sp.) were also ranked abundant on the mid-depth module.

Foliose red algae were ranked rare on both modules of OAR. The mud ectoproct was ranked common and abundant on shallow and mid-depth modules, respectively.

The turf community at SMBAR was the most diverse and developed. Three foliose red algae (*G. exasperata*, *P. latissima*, and *Rhodymenia pacifica*) were frequently observed on the modules, with percent coverage being highest on the shallow module. Eight species of invertebrates were observed on the shallow module, although none was ranked abundant. The mud ectoproct was abundant on both mid-depth and deep modules. Barnacles were also ranked abundant on the mid-depth module.

Macroalgae

Giant kelp occurred on all modules except the mid-depth and deep modules at SMBAR (Tables 2, 3, and 4). *Pterygophera* sp. and *Pelagophycus* sp. also occurred on most modules.

Giant kelp was ranked occasional on the three modules at PBAR. *Pterygophera* sp. was common on both the shallow and mid-depth modules, but ranked only occasional on the deep module.

Giant kelp was ranked abundant on the shallow module at OAR where more than 50 adult and approximately 50 juvenile plants were present; however, most were covered with epiphytes and were severely grazed by sea urchins. Seven healthy adult plants were growing on the mid-depth module along with *Pterygophera* sp. which was ranked common.

Giant kelp, almost non-existent at SMBAR, was ranked occasional on the shallow module.

Discussion

Although SMBAR had been previously surveyed by CDFG biologists in 1989, these were the first observations of PBAR and OAR since their construction. Thus, no previous data exists for comparing the community development. However, biotic communities on all three reefs were similar to those observed on other southern California quarry rock artificial reefs of similar depth and age.

Fish communities on all three reefs were diverse and abundant, and fish production was suggested by the large number of juvenile blacksmith at all reefs and the occasional juvenile sheephead at SMBAR. Blacksmith are especially important to the nearshore reef ecology. Their feeding and nesting habits "fix" energy for other reef organisms. For example, by feeding on plankton in the water column and defecating in the rocky interstices where they nest, blacksmith provide an important source of nutrients for the plant communities. In addition, juvenile blacksmith are food for some species associated with the reefs.

The large number of important sport fish species such as kelp bass, barred sand bass, sculpin, and sheephead suggest that the reefs will support substantial sport fishing. Success has been reported by Commercial Passenger Fishing Vessels targeting sculpin and California halibut (*Paralichthys californicus*) at the three reefs. Only a small number of the basses have been caught, however, suggesting that shallow reef modules may function as periodic habitat for adult fish.

While a rocky substrate is of first importance, the presence of giant kelp greatly increases the abundance of kelp bass and barred sand bass (Quast 1968). Kelp bass tend to shift in response to site preference and a lowered population density at preferred sites. Barred sand bass generally prefer the rock-sand interface of kelp beds. Generally, bass in optimal habitat move little, while those in suboptimal areas seek better habitat. Since only the shallow module at OAR had any significant kelp growth, the bass may not consider the other modules preferred habitat.

The macroinvertebrate communities were not very diverse or well-developed. Only the feather hydroid was ranked abundant. The frequent observations of spiny lobsters and rock scallops suggest that the reefs are capable of supporting the production of these important sport species. Other factors, however, such as water quality and distance from source stock on nearby reefs, may also affect macroinvertebrate abundance and rate of distribution.

The turf communities on all mid-depth and deep modules were dominated by the mud ectoproct. This encrusting invertebrate is a "pioneer" species, being among the first organisms to settle on new habitat. Their presence indicates early successional development in the turf community, while the presence of other species such as barnacle, gorgonians (*Muricea* spp.), and mussels (*Mytilus* sp.) indicates on-going community change. The turf communities on the shallow modules were not dominated by one organism; instead they were comprised of a variety of invertebrates and foliose red algae.

The macroalgae community was generally not well-developed on the reefs. Although giant kelp was observed on all but two modules, it was ranked abundant only on the shallow module at OAR. Since substantial stands of giant kelp have grown on similar quarry rock reefs within months of reef construction, factors other than reef age are most important to giant kelp establishment.

The biota on PBAR and OAR appears to be following typical developmental patterns observed on similar artificial reefs in southern California (Wilson *et al*. 1990). Based upon detailed studies, we predict that the biotic communities at both reefs will become more diverse and complex within five years, especially if forests of giant kelp become established.

The SMBAR did not show the same degree of community development as the other two reefs. This is particularly true for the macroalgae community. Although no attempt was made to determine the causes, they may include (1) the distant location of SMBAR from natural reefs which may effect the amount and type of plant and invertebrate source stock available to it; (2) the large amount of fine particulates in the water and the sediment in Santa Monica Bay may prevent the settlement and growth of invertebrate larva and algal spores on SMBAR; or (3) a combination of these and other factors.

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