

FINAL REPORT

THE USE OF LARGE ARTIFICIAL REEFS TO ENHANCE FISH POPULATIONS
AT DIFFERENT DEPTHS IN THE FLORIDA KEYS

by

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TABLE OF CONTENTS

	<u>Page</u>
Table of Contents.....	i
List of Tables.....	iii
List of Figures.....	v
List of Plates.....	vi
Abbreviations.....	vii
Introduction.....	1
Methods.....	6
Overview.....	6
Artificial Reef Construction and Placement.....	6
Site Conditions.....	9
Sampling.....	14
Analysis.....	17
Fouling Community Photography.....	19
Results.....	19
Shallow Reefs.....	21
Mid-depth Reefs.....	22
Deep Reefs.....	25
Bahia Honda Bridge Rubble Reefs.....	27
American Shoal Bridge Rubble Reefs.....	28
Hawk Channel Bridge Rubble Reefs Combined.....	29
Discussion of Objectives.....	31
1. Quantify Species Composition, Biomass, and Seasonality ...	31
Shallow Prefabricated Units.....	33
Mid-Depth Prefabricated Units.....	33
Deep Prefabricated Units.....	34
Bahia Honda Rubble Reefs.....	35
American Shoal Rubble Reefs.....	36
2. Compare Artificial Reefs to Natural Reefs.....	37
Similarity of Units to Natural Reefs.....	38
Similarity of Rubble Reefs to Other Reefs.....	40
Comparison of Top 15 Species.....	41
Length-Frequency Comparisons.....	43

TABLE OF CONTENTS (cont.)

	<u>Page</u>
3. Evaluate Effects of Different Water Depths.....	44
Species Composition, Frequency, and Abundance.....	44
Recruitment and Colonization.....	47
Biomass.....	48
4. Separate and Compare Trophic Levels.....	50
Browsers.....	51
Piscivores.....	52
Herbivores.....	53
Invertivores.....	54
Planktivores.....	56
5. Document Fouling Community.....	57
6. Determine Fishing Opportunities.....	60
Shallow Prefabricated Units.....	62
Mid-Depth Prefabricated Units.....	63
Deep Prefabricated Units.....	64
Hawk Channel Bridge Rubble Reefs.....	65
Fishing Activity.....	68
7. Evaluate Construction and Placement Costs.....	70
Prefabricated Units.....	71
Bahia Honda Rubble Reefs.....	72
American Shoal Rubble Reefs.....	73
Cost Effectiveness of Artificial Reefs.....	74
Comparisons to Other Artificial and Natural Reefs.....	75
Conclusions and Recommendations.....	79
References.....	87
Acknowledgements.....	90
Tables.....	91
Figures.....	176
Plates.....	194

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Summary of monitoring dates and 411 samples collected.....	92
2. One hundred seventy-nine species censused at all reefs from June 1988 to June 1990.....	93
3. One hundred seventy-nine species censused at all reefs from June 1988 to June 1990, by family.....	97
4. One hundred eight species censused at prefabricated units from June 1988 to June 1990.....	101
5. One hundred three species censused at bridge rubble reefs in Hawk Channel from June to August 1989.....	104
6. One hundred fifty-three species censused on natural reefs from July 1988 to May 1990.....	107
7. Summary of monitoring on shallow prefabricated unit 1 (SAR1) from June 1988 to June 1990.....	111
8. Summary of monitoring on shallow prefabricated unit 2 (SAR2) from June 1988 to June 1990.....	112
9. Summary of monitoring on shallow prefabricated unit 3 (SAR3) from June 1988 to June 1990.....	113
10. Combined summary of monitoring on the 3 shallow prefabricated units.....	115
11. Percent of species shared by artificial and natural reefs.....	117
12. Summary of censuses on the shallow natural reef (SNR) from July 1988 to April 1990.....	118
13. Summary of monitoring on mid-depth prefabricated unit 1 (MAR1) from June 1988 to June 1990.....	121
14. Summary of monitoring on mid-depth prefabricated unit 2 (MAR2) from June 1988 to June 1990.....	123
15. Combined summary of monitoring on the 2 mid-depth prefabricated units.....	125
16. Percent shared of the 15 most frequent, abundant, and heaviest species in various comparisons of reefs.....	127
17. Ranking of the 15 most frequent and abundant species censused at the mid-depth prefabricated units.....	128
18. Summary of censuses on the mid-depth natural reef (MNR) from September 1988 to May 1990.....	129
19. Summary of monitoring on deep prefabricated unit 1 (DAR1) from June 1988 to June 1990.....	132
20. Summary of monitoring on deep prefabricated unit 2 (DAR2) from June 1988 to June 1990.....	134
21. Combined summary of monitoring on the 2 deep prefabricated units.....	136
21a. Ranking of the 15 most frequent and abundant species censused on the deep prefabricated units.....	138
22. Summary of censuses on the deep natural reef (DNR) from September 1988 to May 1990.....	139

LIST OF TABLES (Cont.)

<u>Table</u>	<u>Page</u>
23. Summary of monitoring at the Bahia Honda bridge rubble reefs from June to August 1989.....	142
24. Summary of monitoring at the American Shoal bridge rubble reefs in July and August 1989.....	144
25. Combined summary of monitoring for the Bahia Honda and American Shoal rubble reefs.....	146
26. Summary of settler and colonizer species at the shallow prefabricated units.....	149
27. Summary of settler and colonizer species at the mid-depth prefabricated units.....	150
28. Summary of settler and colonizer species at the deep prefabricated units.....	151
29. Summary of settler and colonizer species at the Bahia Honda bridge rubble reefs.....	152
30. Summary of settler and colonizer species at the American Shoal bridge rubble reefs.....	154
31. Comparison of the 15 most frequent, abundant, and heaviest species at the shallow units to the natural reef.....	155
32. Comparison of the 15 most frequent, abundant, and heaviest species at the mid-depth units to the natural reef.....	156
33. Comparison of the 15 most frequent, abundant, and heaviest species at the deep units to the natural reef.....	157
34. Comparison of the 15 most frequent and abundant species at the Bahia Honda and American Shoal rubble reefs.....	158
35. Comparison of the 15 most frequent and abundant species at Hawk Channel rubble reefs and the mid-depth natural reef.....	159
36. Occurrence and rank of the 15 most frequent species at artificial reefs.....	160
37. Occurrence and rank of the 15 most abundant species at artificial reefs.....	161
38. Occurrence and rank of the 15 heaviest species at artificial reefs.....	162
39. Summary of species by trophic level at the mid-depth prefabricated units.....	163
40. Summary of species by trophic level at the deep prefabricated units.....	165
41. Summary of species by trophic level at the deep natural reef.....	167
42. Summary of species by trophic level at the Bahia Honda rubble reefs.....	170
43. Summary of close-up photography of the fouling community at the prefabricated units.....	173
44. Comparison of artificial and natural reefs in Hawaii and Florida.....	174

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. High profile prefabricated unit design.....	177
2. Low profile prefabricated unit design.....	178
3. Study site location in south Florida.....	179
4. Study site location near Big Pine Shoal and location of the Bahia Honda and American Shoal bridge rubble reefs.....	180
5. Approximate location of prefabricated units and natural reefs within the study area.....	181
6. Points of quarterly fouling community close-up photography.....	182
7. Total number of species recorded at censused artificial and natural reefs.....	183
8. Relative density of fishes recorded at censused artificial and natural reefs.....	184
9. Mean number of species and fishes per census at the prefabricated units.....	185
10. Monthly number of species at each low unit.....	186
11. Monthly number of fishes at each low unit.....	186
12. Monthly number of species at each mid-depth high unit.....	187
13. Monthly number of fishes at each mid-depth high unit.....	187
14. Monthly number of species at each deep high unit.....	188
15. Monthly number of fishes at each deep high unit.....	188
16. Potential contribution of settler species to fish numbers and biomass at prefabricated units.....	189
17. Potential contribution of colonizer species to fish numbers and biomass at prefabricated units.....	189
18. Monthly comparison of settler species as a proportion of total species at mid-depth and deep units.....	190
19. Monthly comparison of potential settler numbers as a proportion of total numbers at mid-depth and deep units.....	190
20. Monthly mean number of species at units in 3 depths.....	191
21. Monthly total of fishes at units in 3 depths.....	191
22. Trophic level as a proportion of total biomass at four sites.....	192
23. Trophic level as a proportion of total numbers at four sites.....	192
24. Monthly numbers of yellowtail snapper at mid-depth and deep units.....	193
25. Monthly numbers of yellowtail snapper and gray snapper at deep units.....	193

LIST OF PLATES

<u>Plate</u>	<u>Page</u>
1. Construction yard view of low profile and high profile prefabricated units.....	195
2. Transportation of prefabricated units to the staging area at the west end of the old Bahia Honda bridge.....	196
3. Underwater view of a mid-depth prefabricated unit about 90 days after placement.....	197
4. Deliberate placement of a mid-depth unit in June, 1988, and an underwater view of a low profile shallow unit.....	198
5. Oblique 1988 aerial photographs of shallow and mid-depth reefs.....	199
6. Underwater views of the shallow and mid-depth natural reefs.....	200
7. Underwater views of the deep natural reef.....	201
8. Steel girders and concrete used to construct patch reefs at the Bahia Honda artificial reef.....	202
9. Underwater views of the American Shoal bridge rubble reef.....	203
10. Underwater views of the fouling community on a mid-depth unit 3 months and 17 months after placement.....	204
11. Underwater views of mid-depth and deep units 17 months after placement.....	205
12. Aggregations of yellowtail snapper, doctorfish, ocean surgeon, and hogfish at a mid-depth unit 17 months after placement.....	206
13. Fish trap containing black grouper, gray snapper, and gray angelfish photographed in the study area.....	207

ABBREVIATIONS

SAR - Shallow prefabricated unit
SARC - Shallow prefabricated units combined
SNR - Shallow natural reef
MAR - Mid-depth prefabricated unit
MARC - Mid-depth prefabricated units combined
MNR - Mid-depth natural reef
DAR - Deep prefabricated unit
DARC - Deep prefabricated units combined
DNR - Deep natural reef
BH - Bahia Honda bridge rubble reef
AMS - American Shoal bridge rubble reef
HAWKC - BH and AMS combined
N = Number of samples

INTRODUCTION

The use of artificial reefs as fishing sites is well established in the Florida Keys. Early residents knew that wrecks, sunk accidentally or deliberately, often produced concentrations of fish. In recent years, artificial "patch reefs" have been created with large concrete slabs, boulders and rubble from bridge removal projects, and large steel vessels have been intentionally sunk. The main purpose of artificial reef construction is to enhance, supplement, or mimic natural reef habitats by providing relief on flat, featureless ocean bottom (Seaman and Sprague 1991). Artificial reef construction increases habitat diversity, vertical relief, and "hard bottom", creating new fishing and diving opportunities.

Florida's coral reef ecosystem supports extensive recreational and commercial fisheries for species dependant on complex reef habitats during some or all stages of their life cycles. Of particular importance are fisheries for snapper, grouper, grunt, and porgy on natural hard bottom and coral reef habitats. Mid-water species such as mackerel, jack, cobia, and barracuda are often caught near habitats with high vertical relief. The marine life industry collects reef fishes and invertebrates for aquariums; fishes targeted include angelfish, butterflyfish, damselfish, wrasse, parrotfish, and goby. Expansion of boating and fishing activity in South Florida and much improved technology have

increased pressure on most reef species with fishery value.

Fishing and diving industries in the Keys have benefited greatly from the sinking of large vessels and rubble reefs. The marine life industry collects live specimens on rubble reefs. Artificial habitats can reduce user conflicts, increase fishing and boating efficiency, make fishing and diving more predictable, increase public access to fishery resources, and enhance fish abundance through attraction and production (Bohnsack 1989). Milon (1991) reported that about 28% of anglers and 14% of divers use artificial habitats in the Dade County (Miami), Florida area.

As habitat for fish, artificial reefs provide food resources, shelter from predation, and sites for orientation and reproduction (Bohnsack and Sutherland 1985). Shulman (1984) concluded that shelter from predation may be more important to fish recruitment than food availability, but some species may be limited more by supply of larval recruits (Bohnsack 1990). Observations of higher fish densities at artificial reefs than at nearby natural reefs are common, although community structures are usually similar (Bohnsack 1990). Research has shown that, although the fish assemblages vary at different artificial reefs because of different physical conditions, increasing habitat complexity increases abundance and diversity (Alevizon and Gorham 1989, Bohnsack and Sutherland 1985, Bohnsack et al. 1989, Bohnsack 1990).

Like many other non-profit and governmental artificial reef programs around the Gulf of Mexico, the Florida Keys Artificial Reef Association (FKARA), organized in 1980, has functioned mainly as an

opportunistic builder of reefs when suitable material or vessels were available. From 1981 to 1987 the FKARA supervised the placement of 35,000 tons of bridge rubble at 6 permitted sites, and the sinking of 5 vessels from 187' to 327' long from Key Largo to Key West (FKARA 1990). All materials were placed onto sandy bottoms. Although fish surveys have been conducted on several of these shallower rubble reef sites for years, available information is limited to relative abundance, general patterns of succession, and, to some degree, recruitment.

The use of prefabricated reef structures in the eastern United States is not common, but as the uses of artificial reefs evolve from exploitation towards resource conservation and management, assessment of their value is taking place (Seaman et al. 1989). In 1987 and 1988 the FKARA obtained donated materials, labor, and work space, funds through fund raising, and a State grant for transportation that allowed construction and placement of 7 prefabricated concrete units of 2 different designs. The largest (27 m² bottom area, 5 m high with PVC, 7 mt) are believed to be the largest prefabricated units ever used in south Florida as artificial marine habitats.

A N.O.A.A. grant through the National Marine Fisheries Service, Marine Fisheries Initiative (MARFIN) program funded the 2 year monitoring project that followed unit placement in June of 1988 and the preparation of this descriptive report. The purpose of this study was to evaluate the potential for fishery enhancement of placing large prefabricated units and concrete rubble in different

depths and locations off the Lower Florida Keys. The project was designed to produce useful information on the responses of fish to the introduction of specific types and profiles of large structures. Examined were production potential, locational differences, fishery value, and economics of two different types of artificial reef construction projects. Censusing adjacent natural bank reefs using standard methods allowed comparisons of community structure. Fishes were censused on 15 bridge rubble "patch reefs" placed from 1983 to 1987 at 2 locations in Hawk Channel for additional comparisons. The study's original objectives were:

1. Quantify the species composition, biomass and seasonality of fishes attracted and produced on large fabricated artificial habitats over a 24 month period.

2. Compare the colonization and community structure of reef fishes on the fabricated habitats to nearby natural reefs.

3. Evaluate the effects of reef siting at different water depths on species composition, recruitment, and biomass.

4. Separate fish communities into trophic levels to assess location of food source (e.g. water column, surrounding bottom, structure fouling community, etc.)

5. Through standard photographic techniques, document and quantify plant and invertebrate fouling communities as a function of substrate and water depth.

6. Determine if large, fabricated habitats can provide significant fishing opportunities.

7. Evaluate the economics of construction, transportation, and placement of artificial habitats to enhance fishery resources and fishing opportunities.

Understanding how much artificial reefs increase fish numbers and biomass is important to wise fishery management and to the proper construction and deployment of artificial reefs (Bohnsack 1989). Basic knowledge of the results of reef building is critical to measure their value in a region as unique and significant as the Florida Keys, where future efforts could include additional concrete rubble reefs, clean steel vessels, and prefabricated concrete units. How artificial reefs should be used in a comprehensive fisheries (and people) management program in the Florida Keys National Marine Sanctuary will be resolved only through continued accumulation of ecological information on fish assemblages associated with reef habitats and documentation of various human uses. The use of structured, consistent methods for assessment of artificial habitats and the collection of long term population data on natural reef communities will facilitate important management decisions. As well, the ability to provide alternative fishing and diving sites through the creation of productive artificial reefs could assist in the management of people in one of the most popular fishing and diving locations in the United States and the world.

METHODS

Overview

Project design was based on recommendations of Bohnsack and Sutherland (1985) in regard to the need for experimentation with large, inexpensive, long lasting, easily handled, and easily transportable, artificial reefs. Efforts were made to collect quantitative data on the short and long-term physical, biological, and economic aspects of artificial reef projects as well as to establish baselines for future comparisons.

Seven prefabricated structures were placed in 1988 in 3 depths on the Florida reef tract near Big Pine Shoal. Of these, three low profile concrete units were placed in the shallowest depth (7 m), and 2 high profile concrete and PVC units were placed at mid-depth (14 m) and deep (24 m) sites. Fish assemblages on the units and nearby natural reefs were censused for 2 years following unit placement. Rubble reefs, placed from 1983 to 1987, were censused in mid 1989. Assemblages were compared by species composition, frequency-of-occurrence, abundance, and biomass. Species at each artificial reef were classified as settler or colonizer species for indications of production potential. Fishery values, if any, and trophic group were determined for each species.

Artificial Reef Construction and Placement

The prefabricated units were designed by the FKARA in collaboration with a structural engineer and built at a construction yard on Big Pine Key in late 1987 and early 1988. Prestressed

concrete (6,000 PSI) beams (15 cm x 20 cm) were used for diagonal and vertical members on the high profile units and for horizontal beams on the low units (Figs. 1 and 2, Plate 1). The units were structurally unified with tied reinforcing steel in the poured concrete (4,000 PSI) base and upper beams. They are designed to last indefinitely and survive severe storms. Grove et al. (1991) note that shapes and dimensions of fabricated reefs with desirable structural integrity and durability are best developed based on knowledge of the "environmental loading" anticipated and the strength of the materials used. Important structural characteristics for artificial habitats include profile, shadow, vertical relief, surface area, substrate, and holes, voids, and interstices that provide cover for fishes (Bohnsack 1990). Japanese experiences using large prefabricated reefs to enhance fish populations suggest that maximum horizontal spread should be emphasized and that vertical profile probably need not be more than about 5 m high (Grove et al. 1991).

The 4 high profile units were fabricated with identical square (5.15 m x 5.15 m) bases (Plate 1) to prevent toppling and open sides to minimize effects of wave surge during storms. The wide base beams were designed to minimize sinking into sand substrates. The concrete portion of the structure was 2.8 m high. Total height, including the PVC "stacks", ranged from 4.6 to 5.4 m (Fig. 1, Plates 2 and 3). The top PVC pieces were seated in a PVC base embedded in the poured concrete top beam and were held in place by large galvanized pins in holes drilled through both pieces. Each high unit covered about 27

m² of bottom, had a volume of 40 m³, a surface area of about 66 m² (43 m² concrete and 23 m² PVC), and weighed approximately 7,300 kg. Structural variation between high units was limited to the 8 vertical concrete end pieces (0.9 to 2.0 m tall) and the PVC tubes, thick walled (15 cm dia, 0.7 to 2.5 m tall) at the top and thin walled at the bottom of the units (11 cm dia, 0.1 to 0.4 m tall). High units had 5 cm dia holes drilled in all top PVC pieces and smaller holes drilled in most bottom PVC pieces. Upper surfaces of the prestressed beams were rough, while the surface of poured concrete was smooth. Most prestressed beams had lengths of 0.5 m dia steel wire attached by 5 cm steel pegs along the upright edge (Plate 1), further diversifying the structures' surfaces. Bohnsack (1990) reports that the surface of material used can influence food availability through differences in fouling community development.

Three low profile units were created by fabricating two separate table-like structures (3.1 m long and 7.0 m long) and placing the shortest structure over the other (Fig. 2, Plate 4). Prestressed beams were used for cross members, and formed and poured concrete with reinforcing steel was used to tie beams together on each end and to form the legs. The 3 structures had nearly identical dimensions. The horizontal portions of the structures were elevated from 0.5 m to 1.2 m above the bottom. The upright surfaces of the prestressed beams were rough and included a strip of steel wire on small pegs as on high profile units. Loops of reinforcing steel were placed in the top of the poured concrete as lifting rings. Each unit covered about 29 m² of bottom, had a volume of 20.4 m³, and weighed

about 2,300 kg (2 sections). One small unit (SAR3) had 2 flat concrete plates installed on the upper surface to hold inserts of several surfaces.

In June 1988, the units were transported via U.S. Highway 1 to a staging area at the southwest end of the old Bahia Honda Bridge east of Big Pine Key (Plate 2). A barge was used to transport the units offshore to the permitted sites where they were carefully placed with the assistance of divers on top of markers set in the bottom (Plate 4). Two high profile units were placed at 14 m depth on June 25, 1988, 50 m apart and 50 m south of a natural linear bank reef. The other two high units were placed at 24 m depth on June 26 and 27, 50 m apart and 50 m north of the natural deep reef. On June 27, the three low units were placed at 7 m depth, 50 m apart and 50 m from a shallow natural bank reef. Mid-depth and deep units were placed perpendicular to the prevailing east-west orientation of current flow. Stakes of reinforcing steel were driven (September 1988) into the bottom 76 cm off the corners of all except 1 deep unit to allow detection of any unit movement.

Site Conditions

The area chosen for placement of the units is a north-south cross section of the Florida reef tract at latitude 24 34'N and longitude 81 20'W, about 8 to 9 km south of Big Pine Key and about 7.5 km east of Looe Key Reef (Figs. 3 - 5). The area is in the blue water zone of the coral reef ecosystem - the outer reef slope, influenced more by the warm offshore Florida Current than by the

seasonally cooler, green waters of the Gulf of Mexico. Gilbert (1974) notes that the richness of the Florida Keys fish fauna is due in large part to the mixing of continental (green water) and insular (blue water) fish faunas.

Mid-depth and deep units were placed onto open, sandy bottom while the shallow (7 m) units were placed on sandy bottom with nearby patches of turtle grass (Thalassia testudinum) (Fig. 5, Plate 5). Mid-depth units were placed on a sandy plain with low, flat, relict rock within about 15 m of the west side of the westernmost unit (MAR2, Plate 5). The natural bank reefs at shallow and deep depths were seaward (south) of the units; at mid-depth, the natural reef was landward (north) of the units.

Currents on the reef tract were typically mild and variable in direction; the strongest were on the deep reef, nearest to deep water and the Florida Current. Winds and seas were usually from the southeast, except when fall and winter colds fronts produced strong northerly winds. Water temperature ranged from 22.0 to 30.5 C (Table 1). Most temperature measurements were made on the bottom with a hand-held thermometer; a few were obtained from the Florida Institute of Oceanography data bank of surface water temperatures at Sombrero Reef, a few miles to the east. Visibility was effected by strong winds, the Florida Current, and tides, and varied from 7 to 18 m during census work. Visibility was lowest on the deep reefs where stratification often occurs; producing clear, warm, blue water on the surface and "dirty", often cooler water, near the bottom.

The shallow (6 to 8 m) natural reef censused was about 50 m wide and 150 m long (Fig. 5, Plates 5 and 6). This reef was an isolated section of linear bank reef (Jaap 1984, Voss 1988) that extended a considerable distance to the east. Overall relief was about 2 m with greatest habitat complexity on the slope along the north edge and on an elevated section to the west. Relief of individual rock outcrops, large vase sponges, and large octocorals was up to 1 m. Soft corals included Pseudopterogorgia sp., Pseudoplexaura sp., and Gorgonia sp. and major stony corals included Siderastrea siderea, Stephanocoenia michelinii, Porites astreoides, P. porites, Agaricia agaricites, Dichocoenia stellaris, Montastraea cavernosa, and Millepora alcicornis. Of all the natural reefs censused, only this area had associated beds of seagrass.

The mid-depth (10 to 12 m) natural reef censused was about 50 m wide and part of an elongated (east-west) bank reef (Fig. 5). The homogeneous reef sloped about 20 to 30 degrees seaward, with overall relief of about 2 m, and well developed sand channels to about 0.7 m deep (Plate 5). Maximum vertical relief provided by octocorals, hard corals, rock, and sponges was about 1.4 m (Plate 6). This reef consisted of a larger proportion of hard corals than the shallow natural reef, including Porites astreoides, Montastraea annularis, Millepora alcicornis, Siderastrea radians, Dichocoenia stokesii, Colpophyllia natans, Oculina diffusa, Manicina areolata, and Meandrina meandrites.

The deep natural reef was censused at a depth of 26 to 31 m on a steep, seaward facing slope of about 40 to 60 degrees. Immediately

south of the reef began the expanse of open sand that descends offshore into deeper waters of the Straits of Florida. At about 15 to 20 m wide, this linear reef was relatively homogeneous, smaller than the shallow and mid-depth reefs censused and somewhat discontinuous beyond the census area to the east and west. This relict reef consisted of large, eroded, rocky areas with relief up to 1.2 m (Plate 7). Exposed rock was encrusted with sponges, octocorals, bryozoans, and hard corals including Stephanocoenia michelinii, Agaricia agaricites, Montastraea cavernosa, and Siderastrea siderea.

Two additional study sites were the Bahia Honda and American Shoal rubble reefs in Hawk Channel (Fig. 4) constructed from 1983 to 1987 by placing large concrete boulders, concrete deck slabs and heavy steel from local bridge removal projects on sand bottom. The Bahia Honda site includes large steel girders from removal of the old Bahia Honda Channel bridge (Plate 8). The location in little-studied Hawk Channel (to 14 m depth), which lies between the reef tract and the island chain, influences physical parameters, particularly water clarity, and probably minimum water temperature. Proximity to tidal channels connecting to the Gulf of Mexico and the depressional nature of the area results in frequent stratification of the water column. These sites appear to be influenced more by green waters of the Gulf of Mexico than by the Florida Straits.

The Bahia Honda rubble site, in 9 to 10 m depth on the north edge of Hawk Channel about 4.5 km offshore from Bahia Honda Channel (Fig. 4), is composed of 19 "patch reefs" placed in 1985 and 1987

containing a total of about 6,000 mt of material (Plate 8). Averaging about 150 m² in area, but with considerable size range, the patches are separated by about 20 to 70 m and are scattered over about 2 ha. Schroeder (1987) reported that a grouping of several small reefs produces higher density and higher total number of recruits than one large reef. Patches vary somewhat in combinations of materials (concrete boulders, slabs, and rubble; steel girders, pipe and pipe hangars), size, vertical profile, and open space within the patch. The patches are just seaward of deep beds of predominantly turtle grass and shoalgrass (Halodule wrightii) that extend offshore to the 9 m depth contour. Vertical relief on the patches ranged to about 2.5 m. In the years between placement and the 1989 censuses, a variety of sponges and large octocorals (to 58 cm tall) have flourished on hard surfaces, along with some stony corals.

The American Shoal rubble reef consists of 4 patch reefs, averaging about 450 m², placed from 1983 to 1987 on sand bottom at a depth of 11 to 12 m on the south (seaward) edge of Hawk Channel (Fig. 4). Patches were constructed by carefully placing a total of 3,800 mt of large concrete slabs, boulders, and steel pipe from local bridge removal projects. Vertical relief ranged to about 2.5 m. The 4 patches vary somewhat in materials and profile: patch 1 is mostly large boulders and slabs with open space between many pieces; patch 2 is both large and small boulders in a large mound with some pipe; patch 3 is high profile large boulders, slabs and pipe; patch 4 is a mound of boulders and slabs. By 1989, octocorals had reached

a height of 50 cm on the oldest material, adding appreciably to the structural complexity of the site (Plate 9). Various sponges and small stony corals were also present.

Sampling

Prefabricated Units

Divers listed and counted all fishes at prefabricated units and estimated the range of fork length of each species using standard visual census techniques (Bohnsack and Talbot 1980, Bohnsack et al. 1989). Large fish were recorded first from a distance; then the unit was inspected closely for small and cryptic species. A zone about 5 m wide around each unit was included to insure all fishes associated with the structure were counted. A second diver recorded cryptic and unusual fishes allowing comparisons and creation of accurate census records. The units were censused on June 30, 1988 (mid-depth units also on June 27), after placement, then monthly for the next 3 months, and every other month thereafter until June 1990.

Natural and Rubble Reefs

On natural reefs and bridge rubble reefs where total counts were not possible, a stationary sampling method developed by Bohnsack and Bannerot (1986), was used to visually sample the community structure of highly diverse and abundant reef fish populations. Stationary censuses were also taken on sand bottom at the 2 mid-depth sites prior to unit deployment to allow comparison of changes as a result of unit placement. A major value of the

stationary sampling method is that quantitative data are collected simultaneously on species composition, abundance, frequency-of-occurrence, and lengths of all visually detectable species. This method, considered extremely effective for censusing reef fish and providing indices of abundance for comparative purposes, is simple, fast, objective, and repeatable (Bohnsack and Bannerot 1986). Sale (1991) concludes that stationary visual censuses can have definite advantages over other census methods. As in other census methods, documentation of many crevice dwelling and cryptic species is poor. Alevizon (1990) assesses various reef fish census methods used in south Florida and reminds us that at night reef fish communities differ substantially from those observed during the day.

Two divers went to different regions of a natural or rubble reef to be censused, and each established an initial census area (177 m²) using a 7.5 m anchored rope to delineate the sample circle's radius. Stationary at the center of the circle, the divers listed all species observed in 5 minutes within an imaginary cylinder extending from the bottom towards the water's surface. After 5 minutes, beginning at the bottom of the list, all individuals of each species within the sample area were counted and the range of fork lengths estimated using 40 cm rulers at the ends of poles carried by the divers to reduce effects of magnification. Fast moving species, such as jacks and mackerels, were counted during the initial 5 minutes. The percentage of sand and rock/coral surface in the sample area was recorded along with water depth, temperature, and visibility. After the initial census, each diver

traveled to a second census site based on a predetermined, randomly derived list of compass headings and distances, and the process was repeated. Distance traveled between censuses was measured by swim kicks and was adequate to preclude overlap. Divers worked in different regions of the reef to avoid interference with the other's counts. At most, 3 censuses were conducted during a single dive on shallow and mid-depth reefs and 2 censuses on the deep reef. Project design required 8 stationary samples from each the mid-depth and deep natural reefs and 12 from the shallow natural reef during months when the adjacent units were counted. All regions of the natural bank reefs near the units were censused during the 2 years of sampling. To insure consistency, the authors conducted all censuses.

The bridge rubble reefs in Hawk Channel were censused from June to August, 1989. A 7.5 meter radius visual census area was established on different patches after they were located with land ranges and a depth recorder. At the American Shoal site, all samples were collected on the 3 westernmost patches (#s 1 - 3). At the Bahia Honda site, several censuses were made on each of the largest patches (#s 1 and 2) which include large, piled steel girders; the remainder were made on about 10 other patches randomly sampled. Poor visibility (< 7 m) precluded censuses on several occasions at both natural and rubble reefs.

Analysis

Census data from prefabricated units, natural reefs, and bridge rubble reefs were entered into a data entry template for "Reef Fish Visual Censusing Samples" provided on Lotus 1-2-3 by the Southeast Fisheries Center of the National Marine Fisheries Service in Miami, Florida (D. Harper, pers. comm. 1989). Multiple samples were processed into a flat data file from which a summary analysis of samples from different locations was performed by the NMFS program. Mean length was determined for each species in each sample from the range of lengths recorded in the field. Total biomass was calculated for each species at all artificial reefs and the deep natural reef using overall mean lengths and length to weight formulas in Bohnsack and Harper (1988). Density was estimated for comparative purposes by dividing the total number of fishes censused at a site by the area censused. Similarity between fish assemblages at 2 reefs was determined by comparing species shared to the total number of species and by comparing the 15 most frequent, abundant, and heaviest species at the two sites.

To determine which species have the potential for being produced by these types of artificial habitats, reef fishes were separated into settlers and colonizers using a modification of the following definitions by Bohnsack et al. (1989):

"Settlers are defined as species that arrived at the artificial reef directly from the plankton as larvae. Colonizers are defined as species that arrive at a reef as juveniles or adults after apparently settling elsewhere and then swimming to the artificial reef."

Production and attraction at artificial reefs are not mutually exclusive and actually occur on a gradient or continuum depending on reef type and location (Bohnsack 1989). Settler species, as defined here, are species of which at least a single young juvenile was recorded, a result of either settling directly from the plankton or moving to the artificial habitat a short time after settling in nearby sand or seagrass. Settler species have documented potential to be supported by these types of artificial habitats at a very early life stage (at least for a short period), benefitting by the food and shelter resources provided. Determination of a settler species was based on the minimum size recorded at a site, juvenile coloration, and known biology of individual species. Questionable individuals were listed as settlers. Colonizer species at a site were those never observed at a young juvenile size, and included visitors and transients. Bohnsack et al. (1991) note that many reef fishes initially use an intermediate habitat (e.g. sand plains, rubble zones, seagrass beds) prior to using reef habitats.

Fishes at the mid-depth and deep units, the deep natural reef, and the Bahia Honda rubble reefs were separated into trophic categories based on designations in Bohnsack et al. (1989) for comparison and assessment of food source.

An economic fishery value classification (commercial, recreational, marine life) was assigned to each species based on lists in Bohnsack et al. (1989), marine life industry lists contained in Florida Administrative Code Chap. 46-42.001 (Marine Life), and commercial experience of both investigators in the

collecting and wholesale of marine life throughout Florida.

Fouling Community Photography

Photography was conducted on a quarterly basis from September 1988 to August 1990. Six points, marked either with nails driven into the concrete or located by measured distances, were established in the same locations on the concrete surfaces of each of the low units (Fig. 6). Six points were established on each side (east and west) of each of the high units (Fig. 6) resulting quarterly in 12 images for each unit. A Nikonos V camera with a 28 mm lens, SB-103 strobe, and close-up unit with a frame measuring 12.8 cm x 18.4 (236 cm²) cm was used with Fujichrome 50 color transparency film. Routine underwater photography of the units was conducted as well.

RESULTS

Four hundred eleven visual fish censuses were conducted in 23 different months from June 1988 to June 1990 (Table 1); a total of 105,405 individuals of 179 species (Table 2) in 44 families (Table 3) was recorded from all sites. Although fishes not identified to species level represented 10% of those listed, they were minor and infrequent contributors to the total number of individuals except for unidentified juvenile grunts and scad in local abundance.

In 104 counts on the 7 prefabricated units, 9,515 individuals (978 kg) of 108 species in 33 families were recorded (Table 4). Combining all 50 samples from bridge rubble reefs showed 43,289

fishes (2,345 kg) of 103 species in 34 families (Table 5). Two hundred fifty-seven censuses on the 3 natural reefs showed 52,601 individuals of 156 species in 39 families (Table 6). By comparison, Bohnsack et al. (1987), using 2 census methods at Looe Key Reef, reported 188 species in 48 families from 10 habitat zones (0 to 12 m depth). At Looe Key Reef, known for its high spur and groove formations, 66 species of grunts, damselfishes, wrasses, sea basses, and parrotfishes made up 35% of total species. Here these families represented 66 species, 36% of the total, with 7 members not identified to species level (Table 3).

Both numbers of species (Fig. 7) and relative fish density (Fig. 8) were comparable at prefabricated units in the same depth. Highest species richness and abundance were at the mid-depth units. The numbers of species were similar at the different natural reefs, but density appeared to increase with greater depth. Fish density ranged from a low of 0.9 inds./m² at the shallow natural reef to 5.9/m² at the Bahia Honda site. Of the Hawk Channel rubble reefs, Bahia Honda had the more diverse and abundant fish assemblage. Biomass density at artificial reefs ranged from a low of 199 g/m² at the Bahia Honda site to a high of 483 g/m² at the deep units. The deep natural reef, the only natural reef for which biomass was reviewed, showed 72 g/m².

The prefabricated units proved to be very stable on the bottom even during high seas (9-11 feet) resulting from the passage of several tropical storms and severe cold fronts during the study period. Monitoring at the end of 2 years revealed that movement was

limited to a few centimeters at the westernmost mid-depth unit (MAR2), the other units appeared not to move at all. Several of the top PVC stacks were removed during the study, possibly due to vandalism.

SHALLOW REEFS

Prefabricated Units

Fourteen counts were made on each of the 3 low profile shallow units from June 1988 to June 1990 (Table 1); summaries are at Table 7 (SAR1), Table 8 (SAR2), and Table 9 (SAR3). All units were censused during the same dive. The number of species recorded at a unit ranged from 38 (SAR1) to 45 (SAR3), and total individuals ranged from 638 (SAR1) to 683 (SAR3). Maximums of 19 species and 89 individuals were recorded in a single unit count. Combining all counts of the 3 shallow units revealed 67 species and 2,002 individuals (Table 10).

The average number of species per census of each unit ranged from 9.6 to 12.3, and the average number of fishes per census ranged from 45.6 to 48.8 (Fig. 9). Trends in numbers of species (Fig. 10) and individuals (Fig. 11) showed rapid increases the first few months, declines the first winter, and increases again the following June. The average number of species increased considerably by the second summer, but the number of individuals increased only slightly and peaked in October. Similarity of species between units ranged 40% (SAR2 and SAR3) to 53% (SAR1 and SAR2) (Table 11). Twenty-two species (33%) were recorded at all 3 units.

Natural Reef

One hundred eleven stationary visual samples were collected at the shallow (6 to 8 m) natural reef in 10 different months from July 1988 to April 1990 (Table 1). Combining all samples showed 107 species and 17,038 total individuals (Table 12). Maximums of 30 species and 335 individuals were recorded in a single census. The number of species, 104, was the lowest of the natural reefs censused (Fig. 7), and fish density ($0.9/\text{m}^2$) the lowest of all reefs, including the units (Fig. 8).

MID-DEPTH REEFS

Prefabricated Units

Sixteen counts were conducted on each of the 2 high profile mid-depth units from June, 1988 to June, 1990 (Table 1); summaries are at Table 13 (MAR1) and Table 14 (MAR2). Both units were censused on the same dive. MAR1 showed totals of 55 species and 2,395 individuals, MAR2 had 58 species and 2,036 individuals. Maximums of 25 species and 873 individuals (800 juvenile grunts) were recorded in a single unit count. Combining counts at both units showed 73 species, 4,421 individuals (Table 15), and an estimated density of 4.2 inds./m^2 when the 800 grunts are excluded (Fig 8). Total biomass was 335 kg (738 lbs.).

The mid-depth units had the highest mean number of species per census (16.5) and the most individuals per sample (113.5) of all

units (Fig. 9). An additional count at each MAR unit only several days after placement, and not made at other units, was included in the data base and slightly lowered mean values. The mean number of species in the 2nd year was 19.3. The number of individuals per sample was more than double that at the shallow units and about two-thirds greater than at the deep units. The average number of species per census was about the same for each of the 2 units, 16 to 17 species, but the average number of individuals was about 27% higher at MAR2 (excluding 800 grunts at MAR1) (Fig. 9). The location of MAR2, within about 15 m of an area of flat, hard bottom with some sponges and gorgonians extending from the bank reef may have accelerated colonization at this unit.

Trends in the fish populations on the MAR units were similar the first year but varied somewhat the second (Figs. 12 and 13). Little seasonality was seen in the bimonthly number of censused species, and near average numbers were reached a few months after placement. The overall number of fishes peaked the first fall, declined substantially the first winter, and increased the 2nd year.

June, 1989 was a month of considerable difference between the units, particularly in grunts. MAR1 (14 total species, 48 inds.) had a single cottonwick grunt (14 cm) while MAR2 (20 species and 270 inds.) showed 211 grunts of 4 species (2-10 cm). Small ledges under the base beams of the units caused by wave surge during windy periods, contributed to the diversity and abundance of crepuscular and juvenile bottom dwelling fishes by providing shelter from predators and probably accounted for these differences. Bohnsack et

al. (1989) concluded that fish assemblages were influenced by microhabitat modifications at reefs including sand chambers opening and closing under concrete modules. The temporal variation in grunts at the mid-depth units, illustrates the highly changeable nature of many fish populations. In a census in August, 1988, 802 grunts (2-8 cm long) were recorded, 5 weeks later there were only 30 (2-8 cm). In October, 1988, 60 tomtates (2-8 cm long) were noted at a unit, 2 days later there were only 5.

The 2 mid-depth units shared 40 species, 55% of their combined total (Table 11). Comparison of the 15 most frequent and abundant species on each unit revealed 72% similarity of frequent species and 67% similarity of abundant species, the second highest of any comparison after the deep units (Table 16). Shared of the 15 most frequent species were blue tang, ocean surgeon, doctorfish, sharpnose puffer, reef butterflyfish, slippery dick, bluehead wrasse, gray angelfish, hogfish, porkfish, masked goby, twospot cardinalfish, and yellowtail snapper (Table 17). Shared of the most abundant were tomtate, bluehead wrasse, yellowtail snapper, mackerel scad, ocean surgeon, masked goby, blue tang, yellowhead wrasse, slippery dick, unidentified scad, twospot cardinalfish, and doctorfish.

In early June, 1988, 5 stationary censuses taken on the open bottom before placement of the mid-depth units showed 11 species and 62 individuals (12.4/census), mostly wrasses, bottom dwelling gobies, sand perch, and sand tilefish. Pre-project density of fishes at these sites was 0.07/m². Bohnsack et al. (1989) in 98 pre-

deployment and sand control samples found 27 species and density of 0.09 inds./m². The 2 year mid-depth unit mean fish density of 4.2/m², excluding 800 juv. grunts in one sample, reflects about a 6,000% post-placement increase in fish density. Including all grunts reflects about a 7,300% increase.

Natural Reef

Seventy-eight stationary samples were collected at the mid-depth (10 to 12 m) natural reef in 10 different months from September, 1988 to May, 1990 (Table 1). Combining all samples showed 114 species and 17,106 individuals (Table 18). Maximums of 33 species and 2,633 individuals (2,500 unid. juvenile grunts) were recorded in a single census. The greatest number of species of all reefs sampled was recorded here, but density, 1.2 inds./m², was the second lowest of all sites (Figs. 7 and 8).

DEEP REEFS

Prefabricated Units

Fifteen counts were made on each of the 2 high profile deep units from June, 1988 to June, 1990 (Table 1). Summaries are at Table 19 (DAR1) and Table 20 (DAR2). Both units were counted on the same dive. Fifty-three species and 1,029 individuals were recorded at DAR1 and 57 species and 2,063 individuals (1,000 round scad in one count) at DAR2. Maximums of 23 species and 1,145 individuals were recorded in a single census. Combining units revealed 69

species and 3,092 individuals (Table 21) and a density of 2.6 inds./m² (excluding 1,000 scad)(Fig. 8). Total biomass was 389 kg (852 lbs.).

The 2 deep units were similar in mean numbers of species and individuals, which were greater than the numbers on the shallow units and less than those on the mid-depth units (Fig. 9). The development of the fish populations on each of the deep units was similar. The number of species increased gradually the first year and leveled off thereafter (Fig. 14). The number of individuals increased gradually most of the first year with a slight decline the first winter and a variable but increasing trend thereafter (Fig. 15). The number of fishes was considerably higher at the end of 24 months than after 12 months.

Comparison of species found on the 2 deep units showed 59% similarity with 41 shared species, the highest similarity of all unit comparisons (Table 11). Comparison of the 15 most frequent and abundant species at each unit showed 88% and 76% similarity, respectively (Table 16). Frequent species found at both units were graysby, bluehead wrasse, hogfish, sharpnose puffer, bicolor damselfish, masked goby, slippery dick, gray snapper, yellowhead wrasse, yellowtail snapper, twospot cardinalfish, spotfin butterflyfish, and doctorfish (Table 21a). Abundant species shared were bluehead wrasse, bicolor damselfish, masked goby, twospot cardinalfish, gray snapper, yellowtail snapper, yellowhead wrasse, slippery dick, graysby, sharpnose puffer, doctorfish, spotfin butterflyfish, and hogfish.

Natural Reef

Sixty-eight stationary surveys were made at the deep (26 to 31 m) natural reef in 10 different months from September, 1988 to May, 1990 (Table 1). Total samples showed 109 species and 18,457 fishes (Table 22). There were maximums of 39 species and 791 individuals in a single count. The mean density of fishes (1.5/m²) was the highest of all natural reefs, about 66% higher than the shallow natural reef, and 25% higher than the mid-depth natural reef (Fig. 8).

BAHIA HONDA BRIDGE RUBBLE REEFS

Twenty-six stationary censuses were made at the Bahia Honda site from June to August 1989; 7 on patch reefs created in 1985 and 19 on patches created in 1987. Of the 19 patch reefs at the site, 13 were sampled. Water temperature ranged from 27 to 30.5 C. Visibility, typically poor on the bottom of Hawk Channel, ranged from about 7 to 12 m during censuses. Due to irregular edges and the small size of some patches, six samples included from 25% to 50% sand. The combination of poor visibility during nearly half of the counts and a high percentage of open bottom in many samples may have resulted in low abundance and density estimates for these habitats. Conducting censuses at times of high visibility would allow total counts to be made on at least the smaller patches. Sixteen qualitative fish surveys made at the site by the principal investigator during 9 different months July, 1985 to May, 1989, were

reviewed for documentation of juveniles (settlers) of species recorded here.

Ninety species were recorded at the Bahia Honda reefs representing 27,151 individuals, of which 73% were tomtate grunts with a mean length of 9 cm (Table 23). Maximums of 32 species and 4,666 individuals were recorded in a single sample. Fish density was estimated at 5.9 inds./m², the highest of all reefs sampled (Fig. 8). Total biomass censused was 915 kg (2,018 lbs.). The Bahia Honda site shared 59 species (57% similarity) with the American Shoal rubble site (Table 11). Of the 15 most frequent, abundant, and heaviest species at each site, Bahia Honda and American Shoal shared 30%, 50%, and 50%, respectively (Tables 16 and 34).

Grunts (4.5/m²) of 7 species comprised 76% of fishes (Table 23). Lane and gray snapper totaled 253 individuals, but only 10 yellowtail snapper were recorded. There were 115 Mycteroperca groupers from 6 to 100 cm long and 23 Epinephelus groupers to 60 cm, with several species occurring in most samples. Seventy-six snook (in 30.8% of samples) averaged 76 cm long, with 35 recorded in a single census.

AMERICAN SHOAL BRIDGE RUBBLE REEFS

Twenty-four stationary censuses were made in July and August 1989 at this site. Of the 4 patch reefs, 6 counts were made on patch 1 (1983 placement), 11 at patch 2 (1985), and 7 at patch 3 (1987). Water temperature was 30 to 31 C and visibility poor, usually about

7 to 8 m during censuses, near the minimum required. Ten of the counts included 25% to 50% sand. As at Bahia Honda, the combination of poor visibility and a high percentage of sand in some census areas may have caused an underestimation of the abundance and density of fishes on the reefs. Eleven fish surveys made by the principal investigator in 7 different months July, 1985 to July, 1988 were reviewed for occurrences of juveniles (settlers) of species recorded here.

Seventy-two species and 16,138 individual fishes were recorded; 63% were tomate with a mean length of 16 cm (Table 24). Thirty-two species were the most recorded in a single sample and 2,402 the maximum number of individuals. (See Bahia Honda above for species similarity). Estimated density of fishes was 3.8 inds./m², the third highest of all sites following the Bahia Honda rubble reefs and the mid-depth units (Fig. 8). Total biomass censused was 1,430 kg (3,153 lbs.).

Six species of grunts, at a density of 3.4/m², comprised 89% of fishes censused. Also included were 305 lane and gray snappers, and 34 yellowtail snappers. There were 16 Mycteroperca groupers from 6 to 50 cm long and 12 Epinephelus groupers. Eight snook (in 25% of samples) averaged 63 cm long.

HAWK CHANNEL RUBBLE REEFS COMBINED

Combining the 2 Hawk Channel sites (Tables 5 and 25) showed 103 species, nearly 50% more species than any set of units but slightly

fewer than the 108 species from all units combined. Species on rubble reefs in Hawk Channel were compared to those on the mid-depth natural reef at about the same depth. Three-quarters of rubble reef species were also found on the natural reef, corresponding to the percentage of similarity found between units and adjacent natural reefs (Table 11). However, there was a higher percentage of species shared (55%), more artificial reef species compared to total species (74%), and a higher percentage of natural reef species found at the rubble reefs (68%). The structural complexity of the rubble reefs that resembles natural reefs may account for higher levels of similarity with MNR. Comparison of the mid-depth units to the Hawk Channel reefs showed similarity consistent with comparisons of each set of units to the adjacent natural reefs (Table 11).

Comparison of the 15 most frequent and abundant species at Hawk Channel sites to those at natural reefs showed greatest similarity (33% and 25%) with the shallow natural reef, the closest natural reef censused, and least with the deep natural reef (7% and 20%) (Table 16). Comparisons with the mid-depth natural reef, showed only 20% similarity in most frequent species and 15% similarity in most abundant (Table 35). Of the 9 most frequent species in Hawk Channel, only striped parrotfish and cocoa damselfish were recorded in the top 15 species by frequency at the mid-depth natural reef (Table 35). Comparing the 15 most abundant species showed only tomtate and striped parrotfish shared with MNR, along with unidentified grunts and unidentified scad. Although overall species lists of the Hawk Channel sites and the mid-depth natural reef were somewhat alike,

the substantially different physical conditions between the two areas appear to result in less similarity of dominant species.

DISCUSSION OF OBJECTIVES

Objective 1. Quantify the species composition, biomass, and seasonality of fishes attracted and produced on large fabricated artificial habitats over a 24 month period.

On several occasions at the shallow and mid-depth units mixed schools of blue tang, ocean surgeon, doctorfish, angelfish, butterflyfish, and hogfish were observed moving between the units and the natural reef. The relatively close proximity, 50 m, of units to well-developed natural reefs confused the question of attraction or production. Regular observations of these species, and others, browsing on plants, sponges, and invertebrates on the units made it apparent that additional food sources and the structural diversity necessary for protection from predators have been made available to both settlers and colonizers. Although this data has limited usefulness in determining fish production at the artificial reefs during the 2-year period, the derived lists of settlers and colonizers point out species and species groups with potential to be produced by these types of habitats, as well as those species that increase their biomass by consuming reef resources and benefit by the new shelter provided.

The degree of fishery production at an artificial reef appears to be a function of location (isolation reduces attraction),

structural complexity, and requirements and sizes of individual species at different life stages. Bohnsack (1989) predicts that production should be more important for reef dependent, habitat limited species at artificial reefs in isolated locations. In this study only the rubble reefs could be considered isolated. Impacts to natural reefs in the Keys through the attraction of fish to relatively small artificial reefs is considered minimal in light of an annual harvest of about 4,000,000 pounds of reef fishes in the Keys (E. Little, pers. comm., 1992) and many thousands of aquarium fishes.

Typically, settlers were smaller species valued as primary marine life fishes, and colonizer species were larger with importance to commercial and recreational fisheries. Generally, settler species outnumbered colonizers (Figs. 16 and 17), but only at the shallow units did settler biomass exceed colonizer biomass (excluding 3 large nurse sharks). Both the mid-depth and deep units averaged about 10 kg of colonizer species biomass in each sample, representing most of the biomass at these sites. Overall at the units, settler species represented about 66% of individuals but only 9% of total biomass.

The proportions of settler species to total species at mid-depth and deep units, with few exceptions, showed comparable seasonal trends (Fig. 18). The percentage of settler species was highest (60% to 80%) the first few months, lowest the first winter (March), and about 50% to 60% thereafter at both sites. The relative abundance of settlers was high (60% to 90%) the first few months,

low (40% to 50%) the first winter, and elevated again the second summer (Fig. 19). General decreases in the numbers of species and individuals on artificial reefs in the winter in south Florida are also reported by Bohnsack and Talbot (1980) and Bohnsack et al. (1989).

Shallow Prefabricated Units

Settler species accounted for 90% of individuals at the shallow units, but only one-half (34/67) of species (Table 26). Gray angelfish (44 kg) represented 85% of settler biomass, while bluehead wrasse and slippery dick were the most abundant and most frequent settlers. Of the 34 settler species, 1 was primary commercial, 3 secondary commercial, 3 recreational, 17 primary marine life, 10 secondary marine life, and 3 had no value designation.

Most abundant and frequent colonizers were doctorfish, hogfish, and spotfin butterflyfish (Table 26). Three large nurse sharks represented 80% of total biomass for the shallow units. Colonizers included 4 primary commercial species, 4 secondary commercial, 7 recreational, 7 primary marine life, and 11 secondary marine life. Seven colonizers had no fishery value designation.

Mid-Depth Prefabricated Units

About 65% of individuals and 31 of 73 species recorded at the mid-depth units were considered settlers, but settlers comprised only 9% of total biomass (Table 27). The most abundant settlers were bluehead wrasse, tomtate, striped grunt, and bridled goby; the most

frequent were blue tang, bluehead wrasse, sharpnose puffer, and porkfish. All but one settler species had a value designation; 3 were primary commercial species, 5 secondary commercial, 4 recreational, 17 primary marine life, and 6 secondary marine life.

Yellowtail snapper, mackerel scad, and ocean surgeon were the most abundant colonizers. Ocean surgeon, slippery dick, doctorfish, hogfish, and gray angelfish were the most frequent. Yellowtail snapper represented 28% of total biomass for the 2 units and reached a high of 98 individuals in a single unit count (MAR1 in November 1989). Large but infrequent visitors were greater amberjack and barracuda. Seven primary commercial species, 2 secondary commercial, 9 recreational, 7 primary marine life, and 19 secondary marine life were colonizers. Seven colonizers had no designated economic value.

Deep Prefabricated Units

About 42% of the fishes and half of the species (34/69) at the deep units were settler species, but settlers made up only 0.4% of the total biomass of 389 kg (Table 28). The most abundant settlers were bluehead wrasse, bridled goby, and bicolor damselfish; the most frequent were graysby, bluehead wrasse, sharpnose puffer, and yellowhead wrasse. Settlers included 3 primary commercial species, 3 secondary commercial, 4 recreational, 21 primary marine life, and 10 secondary marine life. All settler species had a designated economic value.

The most abundant colonizers were yellowtail snapper, gray snapper, slippery dick, doctorfish, and 1,000 round scad on one

occasion; the most frequent were hogfish, slippery dick, yellowtail snapper, gray snapper, and spotfin butterflyfish. Yellowtail and gray snapper represented 14% and 18%, respectively, of the total biomass on the 2 units. Maximums of 26 gray snapper (March 1990) and 49 yellowtail (June 1990) were recorded in a single unit count. Large but infrequent visitors were greater amberjack, mutton snapper, barracuda, permit, and cubera snapper. Colonizers included 8 primary commercial species, 2 secondary commercial, 13 recreational, 5 primary marine life, and 10 secondary marine life. Six colonizer species had no value designation.

Bahia Honda Rubble Reefs

Settler species made up 93% of fishes counted on patch reefs at Bahia Honda, a result of recording 19,955 tomtate, and represented nearly half (43/90) of all species (Table 29). Excluding tomtate, settler species accounted for three-quarters of the remainder. Reef croaker, unidentified juvenile grunts, cocoa damselfish, bridled goby, and gray snapper were other abundant settlers; the most frequent were tomtate, cocoa damselfish, porkfish, blue tang, and striped parrotfish. Settlers represented one-third of total biomass (915 kg) with tomtate, black grouper, and gray snapper making up three-quarters. Settler species included 6 primary commercial species, 3 secondary commercial, 7 recreational, 21 primary marine life, and 12 secondary marine life. Only 2 species had no designated value.

Sixty-nine percent of colonizers were in infrequent schools of clupeids and scad. Other abundant colonizers included bluestriped grunt, white grunt, and snook (Table 29). The most frequent colonizers were white grunt, bluestriped grunt, butter hamlet, snook, and rainbow parrotfish. Seventy-eight percent of colonizer biomass was in 76 snook estimated to weigh 453 kg (1,000 lbs.). Colonizers included 8 primary commercial species, 9 secondary commercial, 16 recreational, 5 primary marine life, and 14 secondary marine life. Nine colonizer species had no economic value.

American Shoal Rubble Reefs

Settler species represented 71% of the individuals and 42% of the species (30/72) at the American Shoal rubble reefs (Table 30). Tomtate (10,207) accounted for 89% of settlers; excluding tomtate showed settlers comprising 26%. Other abundant settlers were lane snapper, striped parrotfish, and porkfish. The most frequent were striped parrotfish, tomtate, redband parrotfish, cocoa damselfish, lane snapper, porkfish, and slippery dick. As a result of 736 kg of tomtate, settler species represented 51% of total biomass (1,430 kg), and lane snapper, gray angelfish, and porkfish also contributed. Settlers included 3 primary commercial species, 3 secondary commercial, 4 recreational, 17 primary marine life, and 10 secondary marine life. All settlers had an economic value.

White grunt accounted for 69% of colonizers with bluestriped grunt, bigeye, gray snapper, and yellowfin mojarra also common. The most frequent colonizers were white grunt, bluestriped grunt,

spotfin butterflyfish, spotted goatfish, ocean surgeon, and yellowfin mojarra. White grunt accounted for 57% of total colonizer biomass (630 kg) with bluestriped grunt, snook, bigeye, permit, and barracuda also important. Colonizers included 4 primary commercial species, 7 secondary commercial, 10 recreational, 5 primary marine life, and 14 secondary marine life. Nine species had no attributed economic value.

Objective 2. Compare the community structure of reef fishes on prefabricated habitats to nearby natural reefs.

The effectiveness of efforts to create artificial habitats to mimic and supplement natural reefs may best be measured by comparing the fish communities that develop with those on natural reefs in similar depths. The length of time required for artificial habitats to become relatively stable in terms of fish community structure appears to be primarily functions of location, reef type and size, and the rate of fouling community development. At the end of 2 years of monitoring, numbers of species and individuals at the shallow (Figs. 10 and 11) and mid-depth units (Figs. 12 and 13), although variable, seemed to have stabilized while at the deep units there was a gradual increasing trend in abundance (Figs. 14 and 15).

Data for artificial and natural reefs are often not precisely comparable due to different census methods used and because the stationary census method may underestimate fish abundance (Bohnsack and Bannerot 1986, Bohnsack et al. 1989). As well, density estimates for the units based on total counts may overestimate true density

because the area of sand surrounding the units is not included in density calculations. Most fishes censused at the units, however, are structure oriented species present as a direct result of the unit placement. The large number of year-round stationary censuses over sizeable areas of the natural reefs should insure relatively accurate estimates of fish abundance for these habitats. Even with the different methods used, relative abundance estimates should be comparable (Bohnsack et al. 1989). Bohnsack et al. (1991) report that most comparative studies of artificial and natural reef fish communities show considerable similarity in species composition although abundance and biomass may vary.

A comparison of the number of species (Fig. 7) and density (Fig. 8) for all sites studied reflects greater species richness on natural reefs but higher density on artificial habitats. On average, the units showed only about 62% as many species as the adjacent natural reefs. About half of the species at the natural reefs were also recorded at the nearby units (Table 11).

Similarity of Units to Natural Reefs

Comparison of species lists for each depth revealed similar percentages of unit species shared with the nearby natural reefs, ranging from 75% to 78% (Table 11). Small cryptic species often appeared in total counts of the units but were usually missed in stationary censuses on adjacent natural reefs. For example, twospot cardinalfish and seaweed blenny were important constituents of fish populations at the shallow units but were not recorded at the

adjacent natural reef, although they undoubtedly occur there. Other than infrequent schooling scad, every species with more than 8 individuals recorded at the mid-depth units was also found at the adjacent natural reef. At the deep units, other than twospot cardinalfish, every species with more than 7 individuals was also recorded at the deep natural reef.

The number of species on each set of units was only 55% to 56% of the total species at each depth (Table 11). The percentages of the pool the units shared with nearby natural reefs, 42% to 44%, were also low and very similar.

Sixty-seven species were recorded at the shallow units and 104 at the shallow natural reef. In decreasing order, wrasses, grunts, surgeonfishes, combtooth blennies, and cardinalfishes were the most abundant families at the units and damselfishes, wrasses, grunts, surgeonfishes, and parrotfishes the most abundant at the natural reef. Density of fishes was 1.6 inds./m² at the shallow units and 0.9/m² at the adjacent natural reef.

Seventy-six species occurred at the mid-depth units and 114 species at the mid-depth natural reef. Grunts, wrasses, jacks, snappers, and surgeonfishes were most abundant at the units and grunts, damselfishes, wrasses, jacks, and parrotfishes the most abundant at the natural reef. Fish density at the mid-depth units was 4.2 inds./m²; at the adjacent natural reef density was 1.2/m².

Sixty-nine species were found at the deep units and 109 species at the deep natural reef. Wrasses, snappers, gobies, damselfishes, and jacks were the most abundant groups on the units, and grunts,

damselfishes, jacks, snappers, and gobies the most abundant on the natural reef. In terms of biomass, snappers, jacks, surgeonfishes, barracuda, and angelfishes were most important at the units and grunts, jacks, snappers, angelfishes, and sea basses most important at the natural reef. Mean fish size was 2.6 times greater on the deep units (126 g) compared to the adjacent natural reef (48 g).

Similarity of Rubble Reefs to Other Reefs

Combined Hawk Channel rubble reefs produced a species total (103) close to that of all prefabricated units (108) and fish density (4.9/m²) slightly higher than the mid-depth units, nearly double that of the deep units, and 3 times that of the low shallow units (Figs. 7 and 8). Even with sizeable areas of sand included in many censuses, fish density was 3 to 5 times higher at rubble reefs than at the natural reefs. Mean fish size at Hawk Channel reefs (55 g) was smaller than that at the mid-depth (76 g) and deep units (126 g) and close to that of the deep natural reef (48 g).

The greater number of species and higher density at Bahia Honda (90 species, 5.9 inds./m²) than at American Shoal (72 species, 3.8/m²) may result from its location - directly offshore from and within the influence of Bahia Honda Channel, a deep, active channel that connects the Gulf of Mexico to the Atlantic. The Bahia Honda site is also in close proximity (50 m) to seagrass beds that extend offshore to the 9 m contour along the north edge of Hawk Channel. The American Shoal reefs are the most isolated from seagrass or hardbottom habitats of all sites studied. The most abundant families

at Bahia Honda reefs were, in decreasing order, grunts, drums, herrings, jacks, and damselfishes, and at the American Shoal site the most abundant were grunts, snappers, parrotfishes, damselfishes, and wrasses. Based on biomass, the most important families at Bahia Honda were snook, grunts, sea basses, parrotfishes, and snappers, and at American Shoal the most important were grunts, snook, snappers, bigeyes, and jacks. Mean fish size was nearly 3 times larger at American Shoal (90 g) than at Bahia Honda (33 g), mainly as a result of larger tomtates at American Shoal.

Comparison of the Hawk Channel sites (9 to 12 m depth) to the mid-depth natural reef (10 to 12 m depth) showed that 75% of artificial reef species were shared with the natural reef, a percentage similar to the relationship between units and natural reefs (Table 11). However, a somewhat higher proportion (55%) of the species pool was shared and a higher percentage (74%) of the pool was found at the rubble sites. About half of the bridge rubble at the Hawk Channel reefs was placed in 1983 and 1985, the remainder in 1987.

Comparison of Top 15 Species

To measure similarity between sites, comparisons were made of the 15 most frequently occurring and abundant, and in some cases, heaviest species. The number of top 15 species in common to two sites was divided by the total number of top 15 species at the two sites to obtain an index of similarity. Various comparisons between artificial and natural reefs are at Table 16.

Assessment of the similarity of dominant species on artificial and natural habitats indicates substantial variation in fish populations between units and natural reefs but high similarity among prefabricated units of the same depth. Comparison of sets of prefabricated units to the adjacent natural reefs showed highest similarity (33%) of the 15 most frequent species at the shallow reefs (Table 31) and lowest (22%) at the deep reef (Table 33). Of the 15 most abundant fishes, similarity was greatest (30%) at the mid-depth reefs (Table 32) and lowest (15%) on the deep reefs. Biomass was compared only between the 15 heaviest species on the deep reefs. Thirty percent similarity occurred with scad and snapper the heaviest fishes on the deep units and scad and grunts the heaviest on the deep natural reef.

Although low similarity was recorded between dominant species at the units and natural reefs, the nearly identical high units placed in deep water showed the highest similarity of all reef comparisons with 88% of the 15 most frequent species and 76% of the 15 most abundant species common to both units (Table 21a). The two high units placed at the mid-depth site showed 72% similarity of the 15 most frequent species and 67% similarity of the 15 most abundant species (Table 17). Although comparisons were not made for the low shallow units, review of data indicates relatively high similarity, with bluehead wrasse, slippery dick, seaweed blenny, sharpnose puffer, porkfish, small grunts, and 3 species of surgeonfish as common elements.

Length-Frequency Comparisons

Based on mean lengths it appears that artificial habitats studied here may have provided shelter and protective cover useful to small individuals of some species. Comparisons between the units and nearby natural reefs showed many species with similar mean length, but a few common species with apparent differences. Assessment of length data must take into account the probability that the total count method used on units is biased towards recording more small fish than the stationary sampling method used on natural reefs.

At mid-depth reefs (Tables 15 and 18), common species with shorter mean length at units included bicolor damselfish (32% smaller), bluehead wrasse (-32%), yellowhead wrasse (-34%), graysby (-38%), and cottonwick (-46%). Doctorfish and ocean surgeon were both 26% larger on the units than at the mid-depth natural reef. At the deep reefs (Tables 21 and 22), smaller species on the deep units included bicolor damselfish (25% smaller), bluehead wrasse (-28%), reef butterflyfish (-31%), graysby (-48%), spotfin hogfish (-57%), yellowhead wrasse (-59%), and blackfin snapper (-68%). Doctorfish and ocean surgeon were 34% larger on the deep units than on the deep natural reef.

Mean length data from the Hawk Channel sites (Table 25) were compared with the mid-depth natural reef. Hawk Channel data were all collected in the summer, possibly resulting in more juveniles recorded, while natural reef censuses were made over 2 years. Common fishes with substantially smaller mean length at the rubble habitats

than at MNR were queen angelfish (36% smaller), sharpnose puffer (-38%), porkfish (-38%), and blue angelfish (-43%). Fishes larger on rubble reefs were spotted goatfish (29% larger) and tomtate (+57%). Acanthurus surgeonfishes (251 inds.) averaged 14.6 cm long on the Hawk Channel rubble reefs and 15.0 cm on the mid-depth natural reef (398 inds.).

Objective Number 3. Evaluate the effects of reef siting at different water depths on species composition, recruitment and biomass.

Water depth appears to be an important factor affecting fish assemblages that develop on artificial habitats, although little information is available on the placement of similar structures or materials at different depths. Here, due to structural differences between the low profile shallow units and the high profile mid-depth and deep units, direct comparisons are made only between the latter two depths. Data from the shallow units provides information on species that could be expected on artificial habitats in this depth on the reef tract.

Species Composition, Frequency, and Abundance

There were some notable differences in fish assemblages on the mid-depth and deep units. For example, seven species of grunts totaled 1,335 individuals on the mid-depth units, but only 2 grunts of 2 species were recorded on the deep units. The greater abundance of large predators on the deep units probably limited utilization by juvenile and subadult grunts, and less undermining by wave surge

with increased depth resulted in fewer microhabitats. Surgeonfishes, especially ocean surgeon and blue tang, were considerably more abundant on the mid units (13.6/count) than on the deep units (3.0/count), where less food appeared available for these herbivores. Sergeant majors, water column feeders, were numerous at the mid-depth units, but virtually none were recorded in deep water. Bluehead wrasse were 75% more abundant at mid-depth, and Chromis, blackfin snapper, bicolor damselfish, and Bodianus hogfish were more abundant at the deep units. A single gray snapper and 337 yellowtail snapper (26 cm ave. length) were recorded on the mid-depth units and 154 gray snapper (31 cm) and 231 yellowtail snapper (25 cm) on the deep units. Thirty-seven hogfish were recorded from both sets of units, just over 1 per sample.

Species among the 15 most frequent on the mid-depth units but not on the deep units were blue tang, ocean surgeon, porkfish, gray angelfish, sergeant major, and cottonwick (Tables 32 and 33). Frequent only at the deep units were yellowtail snapper, yellowhead wrasse, gray snapper, bicolor damselfish, and greater amberjack. Frequent species common to both sets of high units were bluehead wrasse, graysby, hogfish, slippery dick, sharpnose puffer, spotfin butterflyfish, doctorfish, bridled goby, twospot cardinalfish, and reef butterflyfish.

Ranked in the 15 most abundant species at the mid-depth, but not at the deep units, were blue tang, cottonwick, and ocean surgeon; in the top 15 only at the deep units were bicolor damselfish, gray snapper, doctorfish, sharpnose puffer, graysby,

greater amberjack, and hogfish (Table 32 and 33). Shared of the 15 most abundant species were bluehead wrasse, bridled goby, yellowtail snapper, twospot cardinalfish, slippery dick, and yellowhead wrasse.

Frequently occurring species common to the units in all depths were slippery dick, bluehead wrasse, sharpnose puffer, doctorfish, twospot cardinalfish, and hogfish (Tables 31, 32, and 33). Only bluehead wrasse, slippery dick, and twospot cardinalfish were included in lists of the top 15 most abundant species at all units.

Although all 3 sets of units had similar numbers of species, dominant species and their relative abundance differed with depth. Comparisons of the 15 most frequent and abundant species at the mid-depth and deep units showed only 48% similarity of frequent species and 25% similarity of abundant species (Table 16). The shallow units shared with the mid-depth units 50% of the 15 most frequent species and 36% of the most abundant. Shared between the shallow and deep units were 32% of the frequent species and 30% of the most abundant.

A number of species were relatively common at most depths, and several had higher mean abundance in Hawk Channel than at the units on the reef tract. Thirty six species occurred as one of the 15 most frequent at one or more artificial reefs (Table 36). Only doctorfish and slippery dick were listed for all 5 artificial reef sites; frequent species at 3 or more were hogfish, porkfish, sharpnose puffer, bicolor damselfish, blue tang, bluehead wrasse, gray angelfish, ocean surgeon, spotfin butterflyfish, and twospot cardinalfish. Frequent only at the 2 Hawk Channel sites were tomtate (top ranked at both), cocoa damselfish, striped parrotfish, and

white grunt. Listed only at one Hawk Channel site were black grouper, blue angelfish, bluestriped grunt, lane snapper, queen angelfish, redband parrotfish, reef croaker, and spotted goatfish. Frequent only at the units were bluehead wrasse, twospot cardinalfish, graysby, reef butterflyfish, bridled goby, cottonwick, greater amberjack, puddingwife, sergeant major, seaweed blenny, yellowhead wrasse, and yellowtail snapper.

Thirty-eight species were ranked as one of the 15 most abundant at one or more artificial reefs (Table 37). In the top 15 at all artificial reefs was slippery dick; at 3 or more were bluehead wrasse, bridled goby, tomtate, bicolor damselfish, gray snapper, lane snapper, porkfish, twospot cardinalfish, and an unidentified grunt. In the 15 most abundant only in Hawk Channel were bluestriped grunt, cocoa damselfish, striped parrotfish, white grunt, bigeye, redband parrotfish, reef croaker, clupeids, and yellowfin mojarra. Eighteen species abundant only at prefabricated units included twospot cardinalfish, blue tang, doctorfish, ocean surgeon, sharpnose puffer, striped grunt, yellowhead wrasse, and yellowtail snapper.

Recruitment and Colonization

The mean number of species per census at a unit ranged from a low of 10 at 2 of the shallow units to a high of 17 at MAR2, with deep units intermediate (Fig. 9). After excluding a single school of 1,000 round scad recorded at a deep unit and 800 juvenile grunts from a mid-depth sample, the average number of fish per census was

lowest at SAR (46-49 fish) and highest at MAR (100-127), with DAR units (69-71) intermediate (Fig. 9). Mean species per month at the units showed comparable seasonal variation with highest numbers during warmer months (Fig. 20). Following peaks during the initial 4 months, total fishes declined somewhat, and then increased the second year at all units (Fig. 21).

The simple structure of the low units apparently resulted in low diversity and abundance compared to the larger units, even though census data from the shallow natural reef shows high species richness in the area. Fifteen species totaled more than 100 individuals at the mid-depth units (N=32), 7 species totaled more than 100 individuals at the deep units (N=30), but only 2 species (bluehead wrasse and slippery dick) showed more than 100 individuals at the shallow units (N=42).

Settler species recruited to the units were generally the small species most valued by the marine life industry (Tables 26, 27, and 28). The number of settler individuals per census ranged from 43 (SAR) to 65 (MAR), with DAR intermediate with 44 (Fig. 16).

Biomass

The relatively low similarity of frequent and abundant species at different depths appeared also true in terms of the heaviest species at different depths. Although mean biomass was similar, 10.5 kg/sample and 13.0 kg/sample, at the mid-depth and deep units respectively, they shared only 43% of the 15 heaviest species (Tables 32 and 33). The shallow units (Table 31) shared 25% of the

heaviest species with the mid-depth units and 30% of the heaviest species with the deep units. Except at the shallow units, settler biomass represented a small portion of overall biomass (Fig. 16).

Comparison of the 15 heaviest species showed mid-depth and deep units sharing yellowtail snapper, ocean surgeon, greater amberjack, barracuda, gray angelfish, doctorfish, bar jack, hogfish, and french angelfish (Tables 32 and 33). Several scad species, blue tang, porkfish, and blue angelfish were additional important contributors of biomass at the mid-depth units, while snapper (gray, mutton, and cubera), round scad, permit, and yellow jack were additional important contributors at deep units.

Heaviest species common to the units in all depths were gray angelfish, hogfish, doctorfish, ocean surgeon, and french angelfish. Three large nurse sharks comprised 69% of the total biomass (253.91 kg) at the shallow units and gray angelfish 56% of the remainder. Yellowtail snapper made up 28% of total biomass (334.86 kg) at the mid-depth units, surgeonfish 18%, scad 14%, and other jacks 12%. One large school of round scad made up 23% of total biomass (389.37 kg) at the deep units, snappers (gray, yellowtail, cubera, mutton) 44%, other jacks 11%, and barracuda 6%.

Thirty-nine species were recorded as one of the 15 heaviest at one or more artificial reefs (Table 38). Gray angelfish and hogfish were ranked among the 15 heaviest at all 5 artificial reefs, and barracuda, doctorfish, porkfish, french angelfish, gray snapper, ocean surgeon, and yellowtail snapper were listed for 3 or more sites. Among species with greatest biomass only at Hawk Channel

sites were bluestriped grunt, lane snapper, snook, tomtate, white grunt, bigeye, black grouper, rainbow parrotfish, reef croaker, yellow goatfish, and yellowfin mojarra. Listed only from the units were french angelfish, ocean surgeon, bar jack, blue angelfish, greater amberjack, yellow jack, blue tang, cero mackerel, cubera snapper, mackerel scad, margate, mutton snapper, nurse shark, round scad, saucereye porgy, slippery dick, and spotfin butterflyfish.

Objective number 4. Separate fish communities into trophic levels to assess location of food source (i.e. water column, surrounding bottom, structure fouling community, etc.).

Because many fish species are food generalists that consume a wide variety of items, separating species by trophic levels is often imprecise and somewhat arbitrary (Bohnsack et al. 1987). The value of the effort, however, is insight into food resource partitioning and general ecology of the fish fauna, especially where species abundance and biomass estimates are available.

Data from the mid-depth (Table 39) and deep units (Table 40), the deep natural reef (Table 41), and the Bahia Honda rubble reefs (Table 42) were assessed to determine the relative contributions to fish assemblages of 5 primary types of feeders: browsers (consume sessile invertebrates such as sponges, tunicates and polychaete worms attached to hard surfaces), piscivores (consume fishes on and near reefs), herbivores (consume plants from hard surfaces and surrounding bottom), invertivores (consume various size invertebrates from hard surfaces and surrounding bottom), and

planktivores (consume plankton in water column).

Of the sites assessed, piscivores dominated biomass, except at the deep natural reef where invertivores dominated (Fig. 22). The proportion of browser and herbivore biomass was highest at the mid-depth units and lowest at the deep natural reef.

Planktivores dominated numbers except at Bahia Honda where invertivores were by far the most abundant (Fig. 23). The proportion of piscivore numbers was highest at the mid-depth units and comparable at the deep reefs. Browser and herbivore numbers were lowest at the deep natural reef and at Bahia Honda. Relative contributions of the 5 groups were similar at the mid-depth and deep units, the main exceptions being reduced biomass of herbivores and increased numbers of piscivores at the deep units.

Browsers

These omnivores obtain food directly from the hard surfaces of artificial and natural reefs, with supply on artificial habitats mostly functions of reef age, location, and substrate. The succession of the fouling community on artificial surfaces affects the relative abundance of fishes that depend on its various components.

The proportion of browser biomass was highest at the mid-depth (10%) and deep units (6%), and mainly due to gray angelfish, along with french, blue, and queen angelfish. Adult angelfish were often observed in pairs browsing on the fouling community of these units (Plate 11). The greatest proportions of browsers by abundance were

also at the mid-depth (3%) and deep (3%) units. Sharpnose puffer was a frequent browser, especially at reef tract sites, while rock beauty was the most abundant browser at the deep natural reef, and adult angelfish the most abundant at Bahia Honda. Most browsers are important to the marine life industry.

Piscivores

Fish-eating predators use artificial reefs to capitalize on higher density of prey or as shelter for protection and orientation. They dominated total biomass at all sites except for the deep natural reef, where invertivores dominated as a result of numerous grunts (Fig. 22). Most piscivores are valued by commercial and recreational fisheries. They made up 46% of biomass at the mid-depth units, with yellowtail snapper (337 inds.), greater amberjack (22), barracuda (4), and cero (8) most important. At the deep units, 53% of total biomass was contributed by fish-eating species; the heaviest were gray snapper (154 inds.), yellowtail snapper (231), cubera snapper (1), barracuda (4), and 45 greater amberjack (Table 40). Piscivores represented only about 20% of total biomass at the deep natural reef; most important were gray snapper (76 inds.), greater amberjack (14), yellow jack (58), and yellowtail snapper (18). The extensive use of wire fish traps in the deep reef area may have resulted in reduced numbers of predators with fishery value in censuses. Piscivores comprised the greatest proportion (63%) of biomass at the Bahia Honda reefs, with 76 snook, along with Mycteroperca groupers (114 inds.), gray snapper (164), and 5

barracuda (Table 42).

The proportion of piscivores ranged from a low of 1% at Bahia Honda where large numbers of grunts dominated, to a high of 15% at the deep units where yellowtail and gray snapper were common, but grunts were few (Fig. 23). At the mid-depth units the most common piscivore was yellowtail snapper, but only a single gray snapper was recorded. On the deep natural reef the most abundant piscivores were yellowtail snapper, gray snapper, and yellow jack. At Bahia Honda they were gray snapper, Mycteroperca groupers, and snook.

Herbivores

These species feed mostly on plants attached to or embedded in hard surfaces and to a lesser degree on benthic plants on surrounding bottoms. They contributed most to total biomass at the mid-depth units (18%) and Bahia Honda rubble reefs (8%) and least at the deep natural reef (3%) (Fig. 22). Acanthurus surgeonfishes represented 99% of herbivore biomass at the mid-depth units, where only 5 parrotfishes of 3 species were recorded, and 94% of herbivore biomass at the deep units, where only 2 parrotfishes were recorded. Surgeonfishes and parrotfishes dominated herbivore biomass at the deep natural reef, but mean abundance of these groups was 74% and 21% lower than on the mid-depth natural reef. On the Bahia Honda reefs, parrotfishes of 9 species (principally rainbow) accounted for 82% of herbivore biomass, and surgeonfishes contributed 17%.

Ten herbivore species were recorded at both the mid-depth and deep units but herbivore biomass was nearly 3 times higher at mid-

depth, and the number of herbivores more than 80% higher (Tables 39 and 40). Surgeonfishes, often observed feeding on algae on the units, totaled 436 individuals at the mid-depth units but only 89 at the deep units. Only doctorfish occurred at both depths in comparable numbers. Alevizon (1990) notes that as a result of reduced light penetration, primary production by plants is reduced on deep reefs as is the abundance of herbivorous species.

Invertivores

Some of these species consume invertebrates that attach to or use irregular hard surfaces as protective cover, others feed on surrounding bottoms, usually at night, using reefs as protective cover when not feeding. The greatest contribution by invertivores to total biomass (Fig. 22) was on the deep natural (55%) and Bahia Honda reefs (26%), and the least was on the mid-depth units (7%). At the mid-depth units, 25 species of invertivores were recorded with hogfish, porkfish, spotfin butterflyfish, and a single mutton snapper making up 81% of invertivore biomass. Five species of Haemulon grunts (1,299 inds., 3.65 kg) at the mid-depth units were juvenile forms listed as planktivores instead of invertivores based on observations of their feeding in schools on plankton near the top of the units. At the deep units, 25 species of invertivores were recorded but only a single porkfish and a single Haemulon grunt. Mutton snapper (5 inds.), hogfish (37), permit (3), and spotfin butterflyfish (35) made up 93% of invertivore biomass at the deep units. Forty-five invertivores were recorded at the deep natural

reef with tomtate, white grunt, lane snapper, and bluestriped grunt making up 81% of biomass. Thirty-nine were recorded at Bahia Honda with tomtate, bluestriped grunt, white grunt, and porkfish making up 85% of biomass. Although trophic information was not reviewed at American Shoal, grunts (invertivores) alone accounted for 82% of total biomass (22% at Bahia Honda).

The mid-depth units showed 10% invertivores with the most abundant being yellowhead wrasse, slippery dick, reef butterflyfish, hogfish, graysby, and spotfin butterflyfish (Table 39, Fig. 23). Thirteen percent of deep unit species were invertivores; the most abundant were slippery dick, yellowhead wrasse, graysby, hogfish, blackfin snapper, and spotfin butterflyfish. Thirty-seven hogfish were recorded at both the mid-depth and deep units, and were often observed removing bivalve molluscs and other invertebrates from the structure's surface. The deep natural reef showed 37% invertivores; the most abundant were tomtate, white grunt, lane snapper, blackfin snapper, french grunt and yellowhead wrasse. The greatest proportion of invertivores (90%) occurred at the Bahia Honda site as a result of 19,955 tomtate (Fig. 23); removing tomtate showed 62% of the remaining number were invertivores with reef croaker, an unidentified grunt, bluestriped grunt, white grunt, slippery dick, and porkfish most abundant. Categorizing small juvenile tomtate at Bahia Honda as planktivores (as at the mid-depth units) would increase the proportion of planktivores, decrease the high proportion of invertivores, but have little effect on the overall biomass (Figs. 22 and 23).

The foureye butterflyfish, a popular marine life species, is an example of a common reef invertivore found to be rare on artificial habitats. Five hundred twenty-six foureyes were recorded on natural reefs, but only 6 at the Hawk Channel rubble reefs, and none at the units. One of the most specific feeders of all common reef fish, feeding on small polychaete worms and coelenterates, the foureye's absence from the units was probably the result of food limitation or inadequate small protective cover.

Planktivores

These fishes feed on planktonic plants and animals over the top of hard surfaces that also serve as protective cover. They also occur in large, fast moving schools that feed over extensive areas, regardless of bottom type. It is likely that greater exposure to currents on high profile reefs favors planktivores (Bohnsack et al. 1989). The contribution of planktivores to total biomass was similar at the mid-depth (19%) and deep units (24%), and deep natural reef (18%), but was low at Bahia Honda (1%), where 19,955 tomtates (ave. 9 cm length) were all considered invertivores (Fig. 22). Scad and bar jack made up 92% of planktivore biomass at the mid-depth units with minor contributions by juvenile grunts and sergeant major. At the deep units, round scad and bar jack made up over 99% of planktivore biomass; at the deep natural reef, round scad made up 96% of planktivore biomass with contributions by bicolor damselfish and bar jack. Making up most planktivore biomass at the Bahia Honda site were two unidentified clupeids, an unidentified scad, and dusky

damsel fish.

Sixty-one percent of the individuals at the mid-depth units were planktivores (Fig. 23) with 9 species each showing more than 100 individuals (Table 39); the most common were bluehead wrasse, juvenile grunts (tomtates, striped, and cottonwick), and mackerel scad. Only 3 Chromis of 2 species were recorded at the mid-depth units while 783 Chromis of 5 species were recorded at the adjacent mid-depth natural reef. Since the same food source should be available at the mid-depth reefs, a greater concentration of predators, and the lack of suitable small protective cover on the units, may have precluded use by Chromis. Sixty-six percent of fishes at the deep units were planktivores; 1,000 were round scad and most of the rest, bluehead wrasse, bicolor damselfish and twospot cardinalfish. Only 38 Chromis (3 species) were recorded at the deep units, but five species of Chromis (2,191 inds.) made up 22% of planktivore numbers on the deep natural reef. More than half of the individuals at the deep natural reef were planktivores, dominated by round scad and juvenile grunts but with large numbers of damselfishes. Planktivores represented only 5% of total numbers at Bahia Honda with two clupeids and scad the most abundant, and dusky damselfish the most frequent. Although suitable protective cover appeared available at Hawk Channel reefs, no Chromis were recorded.

Objective Number 5. Document and quantify the plant and invertebrate fouling community as a function of substrate and water depth.

Artificial substrates placed in the marine environment of south Florida attract reef biota, sessile organisms including corals, and

other natural reef growth (Jaap 1984). The algae and wide variety of attached invertebrates are a source of food for many fish, both residents of the reef and visitors. About 66 m² of new hard surface was provided by each of the high units and several thousand square meters at each of the rubble sites. Although long term expansion of the fouling community may result in an increase in fishes dependant upon the food resources and shelter provided, infilling of cracks, crevices, and holes by encrusting organisms and sediment may act to reduce available shelter.

Fouling community photography at specific points (on concrete and PVC) on the units was initiated about 2 and 1/2 months after placement and was conducted on about a quarterly basis thereafter (Table 43). Twenty-four images (about 0.57 m² total area) were usually shot at each depth.

Qualitative review of chronological sequences of photographs of different substrates at different depths, along with field notes and other photography (e.g. Plate 10), revealed useful information about trends in succession of the fouling community. The color transparencies are available for possible future quantitative analysis and comparison to long term photography. Recorded as attached to the units were algae (filamentous, encrusting calcareous, frondose, etc.), encrusting and erect Porifera, Scleractinia, Octocorallia, encrusting and erect Hydrozoa, encrusting and erect Bryozoa, Ascidiacea, Annelida worms, and Mollusca (bivalves).

Within 1 year at MAR, unidentified hard corals measured 1 to 2 cm in diameter and encrusting Millepora measured 10 cm diameter on high concrete surfaces. By September, 1989, gorgonians on MAR were up to 8 cm high and Millepora was spreading over much of the high PVC. By January, 1990 hard corals at MAR measured 3 to 5 cm in diameter. In October, 1989, several hard corals on SAR measured 2 to 4 cm diameter.

Inspection of the units in September, 1990 (27 months after placement) showed greatest variety and extent of hard corals at MAR with SAR second and few hard corals at DAR. A substantial variety of small hard corals up to 6 cm in diameter were recorded on MAR including Porites astreoides, Montastraea annularis, Manicina areolata, Meandrina sp., Siderastrea radiata, Oculina difusa, and Stephanocoenia sp. The hydrozoan Millepora was common at MAR with upright growth, and octocorals were up to 20 cm tall. On SAR were the hard corals Mycetophyllia lamarckiana, Porites astreoides, Dichocoenia stokesii, Siderastrea radiata, Siderastrea siderea, and Colpophyllia natans. Millepora formed patches up to 22 cm diameter on SAR, and octocorals were as tall as 20 cm.

Surfaces (concrete and PVC) elevated more than about 0.5 m above the bottom fouled more rapidly and densely than surfaces close to the bottom, (as an example compare lower images, Plates 10 and 11). Reduced fouling near the bottom was probably the result of sand scouring from storm-generated wave surge. For example, by early May, 1989 (about 10 months after placement), PVC on top of the mid-depth units (Fig. 6, point 2) was considerably more fouled by encrusting

and erect organisms than PVC near lower edges (point 6). Feeding by benthic animals could also affect fouling near the bottom.

Point 3, smooth concrete, located 2.5 m above the bottom of the high profile units, fouled more rapidly and densely than point 5, also smooth concrete, but only 0.3 m above the bottom (Fig 6). Close-up photography showed fouling plants and animals gained a foothold on rough concrete surfaces (point 4) on high units more rapidly than on smooth concrete surfaces (point 3).

Within a year on MAR and DAR units, the small bivalve mollusc Dendrostrea frons (frons oyster) and the spiny oyster (Spondylus americanus) became common, both alive on units and as shell debris on the bottom under the unit. Hogfish were observed feeding on molluscs attached to the units, and with angelfish, surgeonfish, and butterflyfish, were common consumers of fouling resources (Plates 11 and 12).

Objective Number 6. Determine if large, fabricated habitats can provide significant fishing opportunities.

Fishing is the major direct use of artificial reefs (Bohnsack et al. 1989), although diving and non-consumptive uses are gaining in popularity in the Florida Keys, especially on sunken vessels. In the past, assessment of the economic value of artificial reefs has been related to commercially or recreationally important species taken by hook and line, and to the diving community (Milon 1991). Here assessment also includes species important to the marine life industry, a substantial fishery in south Florida regulated by the

state of Florida (Chap. 46-42.001 FAC). Species were categorized as "primary" - generally targeted by a fishery with directed effort or "secondary" - of value to the fishery but generally not targeted.

Reef fish landings for the Florida Keys and their monetary value are readily available only for commercial hook and line species. Preliminary data shows nearly 4,000,000 pounds landed in 1990 worth about \$5.4 million at dockside (E. Little, pers. comm, 1992). Seven species of snapper made up 54% of landings in 1990, amberjack 25%, and groupers about 11%. Overall in this study, 54% of total fish biomass at artificial reefs (3,323 kg) were commercially important species.

Rockland (1988) estimated that all recreational fishing in the Florida Keys resulted in output of about \$63 million. Targeted recreational species at artificial habitats in the Keys include most commercial species as well as barracuda, permit, and snook. Recreational marine life harvest for home aquariums is a substantial activity, as well.

Fish assemblages were assessed to determine which species had commercial, recreational, or marine life value. Comparison of the relative importance of species of different fisheries at each reef habitat follows (numbers do not total 100% as some species have more than one value, the number of species are in parentheses):

VALUE	Units combined (N=104)	Hawk Channel (N=50)	Natural (N=257)
Primary commercial	13.9% (15)	15.2% (16)	12.8% (20)
Secondary commercial	6.5% (7)	9.5% (10)	7.1% (11)
Recreational	18.5% (20)	21.9% (23)	17.3% (27)
Primary marine life	35.2% (38)	30.5% (32)	28.8% (45)
Secondary marine life	29.6% (32)	27.6% (29)	36.5% (57)
None established	13.9% (15)	12.4% (13)	12.2% (19)
Total species	108	103	153

Units were comparable to the natural reefs in relative proportion of valued species in all categories, with the proportion of primary marine life species slightly higher at the units. Hawk Channel rubble reefs showed a higher percentage of commercially and recreationally important species than other habitats. Species harvested by the marine life industry accounted for 65% of total species recorded at both the units (70 species) and the natural reefs (102 species), and 58% of those recorded at the Hawk Channel reefs (62).

Shallow Prefabricated Units

Only 22 individuals of 5 species of primary commercial importance were recorded at the shallow units; 15 were hogfish averaging 26 cm long. Three mutton snapper averaging 38 cm and an 80 cm black grouper were also recorded. Seven species of grunts dominated the secondary commercial category, but, with the exception

of a single 40 cm margate and 61 porkfish averaging 9 cm (to 28 cm), all were juveniles. Only 9% of biomass was due to species important to commercial fishing.

Ten recreational species included those important to the commercial industry along with yellow jack. The most abundant fishes at SAR were those important to the marine life fishery. Twenty-four primary marine life species were recorded, the most abundant were bluehead wrasse (724 inds.), gray angelfish (46), sharpnose puffer (59), two-spot cardinalfish (60), blue tang (42), bicolor damselfish (31), and spotfin butterflyfish (12). Common secondary marine life species (21) were slippery dick (389), doctorfish (79), ocean surgeon (68), seaweed blenny (99), and 3 nurse sharks that averaged 58 kg in weight. Only 10 species and 2% of individuals at the shallow units had no economic value.

Mid-Depth Prefabricated Units

Ten species of primary commercial value were recorded at the mid-depth units with yellowtail snapper (337 inds.), hogfish (37), greater amberjack (22), and cero (8) the most important (Table 39). Only one gray snapper and one mutton snapper were recorded. Beginning just over a year after placement, numbers of yellowtail snapper (ave. 26 cm) increased and ranged up to over 100 in a single combined count (Fig. 24). Yellowtail snapper were regularly seen schooling and appeared to orient to the PVC stacks on these units (Plate 12). Seven species of grunts (1,027 inds.) represented most of the secondary commercial species, but all were juveniles except

for a few margate and cottonwick, and 34 porkfish averaging 18 cm. Commercial species represented 44% of total biomass on these units.

Thirteen species of recreational importance included the primary commercial species along with 4 barracuda averaging 6 kg, margate, and porkfish.

Twenty-four species of primary interest to the marine life industry included bluehead wrasse (659 inds.), blue tang (121), yellowhead wrasse (111), twospot cardinalfish (109), sharpnose puffer (83), bicolor damselfish (67), reef butterflyfish (37), gray angelfish (32), and spotfin butterflyfish (32). Twenty-five secondary marine life species included masked goby (273), ocean surgeon (223), slippery dick (108), doctorfish (92), sergeant major (39), graysby (37), and porkfish. Although blue chromis, brown chromis, purple reeffish, rock beauty, and foureye butterflyfish were common marine life species on the adjacent natural reef, only a single brown chromis was recorded on the units. Eight species and 19% of individuals on the mid-depth units had no economic value.

Deep Prefabricated Units

Twelve species of primary commercial importance were recorded at the deep units with yellowtail snapper (231 inds.), gray snapper (154), greater amberjack (45), hogfish (37), and mutton snapper (5) represented by adults. A single large cubera snapper (27 kg) and one cobia were also recorded. Seventy-seven gray snapper were recorded on both DAR1 (ave. 31.5 cm) and DAR2 (ave. 30.8 cm). The number of both yellowtail and gray snapper appeared to increase in year 2 over

year 1 with abundance peaks for the 2 species occurring in different censuses (Fig. 25). The same number of hogfish (37) were recorded at the deep units (ave. 25.5 cm) as at the mid-depth units (ave. 23.3 cm).

Only 4 individuals of 3 species of secondary commercial value were recorded on the deep units. Although nearly 1,000 Haemulon grunts (secondary commercial) were recorded at the mid-depth units and 7,200 grunts of 8 species were recorded at the deep natural reef, only 2 juvenile grunts occurred on the deep units.

Seventeen recreational species included the primary commercial species as well as 4 barracuda that averaged 6 kg, 3 permit, and 5 yellow jack.

Twenty-eight primary marine life species included bluehead wrasse (375 inds.), bicolor damselfish (157), twospot cardinalfish (117), yellowhead wrasse (83), sharpnose puffer (60), spotfin butterflyfish (35), yellowtail reeffish (23), and reef butterflyfish (20). Twenty secondary marine life species included masked goby (298 inds.), slippery dick (84), doctorfish (74), and graysby (54). Excluding one school of 1,000 round scad showed that only 1% of fishes (5 species) at the deep units had no economic value.

Hawk Channel Bridge Rubble Reefs

These sites are not "prefabricated" artificial habitats, but materials were specifically placed to form patch reefs with control over type of material, area covered, patch location, and vertical profile. The desire was to create conditions suitable to enhance the

fish population of a chosen area, particularly for species valuable to commercial and recreational fishermen. A project summary (Kruer 1985) written prior to placement of the first 11 patches at Bahia Honda predicted:

"Species of importance expected to utilize this habitat include black, gag and red grouper, mangrove, lane, mutton, yellowtail, and schoolmaster snapper, hogfish, cobia, barracuda, Spanish and cero mackerel, porgies, permit, snook, grunts, baitfish, tropicals, spiny lobster, stone crab and others".

Bahia Honda Rubble Reefs

Fourteen primary commercial species were recorded at the Bahia Honda site (N=26) with gray snapper (164 inds.), lane snapper (89), gag grouper (71), hogfish (46), and black grouper (30) occurring in half or more samples (Table 42). One hundred fifteen Mycteroperca groupers ranged from 5 to 100 cm in length (ave. 26 cm). Gray snapper averaged 25 cm long and ranged up to 40 cm. Other adult primary commercial species were yellowtail (10), cero (6), Nassau grouper (3), red grouper (1), and mutton snapper (1). Six species of Epinephelus groupers totaled 23 individuals.

Twelve secondary commercial species dominated the population as a result of 20,739 grunts of 7 species, including 19,955 tomtate that averaged 9 cm long. Manooch and Barans (1982) report that tomtates are a major food source for higher trophic level fishes in the southeastern U.S.

The 23 recreational species included those of primary commercial value as well as 76 snook that averaged 6 kg each, porkfish (130 inds.), adult barracuda (5), and permit (1).

Twenty-six primary marine life species included cocoa

damselfish (250), blue tang (79), doctorfish (75), queen angelfish (35), sharpnose puffer (35), gray angelfish (34), blue angelfish (31), and spotfin butterflyfish (23). Important secondary marine life species (26) were masked goby (174 inds.), striped parrotfish (156), slippery dick (139), porkfish (130), and dusky damselfish (42). Because of 3,276 reef croaker, along with large schools of scad and clupeids, 18% (11 species) of the total individuals had no economic value.

American Shoal Rubble Reefs

Seven primary commercial species were recorded at the American Shoal site (N=24) including lane (249 inds.), gray (56), and yellowtail snapper (34), hogfish (18), gag grouper (15), and black grouper (1). Lane snapper averaged 17 cm long (to 22 cm), and gray snapper averaged 22 cm (to 45 cm). Ten secondary commercial species dominated numbers and biomass as a result of tomtate (10,207 inds., ave. 16 cm), white grunt (3,225), and bluestriped grunt (834). Adult bigeye (160 inds.) and porkfish (102) were other common secondary commercial species.

Fourteen recreational species included the primary commercial species along with porkfish, yellow jack (11 inds.), snook (8, ave. 4.4 kg), and permit (3, ave. 11 kg).

Twenty-two primary marine life species included cocoa damselfish (71 inds.), bluehead wrasse (57), bicolor damselfish (51), sharpnose puffer (35), spotfin butterflyfish (28) gray angelfish (22), blue angelfish (21), and high hat (21). Twenty-four

secondary marine life species included striped parrotfish (190 inds.), slippery dick (97), redband parrotfish (70), masked goby (64), spotted goatfish (46), ocean surgeon (36), and doctorfish (32). Only 1% of individuals (8 species) had no economic value.

Fishing Activity

Although no recreational or commercial fishing or marine life collecting was observed at the units, the general area around Big Pine Shoal is heavily fished by all 3 industries. Considering the level of use of electronics in reef fishing, the high profile units have probably been located and fished on occasion. A recreational fishing vessel was observed attempting to anchor on a mid-depth unit, and a lost anchor was removed from a deep unit. Commercial hook and line fishing for yellowtail and gray snapper is an active fishery a short distance west of the study area. A commercial marine life collector once worked to within a few meters of the observer during a census on the mid-depth natural reef, and collectors were routinely seen in the vicinity.

Wire fish traps were extensively used seaward of the reef tract in this area for many years. Illegal usage (shallower than 30.8 m) was routine on the deep natural reef, and traps were observed within about 15 m of the deep units and as shallow as 26.2 m depth. Ten ghost traps (some open, some closed) were found in the area of the deep reef. Observed in traps were groupers, porgies, angelfishes, jacks, hogfish, gray snapper, and others (Plate 13). Based on the level and history of use of fish traps in this vicinity, it is

probable that fish populations on the deep natural reef, and maybe at the deep units, were altered by this nonselective harvest of larger individuals. All use of fish traps in the southeast Florida area was banned in early 1992 by the South Atlantic Fishery Management Council, about 1 1/2 years after cessation of monitoring for this study.

Recreational and commercial fishing occur on both Bahia Honda and American Shoal rubble sites. Catches of red, black, and gag groupers, mutton, lane, gray, and yellowtail snappers, permit, snook, pompano, sawfish, cobia, jacks, and grunts have been documented at the Bahia Honda reefs along with diver catches of spiny lobster (J. Lapp, pers. comm., 1992, Kruer, pers. observs.). Reported catches of Mycteroperca groupers over several years included roughly 80% gags and frequent black groupers under the 20 inch size limit (J. Lapp, pers. comm., 1992). Visual censuses at Bahia Honda showed about 62% of Mycteroperca groupers were gags and 30 black grouper with a mean length of 47 cm (19 inches), ranging 6 to 100 cm (Table 23).

Recreational and commercial catches documented at American Shoal from 1986 to 1991 included lane, yellowtail, gray, schoolmaster, and mutton snappers, gag, yellowedge, red, and black groupers, large jewfish, pompano, barracuda, cero, Spanish mackerel, large king mackerel, bluefish, tomtate, white grunt, greater amberjack, blue runner, jack crevalle, small bonefish, bigeye, and shark (J. Lapp, pers. comm., 1992, Kruer, pers. observs.). In May 1986, April and May 1987, and April 1988, sexually ripe male and

female lane snapper (up to 1 kg), one of few possibly under-utilized local commercial species, were common on the American Shoal site indicating that they may aggregate and spawn there part of the year (Kruer, pers. observs.).

Objective Number 7. Evaluate the economics of constructing, transporting and placing artificial habitats to enhance fishery resources and fishing opportunities.

Although donated materials and labor made up a major portion of the cost to design and construct these prefabricated units, the commercial cost to construct such structures can be estimated. Variations in structural design to improve fishery enhancement effectiveness (i.e. add small spaces) probably would not appreciably alter the costs if similar amounts of material were used. Mass production of such units would probably result in a lower per unit construction cost. Unit transportation costs have the most potential for reduction below those paid in this project; per ton transportation costs were considerably lower for rubble. A limitation on unit size, unless constructed at a waterfront facility, is the ability to transport them via roads to a barge staging area.

Costs associated with constructing the rubble reefs are related to loading and transportation, both on land and water. Most work to date has been with rubble loaded directly onto barges at a bridge removal site, but a number of patch reefs at Bahia Honda were constructed with large concrete debris transported by truck from several Lower Key locations to the barge staging area. Similar

reefs could be created in the Keys to take advantage of concrete and rubble debris routinely generated by the construction industry during reconstruction work, and by future Florida Department of Transportation bridge removal or rehabilitation projects. Suitable material can be stockpiled until several full barge loads (one load is typically 200-300 tons, 10-15 truckloads) are on hand. Eliminating high costs associated with landfill or other disposal could help offset loading and transportation costs.

Records of FKARA projects allows the following estimation of costs for the reefs censused in this study:

Prefabricated Units

Costs to construct 4 large units and 3 small units in 1987/88:

PVC pipe -	\$160
poured concrete -	1,370
wood forms -	267
reinforcing steel -	1,068
equipment rental -	190
gas for torches -	85
miscellaneous materials -	457
transportation of donated material -	675
134 hours labor (paid) x \$12/hour -	<u>1,610</u>
Subtotal -	\$5,882

Donated - Estimated Value:

construction yard on Big Pine Key -	\$2,000
pre-stressed beams -	10,000
225 hours labor (\$15/hour) for permitting, construction, transportation, etc. -	<u>3,375</u>
Subtotal (\$ equivalent donated) -	\$15,375
Total estimated cost to construct 7 units -	\$21,257

Transportation to staging area and Alexander Marine loading and barge work (3 trips) -	12,000
Total estimated cost to construct, transport and place 7 units -	\$33,257

<u>Cost per Unit:</u>	<u>High Units</u>	<u>Low Units</u>
Construct	\$3,800	\$2,000
Transport	1,700	1,700
Total	\$5,500	\$3,700

Bahia Honda Rubble Reefs

Eleven of the 19 patches at the Bahia Honda artificial reef (6,000 mt) were placed from June to August, 1985 (2,700 mt), and 8 were placed from August to October, 1987 (3,300 mt). All materials were donated; some were transported at no cost to the staging area by the Florida Keys Aqueduct Authority and the Florida Department of Transportation, other material was moved there by a contractor hired by the FKARA with state grant funds.

Costs to construct the Bahia Honda rubble reefs:

1985

Transport 90 truck loads of concrete bridge decks and rubble x \$125/load -	\$11,250
15 Misener Marine barge trips (2,700 mt) x \$2,800/load -	\$42,000
3 loads old Bahia Honda Bridge steel girders	
3 loads steel pipe and steel hangars	
9 loads large concrete slabs/rubble	
FKARA miscellaneous expenses -	\$750
100 hours of donated time x \$15/hour -	<u>1,500</u>
Subtotal -	\$55,500

1987

16 Misener Marine barge trips (3,300 mt) from partial removal of Spanish Harbor Bridge x \$3000/load -	\$48,000
FKARA miscellaneous expenses -	500
100 hours of donated time x \$15/hour -	<u>1,500</u>
Subtotal -	\$50,000
Total estimated Bahia Honda Artificial Reef cost -	\$105,500
Cost per metric ton (\$105,000/6,000 mt) = \$18	

American Shoal Rubble Reefs

Of four patch reefs at the American Shoal site (3,850 mt), patch 1 (550 mt) was placed in April, 1983; patch 2 (1,100 mt) in September, 1985; patch 3 (1,650 mt) from September to October, 1987; and patch 4 (550 mt) from October to November, 1987. Patches 1 and 2 are composed of large concrete rubble from partial removal (on 2 occasions) of the nearby Niles Channel Bridge and patches 3 and 4 are from the Kemp Channel Bridge.

Costs to construct the American Shoal patch reefs:

1983

3 Alexander Marine barge loads x \$2,666/load -	\$8,000
FKARA miscellaneous expenses -	300
30 hours of donated time x \$15/hour -	<u>450</u>
Subtotal	\$8,750

1985

11 Misener Marine barge loads x \$2,800/load -	\$30,800
FKARA miscellaneous expenses -	500
80 hours of donated time x \$15/hour -	<u>1,200</u>
Subtotal	\$32,500

1987

12 Misener Marine barge loads x \$3,000/load -	\$36,000
FKARA miscellaneous expenses -	500
80 hours of donated time x \$15/hour -	<u>1,200</u>
Subtotal -	\$37,700
Total estimated American Shoal Artificial Reef cost -	\$78,950
Cost per metric ton (\$78,950/3,850 mt) = \$21	

Cost Effectiveness of Artificial Reefs

Knowledge of the amount of concrete and steel deposited at the bridge rubble sites allows an estimation of the area this material now covers, and with estimated biomass density and construction costs, a comparison of cost effectiveness to the high profile units. Bohnsack et al. (1989) report that small clusters of prefabricated concrete cubes (1.75 m² bottom area each) placed off Key Biscayne, Florida had higher fish density than larger clusters of cubes, but found that biomass density increased with additional cubes. Multiple prefabricated units of the type used here, placed together, might alter standing stock of fishes at individual units from that found here with only 2 units placed 50 m apart. Multiple units might show decreased overall fish density but greater biomass density.

Short tons placed at the rubble sites were converted to cubic yardage using a factor of 0.541 based on the known weight of 3,750 pounds of a cubic yard of solid concrete aggregate. Cubic yards were then converted to cubic meters using the standard factor of 0.76. Calculating 1.2 m (4') as an approximate "average" height of the patches based on observations, and allowing 25% open space within a patch, the American Shoal reefs (4,200 short tons) are estimated to

cover about 1,800 m² of bottom and the Bahia Honda patches (6,600 short tons) about 2,830 m².

Biomass density was determined for the rubble sites by dividing the total recorded biomass at each site by the total area censused at the site ($N \times 177 \text{ m}^2$). American Shoal reefs showed a biomass density of 340 g/m² and Bahia Honda showed 199 g/m². Biomass density at the 4 high units was determined by dividing total biomass recorded (724 kg) by the total area censused in all high unit samples ($62 \times 27 \text{ m}^2 = 1,674 \text{ m}^2$). Mean biomass density at the high units was therefore 432 g/m². In terms of the dollar cost (see estimates above) of resulting fish biomass, the American Shoal rubble reefs are about 3.6 times and the Bahia Honda reefs about 2.5 times more cost effective than the high units. The different physical influences on fish assemblages of artificial habitats in Hawk Channel and on the reef tract may also be an important factor in cost effectiveness in regard to fish biomass. Although the low units are not assessed here, their cost effectiveness when compared to the rubble reefs is considerably less than the high units.

COMPARISONS TO OTHER ARTIFICIAL AND NATURAL REEFS

Table 44 provides a comparison of the general results from this project with studies by Bohnsack et al. (1989) using 50 - 2.3 m³ prefabricated concrete modules arrayed in various numbers off Key Biscayne, studies of a concrete module reef in Hawaii by Brock and

Grace (1987), and studies of a reef made of tires near Pacific Reef in Biscayne National Park, Florida by Stone et al. (1979).

This study of Keys artificial reefs showed total species ranging from 67 to 73 on the units and 72 to 90 on the rubble reefs. On artificial habitats off Key Biscayne there were 74 (1 module reefs) to 96 species (8 module reefs); in Hawaii, 125 species; and at the tire reef in Biscayne National Park, 98 species (Table 44). Total species on natural reefs studied here ranged from 104 to 114, higher than the 81 to 85 species reported for large natural reefs in the studies compared.

Fish densities from 1.7 to 5.9 inds./m² on artificial reefs in this study, were higher than densities on artificial reefs in Hawaii (1.6/m²) and Biscayne National Park (2.1/m²), but considerably lower than densities on the concrete modules off Key Biscayne (24-71/m²). Difference in sizes of artificial reefs in various projects possibly accounts for the differences in the numbers of species, total numbers, and densities (Bohnsack et al. 1989, Ambrose and Swarbrick 1989). Total counts on rubble patch reefs might reflect considerably higher fish densities than those reflected here. Fish densities on natural reefs in this study ranged 0.9 to 1.5 inds./m²; in Hawaii density was 1.6/m²; off Key Biscayne density ranged 1.0 to 1.5/m²; but in Biscayne National Park density was 6.8/m² on natural reefs (8 samples).

In studies compared, biomass density was considerably higher on artificial reefs than on natural reefs (Table 44). On the deep natural reef studied here, biomass density was 72 g/m², off Key

Biscayne on natural reefs it ranged from 47 to 72 g/m², and in Hawaii it was 46 g/m². On artificial reefs studied here biomass density ranged from 397 to 495 g/m² on the high profile units and 199 to 340 g/m² on bridge rubble sites, off Key Biscayne artificial reef biomass ranged 390 to 701 g/m², and in Hawaii it was 1267 g/m². Total mean biomass per sample on the high units (27 m²) here was 10.4 kg at mid-depth and 13.0 kg at deep units, while at 8-block reefs (14 m²) off Key Biscayne mean sample biomass was 10.2 kg. Mean fish size (biomass) was larger in the Keys (75-126 g on high units and 34-91 g on rubble reefs) than off Key Biscayne (6-29 g). It was largest in Hawaii (137 g). Commercial species composed 59% of total biomass on the artificial reefs in this study, 61% at Hawaiian artificial reefs and 61% off Key Biscayne.

Stationary visual censuses conducted in 1983 at nearby Looe Key Reef (Fig. 4) from 0 to 10 m depth on the shallow "forereef" zone (Bohnsack et al. 1987) revealed greater fish abundance and slightly greater diversity than found at the shallow bank reef sampled here. Recorded at Looe Key (N=160) were 116 species and about 250 individuals per census. Here 107 species and 153 fishes per census were recorded (N=111). The 8 most frequent shallow natural reef species recorded here were, in decreasing order, striped parrotfish, yellowhead wrasse, bicolor damselfish, bluehead wrasse, blue tang, foureye butterflyfish, ocean surgeon, and redband parrotfish. All were listed in the 15 most frequent at Looe Key Reef. Comparing relative abundance of fishes at the shallow reef in this study to that found at Looe Key Reef showed harlequin bass, white,

bluestriped, and striped grunts, porkfish, cocoa damselfish, doctorfish, hogfish, high hat, saucereye porgy, and blue angelfish more abundant at the shallow bank reef studied here. Fishes considerably more abundant at Looe Key Reef were yellowtail, schoolmaster, gray, and lane snappers, yellowtail, longspine, dusky, and threespot damselfishes, sergeant major, caeasar, french and tomtate grunts, stoplight and princess parrotfishes, spotted goatfish, bermuda chub, Spanish hogfish, masked goby, bluehead and clown wrasses, blue and brown chromis, glassy sweeper, and barracuda. The greater structural diversity of the complex spur and groove forereef at Looe Key, and its location immediately adjacent to deep waters of the Straits of Florida, probably account for differences observed.

Until now, quantitative information on deep reef fishes of south Florida was lacking, but Alevizon (1990) suggested that there should be strong similarities with insular Caribbean deep reef (> 30 m) fish communities. Based on the deep natural reef (26 to 31 m) data provided here, however, there may be distinctive differences in these populations. Alevizon (1990) reports that Caribbean deep reef fishes are dominated by "strictly carnivorous, non-schooling species" including gobies, basslets, squirrelfishes, wrasses, and sea basses. Here, based on abundance and biomass, dominant families were grunts, jacks, damselfishes, wrasses, gobies, snappers, sea basses, and angelfishes, with grunts, jacks, and snappers often observed schooled.

Conclusions and Recommendations

This Florida Keys study showed that large prefabricated units and concrete rubble patch reefs, placed as artificial marine habitats on sand bottom, greatly enhance the abundance, diversity, and biomass of fish in an area. Densities of individuals and biomass were found considerably higher at artificial reefs than at nearby, natural, bank reefs, a result consistent with other studies. Location, depth, and vertical profile are important factors determining fish assemblages at artificial habitats in the Keys. Fishes were both produced at artificial reefs and attracted from the surrounding area. Fish assemblages at the Hawk Channel artificial reefs were considerably different from those on the offshore reef tract, particularly in terms of dominant species.

Settlers at the artificial reefs were mostly of small species important to the marine life industry, while colonizers were species important to commercial and recreational fishermen. Many settler species were demersal egg layers such as damselfishes, gobies, and blennies, or mouth brooders like cardinalfishes. The isolated rubble reefs in Hawk Channel reflected the greatest proportion (48%) of total biomass potentially produced by settler species, probably the result of their greater structural complexity, age, and large area. Abundance estimates were believed conservative at Hawk Channel sites because of poor visibility and considerable amounts of sand in census areas. Although attraction of adult fishes from the natural

reef to the prefabricated units occurred, the regular movements of many browsers and herbivores back and forth appeared to be mainly for exploitation of new food resources. Large carnivores also tended to colonize these reefs temporarily, often in schools.

Doctorfish and slippery dick were ranked in the 15 most frequent species at all 5 artificial reef sites censused; only slippery dick was ranked as one of the most abundant at all sites, and only gray angelfish and hogfish were highly ranked at all sites based on total biomass. Duplicate high units at the same depth shared roughly three-quarters of the 15 most frequent and abundant species but only just over half of the total species, reflecting the large species pool in these areas. Sets of units and natural reefs at the same depth shared less than half of the total species, with just over half of the total found at the units. Of the 15 most frequent, abundant, and heaviest species, less than one-third were shared by the units and natural reefs, probably because of the very different structural complexity and limited food at the units.

The high profile units, and areas of high vertical relief at rubble reefs, allowed fish to partition space and food resources, increasing both diversity and abundance. Fishes benefitted by the additional hard surfaces provided at all artificial reefs, both for food and cover. Planktivores dominated fish numbers at the mid-depth and deep units and the deep natural reef. Bottom feeding invertivores (especially grunts) were by far the most abundant fishes at the Hawk Channel rubble sites, indicating productive bottom feeding areas. Piscivores dominated biomass at the mid-depth

and deep units and at Bahia Honda, where groupers, snappers, and snook were common. The influence of tidal currents offshore from Bahia Honda Channel may be conducive to diverse and productive benthic communities and high biomass of piscivorous fishes. The relatively low proportion of piscivore biomass at the deep natural reef may be the result of heavy use of fish traps. By the second year, the deep units appeared to be somewhat predator limited, with piscivores common (especially snappers, jacks, and barracuda), but few grunts and Chromis damselfish, common groups on the deep natural reef. Biomass density was nearly 7 times and mean fish weight nearly 3 times higher at the deep units than on the deep reef. Of all artificial reefs, biomass density, was highest at the deep units.

Although fish density increased with depth on the natural reefs studied, highest density and number of species recorded on the units was at mid-depth. Frequent aggregations of yellowtail snapper around the top of the mid-depth units demonstrate the ability of high profile structures to concentrate this valuable species. Browsers and herbivores were more abundant at the mid-depth units than at other artificial reefs. Few parrotfishes occurred at any of the units. The development of hard corals, and the fouling community in general, was most rapid at mid-depth.

The simple, low, shallow units had the lowest abundance of fishes with large nurse sharks contributing most of the biomass. Most fishes recorded at the shallow units were of settler species valuable to marine life collectors, pointing to the potential of shallow artificial habitats to produce fishes for this industry.

Of all reefs studied, the rubble reefs in Hawk Channel had the highest density of fishes and the greatest proportion of species important to the commercial and recreational fishermen. Fish density was 3 to 5 times higher at rubble reefs than at natural reefs. Comparison of dominant species at rubble reefs to those at natural reefs showed highest similarity with the shallow natural reef, the closest reef to Hawk Channel. The 2 similar rubble sites in Hawk Channel shared only half of the 15 most abundant and heaviest species, indicating distinctive fish assemblages in different regions of Hawk Channel.

Artificial reef construction in the Keys has resulted from considerable interest by both fishermen and divers, interest that continues to grow as numbers of these users increase. This study shows the ability of rubble patch reefs and high profile units to produce and concentrate fishes economically important to fishermen and of interest to divers. In a tourist economy the preference of many visiting divers for diving on sunken vessels and unusual structures, as an alternative to natural reefs, lends incentive to the placement of artificial reefs. Species important to the commercial hook and line fishermen comprised nearly two-thirds of total biomass at all artificial reefs combined, as found in other studies. At the American Shoal rubble reef, 99.2% of censused fishes had an economic value. Artificial reefs may take on considerable importance as people management becomes more pressing in the Florida Keys National Marine Sanctuary, and the concept of fishery reserves is reviewed for the South Atlantic region of the United States.

Rubble reefs, built with donated materials, were roughly 3 to 4 times more cost effective than the high units in terms of biomass produced and aggregated. Large concrete rubble, similar to that used in construction of the Hawk Channel patch reefs studied here, is scattered around the Keys at various legal and illegal disposal sites and is routinely generated by the local construction industry. Additional bridge removal and reconstruction planned by the Florida Department of Transportation will also generate large quantities of concrete debris appropriate for artificial reef construction. Modification of the Keys marine environment through use of artificial habitats is already widespread, including numerous small rubble piles under private docks, thousands of bridge pilings, utility pole foundations, riprap seawalls, rock jetties, and illegal artificial reefs composed of various items such as piles of trap debris, appliances, and steel drums. Properly placed, stable, durable, hard surfaces can be of benefit to the marine environment by providing long-term food and shelter resources; but unstable, lightweight material can be a liability.

Because of their relatively small scale, artificial reefs are minor contributors to the overall fish population of the extensive hard bottoms of the Florida Keys, but their ability to enhance fish communities in localized areas is very significant. The current high levels of use and interest in artificial reefs in the Keys requires serious consideration of the value and potential of additional reef building for future management in the Florida Keys ecosystem.

Recommendations for a Continuing Artificial Reef Program in the Florida Keys:

1. Based on the documented biological enhancement that results from properly constructed artificial reefs, and on their value as management tools, well planned reef construction should continue as compatible with objectives of the recently designated Florida Keys National Marine Sanctuary (FKNMS). Artificial reef construction is appropriate only on stable, open, sand bottom, and under no circumstances should their placement displace or damage productive seagrass or hard bottom habitats. Large sandy areas seaward of the reef tract, on the reef tract, in Hawk Channel, and in the Gulf of Mexico offer ample suitable locations.

2. A program to build additional rubble patch reefs in the Florida Keys should be initiated. Based on data presented here reflecting high diversity and abundance of economically valuable fishes at rubble reefs, Monroe County should institute a program to collect and transport suitable concrete rubble to isolated sand bottoms in Hawk Channel, preferably in physically active settings offshore from channels. Careful handling and placement would assure valuable vertical relief and maximum benefit from creation of numerous, small patch reefs. Sources of funding include the Monroe County Boating Improvement Fund, Florida fishing license monies administered by the Florida Department of Natural Resources, and disposal fees paid by the construction industry and public utilities that generate such

materials. Suitable staging areas with deep water access should be located in strategic areas of the Keys where appropriate material can be stockpiled until an adequate amount is on hand for barging to a permitted offshore site.

3. Artificial reefs should be used for management of divers and fishermen to reduce pressure on the natural reef. As a result of dive industry interest, the sinking of additional steel vessels in open, sandy areas offshore from the reef tract, and the placement of large, stable, prefabricated units in shallow, clear water zones should be considered to provide alternative diving sites. Fabricating units with both small and large interstices for fishes would more closely approximate natural conditions and result in even more diverse and interesting fish assemblages. In addition, deep water (> 45 m) wrecks could be placed for hook and line fishermen.

4. Consideration should be given to special rules for Keys artificial reefs. To avoid user conflicts, preclude possible overharvest, and possibly implement no harvest zones in some locations, consideration should be given to the concept of Special Management Zones under the SMZ program of the South Atlantic Fishery Management Council, consistent with FKNMS regulations. Review of artificial habitats (especially rubble reefs) solely to increase biological production should occur, with the idea of no harvest allowed at the site, or to the placement of such reefs within no harvest areas.

5. The artificial habitats studied here should be used for future research. The stability and durability of the prefabricated units and rubble reefs allows for long-term study of their fish assemblages. The use of the same stationary census method on large rubble reefs placed on sand on the reef tract off Long Key and in deep water off Islamorada in the mid 1980's would allow direct comparison to the similar Hawk Channel reefs studied here. The fish assemblages on the large steel vessels intentionally sunk in the Keys need to be quantified and the economic value of the vessels to the local dive industry determined.

6. Natural reef data from the 3 depths censused should be used as a baseline for future comparisons. The site specific quantitative information herein provides a valuable baseline for evaluation of possible changes in fish community structure over time as a result of various management efforts (i.e. fish trap prohibition, marine fishery reserves) and natural influences.

REFERENCES

- Alevizon, W.S. 1990. Fish communities. Pp. 232-245 In N.W. Phillips and K.S. Larson, Eds. Synthesis of Available Biological, Geological, Chemical, Socioeconomic, and Cultural Resource Information for the South Florida Area. U.S. Dept. of Int. Mineral Managem. Serv., MMS 90-0019.
- Alevizon, W.S. and J.C. Gorham. 1989. Effects of artificial reef deployment on nearby resident fishes. *Bull. Mar. Sci.* 44:646-661.
- Ambrose, R.F. and S.L. Swarbrick. 1989. Comparison of fish assemblages on artificial and natural reefs off the coast of southern California. *Bull. Mar. Sci.* 44:718-733.
- Bohnsack, J.A. 1989. Are high densities at artificial reefs the result of habitat limitation or behavioral preference. *Bull. Mar. Sci.* 44:631-645.
- Bohnsack, J.A.. 1990. Habitat structure and the design of artificial reefs. Pp. 412-426 In S. Bell, E. McCoy, and H. Mushinsky, Eds. *Habitat Structure: The Physical Arrangement of Objects in Space*. Chapman and Hall, N.Y., N.Y.
- Bohnsack, J.A. and S.P. Bannerot. 1986. A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. NOAA Technical Report NMFS 41, U.S. Dept. of Commerce, Miami, FL. 15 pp.
- Bohnsack, J.A. and D.E. Harper. 1988. Length-weight relationships of selected marine reef fishes from the southeastern United States and the Caribbean. NOAA Technical Memorandum NMFS-SEFC-215, U.S. Dept. of Commerce, Miami, FL. 31 pp.
- Bohnsack, J.A., D.E. Harper, D.B. McClellan, D.L. Sutherland, and M.W. White. 1987. Resource survey of fishes within Looe Key National Marine Sanctuary. N.O.A.A. Technical Memorandum NOS MEMD 5, U.S. Dept. of Commerce, Wash., D.C. 108 pp.
- Bohnsack, J.A., D.L. Johnson and R.F. Ambrose. 1991. Ecology of artificial reef habitats and fishes. Pp. 61-107 In W. Seaman, Jr. and L. M. Sprague, Eds. *Artificial Habitats for Marine and Freshwater Fisheries*. Academic Press, Inc., San Diego, CA.
- Bohnsack, J.A. and D.L. Sutherland. 1985. Artificial reef research: A review with recommendations for future priorities. *Bull. Mar. Sci.* 37:11-39.

Bohnsack, J.A. and F.H. Talbot. 1980. Species-packing by reef fishes on Australian and Caribbean reefs: an experimental approach. Bull. Mar. Sci. 30:710-723.

Bohnsack, J.A., D.E. Harper, D.B. McClellan, and M. Hulsbeck. 1989. (Draft) The relative importance of recruitment, attraction, and production of reef fishes on natural and modular artificial reefs. N.O.A.A. NMFS/SEFC, Miami, FL. 86 pp.

Brock, R.E. and R.A. Grace. 1987. Fishery enhancement through artificial reef development for nearshore Hawaiian waters. Final report for Coop. Agreem. No. NA-85-ABH-00028. Hawaii Sea Grant, 156 pp.

Florida Keys Artificial Reef Assoc., Inc. 1990. Table summary of artificial reefs in the Florida Keys. FKARA, Inc. P.O. Box 917, Big Pine Key, FL 33043.

Grove, R.S., M. Nakamura, and C.J. Sonu. 1991. Design and engineering of manufactured habitats for fisheries enhancement. Pp. 109-152, In W. Seaman, Jr. and L.M. Sprague, Eds. Artificial Habitats for Marine and Freshwater Fisheries. Academic Press, Inc., San Diego, CA.

Harper, Doug. Personal communication. National Marine Fisheries Center, Southeast Fisheries Center, 75 Rickenbacker Causeway, Miami, FL 33149.

Jaap, W.C. 1984. The ecology of the south Florida coral reefs: a community profile. FWS/OBS-82/08, U.S. Fish and Wildl. Serv., Off. Biol. Servs., Washington, D.C.

Kruer, C. 1985. Project summary of planned Bahia Honda artificial reef project. Florida Keys Artificial Reef Assoc., Inc., Big Pine Key, FL. 10 pp.

Lapp, John. Personal communication. Rt. 5 Box 172D, Big Pine Key, FL 33043.

Little, Ed. Personal communication. National Marine Fisheries Serv., Off. Fish. Stats., 301 Simonton St. Key West, FL 33040.

Manooch, C.S. and C.A. Barans. 1982. Distribution, abundance, and age and growth of the tomtate, Haemulon aurolineatum, along the southeastern United States coast. Fish. Bull. 80:1-19.

Milon, J.W. 1991. Social and economic evaluation of artificial aquatic habitats. Pp. 237-270 In W. Seaman and L.M. Sprague, Eds. Artificial habitats for marine and freshwater fisheries. Academic Press, Inc., San Diego, CA.

Robins, C.R., R. Bailey, C. Bond, J. Brooker, E. Lachner, R. Lea, and W. Scott. 1991. Common and scientific names of fishes from the United States and Canada. Comm. on Names of Fishes, Amer. Fish. Soc., Spec. Publ. No. 20, Bethesda, MD.

Rockland, D.B. 1988. The economic impact of the sport and commercial fisheries of the Florida Keys. Prep. for the Everglades Protection Assoc., Florida Conservation Assoc. and Monroe County Industrial Development Authority. F.C.A. Islamorada, FL.

Sale, P. F. 1991. Reef fish communities: open nonequilibrium systems. Pp 564-598 In P.F. Sale, Ed. The Ecology of Fishes on Coral Reefs, Academic Press, Inc., San Diego, CA.

Schroeder, R.E. 1987. Effects of patch reef size and isolation on coral reef fish recruitment. Bull. Mar. Sci. 41:441.

Seaman, W., Jr. and L.M. Sprague. 1991. Artificial habitat practices in aquatic systems. Pp. 1-27 In W. Seaman, Jr. and L. M. Sprague, Eds. Artificial Habitats for Marine and Freshwater Fisheries. Academic Press, Inc., San Diego, CA.

Seaman, W. Jr., R.M. Buckley and J. Polovina. 1989. Advances in knowledge and priorities for research, technology, and management related to artificial aquatic habitats. Bull. Mar. Sci. 44:527-532.

Shulman, M.J. 1984. Resource exploitation and recruitment patterns in a coral reef assemblage. J. Exp. Mar. Biol. 74:85.

Stone, R.B., H.L. Pratt, R.O. Parker, and G.E. Davis. 1979. A comparison of fish populations on an artificial and natural reef in the Florida Keys. Mar. Fish. Rev. 41:1-11.

Voss, G. 1988. Coral reefs of Florida. Pineapple Press, Sarasota, FL.

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TABLES

Table 1. Summary of monitoring dates and 411 samples collected. SAR=shallow units, SNR=shallow natural reef, MAR=mid-depth units, MNR=mid-depth natural reef, DAR=deep units, DNR=deep natural reef, BH=Bahia Honda rubble reefs, AMS=American Shoal rubble reefs.

Date	Water temp. (C)	SAR	SNR	MAR	MNR	DAR	DNR	BH	AMS
6/27/88	28.0								
6/30/88	29.0	3		2					
7/23/88	30.0	3		2		2			
7/25/88	30.0		12	2		2			
8/10/88	29.0	3		2		2			
9/18/88	28.0	3		2		2			
9/20/88	28.0				2				
9/22/88	29.0				4		3		
10/2/88	28.5 *	3	12						
10/22/88	27.0								
10/23/88	27.0			2	8		8		
12/7/88	22.0	3	3			2			
12/11/88	24.0		9						
12/31/88	24.5			2		2			
2/4/89	25.0	3	12			2			
3/14/89	22.0			2		2			
3/19/89	22.0				8				
4/8/89	25.0 *	3	12				6		
5/6/89	28.0			2	4	2	2		
5/7/89	28.0				4		6		
6/4/89	27.0	3	4						
6/24/89	28.0			2	5	2	2		
6/25/89	27.0				3		6	3	
7/17/89	30.0								2
7/31/89	30.0	3	2						
8/2/89	30.0		10					15	
8/12/89	30.5								8
9/2/89	29.5			2	4	2	2	8	14
9/3/89	29.5				4		6		
10/7/89	28.5	3	12						
11/4/89	25.0			2	4	2	1		
11/5/89	26.0				4		6		
1/7/90	23.0			2	2	2	2		
1/11/90	22.0				6		6		
2/10/90	23.0	3	11						
3/3/90	23.5			2	5	2	2		
3/4/90	23.0				3		6		
4/7/90	24.5 *	3	12						
5/6/90	26.0 *			2	4	2	2		
5/7/90	26.0 *				4		2		
6/16/90	28.5	3					2		
6/30/90	29.0			2		2			
=====	=====	===	===	===	===	===	===	===	===
Total:		42	111	32	78	30	68	26	24

* = water temperature data from Sombrero Reef, obtained from the SEASCAPE program of the Florida Institute of Oceanography.

Table 2. One hundred and seventy-nine species censused at artificial and natural reefs from June 1988 to June 1990.

SPCODE	SPECIES	COMMON NAME	FAMILY	FAMILY NAME	VALUE ¹
ABU SAXA	Abudefduf saxatilis	Sergeant major	POMACENTRIDAE	Damselfishes	ml
ACA BAH	Acanthurus bahianus	Ocean surgeon	ACANTHURIDAE	Surgeonfishes	ml
ACA CHIR	Acanthurus chirurgus	Doctorfish	ACANTHURIDAE	Surgeonfishes	ml
ACA COER	Acanthurus coeruleus	Blue tang	ACANTHURIDAE	Surgeonfishes	ML
ALU SCHO	Aluterus schoepfi	Orange filefish	BALISTIDAE	Leatherjackets	ml
ALU SCRI	Aluterus scriptus	Scrawled filefish	BALISTIDAE	Leatherjackets	ml
AMB PINO	Amblycirrhitus pinos	Redspotted hawkfish	CIRRHITIDAE	Hawkfishes	ML
ANI SUR	Anisotremus surinamensis	Black margate	HAEMULIDAE	Grunts	P,R
ANI VIRG	Anisotremus virginicus	Porkfish	HAEMULIDAE	Grunts	S,R,ml
APO BINO	Apogon binotatus	Barred cardinalfish	APOGONIDAE	Cardinalfishes	ml
APO MACU	Apogon maculatus	Flamefish	APOGONIDAE	Cardinalfishes	ML
APO PSEU	Apogon pseudomaculatus	Twospot cardinalfish	APOGONIDAE	Cardinalfishes	ML
APO SPE.	Apogon sp.	Unid. cardinalfish	APOGONIDAE	Cardinalfishes	ml
ARC PROB	Archosargus probatocephalus	Sheepshead	SPARIDAE	Porgies	P,R
AST STEL	Astrapogon stellatus	Conchfish	APOGONIDAE	Cardinalfishes	
AUL MACU	Aulostomus maculatus	Trumpetfish	AULOSTOMIDAE	Trumpetfishes	
BAL CAPR	Balistes caprisus	Gray triggerfish	BALISTIDAE	Leatherjackets	P,R
BAL VETU	Balistes vetula	Queen triggerfish	BALISTIDAE	Leatherjackets	R,ML
BOD PULC	Bodianus pulchellus	Spotfin hogfish	LABRIDAE	Wrasses	ML
BOD RUFU	Bodianus rufus	Spanish hogfish	LABRIDAE	Wrasses	ML
CAL BAJO	Calamus bajonado	Jolthead porgy	SPARIDAE	Porgies	P,R
CAL CALA	Calamus calamus	Saucereye porgy	SPARIDAE	Porgies	P,R
CAL SPE.	Calamus sp.	Unid. porgy	SPARIDAE	Porgies	P,R
CAN MACR	Cantherines macrocerus	Whitespotted filefish	BALISTIDAE	Leatherjackets	ml
CAN PULL	Cantherines pullus	Orangespotted filefish	BALISTIDAE	Leatherjackets	ml
CAN ROST	Canthigaster rostrata	Sharpnose puffer	TETRAODONTIDAE	Puffers	ML
CAR BART	Caranx bartholomaei	Yellow jack	CARANGIDAE	Jacks	R
CAR CRY	Caranx crysos	Blue runner	CARANGIDAE	Jacks	R
CAR LATU	Caranx latus	Horse-eye jack	CARANGIDAE	Jacks	R
CAR RUBE	Caranx ruber	Bar jack	CARANGIDAE	Jacks	
CAR SPE.	Caranx sp.	Unid. jack	CARANGIDAE	Jacks	
CEN UNDE	Centropomus undecimalis	Snook	CENTROPOMIDAE	Snooks	R
CHA CAPI	Chaetodon capistratus	Four-eye butterflyfish	CHAETODONTIDAE	Butterflyfishes	ML
CHA FABI	Chaetodipterus faber	Spadefish	EPHIPPIDAE	Spadefishes	S,R
CHA OCEL	Chaetodon ocellatus	Spotfin butterflyfish	CHAETODONTIDAE	Butterflyfishes	ML
CHA SEDE	Chaetodon sedentarius	Reef butterflyfish	CHAETODONTIDAE	Butterflyfishes	ML
CHA STRI	Chaetodon striatus	Banded butterflyfish	CHAETODONTIDAE	Butterflyfishes	ML
CHI SCHO	Chilomycterus schoepfi	Striped burrfish	DIODONTIDAE	Spiny puffers	ML
CHR CYAN	Chromis cyanea	Blue chromis	POMACENTRIDAE	Damselfishes	ML
CHR ENCH	Chromis enchrysurus	Yellowtail reef fish	POMACENTRIDAE	Damselfishes	ML
CHR INSO	Chromis insolata	Sunshinefish	POMACENTRIDAE	Damselfishes	ML
CHR MULT	Chromis multilineata	Brown chromis	POMACENTRIDAE	Damselfishes	ml
CHR SCOT	Chromis scotti	Purple reef fish	POMACENTRIDAE	Damselfishes	ML
CLE PARR	Clepticus parrai	Creole wrasse	LABRIDAE	Wrasses	ML
CLU SPE.	Clupeidae	Unid. herring	CLUPEIDAE	Herrings	
COR GLAU	Coryphopterus glaucofraenum	Bridled goby	GOBIIDAE	Gobies	ml
COR PERS	Coryphopterus personatus	Masked goby	GOBIIDAE	Gobies	ml
DAS AMER	Dasyatis americana	Southern stingray	DASYATIDAE	Stingrays	
DEC MACA	Decapterus macarellus	Mackerel scad	CARANGIDAE	Jacks	

Table 2. One hundred and seventy-nine species censused at artificial and natural reefs from June 1988 to June 1990.

SPCODE	SPECIES	COMMON NAME	FAMILY	FAMILY NAME	VALUE ¹
DEC PUNC	Decapterus punctatus	Round scad	CARANGIDAE	Jacks	
DEC SPE.	Decapterus sp.	Unid. scad	CARANGIDAE	Jacks	
DIO HOLO	Diodon holocanthus	Balloonfish	DIODONTIDAE	Porcupinefishes	ml
DIO HYST	Diodon hystrix	Porcupinefish	DIODONTIDAE	Porcupinefishes	ml
DIP FORM	Diplectrum formosum	Sand perch	SERRANIDAE	Sea basses	
ECH NAUC	Echeneis naucrates	Sharksucker	ECHENEIDAE	Remoras	ml
EMB PAND	Emblemaria pandionis	Sailfin blenny	CLINIDAE	Clinids	ml
EPI ADSC	Epinephelus adscensionis	Rock hind	SERRANIDAE	Sea basses	S,ml
EPI CRUE	Epinephelus cruentatus	Graysby	SERRANIDAE	Sea basses	ml
EPI FULV	Epinephelus fulvus	Coney	SERRANIDAE	Sea basses	ML
EPI GUTT	Epinephelus guttatus	Red hind	SERRANIDAE	Sea basses	S,ml
EPI MORI	Epinephelus morio	Red grouper	SERRANIDAE	Sea basses	P,R
EPI SPE.	Epinephelus sp.	Unid. grouper	SERRANIDAE	Sea basses	
EPI STRI	Epinephelus striatus	Nassau grouper	SERRANIDAE	Sea basses	P,R
EQU ACUM	Equetus acuminatus	High-hat	SCIAENIDAE	Drums	ML
EQU LANC	Equetus lanceolatus	Jackknife-fish	SCIAENIDAE	Drums	ML
EQU UMBR	Equetus umbrosus	Cubbyu	SCIAENIDAE	Drums	ml
FIS SPE.	Fistularia sp.	Unid. cornetfish	FISTULARIDAE	Cornetfishes	ml
GER CINE	Gerres cinereus	Yellowfin mojarra	GERREIDAE	Mojarras	
GIN CIRR	Ginglymostoma cirratum	Nurse shark	ORECTOLOBIIDAE	Nurse sharks	ml
GOB OCEA	Gobiosoma oceanops	Neon goby	GOBIIDAE	Gobies	ML
GOB XANT	Gobiosoma xanthiprora	Yellowprow goby	GOBIIDAE	Gobies	ml
GYM FUNE	Gymnothorax funebris	Green moray	MURAENIDAE	Morays	ml
GYM MORI	Gymnothorax moringa	Spotted moray	MURAENIDAE	Morays	ML
GYM VICI	Gymnothorax vicinus	Purplemouth moray	MURAENIDAE	Morays	ml
HAE ALBU	Haemulon album	Margate	HAEMULIDAE	Grunts	S,R
HAE AURO	Haemulon aurolineatum	Tomtate	HAEMULIDAE	Grunts	S
HAE FLAV	Haemulon flavolineatum	French grunt	HAEMULIDAE	Grunts	S
HAE MELA	Haemulon melanurum	Cottonwick	HAEMULIDAE	Grunts	S
HAE PLUM	Haemulon plumieri	White grunt	HAEMULIDAE	Grunts	S
HAE SCIU	Haemulon sciurus	Bluestriped grunt	HAEMULIDAE	Grunts	S
HAE SPE.	Haemulon sp.	Unid. grunt	HAEMULIDAE	Grunts	
HAE STRI	Haemulon striatum	Striped grunt	HAEMULIDAE	Grunts	
HAL BIVI	Halichoeres bivittatus	Slippery dick	LABRIDAE	Wrasses	ml
HAL GARN	Halichoeres garnoti	Yellowhead wrasse	LABRIDAE	Wrasses	ML
HAL MACU	Halichoeres maculipinna	Clown wrasse	LABRIDAE	Wrasses	ML
HAL RADI	Halichoeres radiatus	Puddingwife	LABRIDAE	Wrasses	ML
HAL SPE.	Halichoeres sp.	Unid. wrasse	LABRIDAE	Wrasses	ml
HAR SPE.	Harengula sp.	Unid. sardine	CLUPEIDAE	Herrings	
HEM NOVA	Hemipteronotus novacula	Pearly razorfish	LABRIDAE	Wrasses	ml
HEM SPE.	Hemipteronotus sp.	Unid. razorfish	LABRIDAE	Wrasses	
HEM SPLE	Hemipteronotus splendens	Green razorfish	LABRIDAE	Wrasses	ml
HOL ASCE	Holocentrus adscensionis	Squirrelfish	HOLOCENTRIDAE	Squirrelfishes	ml
HOL BERM	Holacanthus bermudensis	Blue angelfish	POMACANTHIDAE	Angelfishes	ML
HOL CILI	Holacanthus ciliaris	Queen angelfish	POMACANTHIDAE	Angelfishes	ML
HOL CORU	Holocentrus coruscus	Reef squirrelfish	HOLOCENTRIDAE	Squirrelfishes	ml
HOL MARI	Holocentrus marianus	Longjaw squirrelfish	HOLOCENTRIDAE	Squirrelfishes	ml
HOL RUFU	Holocentrus rufus	Longspine squirrelfish	HOLOCENTRIDAE	Squirrelfishes	ml
HOL SPE.	Holocentrus sp.	Unid. squirrelfish	HOLOCENTRIDAE	Squirrelfishes	ml

Table 2. One hundred and seventy-nine species censused at artificial and natural reefs from June 1988 to June 1990.

SPCODE	SPECIES	COMMON NAME	FAMILY	FAMILY NAME	VALUE ¹
HOL TRIC	Holacanthus tricolor	Rock beauty	POMACANTHIDAE	Angelfishes	ML
HYP BERM	Hypleurochilus bermudensis	Barred blenny	BLENNIIDAE	Combtooth blennies	ml
HYP GEMM	Hypoplectrus gemma #	Blue hamlet	SERRANIDAE	Sea basses	ml
HYP NIGR	Hypoplectrus nigricans #	Black hamlet	SERRANIDAE	Sea basses	ml
HYP PUEL	Hypoplectrus puella #	Barred hamlet	SERRANIDAE	Sea basses	ml
HYP UNIC	Hypoplectrus unicolor	Butter hamlet	SERRANIDAE	Sea basses	ml
IOG CALL	Ioglossus calliurus	Blue goby	GOBIIDAE	Gobies	
IOG HELE	Ioglossus helenae	Hovering goby	GOBIIDAE	Gobies	ml
KYP SECT	Kyphosus sectatrix	Bermuda chub	KYPHOSIDAE	Sea chubs	
LAC BICA	Lactophrys bicaudalis	Spotted trunkfish	OSTRACIIDAE	Boxfishes	ml
LAC MAXI	Lachnolaimus maximus	Hogfish	LABRIDAE	Wrasses	P,R
LAC QUAD	Lactophrys quadricornis	Scrawled cowfish	OSTRACIIDAE	Boxfishes	ml
LAC TRIQ	Lactophrys triqueter	Smooth trunkfish	OSTRACIIDAE	Boxfishes	ml
LUT ANAL	Lutjanus analis	Mutton snapper	LUTJANIDAE	Snappers	P,R
LUT APOD	Lutjanus apodus	Schoolmaster	LUTJANIDAE	Snappers	S,R
LUT BUCC	Lutjanus buccanella	Blackfin snapper	LUTJANIDAE	Snappers	P,R
LUT CYAN	Lutjanus cyanopterus	Cubera snapper	LUTJANIDAE	Snappers	P,R
LUT GRIS	Lutjanus griseus	Gray snapper	LUTJANIDAE	Snappers	P,R
LUT SYNA	Lutjanus synagris	Lane snapper	LUTJANIDAE	Snappers	P,R
MAL PLUM	Malacanthus plumieri	Sand tilefish	MALACANTHIDAE	Tilefishes	S,R
MAL SPE.	Malacoctenus sp.	Unid. blenny	CLINIDAE	Clinids	
MAL TRIA	Malacoctenus triangulatus	Saddled blenny	CLINIDAE	Clinids	ML
MIC CHRY	Microspathodon chrysurus	Yellowtail damselfish	POMACENTRIDAE	Damselfishes	ML
MON CILI	Monacanthus ciliatus	Fringed filefish	BALISTIDAE	Leatherjackets	ml
MON HISP	Monacanthus hispidus	Planehead filefish	BALISTIDAE	Leatherjackets	ml
MON SETI	Monacanthus setifer	Pygmy filefish	BALISTIDAE	Leatherjackets	ml
MON SPE.	Monacanthus sp.	Unid. filefish	BALISTIDAE	Leatherjackets	ml
MON TUCK	Monacanthus tuckeri	Slender filefish	BALISTIDAE	Leatherjackets	ML
MUL MART	Mulloidichthys martinicus	Yellow goatfish	MULLIDAE	Goatfishes	S
MUR MILI	Muraena miliaris	Goldentail moray	MURAENIDAE	Morays	ml
MYC BONA	Mycteroperca bonaci	Black grouper	SERRANIDAE	Sea basses	P,R
MYC MICR	Mycteroperca microlepis	Gag	SERRANIDAE	Sea basses	P,R
MYC PHEN	Mycteroperca phenax	Scamp	SERRANIDAE	Sea basses	P,R
MYC SPE.	Mycteroperca sp.	Unid. grouper	SERRANIDAE	Sea basses	P,R
MYR JACO	Myripristes jacobus	Blackbar soldierfish	HOLOCENTRIDAE	Squirrelfishes	ml
OCY CHRY	Ocyurus chrysurus	Yellowtail snapper	LUTJANIDAE	Snappers	P,R
ODO DENT	Odontoscion dentax	Reef croaker	SCIAENIDAE	Drums	
OPI AURI	Opistognathus aurifrons	Yellowhead jawfish	OPISTOGNATHIDAE	Jawfishes	ML
PAR FURC	Paranthias furcifer	Creole-fish	SERRANIDAE	Sea basses	ML
PAR MARM	Parablennius marmoreus	Seaweed blenny	BLENNIIDAE	Combtooth blennies	ML
PEN SCHO	Pempheris schomburgki	Glassy sweeper	PEMPHERIDAE	Sweepers	
POM ARCU	Pomacanthus arcuatus	Gray angelfish	POMACANTHIDAE	Angelfishes	ML
POM DIEN	Pomacentrus dieneaeus	Longfin damselfish	POMACENTRIDAE	Damselfishes	ML
POM FUSC	Pomacentrus fuscus	Dusky damselfish	POMACENTRIDAE	Damselfishes	ml
POM LEUC	Pomacentrus leucostictus	Beaugregory	POMACENTRIDAE	Damselfishes	ML
POM PART	Pomacentrus partitus	Bicolor damselfish	POMACENTRIDAE	Damselfishes	ML
POM PARU	Pomacanthus paru	French angelfish	POMACANTHIDAE	Angelfishes	ML
POM PLAN	Pomacentrus planifrons	Three spot damselfish	POMACENTRIDAE	Damselfishes	ML
POM VARI	Pomacentrus variabilis	Cocoa damselfish	POMACENTRIDAE	Damselfishes	ML

Table 2. One hundred and seventy-nine species censused at artificial and natural reefs from June 1988 to June 1990.

SPCODE	SPECIES	COMMON NAME	FAMILY	FAMILY NAME	VALUE ¹
PRI AREN	Priacanthus arenatus	Bigeye	PRIACANTHIDAE	Bigeyes	S
PSE MACU	Pseudupeneus maculatus	Spotted goatfish	MULLIDAE	Goatfishes	ml
RAC CANA	Rachycentron canadum	Cobia	RACHYCENTRIDAE	Cobias	P,R
RYP SAPO	Rypticus saponaceus	Greater soapfish	GRAMMISTIDAE	Soapfishes	
SCA COEL	Scarus coelestinus	Midnight parrotfish	SCARIDAE	Parrotfishes	ml
SCA COER	Scarus coeruleus	Blue parrotfish	SCARIDAE	Parrotfishes	ml
SCA CRIS	Scartella cristata	Molly miller	BLENNIIDAE	Combtooth blennies	ML
SCA CROI	Scarus croicensis	Striped parrotfish	SCARIDAE	Parrotfishes	ML
SCA GUAC	Scarus guacamaia	Rainbow parrotfish	SCARIDAE	Parrotfishes	ml
SCA SPE.	Scarus sp.	Unid. parrotfish	SCARIDAE	Parrotfishes	ml
SCA TAEN	Scarus taeniopterus	Princess parrotfish	SCARIDAE	Parrotfishes	ml
SCA VETU	Scarus vetula	Queen parrotfish	SCARIDAE	Parrotfishes	ml
SCO MACU	Scomberomorus maculatus	Spanish mackerel	SCOMBRIDAE	Mackerels/Tunas	P,R
SCO PLUM	Scorpaena plumieri	Scorpion fish	SCORPAENIDAE	Scorpion fishes	ml
SCO REGA	Scomberomorus regalis	Cero mackerel	SCOMBRIDAE	Mackerels/Tunas	P,R
SER BALD	Serranus baldwini	Lanternfish	SERRANIDAE	Sea basses	ML
SER DUME	Seriola dumerili	Greater amberjack	CARANGIDAE	Jacks	P,R
SER SUBL	Serranus subligarius	Belted sandfish	SERRANIDAE	Sea basses	ml
SER TABA	Serranus tabacarius	Tobaccofish	SERRANIDAE	Sea basses	ML
SER TIGR	Serranus tigrinus	Harlequin bass	SERRANIDAE	Sea basses	ML
SPA AURO	Sparisoma aurofrenatum	Redband parrotfish	SCARIDAE	Parrotfishes	ML
SPA CHRY	Sparisoma chrysopteron	Redtail parrotfish	SCARIDAE	Parrotfishes	ml
SPA RAD1	Sparisoma radians	Bucktooth parrotfish	SCARIDAE	Parrotfishes	ml
SPA SPE.	Sparisoma sp.	Unid. parrotfish	SCARIDAE	Parrotfishes	ml
SPA VIRI	Sparisoma viride	Stoplight parrotfish	SCARIDAE	Parrotfishes	ml
SPH BARR	Sphyrna barracuda	Barracuda	SPHYRAENIDAE	Barracudas	R
SPH PICU	Sphyrna picudilla	Southern sennet	SPHYRAENIDAE	Barracudas	
SPH SPEN	Sphoeroides spengleri	Bandtail puffer	TETRAODONTIDAE	Puffers	
SYN FOET	Synodus foetens	Inshore lizardfish	SYNODONTIDAE	Lizardfishes	
SYN INTE	Synodus intermedius	Sand diver	SYNODONTIDAE	Lizardfishes	
SYN SPE.	Synodus sp.	Unid. lizardfish	SYNODONTIDAE	Lizardfishes	
THA BIFA	Thalassoma bifasciatum	Bluehead	LABRIDAE	Wrasses	ML
TRA FALC	Trachinotus falcatus	Permit	CARANGIDAE	Jacks	R
TRA GOOD	Trachinotus goodei	Palometa	CARANGIDAE	Jacks	
URO JAMA	Urolophus jamaicensis	Yellow stingray	DASYATIDAE	Stingrays	ml

¹ Economic value: P, primary commercial; S, secondary commercial; R, recreational;

ML, primary marine life; ml, secondary marine life

= color variants of H. unicolor

Table 3. One hundred and seventy-nine species censused at reefs from June 1988 to June 1990, by family.

FAMILY	FAMILY NAME	SPCODE	SPECIES	COMMON NAME	VALUE ¹
DIODONTIDAE	Spiny puffers	CHI SCHO	Chilomycterus schoepfi	Striped burrfish	ML
ECHENEIDAE	Remoras	ECH NAUC	Echeneis naucrates	Sharksucker	ml
EPHIPPIDAE	Spadefishes	CHA FABE	Chaetodipterus faber	Spadefish	S,R
FISTULARIDAE	Cornetfishes	FIS SPE.	Fistularia sp.	Unid. cornetfish	ml
GERREIDAE	Mojarras	GER CINE	Gerres cinereus	Yellowfin mojarra	
GOBIIDAE	Gobies	COR GLAU	Coryphopterus glaucofraenum	Bridled goby	ml
GOBIIDAE	Gobies	COR PERS	Coryphopterus personatus	Masked goby	ml
GOBIIDAE	Gobies	GOB OCEA	Gobiosoma oceanops	Neon goby	ML
GOBIIDAE	Gobies	GOB XANT	Gobiosoma xanthiprora	Yellowprow goby	ml
GOBIIDAE	Gobies	IOG CALL	Ioglossus calliurus	Blue goby	
GOBIIDAE	Gobies	IOG HELE	Ioglossus helenae	Hovering goby	ml
GRAMMISTIDAE	Soapfishes	RYP SAPO	Rypticus saponaceus	Greater soapfish	
HAEMULIDAE	Grunts	ANI SURI	Anisotremus surinamensis	Black margate	P,R
HAEMULIDAE	Grunts	ANI VIRG	Anisotremus virginicus	Porkfish	S,R,ml
HAEMULIDAE	Grunts	HAE ALBU	Haemulon album	Margate	S,R
HAEMULIDAE	Grunts	HAE AURO	Haemulon aurolineatum	Tomtate	S
HAEMULIDAE	Grunts	HAE FLAV	Haemulon flavolineatum	French grunt	S
HAEMULIDAE	Grunts	HAE MELA	Haemulon melanurum	Cottonwick	S
HAEMULIDAE	Grunts	HAE PLUM	Haemulon plumieri	White grunt	S
HAEMULIDAE	Grunts	HAE SCTU	Haemulon sciurus	Bluestriped grunt	S
HAEMULIDAE	Grunts	HAE SPE.	Haemulon sp.	Unid. grunt	
HAEMULIDAE	Grunts	HAE STRI	Haemulon striatum	Striped grunt	
Holocentridae	Squirrelfishes	HOL ASCE	Holocentrus adscensionis	Squirrelfish	ml
Holocentridae	Squirrelfishes	HOL CORU	Holocentrus coruscus	Reef squirrelfish	ml
Holocentridae	Squirrelfishes	HOL MARI	Holocentrus marianus	Longjaw squirrelfish	ml
Holocentridae	Squirrelfishes	HOL RUFU	Holocentrus rufus	Longspine squirrelfish	ml
Holocentridae	Squirrelfishes	HOL SPE.	Holocentrus sp.	Unid. squirrelfish	ml
Holocentridae	Squirrelfishes	MYR JACO	Myripristes jacobus	Blackbar soldierfish	ml
KYPHOSIDAE	Sea chubs	KYP SECT	Kyphosus sectatrix	Bermuda chub	
LABRIDAE	Wrasses	BOD PULC	Bodianus pulchellus	Spotfin hogfish	ML
LABRIDAE	Wrasses	BOD RUFU	Bodianus rufus	Spanish hogfish	ML
LABRIDAE	Wrasses	CLE PARR	Clepticus parrai	Creole wrasse	ML
LABRIDAE	Wrasses	HAL BIVI	Halichoeres bivittatus	Slippery dick	ml
LABRIDAE	Wrasses	HAL GARN	Halichoeres garnoti	Yellowhead wrasse	ML
LABRIDAE	Wrasses	HAL MACU	Halichoeres maculipinna	Clown wrasse	ML
LABRIDAE	Wrasses	HAL RADT	Halichoeres radiatus	Puddingwife	ML
LABRIDAE	Wrasses	HAL SPE.	Halichoeres sp.	Unid. wrasse	ml
LABRIDAE	Wrasses	HEM NOVA	Hemipteronotus novacula	Pearly razorfish	ml
LABRIDAE	Wrasses	HEM SPLE	Hemipteronotus splendens	Green razorfish	ml
LABRIDAE	Wrasses	HEM SPE.	Hemipteronotus sp.	Unid. razorfish	
LABRIDAE	Wrasses	LAC MAXI	Lachnolaimus maximus	Hogfish	P,R
LABRIDAE	Wrasses	THA BIFA	Thalassoma bifasciatum	Bluehead	ML
LUTJANIDAE	Snappers	LUT ANAL	Lutjanus analis	Mutton snapper	P,R
LUTJANIDAE	Snappers	LUT APOD	Lutjanus apodus	Schoolmaster	S,R
LUTJANIDAE	Snappers	LUT BUCC	Lutjanus buccanella	Blackfin snapper	P,R
LUTJANIDAE	Snappers	LUT CYAN	Lutjanus cyanopterus	Cubera snapper	P,R
LUTJANIDAE	Snappers	LUT GRIS	Lutjanus griseus	Gray snapper	P,R
LUTJANIDAE	Snappers	LUT SYNA	Lutjanus synagris	Lane snapper	P,R
LUTJANIDAE	Snappers	OCY CHRY	Ocyurus chrysurus	Yellowtail snapper	P,R

Table 3. One hundred and seventy-nine species censused at all reefs from June 1988 to June 1990, by family.

FAMILY	FAMILY NAME	SPCODE	SPECIES	COMMON NAME	VALUE ¹
MALACANTHIDAE	Tilefishes	MAL PLUM	Malacanthus plumieri	Sand tilefish	S,R
MULLIDAE	Goatfishes	MUL MART	Mulloidichthys martinicus	Yellow goatfish	S
MULLIDAE	Goatfishes	PSE MACU	Pseudupeneus maculatus	Spotted goatfish	ml
MURAENIDAE	Morays	GYM FUNE	Gymnothorax funebris	Green moray	ml
MURAENIDAE	Morays	GYM MORI	Gymnothorax moringa	Spotted moray	ML
MURAENIDAE	Morays	GYM VICI	Gymnothorax vicinus	Purplemouth moray	ml
MURAENIDAE	Morays	MUR MILI	Muraena miliaris	Goldentail moray	ml
OPISTHOGNATHIDAE	Jawfishes	OPI AURI	Opisthognathus aurifrons	Yellowhead jawfish	ML
ORECTOLOBIIDAE	Nurse sharks	GIN CIRR	Ginglymostoma cirratum	Nurse shark	ml
OSTRACIIDAE	Boxfishes	LAC BICA	Lactophrys bicaudalis	Spotted trunkfish	ml
OSTRACIIDAE	Boxfishes	LAC QUAD	Lactophrys quadricornis	Scrawled cowfish	ml
OSTRACIIDAE	Boxfishes	LAC TRIQ	Lactophrys triqueter	Smooth trunkfish	ml
PEMPHERIDAE	Sweepers	PEM SCHO	Pempheris schomburgki	Glassy sweeper	
POMACANTHIDAE	Angelfishes	HOL BERM	Holacanthus bermudensis	Blue angelfish	ML
POMACANTHIDAE	Angelfishes	HOL CILI	Holacanthus ciliaris	Queen angelfish	ML
POMACANTHIDAE	Angelfishes	HOL TRIC	Holacanthus tricolor	Rock beauty	ML
POMACANTHIDAE	Angelfishes	POM ARCU	Pomacanthus arcuatus	Gray angelfish	ML
POMACANTHIDAE	Angelfishes	POM PARU	Pomacanthus paru	French angelfish	ML
POMACENTRIDAE	Damselfishes	ABU SAXA	Abudefduf saxatilis	Sergeant major	ml
POMACENTRIDAE	Damselfishes	CHR CYAN	Chromis cyanea	Blue chromis	ML
POMACENTRIDAE	Damselfishes	CHR ENCH	Chromis enchrysurus	Yellowtail reeffish	ML
POMACENTRIDAE	Damselfishes	CHR INSO	Chromis insolata	Sunshinefish	ML
POMACENTRIDAE	Damselfishes	CHR MULT	Chromis multilineata	Brown chromis	ml
POMACENTRIDAE	Damselfishes	CHR SCOT	Chromis scotti	Purple reeffish	ML
POMACENTRIDAE	Damselfishes	MIC CHRY	Microspathodon chrysurus	Yellowtail damselfish	ML
POMACENTRIDAE	Damselfishes	POM DIEN	Pomacentrus dieneae	Longfin damselfish	ML
POMACENTRIDAE	Damselfishes	POM FUSC	Pomacentrus fuscus	Dusky damselfish	ml
POMACENTRIDAE	Damselfishes	POM LEUC	Pomacentrus leucostictus	Beaugregory	ML
POMACENTRIDAE	Damselfishes	POM PART	Pomacentrus partitus	Bicolor damselfish	ML
POMACENTRIDAE	Damselfishes	POM PLAN	Pomacentrus planifrons	Three spot damselfish	ML
POMACENTRIDAE	Damselfishes	POM VARI	Pomacentrus variabilis	Cocoa damselfish	ML
PRIACANTHIDAE	Bigeyes	PRI AREN	Priacanthus arenatus	Bigeye	S
RACHYCENTRIDAE	Cobias	RAC CANA	Rachycentron canadum	Cobia	P,R
SCARIDAE	Parrotfishes	SCA COEL	Scarus coelestinus	Midnight parrotfish	ml
SCARIDAE	Parrotfishes	SCA COER	Scarus coeruleus	Blue parrotfish	ml
SCARIDAE	Parrotfishes	SCA CROI	Scarus croicensis	Striped parrotfish	ML
SCARIDAE	Parrotfishes	SCA GUAC	Scarus guacanaia	Rainbow parrotfish	ml
SCARIDAE	Parrotfishes	SCA SPE.	Scarus sp.	Unid. parrotfish	ml
SCARIDAE	Parrotfishes	SCA TAEN	Scarus taeniopterus	Princess parrotfish	ml
SCARIDAE	Parrotfishes	SCA VETU	Scarus vetula	Queen parrotfish	ml
SCARIDAE	Parrotfishes	SPA AURO	Sparisoma aurofrenatum	Redband parrotfish	ML
SCARIDAE	Parrotfishes	SPA CHRY	Sparisoma chrysopterus	Redtail parrotfish	ml
SCARIDAE	Parrotfishes	SPA RADII	Sparisoma radians	Bucktooth parrotfish	ml
SCARIDAE	Parrotfishes	SPA SPE.	Sparisoma sp.	Unid. parrotfish	ml
SCARIDAE	Parrotfishes	SPA VIRI	Sparisoma viride	Stoplight parrotfish	ml
SCIAENIDAE	Drums	EQU ACUM	Equetus acuminatus	High-hat	ML
SCIAENIDAE	Drums	EQU LANC	Equetus lanceolatus	Jackknife-fish	ML
SCIAENIDAE	Drums	EQU UMBR	Equetus umbrosus	Cubby	ml
SCIAENIDAE	Drums	ODO DENT	Odontoscion dentax	Reef croaker	

Table 3. One hundred and seventy-nine species censused at reefs from June 1988 to June 1990, by family.

FAMILY	FAMILY NAME	SPCODE	SPECIES	COMMON NAME	VALUE ¹
SCOMBRIDAE	Mackerels/Tunas	SCO MACU	<i>Scomberomorus maculatus</i>	Spanish mackerel	P,R
SCOMBRIDAE	Mackerels/Tunas	SCO REGA	<i>Scomberomorus regalis</i>	Cero mackerel	P,R
SCORPAENIDAE	Scorpion fishes	SCO PLUM	<i>Scorpaena plumieri</i>	Scorpion fish	ml
SERRANIDAE	Sea basses	MYC SPE.	<i>Mycteroperca</i> sp.	Unid. grouper	P,R
SERRANIDAE	Sea basses	DIP FORM	<i>Diplacanthus formosus</i>	Sand perch	
SERRANIDAE	Sea basses	EPI ADSC	<i>Epinephelus adscensionis</i>	Rock hind	S,ml
SERRANIDAE	Sea basses	EPI CRUE	<i>Epinephelus cruentatus</i>	Graysby	ml
SERRANIDAE	Sea basses	EPI FULV	<i>Epinephelus fulvus</i>	Coney	ML
SERRANIDAE	Sea basses	EPI GUTT	<i>Epinephelus guttatus</i>	Red hind	S,ml
SERRANIDAE	Sea basses	EPI MORI	<i>Epinephelus morio</i>	Red grouper	P,R
SERRANIDAE	Sea basses	EPI SPE.	<i>Epinephelus</i> sp.	Unid. grouper	
SERRANIDAE	Sea basses	EPI STRI	<i>Epinephelus striatus</i>	Nassau grouper	P,R
SERRANIDAE	Sea basses	HYP GEMM	<i>Hypoplectrus gemma</i> #	Blue hamlet	ml
SERRANIDAE	Sea basses	HYP NIGR	<i>Hypoplectrus nigricans</i> #	Black hamlet	ml
SERRANIDAE	Sea basses	HYP PUEL	<i>Hypoplectrus puella</i> #	Barred hamlet	ml
SERRANIDAE	Sea basses	HYP UNIC	<i>Hypoplectrus unicolor</i>	Butter hamlet	ml
SERRANIDAE	Sea basses	MYC BONA	<i>Mycteroperca bonaci</i>	Black grouper	P,R
SERRANIDAE	Sea basses	MYC MICR	<i>Mycteroperca microlepis</i>	Gag	P,R
SERRANIDAE	Sea basses	MYC PHEN	<i>Mycteroperca phenax</i>	Scamp	P,R
SERRANIDAE	Sea basses	PAR FURC	<i>Paranthias furcifer</i>	Creole-fish	ML
SERRANIDAE	Sea basses	SER BALD	<i>Serranus baldwini</i>	Lanternfish	ML
SERRANIDAE	Sea basses	SER SUBL	<i>Serranus subligarius</i>	Belted sandfish	ml
SERRANIDAE	Sea basses	SER TABA	<i>Serranus tabacarius</i>	Tobaccofish	ML
SERRANIDAE	Sea basses	SER TIGR	<i>Serranus tigrinus</i>	Harlequin bass	ML
SPARIDAE	Porgies	ARC PROB	<i>Archosargus probatocephalus</i>	Sheepshead	P,R
SPARIDAE	Porgies	CAL BAJO	<i>Calamus bajonado</i>	Jolthead porgy	P,R
SPARIDAE	Porgies	CAL CALA	<i>Calamus calamus</i>	Saucereye porgy	P,R
SPARIDAE	Porgies	CAL SPE.	<i>Calamus</i> sp.	Unid. porgy	P,R
SPHYRAENIDAE	Barracudas	SPH BARR	<i>Sphyraena barracuda</i>	Barracuda	R
SPHYRAENIDAE	Barracudas	SPH PICU	<i>Sphyraena picudilla</i>	Southern sennet	
SYNOdontIDAE	Lizardfishes	SYN FOET	<i>Synodus foetens</i>	Inshore lizardfish	
SYNOdontIDAE	Lizardfishes	SYN INTE	<i>Synodus intermedius</i>	Sand diver	
SYNOdontIDAE	Lizardfishes	SYN SPE.	<i>Synodus</i> sp.	Unid. lizardfish	
TETRAodontIDAE	Puffers	CAN ROST	<i>Canthigaster rostrata</i>	Sharpnose puffer	ML
TETRAodontIDAE	Puffers	SPH SPEN	<i>Sphoeroides spengleri</i>	Bandtail puffer	

¹ Economic value: P, primary commercial; S, secondary commercial; R, recreational;
 ML, primary marine life; ml, secondary marine life
 # = color variants of *H. unicolor*

Table 4. One hundred and eight species censused at fabricated units from June 1988 to June 1990.

SPCODE	SCIENTIFIC NAME	COMMON NAME	FAMILY	FAMILY NAME	VALUE
ABU SAXA	Abudefduf saxatilis	Sergeant major	POMACENTRIDAE	Damselfishes	ml
ACA BANI	Acanthurus bahianus	Ocean surgeon	ACANTHURIDAE	Surgeonfishes	ml
ACA CHIR	Acanthurus chirurgus	Doctorfish	ACANTHURIDAE	Surgeonfishes	ml
ACA COER	Acanthurus coeruleus	Blue tang	ACANTHURIDAE	Surgeonfishes	ML
ALU SCHO	Aluterus schoepfi	Orange filefish	BALISTIDAE	Leatherjackets	ml
ALU SCRI	Aluterus scriptus	Scrawled filefish	BALISTIDAE	Leatherjackets	ml
ANI VIRG	Anisotremus virginicus	Porkfish	HAEMULIDAE	Grunts	S,R,ml
APO PSEU	Apogon pseudomaculatus	Twospot cardinalfish	APOGONIDAE	Cardinalfishes	ML
APO SPE.	Apogon sp.	Unid. cardinalfish	APOGONIDAE	Cardinalfishes	
AST STEL	Astrapogon stellatus	Conchfish	APOGONIDAE	Cardinalfishes	
BOD PULC	Bodianus pulchellus	Spotfin hogfish	LABRIDAE	Wrasses	ML
BOD RUFU	Bodianus rufus	Spanish hogfish	LABRIDAE	Wrasses	ML
CAL CALA	Calamus calamus	Saucer eye porgy	SPARIDAE	Porgies	P,R
CAL SPE.	Calamus sp.	Unknown porgy	SPARIDAE	Porgies	P,R
CAN ROST	Canthigaster rostrata	Sharpnose puffer	TETRAODONTIDAE	Puffers	ML
CAR BART	Caranx bartholomaei	Yellow jack	CARANGIDAE	Jacks	R
CAR CRYC	Caranx crysos	Blue runner	CARANGIDAE	Jacks	R
CAR RUBE	Caranx ruber	Bar jack	CARANGIDAE	Jacks	
CHA OCEL	Chaetodon ocellatus	Spotfin butterflyfish	CHAETODONTIDAE	Butterflyfishes	ML
CHA SEDE	Chaetodon sedentarius	Reef butterflyfish	CHAETODONTIDAE	Butterflyfishes	ML
CHA STRI	Chaetodon striatus	Banded butterflyfish	CHAETODONTIDAE	Butterflyfishes	ML
CHR ENCH	Chromis enchrysurus	Yellowtail reeffish	POMACENTRIDAE	Damselfishes	ML
CHR INSO	Chromis insolata	Sunshinefish	POMACENTRIDAE	Damselfishes	ML
CHR MULT	Chromis multilineata	Brown chromis	POMACENTRIDAE	Damselfishes	ml
CHR SCOT	Chromis scotti	Purple reeffish	POMACENTRIDAE	Damselfishes	ML
CLE PARR	Clepticus parrai	Creole wrasse	LABRIDAE	Wrasses	ML
COR GLAU	Coryphopterus glaucofraenum	Bridled goby	GOBIIDAE	Gobies	ml
DEC MACA	Decapterus macarellus	Mackerel scad	CARANGIDAE	Jacks	
DEC PUNC	Decapterus punctatus	Round scad	CARANGIDAE	Jacks	
DEC SPE.	Decapterus sp.	Unid. scad	CARANGIDAE	Jacks	
DIP FORM	Diplectrum formosum	Sand perch	SERRANIDAE	Sea basses	
ECH NAUC	Echenis naucrates	Sharksucker	ECHENEIDAE	Remoras	ml
EMB PAND	Emblemaria pandionis	Sailfin blenny	CLINIIDAE	Clinids	ml
EPI ADSC	Epinephelus adscensionis	Rock hind	SERRANIDAE	Sea basses	S,ml
EPI CRUE	Epinephelus cruentatus	Graysby	SERRANIDAE	Sea basses	ml
EPI FULV	Epinephelus fulvus	Coney	SERRANIDAE	Sea basses	ml
EPI GUTT	Epinephelus guttatus	Red hind	SERRANIDAE	Sea basses	S,ml
EQU ACUM	Equetus acuminatus	High-hat	SCIAENIDAE	Drums	ML
EQU LANC	Equetus lanceolatus	Jackknife-fish	SCIAENIDAE	Drums	ML
GIN CIRR	Ginglymostoma cirratum	Nurse shark	ORECTOLOBIIDAE	Carpet sharks	ml
GOB OCEA	Gobiosoma oceanops	Neon goby	GOBIIDAE	Gobies	ML
GYM MORI	Gymnothorax moringa	Spotted moray	MURAENIDAE	Morays	ML
HAE ALBU	Haemulon album	Margate	HAEMULIDAE	Grunts	S,R
HAE AURO	Haemulon aurolineatum	Tomtate	HAEMULIDAE	Grunts	S
HAE FLAV	Haemulon flavolineatum	French grunt	HAEMULIDAE	Grunts	S
HAE MELA	Haemulon melanurum	Cottonwick	HAEMULIDAE	Grunts	S
HAE PLUM	Haemulon plumieri	White grunt	HAEMULIDAE	Grunts	S
HAE SPE.	Haemulon sp.	Unidentified grunt	HAEMULIDAE	Grunts	
HAE STRI	Haemulon striatum	Striped grunt	HAEMULIDAE	Grunts	

Table 4. One hundred and eight species censused at fabricated units from June 1988 to June 1990.

SPCODE	SCIENTIFIC NAME	COMMON NAME	FAMILY	FAMILY NAME	VALUE ¹
HAL BIVI	Halichoeres bivittatus	Slippery dick	LABRIDAE	Wrasses	ml
HAL GARN	Halichoeres garnoti	Yellowhead wrasse	LABRIDAE	Wrasses	ML
HAL RADI	Halichoeres radiatus	Puddingwife	LABRIDAE	Wrasses	ML
HAL SPE.	Halichoeres sp.	Unid. wrasse	LABRIDAE	Wrasses	
HEM SPE.	Hemipteronotus sp.	Unid. razorfish	LABRIDAE	Wrasses	
HEM SPLE	Hemipteronotus splendens	Green razorfish	LABRIDAE	Wrasses	ml
HOL BERM	Holacanthus bermudensis	Blue angelfish	POMACANTHIDAE	Angelfishes	ML
HOL CILI	Holacanthus ciliaris	Queen angelfish	POMACANTHIDAE	Angelfishes	ML
HOL CORU	Holocentrus coruscus	Reef squirrelfish	HOLOCENTRIDAE	Squirrelfishes	ml
HOL MARI	Holocentrus marianus	Longjaw squirrelfish	HOLOCENTRIDAE	Squirrelfishes	ml
HOL SPE.	Holocentrus sp.	Unid. squirrelfish	HOLOCENTRIDAE	Squirrelfishes	ml
HOL TRIC	Holacanthus tricolor	Rock beauty	POMACANTHIDAE	Angelfishes	ML
IOG HELE	Ioglossus helenae	Hovering goby	GOBIIDAE	Gobies	ml
KYP SECT	Kyphosus sectatrix	Bermuda chub	KYPHOSIDAE	Sea chubs	
LAC BICA	Lactophrys bicaudalis	Spotted trunkfish	OSTRACIIDAE	Boxfishes	ml
LAC MAXI	Lachnolaimus maximus	Hogfish	LABRIDAE	Wrasses	P,R
LAC QUAD	Lactophrys quadricornis	Scrawled cowfish	OSTRACIIDAE	Boxfishes	ml
LAC TRIQ	Lactophrys triqueter	Smooth trunkfish	OSTRACIIDAE	Boxfishes	ml
LUT ANAL	Lutjanus analis	Mutton snapper	LUTJANIDAE	Snappers	P,R
LUT BUCC	Lutjanus buccanella	Blackfin snapper	LUTJANIDAE	Snappers	P,R
LUT CYAN	Lutjanus cyanopterus	Cubera snapper	LUTJANIDAE	Snappers	P,R
LUT GRIS	Lutjanus griseus	Gray snapper	LUTJANIDAE	Snappers	P,R
MAL SPE.	Malacoctenus sp.	Unid. blenny	CLINIDAE	Clinids	
MAL TRIA	Malacoctenus triangulatus	Saddled blenny	CLINIDAE	Clinids	ML
MIC CHRY	Microspathodon chrysurus	Yellowtail damselfish	POMACENTRIDAE	Damselfishes	ML
MON CILI	Monacanthus ciliatus	Fringed filefish	BALISTIDAE	Leatherjackets	ml
MON HISP	Monacanthus hispidus	Planehead filefish	BALISTIDAE	Leatherjackets	ml
MON SPE.	Monacanthus sp.	Unid. filefish	BALISTIDAE	Leatherjackets	ml
MYC BONA	Mycteroperca bonaci	Black grouper	SERRANIDAE	Sea basses	P,R
MYC MICR	Mycteroperca microlepis	Gag	SERRANIDAE	Sea basses	P,R
MYC SPE.	Mycteroperca sp.	Unid. grouper	SERRANIDAE	Sea basses	P,R
OCY CHRY	Ocyurus chrysurus	Yellowtail snapper	LUTJANIDAE	Snappers	P,R
OPI AURI	Opistognathus aurifrons	Yellowhead jawfish	OPISTOGNATHIDAE	Jawfishes	ML
PAR FURC	Paranthias furcifer	Creole-fish	SERRANIDAE	Sea basses	ML
PAR MARM	Parablennius marmoreus	Seaweed blenny	BLENNIIDAE	Combtooth blennies	ML
POM ARCU	Pomacanthus arcuatus	Gray angelfish	POMACANTHIDAE	Angelfishes	ML
POM LEUC	Pomacentrus leucostictus	Beaugregory	POMACENTRIDAE	Damselfishes	ML
POM PART	Pomacentrus partitus	Bicolor damselfish	POMACENTRIDAE	Damselfishes	ML
POM PARU	Pomacanthus paru	French angelfish	POMACANTHIDAE	Angelfishes	ML
POM PLAN	Pomacentrus planifrons	Three spot damselfish	POMACENTRIDAE	Damselfishes	ML
POM VARI	Pomacentrus variabilis	Cocoa damselfish	POMACENTRIDAE	Damselfishes	ML
PSE MACU	Pseudupeneus maculatus	Spotted goatfish	MULLIDAE	Goatfishes	ml
RAC CANA	Rachycentron canadum	Cobia	RACHYCENTRIDAE	Cobias	P,R
RYP SAPO	Rypticus saponaceus	Greater soapfish	GRAMMISTIDAE	Soapfishes	
SCA CROI	Scarus croicensis	Striped parrotfish	SCARIDAE	Parrotfishes	ML
SCA SPE.	Scarus sp.	Unid. parrotfish	SCARIDAE	Parrotfishes	ml
SCO PLUM	Scorpaena plumieri	Scorpion fish	SCORPAENIDAE	Scorpionfishes	ml
SCQ REGA	Scomberomorus regalis	Cero mackerel	SCOMBRIDAE	Mackerels/Tunas	P,R
SER BALD	Serranus baldwini	Lanternfish	SERRANIDAE	Sea basses	ML

Table 4. One hundred and eight species censused at fabricated units from June 1988 to June 1990.

SPCODE	SCIENTIFIC NAME	COMMON NAME	FAMILY	FAMILY NAME	1 VALUE
SER DUME	<i>Seriola dumerili</i>	Greater amberjack	CARANGIDAE	Jacks	P,R
SER TABA	<i>Serranus tabacarius</i>	Tobaccofish	SERRANIDAE	Sea basses	ML
SER TIGR	<i>Serranus tigrinus</i>	Harlequin bass	SERRANIDAE	Sea basses	ML
SPA AURO	<i>Sparisoma aurofrenatum</i>	Redband parrotfish	SCARIDAE	Parrotfishes	ML
SPA CHRY	<i>Sparisoma chrysopteron</i>	Redtail parrotfish	SCARIDAE	Parrotfishes	ml
SPH BARR	<i>Sphyaena barracuda</i>	Barracuda	SPHYRAENIDAE	Barracudas	R
SYN FOET	<i>Synodus foetens</i>	Inshore lizardfish	SYNODONTIDAE	Lizardfishes	
THA BIFA	<i>Thalassoma bifasciatum</i>	Bluehead	LABRIDAE	Wrasses	ML
TRA FALC	<i>Trachinotus falcatus</i>	Permit	CARANGIDAE	Jacks	R
URO JAMA	<i>Urolophus jamaicensis</i>	Yellow stingray	DASYATIDAE	Stingrays	ml

1 Economic value: P, primary commercial; S, secondary commercial; R, recreational;
ML, primary marine life; ml, secondary marine life

Table 5. One hundred and three species censused at bridge rubble reefs in Hawk Channel from June to August 1989.

SPCODE	SPECIES	COMMON NAME	FAMILY	FAMILY NAME	VALUE ¹
ABU SAXA	Abudefduf saxatilis	Sergeant major	POMACENTRIDAE	Damselfishes	ml
ACA BAH1	Acanthurus bahianus	Ocean surgeon	ACANTHURIDAE	Surgeonfishes	ml
ACA CHIR	Acanthurus chirurgus	Doctorfish	ACANTHURIDAE	Surgeonfishes	ml
ACA COER	Acanthurus coeruleus	Blue tang	ACANTHURIDAE	Surgeonfishes	ML
AMB PINO	Amblycirrhitus pinos	Redspotted hawkfish	CIRRHITIDAE	Hawkfishes	ML
ANI VIRG	Anisotremus virginicus	Porkfish	HAEMULIDAE	Grunts	S,R,ml
APO MACU	Apogon maculatus	Flamefish	APOGONIDAE	Cardinalfishes	ML
APO PSEU	Apogon pseudomaculatus	Twospot cardinalfish	APOGONIDAE	Cardinalfishes	ML
ARC PROB	Archosargus probatocephalus	Sheepshead	SPARIDAE	Porgies	P,R
AUL MACU	Aulostomus maculatus	Trumpetfish	AULOSTOMIDAE	Trumpetfishes	
CAL BAJO	Calamus bajonado	Jolthead porgy	SPARIDAE	Porgies	P,R
CAL CALA	Calamus calamus	Saucereye porgy	SPARIDAE	Porgies	P,R
CAN ROST	Canthigaster rostrata	Sharpnose puffer	TETRAODONTIDAE	Puffers	ML
CAR BART	Caranx bartholomaei	Yellow jack	CARANGIDAE	Jacks	R
CAR CRYX	Caranx crysos	Blue runner	CARANGIDAE	Jacks	R
CAR RUBE	Caranx ruber	Bar jack	CARANGIDAE	Jacks	
CAR SPE.	Caranx sp.	Unid. jack	CARANGIDAE	Jacks	
CEN UNDE	Centropomus undecimalis	Snook	CENTROPOMIDAE	Snooks	R
CHA CAPI	Chaetodon capistratus	Four-eye butterflyfish	CHAETODONTIDAE	Butterflyfishes	ML
CHA FABI	Chaetodiporus faber	Atlantic spadefish	EPHIPPIDAE	Spadefishes	S,R
CHA OCEL	Chaetodon ocellatus	Spotfin butterflyfish	CHAETODONTIDAE	Butterflyfishes	ML
CHA SEDE	Chaetodon sedentarius	Reef butterflyfish	CHAETODONTIDAE	Butterflyfishes	ML
CLU SPE.	Clupeidae	Unid. herring	CLUPEIDAE	Herrings	
COR GLAU	Coryphopterus glaucofraenum	Bridled goby	GOBIIDAE	Gobies	ml
DEC SPE.	Decapterus sp.	Unid. scad	CARANGIDAE	Jacks	
DIO HYST	Diodon hystrix	Porcupinefish	DIODONTIDAE	Porcupinefishes	ml
EPI ADSC	Epinephelus adscensionis	Rock hind	SERRANIDAE	Sea basses	S,ml
EPI CRUE	Epinephelus cruentatus	Graysby	SERRANIDAE	Sea basses	ml
EPI FULV	Epinephelus fulvus	Coney	SERRANIDAE	Sea basses	ML
EPI GUTT	Epinephelus guttatus	Red hind	SERRANIDAE	Sea basses	S,ml
EPI MORI	Epinephelus morio	Red grouper	SERRANIDAE	Sea basses	P,R
EPI STRI	Epinephelus striatus	Nassau grouper	SERRANIDAE	Sea basses	P,R
EQU ACUM	Equetus acuminatus	High-hat	SCIAENIDAE	Drums	ML
EQU UMBR	Equetus umbrosus	Cubbyu	SCIAENIDAE	Drums	ml
GER CINE	Gerres cinereus	Yellowfin mojarra	GERREIDAE	Mojarras	
GOB OCEA	Gobiosoma oceanops	Neon goby	GOBIIDAE	Gobies	ML
GYM FUNE	Gymnothorax funebris	Green moray	MURAENIDAE	Morays	ml
GYM MORI	Gymnothorax moringa	Spotted moray	MURAENIDAE	Morays	ML
HAE ALBU	Haemulon album	Margate	HAEMULIDAE	Grunts	S,R
HAE AURO	Haemulon aurolineatum	Tomtate	HAEMULIDAE	Grunts	S
HAE FLAV	Haemulon flavolineatum	French grunt	HAEMULIDAE	Grunts	S
HAE PLUM	Haemulon plumieri	White grunt	HAEMULIDAE	Grunts	S
HAE SCIU	Haemulon sciurus	Bluestriped grunt	HAEMULIDAE	Grunts	S
HAE SPE.	Haemulon sp.	Unid. grunt	HAEMULIDAE	Grunts	
HAE STRI	Haemulon striatum	Striped grunt	HAEMULIDAE	Grunts	
HAL BIVI	Halichoeres bivittatus	Slippery dick	LABRIDAE	Wrasses	ml
HAL GARN	Halichoeres garnoti	Yellowhead wrasse	LABRIDAE	Wrasses	ML
HAL RAD1	Halichoeres radiatus	Puddingwife	LABRIDAE	Wrasses	ML
HAL SPE.	Halichoeres sp.	Unid. wrasse	LABRIDAE	Wrasses	

Table 5. One hundred and three species censused at bridge rubble reefs in Hawk Channel from June to August 1989.

SPCODE	SPECIES	COMMON NAME	FAMILY	FAMILY NAME	VALUE
HAR SPE.	Harengula sp.	Unid. sardine	CARANGIDAE	Jacks	
HOL BERM	Holacanthus bermudensis	Blue angelfish	POMACANTHIDAE	Angelfishes	ML
HOL CILI	Holacanthus ciliaris	Queen angelfish	POMACANTHIDAE	Angelfishes	ML
HOL RUFU	Holocentrus rufus	Longspine squirrelfish	HOLOCENTRIDAE	Squirrelfishes	ml
HOL TRIC	Holacanthus tricolor	Rock beauty	POMACANTHIDAE	Angelfishes	ML
HYP GEMM	Hypoplectrus gemma #	Blue hamlet	SERRANIDAE	Sea basses	ml
HYP NIGR	Hypoplectrus nigricans #	Black hamlet	SERRANIDAE	Sea basses	ml
HYP PUEL	Hypoplectrus puella #	Barred hamlet	SERRANIDAE	Sea basses	ml
HYP UNIC	Hypoplectrus unicolor	Butter hamlet	SERRANIDAE	Sea basses	ml
IOG CALL	Ioglossus calliurus	Blue goby	GOBIIDAE	Gobies	ML
LAC BICA	Lactophrys bicaudalis	Spotted trunkfish	OSTRACIIDAE	Boxfishes	ml
LAC MAXI	Lachnolaimus maximus	Hogfish	LABRIDAE	Wrasses	P,R
LAC QUAD	Lactophrys quadricornis	Scrawled cowfish	OSTRACIIDAE	Boxfishes	ml
LUT ANAL	Lutjanus analis	Mutton snapper	LUTJANIDAE	Snappers	P,R
LUT GRIS	Lutjanus griseus	Gray snapper	LUTJANIDAE	Snappers	P,R
LUT SYNA	Lutjanus synagris	Lane snapper	LUTJANIDAE	Snappers	P,R
MAL TRIA	Malacoctenus triangulatus	Saddled blenny	CLINIDAE	Clinids	ml
MUL MART	Mulloidichthys martinicus	Yellow goatfish	MULLIDAE	Goatfishes	S
MYC BONA	Mycteroperca bonaci	Black grouper	SERRANIDAE	Sea basses	P,R
MYC MICR	Mycteroperca microlepis	Gag	SERRANIDAE	Sea basses	P,R
MYC PHEN	Mycteroperca phenax	Scamp	SERRANIDAE	Sea basses	P,R
MYC SPE.	Mycteroperca sp.	Unid. grouper	SERRANIDAE	Sea basses	P,R
MYR JACO	Myripristis jacobus	Blackbar soldierfish	HOLOCENTRIDAE	Squirrelfishes	ml
OCY CHRY	Ocyurus chrysurus	Yellowtail snapper	LUTJANIDAE	Snappers	P,R
ODO DENT	Odontoscion dentex	Reef croaker	SCIAENIDAE	Drums	
OPI AURI	Opistognathus aurifrons	Yellowhead jawfish	OPISTOGNATHIDAE	Jawfishes	ML
PAR MARM	Parablennius marmoratus	Seaweed blenny	BLENNIIDAE	Blennies	ML
POM ARCU	Pomacanthus arcuatus	Gray angelfish	POMACANTHIDAE	Angelfishes	ML
POM FUSC	Pomacentrus fuscus	Dusky damselfish	POMACENTRIDAE	Damselfishes	ml
POM LEUC	Pomacentrus leucostictus	Beaugregory	POMACENTRIDAE	Damselfishes	ML
POM PART	Pomacentrus partitus	Bicolor damselfish	POMACENTRIDAE	Damselfishes	ML
POM PARU	Pomacanthus paru	French angelfish	POMACANTHIDAE	Angelfishes	ML
POM PLAN	Pomacentrus planifrons	Three spot damselfish	POMACENTRIDAE	Damselfishes	ML
POM VARI	Pomacentrus variabilis	Cocoa damselfish	POMACENTRIDAE	Damselfishes	ML
PRI AREN	Priacanthus arenatus	Bigeye	PRIACANTHIDAE	Bigeyes	S
PSE MACU	Pseudupeneus maculatus	Spotted goatfish	MULLIDAE	Goatfishes	ml
SCA COEL	Scarus coelestinus	Midnight parrotfish	SCARIDAE	Parrotfishes	ml
SCA COER	Scarus coerulesus	Blue parrotfish	SCARIDAE	Parrotfishes	ml
SCA CRIS	Scartella cristata	Molly miller	BLENNIIDAE	Combtooth blennies	ML
SCA CROI	Scarus croicensis	Striped parrotfish	SCARIDAE	Parrotfishes	ML
SCA GUAC	Scarus guacamaia	Rainbow parrotfish	SCARIDAE	Parrotfishes	ml
SCA VETU	Scarus vetula	Queen parrotfish	SCARIDAE	Parrotfishes	ml
SCO PLUM	Scorpaena plumieri	Scorpion fish	SCORPAENIDAE	Scorpionfishes	ml
SCO REGA	Scomberomorus regalis	Cero mackerel	SCOMBRIDAE	Mackerels/Tunas	P,R
SER BALD	Serranus baldwini	Lanternfish	SERRANIDAE	Sea basses	ML
SER SUBL	Serranus subligarius	Belted sandfish	SERRANIDAE	Sea basses	ml
SER TIGR	Serranus tigrinus	Harlequin bass	SERRANIDAE	Sea basses	ML
SPA AURO	Sparisoma aurofrenatum	Redband parrotfish	SCARIDAE	Parrotfishes	ML
SPA CHRY	Sparisoma chrysotermum	Redtail parrotfish	SCARIDAE	Parrotfishes	ml

Table 5. One hundred and three species censused at bridge rubble reefs in Hawk Channel from June to August 1989.

SPCODE	SPECIES	COMMON NAME	FAMILY	FAMILY NAME	1 VALUE
99 SPA SPE.	Sparisoma sp.	Unid. parrotfish	SCARIDAE	Parrotfishes	ml
100 SPA VIRI	Sparisoma viride	Stoplight parrotfish	SCARIDAE	Parrotfishes	ml
101 SPH BARR	Sphyræna barracuda	Barracuda	SPHYRAENIDAE	Barracudas	R
102 SPH SPEN	Sphoeroides spengleri	Bandtail puffer	TETRAODONTIDAE	Puffers	
103 SYN FOET	Synodus foetens	Inshore lizardfish	SYNODONTIDAE	Lizardfishes	
104 THA BIFA	Thalassoma bifasciatum	Bluehead	LABRIDAE	Wrasses	ML
105 TRA FALC	Trachinotus falcatus	Permit	CARANGIDAE	Jacks	R

1 Economic value: P, primary commercial; S, secondary commercial; R, recreational;
 ML, primary marine life; ml, secondary marine life
 # = color variants of *H. unicolor*

Table 6. One hundred and fifty-three species censused on all natural reefs from July 1988 to May 1990.

SPCODE	SCIENTIFIC NAME	COMMON NAME	FAMILY	FAMILY NAME	VALUE
ABU SAXA	Abudefduf saxatilis	Sergeant major	POMACENTRIDAE	Damselfishes	ml
ACA BAH1	Acanthurus bahianus	Ocean surgeon	ACANTHURIDAE	Surgeonfishes	ml
ACA CHIR	Acanthurus chirurgus	Doctorfish	ACANTHURIDAE	Surgeonfishes	ml
ACA COER	Acanthurus coeruleus	Blue tang	ACANTHURIDAE	Surgeonfishes	ML
ALU SCRI	Aluterus scriptus	Scrawled filefish	BALISTIDAE	Leatherjackets	ml
AMB PINO	Amblycirrhitus pinos	Redspotted hawkfish	CIRRHITIDAE	Hawkfishes	ML
ANI SURI	Anisotremus surinamensis	Black margate	HAEMULIDAE	Grunts	P,R
ANI VIRG	Anisotremus virginicus	Porkfish	HAEMULIDAE	Grunts	S,R,ml
APO BINO	Apogon binotatus	Barred cardinalfish	APOGONIDAE	Cardinalfishes	ml
APO MACU	Apogon maculatus	Flamefish	APOGONIDAE	Cardinalfishes	ML
APO PSEU	Apogon pseudomaculatus	Twospot cardinalfish	APOGONIDAE	Cardinalfishes	ML
APO SPE.	Apogon sp.	Unid. cardinalfish	APOGONIDAE	Cardinalfishes	ml
AUL MACU	Aulostomus maculatus	Trumpetfish	AULOSTOMIDAE	Trumpetfishes	
BAL CAPR	Balistes capriscus	Gray triggerfish	BALISTIDAE	Leatherjackets	P,R
BAL VETU	Balistes vetula	Queen triggerfish	BALISTIDAE	Leatherjackets	R,ml
BOD PULC	Bodianus pulchellus	Spotfin hogfish	LABRIDAE	Wrasses	ML
BOD RUFU	Bodianus rufus	Spanish hogfish	LABRIDAE	Wrasses	ML
CAL BAJO	Calamus bajonado	Jolthead porgy	SPARIDAE	Porgies	P,R
CAL CALA	Calamus calamus	Saucereye porgy	SPARIDAE	Porgies	P,R
CAN MACR	Cantherhines macrocerus	Whitespotted filefish	BALISTIDAE	Leatherjackets	ml
CAN PULL	Cantherhines pullus	Orangespotted filefish	BALISTIDAE	Leatherjackets	ml
CAN ROST	Canthigaster rostrata	Sharpnose puffer	TETRAODONTIDAE	Puffers	ML
CAR BART	Caranx bartholomaei	Yellow jack	CARANGIDAE	Jacks	R
CAR CRYC	Caranx crysos	Blue runner	CARANGIDAE	Jacks	R
CAR LATU	Caranx latus	Horse-eye jack	CARANGIDAE	Jacks	R
CAR RUBE	Caranx ruber	Bar jack	CARANGIDAE	Jacks	
CHA CAPI	Chaetodon capistratus	Four-eye butterflyfish	CHAETODONTIDAE	Butterflyfishes	ML
CHA FABI	Chaetodipterus faber	Atlantic spadefish	EPHIPPIDAE	Spadefishes	S,R
CHA OCEL	Chaetodon ocellatus	Spotfin butterflyfish	CHAETODONTIDAE	Butterflyfishes	ML
CHA SEDE	Chaetodon sedentarius	Reef butterflyfish	CHAETODONTIDAE	Butterflyfishes	ML
CHA STRI	Chaetodon striatus	Banded butterflyfish	CHAETODONTIDAE	Butterflyfishes	ML
CHI SCHO	Chilomycterus schoepfi	Striped burrfish	DIODONTIDAE	Porcupinefishes	ml
CHR CYAN	Chromis cyanea	Blue chromis	POMACENTRIDAE	Damselfishes	ML
CHR ENCH	Chromis enchrysurus	Yellowtail reeffish	POMACENTRIDAE	Damselfishes	ML
CHR INSO	Chromis insolata	Sunshinefish	POMACENTRIDAE	Damselfishes	ML
CHR MULT	Chromis multilineata	Brown chromis	POMACENTRIDAE	Damselfishes	ml
CHR SCOT	Chromis scotti	Purple reeffish	POMACENTRIDAE	Damselfishes	ML
CLE PARR	Clepticus parrai	Creole wrasse	LABRIDAE	Wrasses	ML
COR GLAU	Coryphopterus glaucofraenum	Bridled goby	GOBIIDAE	Gobies	ml
COR PERS	Coryphopterus personatus	Masked goby	GOBIIDAE	Gobies	ml
DAS AMER	Dasyatis americana	Southern stingray	DASYATIDAE	Stingrays	
DEC PUNC	Decapterus punctatus	Round scad	CARANGIDAE	Jacks	
DEC SPE.	Decapterus sp.	Unid. scad	CARANGIDAE	Jacks	
DIO HOLO	Diodon holocanthus	Balloonfish	DIODONTIDAE	Porcupinefishes	ml
DIO HYST	Diodon hystrix	Porcupinefish	DIODONTIDAE	Porcupinefishes	ml
ECH NAUC	Echeneis naucrates	Sharksucker	ECHENEIDAE	Remoras	ml
EMB PAND	Eblemaria pandionis	Sailfin blenny	CLINIDAE	Clinids	ml
EPI ADSC	Epinephelus adscensionis	Rock hind	SERRANIDAE	Sea basses	S,ml
EPI CRUE	Epinephelus cruentatus	Graysby	SERRANIDAE	Sea basses	ml

Table 6. One hundred and fifty-three species censused on all natural reefs from July 1988 to May 1990.

SPCODE	SCIENTIFIC NAME	COMMON NAME	FAMILY	FAMILY NAME	VALUE
EPI FULV	<i>Epinephelus fulvus</i>	Coney	SERRANIDAE	Sea basses	ML
EPI GUTT	<i>Epinephelus guttatus</i>	Red hind	SERRANIDAE	Sea basses	S,ml
EPI MORI	<i>Epinephelus morio</i>	Red grouper	SERRANIDAE	Sea basses	P,R
EPI SPE.	<i>Epinephelus sp.</i>	Unid. grouper	SERRANIDAE	Sea basses	
EPI STRI	<i>Epinephelus striatus</i>	Nassau grouper	SERRANIDAE	Sea basses	P,R
EQU ACUM	<i>Equetus acuminatus</i>	High-hat	SCIAENIDAE	Drums	ML
EQU LANC	<i>Equetus lanceolatus</i>	Jacknife-fish	SCIAENIDAE	Drums	ML
FIS SPE.	<i>Fistularia sp.</i>	Unid. cornetfish	FISTULARIDAE	Cornetfishes	
GER CINE	<i>Gerres cinereus</i>	Yellowfin mojarra	GERREIDAE	Mojarras	
GIN CIR	<i>Ginglymostoma cirratum</i>	Nurse shark	ORECTOLOBIDAE	Carpet sharks	ml
GOB OCEA	<i>Gobiosoma oceanops</i>	Neon goby	GOBIIDAE	Gobies	ML
GOB XANT	<i>Gobiosoma xanthiprora</i>	Yellowprow goby	GOBIIDAE	Gobies	ml
GYM FUNE	<i>Gymnothorax funebris</i>	Green moray	MURAENIDAE	Morays	ml
GYM MORI	<i>Gymnothorax moringa</i>	Spotted moray	MURAENIDAE	Morays	ML
GYM VICI	<i>Gymnothorax vicinus</i>	Purplemouth moray	MURAENIDAE	Morays	ml
HAE ALBU	<i>Haemulon album</i>	Margate	HAEMULIDAE	Grunts	S
HAE AURO	<i>Haemulon aurolineatum</i>	Tomate	HAEMULIDAE	Grunts	S
HAE FLAV	<i>Haemulon flavolineatum</i>	French grunt	HAEMULIDAE	Grunts	S
HAE MELA	<i>Haemulon melanurum</i>	Cottonwick	HAEMULIDAE	Grunts	S
HAE PLUM	<i>Haemulon plumieri</i>	White grunt	HAEMULIDAE	Grunts	S
HAE SCIU	<i>Haemulon sciurus</i>	Bluestriped grunt	HAEMULIDAE	Grunts	S
HAE SPE.	<i>Haemulon sp.</i>	Unidentified grunt	HAEMULIDAE	Grunts	
HAE STRI	<i>Haemulon striatum</i>	Striped grunt	HAEMULIDAE	Grunts	
HAL BIVI	<i>Halichoeres bivittatus</i>	Slippery dick	LABRIDAE	Wrasses	ml
HAL GARN	<i>Halichoeres garnoti</i>	Yellowhead wrasse	LABRIDAE	Wrasses	ML
HAL MACU	<i>Halichoeres maculipinna</i>	Clown wrasse	LABRIDAE	Wrasses	ML
HAL RAD1	<i>Halichoeres radiatus</i>	Puddingwife	LABRIDAE	Wrasses	ML
HAL SPE.	<i>Halichoeres sp.</i>	Unid. wrasse	LABRIDAE	Wrasses	
HEM NOVA	<i>Hemipteronotus novacula</i>	Pearly razorfish	LABRIDAE	Wrasses	ml
HEM SPLE	<i>Hemipteronotus splendens</i>	Green razorfish	LABRIDAE	Wrasses	ml
HOL ASCE	<i>Holocentrus ascensionis</i>	Squirrelfish	HOLOCENTRIDAE	Squirrelfishes	ml
HOL BERM	<i>Holacanthus bermudensis</i>	Blue angelfish	POMACANTHIDAE	Angelfishes	ML
HOL CILI	<i>Holacanthus ciliaris</i>	Queen angelfish	POMACANTHIDAE	Angelfishes	ML
HOL CORU	<i>Holocentrus coruscus</i>	Reef squirrelfish	HOLOCENTRIDAE	Squirrelfishes	ml
HOL MARI	<i>Holocentrus marianus</i>	Longjaw squirrelfish	HOLOCENTRIDAE	Squirrelfishes	ml
HOL RUFU	<i>Holocentrus rufus</i>	Longspine squirrelfish	HOLOCENTRIDAE	Squirrelfishes	ml
HOL TRIC	<i>Holacanthus tricolor</i>	Rock beauty	POMACANTHIDAE	Angelfishes	ML
HYP BERM	<i>Hypleurochilus bermudensis</i>	Barred blenny	BLENNIIDAE	Combtooth blennies	ml
HYP GEMM	<i>Hypoplectrus gemma</i> ‡	Blue hamlet	SERRANIDAE	Sea basses	ml
HYP NIGR	<i>Hypoplectrus nigricans</i> ‡	Black hamlet	SERRANIDAE	Sea basses	ml
HYP PUEL	<i>Hypoplectrus puella</i> ‡	Barred hamlet	SERRANIDAE	Sea basses	ml
HYP UNIC	<i>Hypoplectrus unicolor</i>	Butter hamlet	SERRANIDAE	Sea basses	ml
IOG CALL	<i>Ioglossus calliurus</i>	Blue goby	GOBIIDAE	Gobies	
IOG HELE	<i>Ioglossus helenae</i>	Hovering goby	GOBIIDAE	Gobies	ml
LAC BICA	<i>Lactophrys bicaudalis</i>	Spotted trunkfish	OSTRACIIDAE	Boxfishes	ml
LAC MAXI	<i>Lachnolaimus maximus</i>	Hogfish	LABRIDAE	Wrasses	P,R
LAC QUAD	<i>Lactophrys quadricornis</i>	Scrawled cowfish	OSTRACIIDAE	Boxfishes	ml
LUT ANAL	<i>Lutjanus analis</i>	Mutton snapper	LUTJANIDAE	Snappers	P,R
LUT APOD	<i>Lutjanus apodus</i>	Schoolmaster	LUTJANIDAE	Snappers	P,R

Table 6. One hundred and fifty-three species censused on all natural reefs from July 1988 to May 1990.

SPCODE	SCIENTIFIC NAME	COMMON NAME	FAMILY	FAMILY NAME	VALUE
LUT BUCC	Lutjanus buccanella	Blackfin snapper	LUTJANIDAE	Snappers	P,R
LUT GRIS	Lutjanus griseus	Gray snapper	LUTJANIDAE	Snappers	P,R
LUT SYNA	Lutjanus synagris	Lane snapper	LUTJANIDAE	Snappers	P,R
MAL PLUM	Malacanthus plumieri	Sand tilefish	MALACANTHIDAE	Tilefishes	S,R
MAL TRIA	Malacoctenus triangulatus	Saddled blenny	CLINIDAE	Clinids	ML
MIC CHRY	Microspathodon chrysurus	Yellowtail damselfish	POMACENTRIDAE	Damselfishes	ML
MON CILI	Monacanthus ciliatus	Fringed filefish	BALISTIDAE	Leather jackets	ml
MON HISP	Monacanthus hispidus	Planehead filefish	BALISTIDAE	Leather jackets	ml
MON SETI	Monacanthus setifer	Pygmy filefish	BALISTIDAE	Leather jackets	ml
MON SPE.	Monacanthus sp.	Unid. filefish	BALISTIDAE	Leather jackets	ml
MON TUCK	Monacanthus tuckeri	Slender filefish	BALISTIDAE	Leather jackets	ml
MUL MART	Mulloidichthys martinicus	Yellow goatfish	MULLIDAE	Goatfishes	S
MUR MILI	Muraena miliaris	Goldentail moray	MURAENIDAE	Morays	ml
MYC BONA	Mycteroperca bonaci	Black grouper	SERRANIDAE	Sea basses	P,R
MYC MICR	Mycteroperca microlepis	Gag	SERRANIDAE	Sea basses	P,R
MYC SPE.	Mycteroperca sp.	Unid. grouper	SERRANIDAE	Sea basses	P,R
OCY CHRY	Ocyurus chrysurus	Yellowtail snapper	LUTJANIDAE	Snappers	P,R
ODO DENT	Odontoscion dentex	Reef croaker	SCIAENIDAE	Drums	
OPI AURI	Opistognathus aurifrons	Yellowhead jawfish	OPISTOGNATHIDAE	Jawfishes	ML
PAR MARM	Parablennius marmoreus	Seaweed blenny	BLENNIIDAE	Blennies	ML
PEM SCHO	Pempheris schomburgki	Glassy sweeper	PEMPHERIDAE	Sweepers	
POM ARCU	Pomacanthus arcuatus	Gray angelfish	POMACANTHIDAE	Angelfishes	ML
POM DIEN	Pomacentrus dieneae	Longfin damselfish	POMACENTRIDAE	Damselfishes	ML
POM FUSC	Pomacentrus fuscus	Dusky damselfish	POMACENTRIDAE	Damselfishes	ml
POM LEUC	Pomacentrus leucostictus	Beaugregory	POMACENTRIDAE	Damselfishes	ML
POM PART	Pomacentrus partitus	Bicolor damselfish	POMACENTRIDAE	Damselfishes	ML
POM PARU	Pomacanthus paru	French angelfish	POMACANTHIDAE	Angelfishes	ML
POM PLAN	Pomacentrus planifrons	Three spot damselfish	POMACENTRIDAE	Damselfishes	ML
POM VARI	Pomacentrus variabilis	Cocoa damselfish	POMACENTRIDAE	Damselfishes	ML
PSE MACU	Pseudupeneus maculatus	Spotted goatfish	MULLIDAE	Goatfishes	ml
RYP SAPO	Rypticus saponaceus	Greater soapfish	GRAMMISTIDAE	Soapfishes	
SCA COEL	Scarus coelestinus	Midnight parrotfish	SCARIDAE	Parrotfishes	ml
SCA COER	Scarus coeruleus	Blue parrotfish	SCARIDAE	Parrotfishes	ml
SCA CRIS	Scartella cristata	Molly miller	BLENNIIDAE	Combtooth blennies	ML
SCA CROI	Scarus croicensis	Striped parrotfish	SCARIDAE	Parrotfishes	ML
SCA GUAC	Scarus guacamaia	Rainbow parrotfish	SCARIDAE	Parrotfishes	ml
SCA SPE.	Scarus sp.	Unid. parrotfish	SCARIDAE	Parrotfishes	ml
SCA TAEN	Scarus taeniopterus	Princess parrotfish	SCARIDAE	Parrotfishes	ml
SCA VETU	Scarus vetula	Queen parrotfish	SCARIDAE	Parrotfishes	ml
SCO MACU	Scomberomorus maculatus	Spanish mackerel	SCOMBRIDAE	Mackerels/Tunas	P,R
SCO PLUM	Scorpaena plumieri	Scorpion fish	SCORPAENIDAE	Scorpionfishes	ml
SCO REGA	Scomberomorus regalis	Cero mackerel	SCOMBRIDAE	Mackerels/Tunas	P,R
SER BALD	Serranus baldwini	Lanternfish	SERRANIDAE	Sea basses	ML
SER DUME	Seriola dumerili	Greater amberjack	CARANGIDAE	Jacks	P,R
SER TABA	Serranus tabacarius	Tobaccofish	SERRANIDAE	Sea basses	ML
SER TIGR	Serranus tigrinus	Harlequin bass	SERRANIDAE	Sea basses	ML
SPA AURO	Sparisoma aurofrenatum	Redband parrotfish	SCARIDAE	Parrotfishes	ML
SPA CHRY	Sparisoma chrysotermum	Redtail parrotfish	SCARIDAE	Parrotfishes	ml
SPA RAD1	Sparisoma radians	Bucktooth parrotfish	SCARIDAE	Parrotfishes	ml

Table 6. One hundred and fifty-three species censused on all natural reefs from July 1988 to May 1990.

SPCODE	SCIENTIFIC NAME	COMMON NAME	FAMILY	FAMILY NAME	VALUE ¹
SPA SPE.	Sparisoma sp.	Unid. parrotfish	SCARIDAE	Parrotfishes	ml
SPA VIRI	Sparisoma viride	Stoplight parrotfish	SCARIDAE	Parrotfishes	ml
SPH BARR	Sphyaena barracuda	Barracuda	SPHYRAENIDAE	Barracudas	R
SPH PICU	Sphyaena picudilla	Southern sennet	SPHYRAENIDAE	Barracudas	
SYN FOET	Synodus foetens	Inshore lizardfish	SYNODONTIDAE	Lizardfishes	
SYN SPE.	Synodus sp.	Unid. lizardfish	SYNODONTIDAE	Lizardfishes	
THA BIFA	Thalassoma bifasciatum	Bluehead	LABRIDAE	Wrasses	ML
TRA GOOD	Trachinotus goodei	Palometa	CARANGIDAE	Jacks	
URO JAMA	Urolophus jamaicensis	Yellow stingray	DASYATIDAE	Stingrays	ml

¹ Economic value: P, primary commercial; S, secondary commercial; R, recreational;
 ML, primary marine life; ml, secondary marine life
 # = color variant of *M. unicolor*

Table 7. Summary of monitoring at shallow fabricated unit 1 (SAR1) from June 1988 - June 1990.

Species	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=14)	%			High	Low	Mean	Min.	Max.
ACA BAH1	21	7	50.0%	1.50	2.44	8	0	7.3	2	18
ACA CHIR	32	8	57.1%	2.29	2.92	10	0	13.3	4	28
ACA COER	16	13	92.9%	1.14	0.53	2	0	9.3	3	18
ANI VIRG	27	8	57.1%	1.93	3.22	11	0	6.9	1	25
APO PSEU	16	7	50.0%	1.14	1.88	7	0	4.6	3	6
BOD RUFU	4	2	14.3%	0.29	0.83	3	0	3.8	3	5
CAN ROST	23	7	50.0%	1.64	1.91	5	0	4.7	1	8
CAR BART	2	1	7.1%	0.14	0.53	2	0	30.0	30	30
CHA SEDE	1	1	7.1%	0.07	0.27	1	0	3.0	3	3
CHR MULT	1	1	7.1%	0.07	0.27	1	0	3.0	3	3
DIP FORM	1	1	7.1%	0.07	0.27	1	0	10.0	10	10
ECH NAUC	2	1	7.1%	0.14	0.53	2	0	15.0	15	15
EMB PAND	1	1	7.1%	0.07	0.27	1	0	4.0	4	4
EPI ADSC	4	4	28.6%	0.29	0.47	1	0	11.5	8	15
EPI CRUE	1	1	7.1%	0.07	0.27	1	0	15.0	15	15
EQU ACUM	1	1	7.1%	0.07	0.27	1	0	2.0	2	2
GIN CIRR	1	1	7.1%	0.07	0.27	1	0	160.0	160	160
GOB OCEA	2	1	7.1%	0.14	0.53	2	0	4.0	3	5
HAE AURO	30	2	14.3%	2.14	5.79	20	0	2.0	1	2
HAE MELA	1	1	7.1%	0.07	0.27	1	0	8.0	8	8
HAE SPE.	16	2	14.3%	1.14	4.00	15	0	1.2	1	4
HAE STRI	15	1	7.1%	1.07	4.01	15	0	2.0	1	2
HAL BIVI	113	14	100.0%	8.07	5.58	23	3	7.4	4	12
HAL GARN	2	2	14.3%	0.14	0.36	1	0	2.0	2	2
HAL RAD1	1	1	7.1%	0.07	0.27	1	0	4.0	4	4
HOL CORU	1	1	7.1%	0.07	0.27	1	0	3.0	3	3
HOL SPE.	6	2	14.3%	0.43	1.16	4	0	5.3	4	7
LAC MAXI	2	2	14.3%	0.14	0.36	1	0	27.5	25	30
LAC QUAD	1	1	7.1%	0.07	0.27	1	0	15.0	15	15
MAL TRIA	2	1	7.1%	0.14	0.53	2	0	4.0	4	4
OCY CHRY	1	1	7.1%	0.07	0.27	1	0	7.0	7	7
OPI AURI	5	1	7.1%	0.36	1.34	5	0	5.0	4	6
PAR MARM	28	6	42.9%	2.00	3.21	11	0	3.6	2	6
POM ARCU	22	13	92.9%	1.57	0.65	2	0	31.5	25	40
POM PART	2	2	14.3%	0.14	0.36	1	0	4.5	4	5
SCA CRIS	1	1	7.1%	0.07	0.27	1	0	4.0	4	4
SYN FOET	1	1	7.1%	0.07	0.27	1	0	7.0	7	7
THA BIFA	232	13	92.9%	16.57	9.01	31	0	4.5	1	10

NO. SAMPLES = 14
 NO. SPECIES = 38
 TOT. INDIVIDUALS = 638

Table 8. Summary of monitoring at shallow fabricated unit 2 (SAR2) from June 1988 - June 1990.

Species	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=14)	%			High	Low	Mean	Min.	Max.
ABU SAXA	1	1	7.1%	0.07	0.27	1	0	3.0	3	3
ACA BAH1	11	4	28.6%	0.79	1.48	4	0	5.8	3	8
ACA CHIR	20	9	64.3%	1.43	1.40	4	0	15.1	3	30
ACA COER	10	2	14.3%	0.71	1.98	7	0	5.0	4	6
ANI VIRG	22	10	71.4%	1.57	1.45	4	0	5.8	1	28
APO PSEU	9	5	35.7%	0.64	1.15	4	0	3.9	3	4
BOD RUFU	1	1	7.1%	0.07	0.27	1	0	4.0	4	4
CAL CALA	1	1	7.1%	0.07	0.27	1	0	40.0	40	40
CAN ROST	19	11	78.6%	1.36	1.34	5	0	3.5	2	6
CHA SEDE	1	1	7.1%	0.07	0.27	1	0	4.0	4	4
CHR ENCH	1	1	7.1%	0.07	0.27	1	0	2.0	2	2
CHR MULT	5	4	28.6%	0.36	0.63	2	0	4.2	2	5
CHR SCOT	1	1	7.1%	0.07	0.27	1	0	1.0	1	1
COR GLAU	1	1	7.1%	0.07	0.27	1	0	3.0	3	3
DIP FORM	2	1	7.1%	0.14	0.53	2	0	7.0	6	8
ECH NAUC	1	1	7.1%	0.07	0.27	1	0	25.0	25	25
EMB PAND	1	1	7.1%	0.07	0.27	1	0	2.0	2	2
EQU ACUM	1	1	7.1%	0.07	0.27	1	0	4.0	4	4
GIN CIRRR	1	1	7.1%	0.07	0.27	1	0	266.0	266	266
GOB OCEA	4	2	14.3%	0.29	0.83	3	0	3.8	3	5
HAE AURO	5	1	7.1%	0.36	1.34	5	0	1.0	1	1
HAE SPE.	50	1	7.1%	3.57	13.36	50	0	1.0	1	1
HAL BIVI	134	13	92.9%	9.57	4.22	16	0	6.4	2	12
HAL GARN	1	1	7.1%	0.07	0.27	1	0	3.0	3	3
HAL RAD1	5	4	28.6%	0.36	0.63	2	0	6.4	4	8
HEM SPE.	5	2	14.3%	0.36	1.08	4	0	5.8	4	8
LAC MAXI	4	4	28.6%	0.29	0.47	1	0	25.0	20	30
MAL TRIA	5	3	21.4%	0.36	0.74	2	0	4.0	2	5
MON SPE.	1	1	7.1%	0.07	0.27	1	0	5.0	5	5
MYC MICR	1	1	7.1%	0.07	0.27	1	0	80.0	80	80
MYC SPE.	2	2	14.3%	0.14	0.36	1	0	5.0	5	5
OCY CHRY	1	1	7.1%	0.07	0.27	1	0	5.0	5	5
OPI AURI	2	1	7.1%	0.14	0.53	2	0	6.0	6	7
PAR MARM	39	10	71.4%	2.79	2.58	7	0	3.8	2	6
POM ARCU	10	6	42.9%	0.71	0.91	2	0	33.2	30	35
POM PART	22	5	35.7%	1.57	2.90	9	0	3.2	1	6
POM VARI	1	1	7.1%	0.07	0.27	1	0	2.0	2	2
SCA CRIS	2	2	14.3%	0.14	0.36	1	0	5.0	5	5
SCA CROI	2	1	7.1%	0.14	0.53	2	0	2.0	1	2
SCA SPE.	4	1	7.1%	0.29	1.07	4	0	3.0	2	4
SER TIGR	1	1	7.1%	0.07	0.27	1	0	3.0	3	3
THA BIFA	270	13	92.9%	19.29	13.60	40	0	4.2	1	8
URO JAMA	1	1	7.1%	0.07	0.27	1	0	25.0	25	25

NO. SAMPLES = 14
 NO. SPECIES = 43
 TOT. INDIVIDUALS = 681

Table 9. Summary of monitoring on shallow fabricated unit 3 (SAR3) from June 1988 - June 1990.

Species	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=14)	%			High	Low	Mean	Min.	Max.
ABU SAXA	1	1	7.1%	0.07	0.27	1	0	4.0	4	4
ACA BAH1	36	13	92.9%	2.57	2.24	8	0	10.9	3	26
ACA CHIR	27	9	64.3%	1.93	2.23	8	0	15.4	4	25
ACA COER	16	6	42.9%	1.14	1.61	4	0	6.3	2	18
ANI VIRG	12	8	57.1%	0.86	0.86	2	0	19.8	4	28
APD PSEU	35	11	78.6%	2.50	2.62	9	0	3.5	2	6
AST STEL	1	1	7.1%	0.07	0.27	1	0	5.0	5	5
CAN ROST	17	10	71.4%	1.21	1.31	4	0	3.6	1	6
CAR RUBE	6	3	21.4%	0.43	0.94	3	0	18.0	8	30
CHA OCEL	12	6	42.9%	0.86	1.03	2	0	12.8	10	18
CHA SEDE	1	1	7.1%	0.07	0.27	1	0	3.0	3	3
CHR MULT	1	1	7.1%	0.07	0.27	1	0	6.0	6	6
COR GLAU	1	1	7.1%	0.07	0.27	1	0	4.0	4	4
DIP FORM	2	2	14.3%	0.14	0.36	1	0	10.0	8	12
EMB PAND	2	2	14.3%	0.14	0.36	1	0	4.5	4	5
EPI CRUE	1	1	7.1%	0.07	0.27	1	0	3.0	3	3
GIN CIRR	1	1	7.1%	0.07	0.27	1	0	190.0	190	190
GOB OCEA	3	2	14.3%	0.21	0.58	2	0	3.7	3	4
HAE ALBU	1	1	7.1%	0.07	0.27	1	0	40.0	40	40
HAE AURO	29	3	21.4%	2.07	6.91	26	0	2.3	1	6
HAE MELA	3	3	21.4%	0.21	0.43	1	0	5.7	4	7
HAE PLUM	1	1	7.1%	0.07	0.27	1	0	5.0	5	5
HAE SPE.	16	5	35.7%	1.14	1.79	5	0	3.7	1	6
HAE STRI	1	1	7.1%	0.07	0.27	1	0	6.0	6	6
HAL BIVI	142	13	92.9%	10.14	5.68	20	0	6.7	2	12
HAL RAD1	2	2	14.3%	0.14	0.36	1	0	3.5	3	4
HEM SPE.	2	1	7.1%	0.14	0.53	2	0	4.0	3	5
HOL BERM	3	3	21.4%	0.21	0.43	1	0	23.7	1	35
HOL CILI	1	1	7.1%	0.07	0.27	1	0	28.0	28	28
HOL MARI	3	1	7.1%	0.21	0.80	3	0	6.0	6	6
LAC BICA	1	1	7.1%	0.07	0.27	1	0	6.0	6	6
LAC MAXI	9	7	50.0%	0.64	0.74	2	0	26.1	15	35
LUT ANAL	3	3	21.4%	0.21	0.43	1	0	38.3	35	40
MAL SPE.	2	1	7.1%	0.14	0.53	2	0	3.0	3	3
MAL TRIA	1	1	7.1%	0.07	0.27	1	0	4.0	4	4
PAR MARM	32	8	57.1%	2.29	2.64	7	0	3.9	2	5
POM ARCU	14	10	71.4%	1.00	0.78	2	0	29.9	2	40
POM LEUC	2	1	7.1%	0.14	0.53	2	0	3.0	3	4
POM PART	7	4	28.6%	0.50	0.94	3	0	1.9	1	3
POM PARU	1	1	7.1%	0.07	0.27	1	0	30.0	30	30
POM VARI	3	3	21.4%	0.21	0.43	1	0	3.0	1	5
SCA CRIS	5	3	21.4%	0.36	0.74	2	0	4.2	3	5
SPH BARR	1	1	7.1%	0.07	0.27	1	0	4.0	4	4
SYN INTE	1	1	7.1%	0.07	0.27	1	0	10.0	10	10
THA BIFA	222	13	92.9%	15.86	10.06	38	0	4.5	1	8

Table 9. Summary of monitoring on shallow fabricated unit 3 (SAR3) from June 1988 - June 1990.

Species	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=14)	%			High	Low	Mean	Min.	Max.
		=====								
=====										
NO. SAMPLES	=	14								
NO. SPECIES	=	45								
TOT. INDIVIDUALS	=	683								

Table 10. Combined summary of monitoring on 3 shallow fabricated units from June 1988 - June 1990.

Species	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=42)	%			High	Low	Mean	Min.	Max.
ABU SAXA	2	2	4.8%	0.05	0.22	1	0	3.5	3	4
ACA BAH1	68	24	57.1%	1.62	2.17	8	0	9.0	2	26
ACA CHIR	79	26	61.9%	1.88	2.24	10	0	14.5	3	30
ACA COER	42	21	50.0%	1.00	1.48	7	0	7.1	2	18
ANI VIRG	61	26	61.9%	1.45	2.10	11	0	9.0	1	28
APO PSEU	60	23	54.8%	1.43	2.09	9	0	3.8	2	6
AST STEL	1	1	2.4%	0.02	0.15	1	0	5.0	5	5
BLE CRIS	8	6	14.3%	0.19	0.51	2	0	4.4	3	5
BOD RUFU	5	3	7.1%	0.12	0.50	3	0	3.8	3	5
CAL CALA	1	1	2.4%	0.02	0.15	1	0	40.0	40	40
CAN ROST	59	28	66.7%	1.40	1.52	5	0	4.0	1	8
CAR BART	2	1	2.4%	0.05	0.31	2	0	30.0	30	30
CAR RUBE	6	3	7.1%	0.14	0.57	3	0	18.0	8	30
CHA OCEL	12	6	14.3%	0.29	0.71	2	0	12.8	10	18
CHA SEDE	3	3	7.1%	0.07	0.26	1	0	3.3	3	4
CHR ENCH	1	1	2.4%	0.02	0.15	1	0	2.0	2	2
CHR MULT	7	6	14.3%	0.17	0.44	2	0	4.3	2	6
CHR SCOT	1	1	2.4%	0.02	0.15	1	0	1.0	1	1
COR GLAU	2	2	4.8%	0.05	0.22	1	0	3.5	3	4
DIP FORM	5	4	9.5%	0.12	0.40	2	0	8.8	6	12
ECH NAUC	3	2	4.8%	0.07	0.34	2	0	18.3	15	25
EMB PAND	4	4	9.5%	0.10	0.30	1	0	3.8	2	5
EPI ADSC	4	4	9.5%	0.10	0.30	1	0	11.5	8	15
EPI CRUE	2	2	4.8%	0.05	0.22	1	0	9.0	3	15
EQU ACUM	2	2	4.8%	0.05	0.22	1	0	3.0	2	4
GIN CIRRR	3	3	7.1%	0.07	0.26	1	0	205.3	160	266
GOB OCEA	9	5	11.9%	0.21	0.65	3	0	3.8	3	5
HAE ALBU	1	1	2.4%	0.02	0.15	1	0	40.0	40	40
HAE AURO	64	6	14.3%	1.52	5.20	26	0	2.1	1	6
HAE MELA	4	4	9.5%	0.10	0.30	1	0	6.3	4	8
HAE PLUM	1	1	2.4%	0.02	0.15	1	0	5.0	5	5
HAE SPE.	82	8	19.0%	1.95	8.00	50	0	1.6	1	6
HAE STRI	16	2	4.8%	0.38	2.32	15	0	2.3	1	6
HAL BIVI	389	40	95.2%	9.26	5.15	23	0	6.8	2	12
HAL GARN	3	3	7.1%	0.07	0.26	1	0	2.3	2	3
HAL RAD1	8	7	16.7%	0.19	0.45	2	0	5.4	3	8
HEM SPE.	7	3	7.1%	0.17	0.70	4	0	5.3	3	8
HOL BERM	3	3	7.1%	0.07	0.26	1	0	23.7	1	35
HOL CILI	1	1	2.4%	0.02	0.15	1	0	28.0	28	28
HOL CORU	1	1	2.4%	0.02	0.15	1	0	3.0	3	3
HOL MARI	3	1	2.4%	0.07	0.46	3	0	6.0	6	6
HOL SPE.	6	2	4.8%	0.14	0.68	4	0	5.3	4	7
LAC BICA	1	1	2.4%	0.02	0.15	1	0	6.0	6	6
LAC MAXI	15	13	31.0%	0.36	0.58	2	0	26.0	15	35
LAC QUAD	1	1	2.4%	0.02	0.15	1	0	15.0	15	15
LUT ANAL	3	3	7.1%	0.07	0.26	1	0	38.3	35	40
MAL SPE.	2	1	2.4%	0.05	0.31	2	0	3.0	3	3

Table 10. Combined summary of monitoring on 3 shallow fabricated units from June 1988 - June 1990.

Species	Total Indiv.	SAMPLE FREQUENCY			Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=42)	%	Mean Abund.		High	Low	Mean	Min.	Max.
MAL TRIA	8	5	11.9%	0.19	0.55	2	0	4.0	2	5
MON SPE.	1	1	2.4%	0.02	0.15	1	0	5.0	5	5
MYC MICR	1	1	2.4%	0.02	0.15	1	0	80.0	80	80
MYC SPE.	2	2	4.8%	0.05	0.22	1	0	5.0	5	5
OCY CHRY	2	2	4.8%	0.05	0.22	1	0	6.0	5	7
OPI AURI	7	2	4.8%	0.17	0.82	5	0	5.3	4	7
PAR MARM	99	24	57.1%	2.36	2.77	11	0	3.8	2	6
POM ARCU	46	29	69.0%	1.10	0.85	2	0	31.4	2	40
POM LEUC	2	1	2.4%	0.05	0.31	2	0	3.0	3	4
POM PART	31	11	26.2%	0.74	1.84	9	0	3.0	1	6
POM PARU	1	1	2.4%	0.02	0.15	1	0	30.0	30	30
POM VARI	4	4	9.5%	0.10	0.30	1	0	2.8	1	5
SCA CROI	2	1	2.4%	0.05	0.31	2	0	2.0	1	2
SCA SPE.	4	1	2.4%	0.10	0.62	4	0	3.0	2	4
SER TIGR	1	1	2.4%	0.02	0.15	1	0	3.0	3	3
SPH BARR	1	1	2.4%	0.02	0.15	1	0	4.0	4	4
SYN FOET	1	1	2.4%	0.02	0.15	1	0	7.0	7	7
SYN INTE	1	1	2.4%	0.02	0.15	1	0	10.0	10	10
THA BIFA	724	39	92.9%	17.24	10.90	40	0	4.4	1	10
URO JAMA	1	1	2.4%	0.02	0.15	1	0	25.0	25	25

NO. SAMPLES = 42
 NO. SPECIES = 67
 TOT. INDIVIDUALS = 2002

Table 11. Percent of species shared by artificial reefs (AR), between artificial reefs and natural reefs (NR), and between prefabricated units and bridge rubble sites. Censuses conducted June 1988 - June 1990.

Reefs compared	% shared of total species
SAR1 and SAR2	53% (28/53)
SAR1 and SAR3	43% (25/58)
SAR2 and SAR3	40% (25/63)
All SAR	33% (22/67)
MAR1 and MAR2	55% (40/73)
DAR1 and DAR2	59% (41/69)
AMS and BH	57% (59/103)

Reefs compared	% shared of total species	% of AR species shared with NR	AR species as % of total	% of NR species at AR
SARC to SNR	44% (52/119)	78% (52/67)	56% (67/119)	50% (52/104)
MARC to MNR	44% (57/130)	78% (57/73)	56% (73/130)	50% (57/114)
DARC to DNR	42% (52/125)	75% (52/69)	55% (69/125)	48% (52/109)
HAWKC to MNR	55% (77/140)	75% (77/103)	74% (103/140)	68% (77/114)

Reefs compared	% shared of total species	% of MARC species shared with HAWKC	% of total at MARC	% of HAWKC species at MARC
MARC to HAWKC	42% (52/124)	71% (52/73)	59% (73/124)	50% (52/103)

Table 12. Summary of censuses on the shallow natural reef (SNR) from July 1988 - April 1990.

Species	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=111)	%			High	Low	Mean	Min.	Max.
ABU SAXA	10	7	6.3%	0.09	0.39	3	0			
ACA BAH1	381	91	82.0%	3.43	2.88	12	0	6.9	3	12
ACA CHIR	253	74	66.7%	2.28	2.80	15	0	13.7	3	25
ACA COER	1011	95	85.6%	9.11	16.34	110	0	13.4	3	25
ALU SCRI	1	1	0.9%	0.01	0.09	1	0	19.2	3	40
AMB PINO	3	2	1.8%	0.03	0.21	2	0	25.0	25	25
ANI VIRG	130	38	34.2%	1.17	3.62	27	0	5.0	5	5
AUL MACU	8	4	3.6%	0.07	0.40	3	0	18.0	4	40
BOD RUFU	13	9	8.1%	0.12	0.42	2	0	30.1	10	50
CAL BAJO	1	1	0.9%	0.01	0.09	1	0	6.2	2	12
CAL CALA	99	51	45.9%	0.89	1.27	5	0	20.0	20	20
CAN PULL	1	1	0.9%	0.01	0.09	1	0	18.7	4	28
CAN ROST	75	49	44.1%	0.68	0.91	4	0	8.0	8	8
CAR BART	8	6	5.4%	0.07	0.32	2	0	5.6	2	10
CAR CRY5	10	4	3.6%	0.09	0.56	5	0	29.5	16	50
CAR LATU	1	1	0.9%	0.01	0.09	1	0	24.3	15	28
CAR RUBE	31	5	4.5%	0.28	1.54	10	0	45.0	45	45
CHA CAPI	228	94	84.7%	2.05	1.34	6	0	19.7	5	35
CHA OCEL	38	18	16.2%	0.34	0.85	4	0	7.8	3	12
CHA SEDE	26	22	19.8%	0.23	0.50	2	0	12.3	5	18
CHA STRI	36	23	20.7%	0.32	0.68	2	0	6.5	3	12
CHR CYAN	24	10	9.0%	0.22	1.00	9	0	11.5	6	15
CHR MULT	2	1	0.9%	0.02	0.19	2	0	4.5	2	10
CHR SCOT	1	1	0.9%	0.01	0.09	1	0	5.0	5	5
COR GLAU	24	10	9.0%	0.22	0.81	5	0	4.0	4	4
DIO HOLO	10	10	9.0%	0.09	0.29	1	0	4.6	4	6
DIO HYST	3	3	2.7%	0.03	0.16	1	0	12.6	10	18
ECH NAUC	1	1	0.9%	0.01	0.09	1	0	18.0	14	20
EPI ADSC	15	12	10.8%	0.14	0.44	3	0	6.0	6	6
EPI CRUE	35	26	23.4%	0.32	0.67	4	0	19.9	6	40
EPI FULV	5	5	4.5%	0.05	0.21	1	0	13.8	7	20
EPI GUTT	4	4	3.6%	0.04	0.19	1	0	16.8	6	30
EPI STRI	1	1	0.9%	0.01	0.09	1	0	13.5	11	16
EQU ACUM	103	14	12.6%	0.93	5.84	56	0	30.0	30	30
GIN CIRRR	1	1	0.9%	0.01	0.09	1	0	11.2	7	14
GOB OCEA	81	14	12.6%	0.73	2.95	25	0	80.0	80	80
GYM FUNE	1	1	0.9%	0.01	0.09	1	0	3.0	2	5
GYM MORI	3	3	2.7%	0.03	0.16	1	0	110.0	110	110
HAE AURO	806	16	14.4%	7.26	35.65	300	0	41.7	40	45
HAE FLAV	82	7	6.3%	0.74	4.32	40	0	3.8	2	10
HAE MELA	135	9	8.1%	1.22	5.27	35	0	5.9	3	15
HAE PLUM	1821	80	72.1%	16.41	28.99	120	0	15.0	4	25
HAE SCIU	634	38	34.2%	5.71	15.14	100	0	16.3	2	30
HAE SPE.	135	2	1.8%	1.22	10.03	100	0	19.4	10	35
HAE STRI	213	2	1.8%	1.92	19.01	200	0	4.3	3	6
HAL BIVI	484	76	68.5%	4.36	4.24	18	0	4.2	3	25
HAL GARN	660	105	94.6%	5.95	5.03	40	0	7.4	3	12
								7.6	2	18

Table 12. Summary of censuses on the shallow natural reef (SNR) from July 1988 - April 1990.

Species	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=111)	%			High	Low	Mean	Min.	Max.
HAL MACU	139	59	53.2%	1.25	1.50	6	0	8.1	3	13
HAL RAD1	45	35	31.5%	0.41	0.78	6	0	6.3	4	15
HAL SPE.	8	4	3.6%	0.07	0.44	4	0	10.5	4	18
HEM NOVA	1	1	0.9%	0.01	0.09	1	0	5.0	5	5
HEM SPLE	2	1	0.9%	0.02	0.19	2	0	6.0	6	6
HOL BERM	63	43	38.7%	0.57	0.85	4	0	27.9	15	40
HOL CILI	23	18	16.2%	0.21	0.51	2	0	22.9	5	30
HOL TRIC	73	41	36.9%	0.66	1.00	4	0	8.6	2	18
HYP BERM	1	1	0.9%	0.01	0.09	1	0	6.0	6	6
HYP GEMM #	3	3	2.7%	0.03	0.16	1	0	7.7	6	10
HYP NIGR #	1	1	0.9%	0.01	0.09	1	0	10.0	10	10
HYP PUEL #	5	5	4.5%	0.05	0.21	1	0	6.4	5	8
HYP UNIC	13	10	9.0%	0.12	0.40	2	0	6.5	4	9
IOG CALL	1	1	0.9%	0.01	0.09	1	0	5.0	5	5
IOG HELE	2	1	0.9%	0.02	0.19	2	0	4.0	4	4
LAC BICA	7	7	6.3%	0.06	0.24	1	0	11.7	2	18
LAC MAXI	89	53	47.7%	0.80	1.36	11	0	21.5	10	40
LAC QUAD	6	6	5.4%	0.05	0.23	1	0	30.0	25	40
LUT ANAL	1	1	0.9%	0.01	0.09	1	0	40.0	40	40
MAL TRIA	8	6	5.4%	0.07	0.35	3	0	4.6	4	6
MIC CHRY	5	5	4.5%	0.05	0.21	1	0	8.0	7	11
MON CILI	1	1	0.9%	0.01	0.09	1	0	15.0	15	15
MON SETI	1	1	0.9%	0.01	0.09	1	0	15.0	15	15
MON SPE.	1	1	0.9%	0.01	0.09	1	0	25.0	25	25
MON TUCK	5	5	4.5%	0.05	0.21	1	0	4.6	3	6
MUL MART	1	1	0.9%	0.01	0.09	1	0	16.0	16	16
MUR MILI	2	2	1.8%	0.02	0.13	1	0	35.0	30	40
MYC BONA	19	17	15.3%	0.17	0.44	3	0	36.3	20	50
MYC MICR	1	1	0.9%	0.01	0.09	1	0	45.0	45	45
OCY CHRY	103	28	25.2%	0.93	2.80	20	0	12.7	3	30
OPI AURI	51	16	14.4%	0.46	1.59	12	0	5.9	4	8
POM ARCU	68	43	38.7%	0.61	0.85	3	0	28.5	3	38
POM DIEN	5	4	3.6%	0.05	0.25	2	0	4.0	1	7
POM FUSC	13	10	9.0%	0.12	0.40	2	0	6.2	4	8
POM LEUC	5	5	4.5%	0.05	0.21	1	0	6.4	4	8
POM PART	4493	104	93.7%	40.48	22.67	103	0	4.4	2	8
POM PARU	10	9	8.1%	0.09	0.32	2	0	23.7	1	35
POM PLAN	22	13	11.7%	0.20	0.77	7	0	4.7	2	10
POM VARI	150	78	70.3%	1.35	1.24	6	0	4.9	2	9
PSE MACU	62	31	27.9%	0.56	1.15	6	0	12.1	6	20
SCA COER	1	1	0.9%	0.01	0.09	1	0	5.0	5	5
SCA CROI	538	106	95.5%	4.85	4.30	27	0	7.1	2	18
SCA GUAC	40	14	12.6%	0.36	1.44	13	0	38.1	15	55
SCA SPE.	23	6	5.4%	0.21	1.05	8	0	5.5	4	10
SCA VETU	15	8	7.2%	0.14	0.51	3	0	12.7	6	25
SCO PLUM	1	1	0.9%	0.01	0.09	1	0	30.0	30	30
SCO REGA	12	5	4.5%	0.11	0.59	5	0	35.3	30	40

Table 12. Summary of censuses on the shallow natural reef (SNR) from July 1988 - April 1990.

Species	SAMPLE FREQUENCY			Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
	Total Indiv. (N=111)	%				High	Low	Mean	Min.	Max.
SER BALD	9	7	6.3%	0.08	0.33	2	0	4.9	3	6
SER TABA	1	1	0.9%	0.01	0.09	1	0	5.0	5	5
SER TIGR	142	81	73.0%	1.28	1.10	4	0	7.1	3	10
SPA AURO	231	83	74.8%	2.08	2.06	12	0	9.9	1	28
SPA CHRY	37	18	16.2%	0.33	1.22	11	0	16.2	5	22
SPA RAD1	3	3	2.7%	0.03	0.16	1	0	8.7	8	9
SPA SPE.	9	4	3.6%	0.08	0.47	4	0	6.4	4	18
SPA VIRI	66	41	36.9%	0.59	0.98	6	0	11.3	4	45
SPH BARR	5	4	3.6%	0.05	0.25	2	0	66.8	25	130
SYN FOET	1	1	0.9%	0.01	0.09	1	0	28.0	28	28
SYN SPE.	1	1	0.9%	0.01	0.09	1	0	6.0	6	6
THA BIFA	2731	102	91.9%	24.60	20.88	150	0	6.4	2	12
URO JAMA	15	15	13.5%	0.14	0.34	1	0	28.6	20	35

= color variants of H. unicolor

NO. SAMPLES = 111
 NO. SPECIES = 104
 TOT. INDIVIDUALS = 17038

Table 13. Summary of monitoring on mid-depth fabricated unit 1 (MAR1) from June 1988 - June 1990.

Species	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=16)	%			High	Low	Mean	Min.	Max.
ABU SAXA	13	6	37.5%	0.81	1.28	4	0	8.8	6	12
ACA BAH1	133	15	93.8%	8.31	3.96	15	0	19.1	4	30
ACA CHIR	42	11	68.8%	2.63	3.22	12	0	20.2	10	30
ACA COER	68	16	100.0%	4.25	3.11	12	1	17.2	5	30
ANI VIRG	18	11	68.8%	1.13	0.89	2	0	18.9	15	25
AP0 PSEU	43	8	50.0%	2.69	6.29	24	0	3.1	2	6
AP0 SPE.	2	1	6.3%	0.13	0.50	2	0	6.0	6	6
CAL CALA	1	1	6.3%	0.06	0.25	1	0	16.0	16	16
CAN ROST	42	14	87.5%	2.63	2.09	7	0	5.0	2	10
CAR RUBE	18	5	31.3%	1.13	2.60	10	0	16.4	10	30
CHA OCEL	23	12	75.0%	1.44	0.96	3	0	12.1	6	20
CHA SEDE	23	13	81.3%	1.44	0.89	3	0	8.2	3	12
CHR MULT	1	1	6.3%	0.06	0.25	1	0	2.0	2	2
COR GLAU	126	8	50.0%	7.88	10.26	27	0	3.5	2	5
DEC MACA	150	1	6.3%	9.38	37.50	150	0	17.0	16	18
DEC PUNC	20	2	12.5%	1.25	3.87	15	0	11.5	10	15
DEC SPE.	50	1	6.3%	3.13	12.50	50	0	25.0	25	25
DIP FORM	8	3	18.8%	0.50	1.32	5	0	7.3	3	12
ECH NAUC	1	1	6.3%	0.06	0.25	1	0	8.0	8	8
EPI CRUE	25	13	81.3%	1.56	1.09	4	0	8.9	5	14
EPI GUTT	1	1	6.3%	0.06	0.25	1	0	8.0	8	8
GOB OCEA	3	1	6.3%	0.19	0.75	3	0	4.0	4	4
HAE ALBU	2	2	12.5%	0.13	0.34	1	0	22.0	14	30
HAE AURO	522	4	25.0%	32.63	124.69	500	0	4.1	2	10
HAE FLAV	3	1	6.3%	0.19	0.75	3	0	8.0	8	8
HAE MELA	15	7	43.8%	0.94	1.39	4	0	10.9	6	18
HAE SPE.	14	2	12.5%	0.88	2.50	9	0	4.4	2	6
HAE STRI	306	2	12.5%	19.13	74.91	300	0	5.0	2	8
HAL BIVI	53	12	75.0%	3.31	2.89	10	0	8.7	4	15
HAL GARN	56	6	37.5%	3.50	11.17	45	0	4.3	1	8
HAL RAD1	1	1	6.3%	0.06	0.25	1	0	4.0	4	4
HEM SPLE	3	2	12.5%	0.19	0.54	2	0	8.0	6	12
HOL CILI	2	1	6.3%	0.13	0.50	2	0	2.0	2	2
LAC BICA	2	2	12.5%	0.13	0.34	1	0	16.0	12	20
LAC MAXI	20	11	68.8%	1.25	1.24	4	0	24.1	15	35
LUT BUCC	5	4	25.0%	0.31	0.60	2	0	7.8	2	12
LUT GRIS	1	1	6.3%	0.06	0.25	1	0	40.0	40	40
MAL SPE.	1	1	6.3%	0.06	0.25	1	0	2.0	2	2
MAL TRIA	1	1	6.3%	0.06	0.25	1	0	2.0	2	2
MON HISP	1	1	6.3%	0.06	0.25	1	0	12.0	12	12
MYC BONA	1	1	6.3%	0.06	0.25	1	0	35.0	35	35
OCY CHRY	168	7	43.8%	10.50	25.16	98	0	26.1	15	35
POM ARCU	19	11	68.8%	1.19	0.91	2	0	27.5	20	35
POM PART	30	5	31.3%	1.88	4.56	18	0	2.8	1	4
POM PLAN	1	1	6.3%	0.06	0.25	1	0	1.0	1	1
PSE MACU	5	4	25.0%	0.31	0.60	2	0	8.8	6	10
RYP SAPO	1	1	6.3%	0.06	0.25	1	0	30.0	30	30

Table 13. Summary of monitoring on mid-depth fabricated unit 1 (MAR1) from June 1988 - June 1990.

Species	Total Indiv.	SAMPLE FREQUENCY			Mean Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=16)	%	Abund.		High	Low	Mean	Min.	Max.
ABU SAXA	13	6	37.5%	0.81	1.28	4	0	8.8	6	12
ACA BAH1	133	15	93.8%	8.31	3.96	15	0	19.1	4	30
ACA CHIR	42	11	68.8%	2.63	3.22	12	0	20.2	10	30
ACA COER	68	16	100.0%	4.25	3.11	12	1	17.2	5	30
ANI VIRG	18	11	68.8%	1.13	0.89	2	0	18.9	15	25
APO PSEU	43	8	50.0%	2.69	6.29	24	0	3.1	2	6
APO SPE.	2	1	6.3%	0.13	0.50	2	0	6.0	6	6
CAL CALA	1	1	6.3%	0.06	0.25	1	0	16.0	16	16
CAN ROST	42	14	87.5%	2.63	2.09	7	0	5.0	2	10
CAR RUBE	18	5	31.3%	1.13	2.60	10	0	16.4	10	30
CHA OCEL	23	12	75.0%	1.44	0.96	3	0	12.1	6	20
CHA SEDE	23	13	81.3%	1.44	0.89	3	0	8.2	3	12
CHR MULT	1	1	6.3%	0.06	0.25	1	0	2.0	2	2
COR GLAU	126	8	50.0%	7.88	10.26	27	0	3.5	2	5
DEC MACA	150	1	6.3%	9.38	37.50	150	0	17.0	16	18
DEC PUNC	20	2	12.5%	1.25	3.87	15	0	11.5	10	15
DEC SPE.	50	1	6.3%	3.13	12.50	50	0	25.0	25	25
DIP FORM	8	3	18.8%	0.50	1.32	5	0	7.3	3	12
ECH NAUC	1	1	6.3%	0.06	0.25	1	0	8.0	8	8
EPI CRUE	25	13	81.3%	1.56	1.09	4	0	8.9	5	14
EPI GUTT	1	1	6.3%	0.06	0.25	1	0	8.0	8	8
GOB OCEA	3	1	6.3%	0.19	0.75	3	0	4.0	4	4
HAE ALBU	2	2	12.5%	0.13	0.34	1	0	22.0	14	30
HAE AURO	522	4	25.0%	32.63	124.69	500	0	4.1	2	10
HAE FLAV	3	1	6.3%	0.19	0.75	3	0	8.0	8	8
HAE MELA	15	7	43.8%	0.94	1.39	4	0	10.9	6	18
HAE SPE.	14	2	12.5%	0.88	2.50	9	0	4.4	2	6
HAE STRI	306	2	12.5%	19.13	74.91	300	0	5.0	2	8
HAL BIVI	53	12	75.0%	3.31	2.89	10	0	8.7	4	15
HAL GARN	56	6	37.5%	3.50	11.17	45	0	4.3	1	8
HAL RAD1	1	1	6.3%	0.06	0.25	1	0	4.0	4	4
HEM SPLE	3	2	12.5%	0.19	0.54	2	0	8.0	6	12
HOL CILI	2	1	6.3%	0.13	0.50	2	0	2.0	2	2
LAC BICA	2	2	12.5%	0.13	0.34	1	0	16.0	12	20
LAC MAXI	20	11	68.8%	1.25	1.24	4	0	24.1	15	35
LUT BUCC	5	4	25.0%	0.31	0.60	2	0	7.8	2	12
LUT GRIS	1	1	6.3%	0.06	0.25	1	0	40.0	40	40
MAL SPE.	1	1	6.3%	0.06	0.25	1	0	2.0	2	2
MAL TRIA	1	1	6.3%	0.06	0.25	1	0	2.0	2	2
MON HISP	1	1	6.3%	0.06	0.25	1	0	12.0	12	12
MYC BONA	1	1	6.3%	0.06	0.25	1	0	35.0	35	35
OCY CHRY	168	7	43.8%	10.50	25.16	98	0	26.1	15	35
POM ARCU	19	11	68.8%	1.19	0.91	2	0	27.5	20	35
POM PART	30	5	31.3%	1.88	4.56	18	0	2.8	1	4
POM PLAN	1	1	6.3%	0.06	0.25	1	0	1.0	1	1
PSE MACU	5	4	25.0%	0.31	0.60	2	0	8.8	6	10
RYP SAPO	1	1	6.3%	0.06	0.25	1	0	30.0	30	30

PLATE 13



Table 13. Summary of monitoring on mid-depth fabricated unit 1 (MAR1) from June 1988 - June 1990.

Species	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=16)	%			High	Low	Mean	Min.	Max.
SCA CROI	1	1	6.3%	0.06	0.25	1	0	6.0	6	6
SCO PLUM	1	1	6.3%	0.06	0.25	1	0	20.0	20	20
SER DUME	22	2	12.5%	1.38	5.24	21	0	43.3	40	50
SER TIGR	3	3	18.8%	0.19	0.40	1	0	3.7	2	5
SPA AURO	2	1	6.3%	0.13	0.50	2	0	16.0	2	30
SPH BARR	2	2	12.5%	0.13	0.34	1	0	90.0	80	100
THA BIFA	319	12	75.0%	19.94	23.52	75	0	4.1	1	10
URO JAMA	1	1	6.3%	0.06	0.25	1	0	20.0	20	20

NO. SAMPLES = 16
 NO. SPECIES = 55
 TOT. INDIVIDUALS = 2395

Table 14. Summary of monitoring on mid-depth fabricated unit 2 (MAR2) from June 1988 - June 1990.

Species	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=16)	%			High	Low	Mean	Min.	Max.
ABU SAXA	26	11	68.8%	1.63	1.78	5	0	9.2	5	12
ACA BAH1	90	16	100.0%	5.63	3.34	12	1	20.6	15	30
ACA CHIR	50	9	56.3%	3.13	4.56	17	0	19.7	14	30
ACA COER	53	15	93.8%	3.31	3.42	14	0	11.0	2	25
ALU SCHO	1	1	6.3%	0.06	0.25	1	0	10.0	10	10
ALU SCRI	1	1	6.3%	0.06	0.25	1	0	30.0	30	30
ANI VIRG	16	12	75.0%	1.00	0.82	3	0	17.8	3	22
APO PSEU	66	8	50.0%	4.13	8.35	33	0	4.0	2	8
CAL CALA	1	1	6.3%	0.06	0.25	1	0	15.0	15	15
CAN ROST	41	12	75.0%	2.56	2.06	7	0	5.4	1	12
CAR RUBE	86	3	18.8%	5.38	17.58	70	0	20.7	20	24
CHA OCEL	9	5	31.3%	0.56	0.89	2	0	13.6	12	15
CHA SEDE	14	8	50.0%	0.88	1.02	3	0	8.6	6	10
CHA STRI	1	1	6.3%	0.06	0.25	1	0	12.0	12	12
CHR INSO	2	2	12.5%	0.13	0.34	1	0	3.5	3	4
COR GLAU	147	10	62.5%	9.19	11.10	35	0	3.3	2	5
DEC MACA	150	1	6.3%	9.38	37.50	150	0	17.0	16	18
DEC SPE.	50	1	6.3%	3.13	12.50	50	0	25.0	25	25
DIP FORM	1	1	6.3%	0.06	0.25	1	0	8.0	8	8
EPI CRUE	12	7	43.8%	0.75	1.06	3	0	8.3	5	12
EPI GUTT	2	1	6.3%	0.13	0.50	2	0	7.0	6	8
EQU ACUM	6	5	31.3%	0.38	0.62	2	0	6.5	1	10
EQU LANC	2	2	12.5%	0.13	0.34	1	0	5.0	4	6
GOB OCEA	3	2	12.5%	0.19	0.54	2	0	3.3	3	4
GYM MORI	8	7	43.8%	0.50	0.63	2	0	36.3	20	60
HAE AURO	117	5	31.3%	7.31	16.21	60	0	4.6	2	8
HAE FLAV	40	6	37.5%	2.50	4.56	16	0	7.5	4	12
HAE MELA	135	9	56.3%	8.44	14.04	45	0	9.0	2	20
HAE SPE.	145	2	12.5%	9.06	34.94	140	0	3.1	2	6
HAE STRI	2	1	6.3%	0.13	0.50	2	0	5.0	4	6
HAL BIVI	55	13	81.3%	3.44	2.45	8	0	7.4	4	14
HAL GARN	55	7	43.8%	3.44	5.54	15	0	4.7	2	8
HAL RAD1	1	1	6.3%	0.06	0.25	1	0	20.0	20	20
HOL BERM	9	5	31.3%	0.56	0.96	3	0	28.1	4	38
HOL CILI	2	2	12.5%	0.13	0.34	1	0	28.0	28	28
HOL CORU	7	2	12.5%	0.44	1.21	4	0	6.6	6	8
LAC BICA	1	1	6.3%	0.06	0.25	1	0	15.0	15	15
LAC MAXI	17	9	56.3%	1.06	1.48	5	0	22.1	14	30
LAC QUAD	1	1	6.3%	0.06	0.25	1	0	30.0	30	30
LAC TRIQ	1	1	6.3%	0.06	0.25	1	0	20.0	20	20
LUT ANAL	1	1	6.3%	0.06	0.25	1	0	45.0	45	45
LUT BUCC	2	2	12.5%	0.13	0.34	1	0	4.5	4	5
MON HISP	2	1	6.3%	0.13	0.50	2	0	16.0	15	18
MYC SPE.	3	2	12.5%	0.19	0.54	2	0	5.3	4	6
OCY CHRY	169	8	50.0%	10.56	16.50	50	0	25.7	18	35
PAR MARM	6	4	25.0%	0.38	0.72	2	0	4.3	3	5
POM ARCU	13	9	56.3%	0.81	0.83	2	0	28.9	25	35

Table 14. Summary of monitoring on mid-depth fabricated unit 2 (MAR2) from June 1988 - June 1990.

Species	SAMPLE FREQUENCY				SAMP. FREQ. RANGE			FISH LENGTH (cm)		
	Total Indiv.	(N=16)	%	Mean Abund.	Stand. Dev.	High	Low	Mean	Min.	Max.
POM PART	37	9	56.3%	2.31	4.53	18	0	2.9	1	4
POM PARU	7	4	25.0%	0.44	0.81	2	0	26.1	25	30
PSE MACU	1	1	6.3%	0.06	0.25	1	0	14.0	14	14
RYP SAPO	2	2	12.5%	0.13	0.34	1	0	25.0	25	25
SCO REGA	8	1	6.3%	0.50	2.00	8	0	35.0	30	40
SER TIGR	4	3	18.8%	0.25	0.58	2	0	3.8	3	5
SPA AURO	1	1	6.3%	0.06	0.25	1	0	15.0	15	15
SPA CHRY	1	1	6.3%	0.06	0.25	1	0	12.0	12	12
SPH BARR	2	2	12.5%	0.13	0.34	1	0	97.5	75	120
SYN FOET	1	1	6.3%	0.06	0.25	1	0	25.0	25	25
THA BIFA	340	14	87.5%	21.25	21.29	65	0	4.1	1	10

NO. SAMPLES = 16
 NO. SPECIES = 58
 TOT. INDIVIDUALS = 2026

Table 15. Combined summary of monitoring on 2 mid-depth fabricated units from June 1988 - June 1990.

Species	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=32)	%			High	Low	Mean	Min.	Max.
ABU SAXA	39	17	53.1%	1.22	1.58	5	0	9.1	5	12
ACA BAH1	223	31	96.9%	6.97	3.86	15	0	19.7	4	30
ACA CHIR	92	20	62.5%	2.88	3.89	17	0	19.9	10	30
ACA COER	121	31	96.9%	3.78	3.25	14	0	14.5	2	30
ALU SCHO	1	1	3.1%	0.03	0.18	1	0	10.0	10	10
ALU SCRI	1	1	3.1%	0.03	0.18	1	0	30.0	30	30
ANI VIRG	34	23	71.9%	1.06	0.84	3	0	18.4	3	25
APO PSEU	109	16	50.0%	3.41	7.31	33	0	3.6	2	8
APO SPE.	2	1	3.1%	0.06	0.35	2	0	6.0	6	6
CAL CALA	2	2	6.3%	0.06	0.25	1	0	15.5	15	16
CAN ROST	83	26	81.3%	2.59	2.05	7	0	5.2	1	12
CAR RUBE	104	8	25.0%	3.25	12.55	70	0	20.0	10	30
CHA OCEL	32	17	53.1%	1.00	1.02	3	0	12.5	6	20
CHA SEDE	37	21	65.6%	1.16	0.99	3	0	8.4	3	12
CHA STRI	1	1	3.1%	0.03	0.18	1	0	12.0	12	12
CHR INSO	2	2	6.3%	0.06	0.25	1	0	3.5	3	4
CHR MULT	1	1	3.1%	0.03	0.18	1	0	2.0	2	2
COR GLAU	273	18	56.3%	8.53	10.53	35	0	3.4	2	5
DEC MACA	300	2	6.3%	9.38	36.89	150	0	17.0	16	18
DEC PUNC	20	2	6.3%	0.63	2.77	15	0	11.5	10	15
DEC SPE.	100	2	6.3%	3.13	12.30	50	0	25.0	25	25
DIP FORM	9	4	12.5%	0.28	0.96	5	0	7.3	3	12
ECH NAUC	1	1	3.1%	0.03	0.18	1	0	8.0	8	8
EPI CRUE	37	20	62.5%	1.16	1.14	4	0	8.7	5	14
EPI GUTT	3	2	6.3%	0.09	0.39	2	0	7.3	6	8
EQU ACUM	6	5	15.6%	0.19	0.47	2	0	6.5	1	10
EQU LANC	2	2	6.3%	0.06	0.25	1	0	5.0	4	6
GOB OCEA	6	3	9.4%	0.19	0.64	3	0	3.7	3	4
GYM MORI	8	7	21.9%	0.25	0.51	2	0	36.3	20	60
HAE ALBU	2	2	6.3%	0.06	0.25	1	0	22.0	14	30
HAE AURO	639	9	28.1%	19.97	88.41	500	0	4.2	2	10
HAE FLAV	43	7	21.9%	1.34	3.42	16	0	7.6	4	12
HAE MELA	150	16	50.0%	4.69	10.53	45	0	9.2	2	20
HAE SPE.	159	4	12.5%	4.97	24.72	140	0	3.2	2	6
HAE STRI	308	3	9.4%	9.63	53.00	300	0	5.0	2	8
HAL BIVI	108	25	78.1%	3.38	2.64	10	0	8.0	4	15
HAL GARN	111	13	40.6%	3.47	8.67	45	0	4.5	1	8
HAL RAD1	2	2	6.3%	0.06	0.25	1	0	12.0	4	20
HEM SPLE	3	2	6.3%	0.09	0.39	2	0	8.0	6	12
HOL BERM	9	5	15.6%	0.28	0.73	3	0	28.1	4	38
HOL CILI	4	3	9.4%	0.13	0.42	2	0	15.0	2	28
HOL CORU	7	2	6.3%	0.22	0.87	4	0	6.6	6	8
LAC BICA	3	3	9.4%	0.09	0.30	1	0	15.7	12	20
LAC MAXI	37	20	62.5%	1.16	1.35	5	0	23.2	14	35
LAC QUAD	1	1	3.1%	0.03	0.18	1	0	30.0	30	30
LAC TRIQ	1	1	3.1%	0.03	0.18	1	0	20.0	20	20
LUT ANAL	1	1	3.1%	0.03	0.18	1	0	45.0	45	45

Table 15. Combined summary of monitoring on 2 mid-depth fabricated units from June 1988 - June 1990.

Species	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=32)	%			High	Low	Mean	Min.	Max.
LUT BUCC	7	6	18.8%	0.22	0.49	2	0	6.9	2	12
LUT GRIS	1	1	3.1%	0.03	0.18	1	0	40.0	40	40
MAL SPE.	1	1	3.1%	0.03	0.18	1	0	2.0	2	2
MAL TRIA	1	1	3.1%	0.03	0.18	1	0	2.0	2	2
MON HISP	3	2	6.3%	0.09	0.39	2	0	14.7	12	18
MYC BONA	1	1	3.1%	0.03	0.18	1	0	35.0	35	35
MYC SPE.	3	2	6.3%	0.09	0.39	2	0	5.3	4	6
OCY CHRY	337	15	46.9%	10.53	20.93	98	0	25.9	15	35
PAR MARM	6	4	12.5%	0.19	0.54	2	0	4.3	3	5
POM ARCU	32	20	62.5%	1.00	0.88	2	0	28.1	20	35
POM PART	67	14	43.8%	2.09	4.47	18	0	2.8	1	4
POM PARU	7	4	12.5%	0.22	0.61	2	0	26.1	25	30
POM PLAN	1	1	3.1%	0.03	0.18	1	0	1.0	1	1
PSE MACU	6	5	15.6%	0.19	0.47	2	0	9.7	6	14
RYP SAPO	3	3	9.4%	0.09	0.30	1	0	26.7	25	30
SCA CROI	1	1	3.1%	0.03	0.18	1	0	6.0	6	6
SCO PLUM	1	1	3.1%	0.03	0.18	1	0	20.0	20	20
SCO REGA	8	1	3.1%	0.25	1.41	8	0	35.0	30	40
SER DUME	22	2	6.3%	0.69	3.71	21	0	43.3	40	50
SER TIGR	7	6	18.8%	0.22	0.49	2	0	3.7	2	5
SPA AURO	3	2	6.3%	0.09	0.39	2	0	15.7	2	30
SPA CHRY	1	1	3.1%	0.03	0.18	1	0	12.0	12	12
SPH BARR	4	4	12.5%	0.13	0.34	1	0	93.8	75	120
SYN FOET	1	1	3.1%	0.03	0.18	1	0	25.0	25	25
THA BIFA	659	26	81.3%	20.59	22.08	75	0	4.1	1	10
URO JAMA	1	1	3.1%	0.03	0.18	1	0	20.0	20	20

NO. SAMPLES = 32
 NO. SPECIES = 73
 TOT. INDIVIDUALS = 4421

Table 16. Percent shared of the 15 most frequent, abundant, and heaviest species in various comparisons of reefs.

Reefs compared	% shared of top 15 species by frequency	% shared of top 15 species by total number	% shared of top 15 species by biomass
SARC to SNR	33%	26%	
SARC to MARC	50%	36%	25%
SARC to DARC	32%	30%	30%
SNR to MNR	58%	36%	
SNR to DNR	20%	25%	
MARC to MNR	27%	30%	
MARC to DARC	48%	25%	43%
MARC to HAWKC	31%	15%	
MNR to DNR	41%	36%	
DARC to DNR	22%	15%	30%
BHA to AMS	30%	50%	50%
HAWKC to SNR	33%	25%	
HAWKC to MNR	20%	15%	
HAWKC to DNR	7%	20%	
Similarity among replicates of fabricated units			
MAR1 to MAR2	72%	67%	
DAR1 to DAR2	88%	76%	

Table 17. Ranking of 15 most frequent and 15 most abundant species at the mid-depth fabricated units from June 1988 - June 1990.

Mid-depth Fabricated Unit 1 (N=16)

Species	% Frequency	Species	Total No.
Blue tang	100.0%	Tomtate	522
Ocean surgeon	93.8%	Bluehead wrasse	319
Sharpnose puffer	87.5%	Striped grunt	306
Graysby	81.3%	Yellowtail snapper	168
Reef butterflyfish	81.3%	Mackeral scad	150
Spotfin butterflyfish	75.0%	Ocean surgeon	133
Slippery dick	75.0%	Masked goby	126
Bluehead wrasse	75.0%	Blue tang	68
Gray angelfish	68.8%	Yellowhead wrasse	56
Hogfish	68.8%	Slippery dick	53
Doctorfish	68.8%	Unid. scad	50
Porkfish	68.8%	Twospot cardinalfish	43
Masked goby	50.0%	Doctorfish	42
Twospot cardinalfish	50.0%	Sharpnose puffer	42
Yellowtail snapper	43.8%	Bicolor damselfish	30

Mid-depth Fabricated Unit 2 (N=16)

Species	% Frequency	Species	Total No.
Ocean surgeon	100.0%	Bluehead wrasse	340
Blue tang	93.8%	Yellowtail snapper	169
Bluehead wrasse	87.5%	Mackeral scad	150
Slippery dick	81.3%	Masked goby	147
Porkfish	75.0%	Unid. grunt	145
Sharpnose puffer	75.0%	Cottonwick	135
Sergeant major	68.8%	Tomtate	117
Masked goby	62.5%	Ocean surgeon	90
Bicolor damselfish	56.3%	Bar jack	86
Hogfish	56.3%	Twospot cardinalfish	66
Cottonwick	56.3%	Yellowhead wrasse	55
Gray angelfish	56.3%	Slippery dick	55
Doctorfish	56.3%	Blue tang	53
Twospot cardinalfish	50.0%	Doctorfish	50
Yellowtail snapper	50.0%	Unid. scad	50
Reef butterflyfish	50.0%		

Table 18. Summary of censuses on the mid-depth natural reef (MNR) from September 1988 - May 1990.

Species	SAMPLE FREQUENCY			Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
	Total Indiv.	(N=78)	%			High	Low	Mean	Min.	Max.
ABU SAXA	12	6	7.7%	0.15	0.63	4	0	6.6	5	10
ACA BAH1	175	64	82.1%	2.24	2.36	15	0	15.6	4	25
ACA CHIR	121	45	57.7%	1.55	2.10	10	0	15.9	5	25
ACA COER	102	49	62.8%	1.31	1.45	9	0	12.9	4	25
AMB PINO	9	8	10.3%	0.12	0.36	2	0	5.1	4	6
ANI VIRG	30	21	26.9%	0.38	0.74	3	0	21.6	14	30
APO BINO	5	3	3.8%	0.06	0.34	2	0	3.8	2	5
APO MACU	23	2	2.6%	0.29	1.83	12	0	4.0	3	5
APO PSEU	5	3	3.8%	0.06	0.34	2	0	5.2	4	6
BAL VETU	1	1	1.3%	0.01	0.11	1	0	25.0	25	25
BOD PULC	1	1	1.3%	0.01	0.11	1	0	3.0	3	3
BOD RUFU	16	13	16.7%	0.21	0.49	2	0	9.1	2	25
CAL BAJ0	2	1	1.3%	0.03	0.23	2	0	16.0	8	25
CAL CALA	46	29	37.2%	0.59	0.92	4	0	19.3	6	30
CAN MACR	2	2	2.6%	0.03	0.16	1	0	27.0	16	38
CAN PULL	2	2	2.6%	0.03	0.16	1	0	27.5	25	30
CAN ROST	125	53	67.9%	1.60	1.44	6	0	4.7	2	8
CAR BART	5	3	3.8%	0.06	0.34	2	0	48.2	45	50
CAR CRY5	27	3	3.8%	0.35	2.36	20	0	19.8	15	25
CAR RUBE	8	4	5.1%	0.10	0.50	3	0	20.0	15	25
CHA CAPI	187	65	83.3%	2.40	1.59	6	0	6.9	4	12
CHA OCEL	37	20	25.6%	0.47	0.88	4	0	12.2	10	15
CHA SEDE	120	55	70.5%	1.54	1.41	7	0	8.4	3	12
CHA STRI	14	9	11.5%	0.18	0.53	2	0	11.6	8	15
CHI SCHO	1	1	1.3%	0.01	0.11	1	0	10.0	10	10
CHR CYAN	453	70	89.7%	5.81	5.09	28	0	6.5	2	13
CHR ENCH	1	1	1.3%	0.01	0.11	1	0	3.0	3	3
CHR INSO	5	4	5.1%	0.06	0.29	2	0	3.4	2	4
CHR MULT	240	33	42.3%	3.08	6.70	34	0	8.3	3	13
CHR SCOT	83	16	20.5%	1.06	3.78	28	0	3.0	1	7
CLE PARR	47	10	12.8%	0.60	2.32	14	0	4.3	1	10
COR GLAU	52	8	10.3%	0.67	2.38	13	0	4.1	3	5
COR PERS	15	2	2.6%	0.19	1.49	13	0	3.9	2	5
DEC SPE.	725	1	1.3%	9.29	82.09	725	0	20.0	20	20
DIO HOLO	1	1	1.3%	0.01	0.11	1	0	15.0	15	15
ECH NAUC	3	3	3.8%	0.04	0.19	1	0	12.0	11	13
EPI ADSC	10	6	7.7%	0.13	0.49	3	0	13.4	12	15
EPI CRUE	103	50	64.1%	1.32	1.41	7	0	14.0	4	46
EPI FULV	5	5	6.4%	0.06	0.25	1	0	12.6	8	20
EPI GUTT	14	12	15.4%	0.18	0.45	2	0	16.4	8	25
EPI MORI	1	1	1.3%	0.01	0.11	1	0	45.0	45	45
EPI SPE.	1	1	1.3%	0.01	0.11	1	0	12.0	12	12
EPI STRI	1	1	1.3%	0.01	0.11	1	0	65.0	65	65
EQU ACUM	9	8	10.3%	0.12	0.36	2	0	8.3	6	11
GIN CIRR	2	1	1.3%	0.03	0.23	2	0	280.0	280	280
GOB OCEA	209	31	39.7%	2.68	5.77	29	0	3.5	1	5
GOB XANT	1	1	1.3%	0.01	0.11	1	0	3.0	3	3

Table 18. Summary of censuses on the mid-depth natural reef (MNR) from September 1988 - May 1990.

Species	Total Indiv.	SAMPLE FREQUENCY			Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=78)	%	Mean Abund.		High	Low	Mean	Min.	Max.
GYM FUNE	2	2	2.6%	0.03	0.16	1	0	125.0	100	150
GYM MORI	3	3	3.8%	0.04	0.19	1	0	31.7	20	45
HAE ALBU	1	1	1.3%	0.01	0.11	1	0	30.0	30	30
HAE AURO	2140	11	14.1%	27.44	99.73	700	0	4.9	3	10
HAE FLAV	316	10	12.8%	4.05	23.43	200	0	5.3	3	14
HAE MELA	7	2	2.6%	0.09	0.56	4	0	17.1	9	30
HAE PLUM	61	19	24.4%	0.78	2.12	12	0	20.6	15	27
HAE SCIU	115	14	17.9%	1.47	6.64	48	0	22.1	15	25
HAE SPE.	3500	5	6.4%	44.87	289.60	2500	0	3.0	2	6
HAE STRI	4	2	2.6%	0.05	0.36	3	0	5.3	4	6
HAL BIVI	88	30	38.5%	1.13	2.37	14	0	7.6	4	12
HAL GARN	477	74	94.9%	6.12	4.60	27	0	6.8	1	15
HAL MACU	16	13	16.7%	0.21	0.49	2	0	9.0	6	14
HAL RAD1	7	7	9.0%	0.09	0.29	1	0	6.6	4	10
HOL BERM	51	40	51.3%	0.65	0.80	4	0	29.1	5	40
HOL CILI	17	12	15.4%	0.22	0.57	3	0	23.6	8	35
HOL TRIC	75	46	59.0%	0.96	1.07	5	0	8.8	3	22
HYP BERM	1	1	1.3%	0.01	0.11	1	0	7.0	7	7
HYP GEMM #	12	10	12.8%	0.15	0.43	2	0	7.4	5	11
HYP NIGR #	1	1	1.3%	0.01	0.11	1	0	6.0	6	6
HYP PUEL #	4	4	5.1%	0.05	0.22	1	0	8.8	6	12
HYP UNIC	28	22	28.2%	0.36	0.62	2	0	7.2	3	12
IOG CALL	2	2	2.6%	0.03	0.16	1	0	4.5	4	5
IOG HELE	5	2	2.6%	0.06	0.41	3	0	4.0	3	4
LAC BICA	11	10	12.8%	0.14	0.39	2	0	14.4	6	25
LAC MAXI	60	37	47.4%	0.77	0.92	3	0	22.3	15	44
LAC QUAD	11	10	12.8%	0.14	0.39	2	0	24.3	18	30
LUT ANAL	1	1	1.3%	0.01	0.11	1	0	35.0	35	35
LUT SYNA	1	1	1.3%	0.01	0.11	1	0	30.0	30	30
MAL PLUM	1	1	1.3%	0.01	0.11	1	0	15.0	15	15
MAL TRIA	5	4	5.1%	0.06	0.29	2	0	5.0	5	6
MON SETI	1	1	1.3%	0.01	0.11	1	0	14.0	14	14
MON TUCK	6	6	7.7%	0.08	0.27	1	0	4.3	4	5
MYC BONA	7	5	6.4%	0.09	0.37	2	0	49.1	35	60
MYC MICR	1	1	1.3%	0.01	0.11	1	0	28.0	28	28
MYC SPE.	1	1	1.3%	0.01	0.11	1	0	18.0	18	18
OCY CHRY	150	27	34.6%	1.92	5.34	40	0	21.0	4	35
OPI AURI	10	6	7.7%	0.13	0.54	4	0	7.2	3	12
PEM SCHO	1	1	1.3%	0.01	0.11	1	0	10.0	10	10
POM ARCU	27	21	26.9%	0.35	0.64	3	0	25.4	18	35
POM DIEN	7	5	6.4%	0.09	0.40	3	0	4.9	3	6
POM FUSC	14	11	14.1%	0.18	0.48	2	0	5.6	4	8
POM LEUC	4	4	5.1%	0.05	0.22	1	0	4.8	4	6
POM PART	3699	78	100.0%	47.42	22.65	104	5	4.1	1	7
POM PARU	3	2	2.6%	0.04	0.25	2	0	26.7	25	30
POM PLAN	41	22	28.2%	0.53	1.02	5	0	5.0	2	9
POM VARI	112	55	70.5%	1.44	1.26	7	0	5.4	2	10

Table 18. Summary of censuses on the mid-depth natural reef (MNR) from September 1988 - May 1990.

Species	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=78)	%			High	Low	Mean	Min.	Max.
PSE MACU	49	25	32.1%	0.63	1.23	7	0	11.9	5	25
RYP SAPO	1	1	1.3%	0.01	0.11	1	0	22.0	22	22
SCA COEL	1	1	1.3%	0.01	0.11	1	0	30.0	30	30
SCA COER	11	5	6.4%	0.14	0.68	5	0	33.0	20	40
SCA CROI	246	65	83.3%	3.15	2.42	9	0	8.0	3	18
SCA GUAC	3	2	2.6%	0.04	0.25	2	0	51.0	45	58
SCA SPE.	3	2	2.6%	0.04	0.25	2	0	7.7	4	15
SCA TAEN	5	3	3.8%	0.06	0.37	3	0	11.0	5	20
SCA VETU	10	7	9.0%	0.13	0.44	2	0	14.8	6	25
SCO MACU	4	1	1.3%	0.05	0.45	4	0	40.0	30	50
SCO PLUM	2	2	2.6%	0.03	0.16	1	0	22.5	20	25
SCO REGA	6	5	6.4%	0.08	0.31	2	0	33.8	25	50
SER BALD	2	2	2.6%	0.03	0.16	1	0	6.0	6	6
SER DUME	15	2	2.6%	0.19	1.59	14	0	77.0	35	80
SER TABA	13	11	14.1%	0.17	0.44	2	0	6.1	2	13
SER TIGR	94	52	66.7%	1.21	1.06	4	0	6.4	3	11
SPA AURO	162	64	82.1%	2.08	1.56	6	0	10.1	2	26
SPA CHRY	19	9	11.5%	0.24	1.18	10	0	15.4	5	22
SPA VIRI	32	24	30.8%	0.41	0.69	3	0	15.8	4	30
SPH BARR	2	1	1.3%	0.03	0.23	2	0	105.0	90	120
SPH PICU	2	1	1.3%	0.03	0.23	2	0	30.0	30	30
THA BIFA	2255	77	98.7%	28.91	16.00	100	0	6.0	1	11
URO JAMA	5	5	6.4%	0.06	0.25	1	0	27.6	20	30

= color variants of *H. unicolor*

NO. SAMPLES = 78
 NO. SPECIES = 114
 TOT. INDIVIDUALS = 17106

Table 19. Summary of monitoring on deep fabricated unit 1 (DAR1) from June 1988 - June 1990

Species	Total Indiv.	SAMPLE FREQUENCY			Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=15)	% Abund.	Mean		High	Low	Mean	Min.	Max.
ACA BAH1	1	1	6.7%	0.07	0.26	1	0	20.0	20	20
ACA CHIR	22	6	40.0%	1.47	2.61	8	0	21.9	15	30
ACA COER	8	3	20.0%	0.53	1.25	4	0	12.8	10	16
ALU SCRI	1	1	6.7%	0.07	0.26	1	0	50.0	50	50
ANI VIRG	1	1	6.7%	0.07	0.26	1	0	1.0	1	1
APO PSEU	81	8	53.3%	5.40	9.14	34	0	3.6	1	6
APO SPE.	6	2	13.3%	0.40	1.30	5	0	2.3	1	4
BOD PULC	6	2	13.3%	0.40	1.12	4	0	4.0	2	7
CAL CALA	1	1	6.7%	0.07	0.26	1	0	25.0	25	25
CAN ROST	29	11	73.3%	1.93	1.87	6	0	4.3	2	8
CAR BART	1	1	6.7%	0.07	0.26	1	0	60.0	60	60
CAR CRY5	6	2	13.3%	0.40	1.12	4	0	18.0	15	20
CAR RUBE	12	2	13.3%	0.80	2.60	10	0	23.3	20	28
CHA OCEL	14	7	46.7%	0.93	1.03	2	0	10.9	8	12
CHA SEDE	9	6	40.0%	0.60	0.83	2	0	5.9	3	10
CHR ENCH	10	3	20.0%	0.67	1.84	7	0	1.9	1	2
CHR INSO	10	5	33.3%	0.67	1.35	5	0	2.1	1	3
CHR SCOT	4	3	20.0%	0.27	0.59	2	0	2.5	1	3
COR GLAU	120	9	60.0%	8.00	9.03	24	0	3.3	2	6
ECH NAUC	1	1	6.7%	0.07	0.26	1	0	11.0	11	11
EPI CRUE	33	14	93.3%	2.20	1.37	6	0	7.5	2	15
EPI GUTT	1	1	6.7%	0.07	0.26	1	0	4.0	4	4
GYM MORI	1	1	6.7%	0.07	0.26	1	0	30.0	30	30
HAE STRI	1	1	6.7%	0.07	0.26	1	0	6.0	6	6
HAL BIVI	34	9	60.0%	2.27	2.49	6	0	6.2	4	12
HAL GARN	43	8	53.3%	2.87	4.60	16	0	3.9	1	8
HAL SPE.	1	1	6.7%	0.07	0.26	1	0	6.0	6	6
HOL BERM	2	1	6.7%	0.13	0.52	2	0	2.0	2	3
HOL CILI	3	3	20.0%	0.20	0.41	1	0	4.0	3	5
LAC BICA	1	1	6.7%	0.07	0.26	1	0	16.0	16	16
LAC MAXI	14	11	73.3%	0.93	0.70	2	0	26.2	16	35
LUT ANAL	2	2	13.3%	0.13	0.35	1	0	67.5	55	80
LUT BUCC	28	6	40.0%	1.87	4.66	18	0	5.1	2	10
LUT GRIS	77	9	60.0%	5.13	7.47	26	0	31.5	15	60
MON CILI	1	1	6.7%	0.07	0.26	1	0	2.0	2	2
MYC BONA	1	1	6.7%	0.07	0.26	1	0	4.0	4	4
MYC SPE.	2	1	6.7%	0.13	0.52	2	0	3.0	2	4
OCY CHRY	64	8	53.3%	4.27	5.52	15	0	24.9	14	40
PAR FURC	6	5	33.3%	0.40	0.63	2	0	9.7	5	16
PAR MARM	4	2	13.3%	0.27	0.70	2	0	3.5	2	4
POM ARCU	6	3	20.0%	0.40	0.83	2	0	29.0	18	35
POM PART	129	9	60.0%	8.60	10.39	26	0	3.2	1	6
POM PARU	7	5	33.3%	0.47	0.74	2	0	27.6	25	35
POM VARI	1	1	6.7%	0.07	0.26	1	0	7.0	7	7
SCA CRIS	1	1	6.7%	0.07	0.26	1	0	4.0	4	4
SCA SPE.	1	1	6.7%	0.07	0.26	1	0	3.0	3	3
SER BALD	2	1	6.7%	0.13	0.52	2	0	4.0	3	5

Table 19. Summary of monitoring on deep fabricated unit 1 (DAR1) from June 1988 - June 1990

Species	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N=15)	%			High	Low	Mean	Min.	Max.
SER DUME	9	5	33.3%	0.60	0.99	3	0	35.0	18	50
SER TABA	2	2	13.3%	0.13	0.35	1	0	3.0	2	4
SER TIGR	6	5	33.3%	0.40	0.63	2	0	3.5	2	5
SPH BARR	1	1	6.7%	0.07	0.26	1	0	80.0	80	80
THA BIFA	200	14	93.3%	13.33	12.09	32	0	4.4	1	10
TRA FALC	2	2	13.3%	0.13	0.35	1	0	50.0	50	50

NO. SAMPLES = 15
 NO. SPECIES = 53
 TOT. INDIVIDUALS = 1029

Table 20. Summary of monitoring on deep fabricated unit 2 (DAR2) from June 1988 - June 1990.

Species	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N = 15)	%			High	Low	Mean	Min.	Max.
ACA BAH1	6	2	13.3%	0.40	1.12	4	0	24.7	15	30
ACA CHIR	52	12	80.0%	3.47	2.42	7	0	23.0	15	35
APO PSEU	36	8	53.3%	2.40	3.18	9	0	2.8	1	5
APO SPE.	1	1	6.7%	0.07	0.26	1	0	2.0	2	2
BOD PULC	5	4	26.7%	0.33	0.62	2	0	3.4	1	5
BOD RUFU	2	2	13.3%	0.13	0.35	1	0	4.0	3	5
CAL CALA	3	3	20.0%	0.20	0.41	1	0	28.3	25	35
CAL SPE.	1	1	6.7%	0.07	0.26	1	0	25.0	25	25
CAN ROST	31	10	66.7%	2.07	2.52	8	0	4.7	1	10
CAR BART	4	2	13.3%	0.27	0.80	3	0	44.8	30	80
CAR CRY5	1	1	6.7%	0.07	0.26	1	0	25.0	25	25
CAR RUBE	8	1	6.7%	0.53	2.07	8	0	22.0	20	25
CHA OCEL	21	12	80.0%	1.40	0.83	2	0	13.0	10	15
CHA SEDE	11	9	60.0%	0.73	0.70	2	0	6.7	2	10
CHR ENCH	13	3	20.0%	0.87	2.39	9	0	2.0	1	2
CHR SCOT	1	1	6.7%	0.07	0.26	1	0	1.0	1	1
CLE PARR	1	1	6.7%	0.07	0.26	1	0	4.0	4	4
COR GLAU	178	9	60.0%	11.87	12.44	34	0	3.4	2	5
DEC PUNC	1000	1	6.7%	66.67	258.20	1000	0	18.0	15	20
EPI ADSC	1	1	6.7%	0.07	0.26	1	0	2.0	2	2
EPI CRUE	21	11	73.3%	1.40	1.18	3	0	7.5	2	14
EPI FULV	2	1	6.7%	0.13	0.52	2	0	5.0	5	5
EPI GUTT	1	1	6.7%	0.07	0.26	1	0	10.0	10	10
EQU ACUM	1	1	6.7%	0.07	0.26	1	0	1.0	1	1
GYM MORI	1	1	6.7%	0.07	0.26	1	0	40.0	40	40
HAL BIVI	50	12	80.0%	3.33	2.38	8	0	6.7	4	10
HAL GARN	40	11	73.3%	2.67	3.66	12	0	4.1	1	10
HAL SPE.	1	1	6.7%	0.07	0.26	1	0	3.0	3	3
HOL BERM	1	1	6.7%	0.07	0.26	1	0	25.0	25	25
HOL CILI	2	2	13.3%	0.13	0.35	1	0	3.0	2	4
HOL TRIC	2	2	13.3%	0.13	0.35	1	0	6.5	3	10
IOG HELE	2	2	13.3%	0.13	0.35	1	0	3.0	2	4
KYP SECT	1	1	6.7%	0.07	0.26	1	0	20.0	20	20
LAC BICA	3	3	20.0%	0.20	0.41	1	0	15.3	15	16
LAC MAXI	23	13	86.7%	1.53	0.99	3	0	25.0	14	35
LAC QUAD	2	2	13.3%	0.13	0.35	1	0	28.0	26	30
LUT ANAL	3	3	20.0%	0.20	0.41	1	0	50.0	30	80
LUT BUCC	9	2	13.3%	0.60	2.06	8	0	2.9	2	4
LUT CYAN	1	1	6.7%	0.07	0.26	1	0	110.0	110	110
LUT GRIS	77	10	66.7%	5.13	6.52	17	0	30.8	12	50
MIC CHRY	1	1	6.7%	0.07	0.26	1	0	1.0	1	1
MYC SPE.	2	1	6.7%	0.13	0.52	2	0	2.0	2	2
OCY CHRY	167	13	86.7%	11.13	13.34	49	0	24.3	15	35
PAR FURC	1	1	6.7%	0.07	0.26	1	0	9.0	9	9
PAR MARM	6	5	33.3%	0.40	0.63	2	0	4.5	2	9
POM ARCU	11	7	46.7%	0.73	0.88	2	0	31.2	25	40
POM PART	28	6	40.0%	1.87	2.83	9	0	2.1	1	3

Table 20. Summary of monitoring on deep fabricated unit 2 (DAR2) from June 1988 - June 1990.

Species	SAMPLE FREQUENCY			Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
	Total Indiv. (N = 15)		%			High	Low	Mean	Min.	Max.
POM PARU	4	3	20.0%	0.27	0.59	2	0	27.8	25	30
POM VARI	1	1	6.7%	0.07	0.26	1	0	2.0	2	2
PSE MACU	1	1	6.7%	0.07	0.26	1	0	15.0	15	15
RAC CANA	1	1	6.7%	0.07	0.26	1	0	120.0	120	120
RYP SAPO	3	3	20.0%	0.20	0.41	1	0	17.0	6	25
SER DUME	36	4	26.7%	2.40	5.70	21	0	25.3	15	30
SER TIGR	1	1	6.7%	0.07	0.26	1	0	3.0	3	3
SPH BARR	3	3	20.0%	0.20	0.41	1	0	100.0	80	110
THA BIFA	175	11	73.3%	11.67	15.76	56	0	3.8	1	10
TRA FALC	1	1	6.7%	0.07	0.26	1	0	50.0	50	50

NO. SAMPLES = 15
 NO. SPECIES = 57
 TOT. INDIVIDUALS = 2063

Table 21. Combined summary of monitoring on 2 deep fabricated units from June 1988 - June 1990.

Species	SAMPLE FREQUENCY				SAMP. FREQ. RANGE			FISH LENGTH (cm)		
	Total			Mean	Stand.					
	Indiv. (N = 30)		% Abund.	Dev.	High	Low	Mean	Min.	Max.	
ACA BAH1	7	3	10.0%	0.23	0.82	4	0	24.0	15	30
ACA CHIR	74	18	60.0%	2.47	2.67	8	0	22.6	15	35
ACA COER	8	3	10.0%	0.27	0.91	4	0	12.8	10	16
ALU SCRI	1	1	3.3%	0.03	0.18	1	0	50.0	50	50
ANI VIRG	1	1	3.3%	0.03	0.18	1	0	1.0	1	1
APO PSEU	117	16	53.3%	3.90	6.90	34	0	3.4	1	6
APO SPE.	7	3	10.0%	0.23	0.94	5	0	2.3	1	4
BOD PULC	11	6	20.0%	0.37	0.89	4	0	3.7	1	7
BOD RUFU	2	2	6.7%	0.07	0.25	1	0	4.0	3	5
CAL CALA	4	4	13.3%	0.13	0.35	1	0	27.5	25	35
CAL SPE.	1	1	3.3%	0.03	0.18	1	0	25.0	25	25
CAN ROST	60	21	70.0%	2.00	2.18	8	0	4.5	1	10
CAR BART	5	3	10.0%	0.17	0.59	3	0	47.8	30	80
CAR CRY5	7	3	10.0%	0.23	0.82	4	0	19.0	15	25
CAR RUBE	20	3	10.0%	0.67	2.31	10	0	22.8	20	28
CHA OCEL	35	19	63.3%	1.17	0.95	2	0	12.1	8	15
CHA SEDE	20	15	50.0%	0.67	0.76	2	0	6.4	2	10
CHR ENCH	23	6	20.0%	0.77	2.10	9	0	2.0	1	2
CHR INSO	10	5	16.7%	0.33	0.99	5	0	2.1	1	3
CHR SCOT	5	4	13.3%	0.17	0.46	2	0	2.2	1	3
CLE PARR	1	1	3.3%	0.03	0.18	1	0	4.0	4	4
COR GLAU	298	18	60.0%	9.93	10.86	34	0	3.3	2	6
DEC PUNC	1000	1	3.3%	33.33	182.57	1000	0	18.0	15	20
ECH NAUC	1	1	3.3%	0.03	0.18	1	0	11.0	11	11
EPI ADSC	1	1	3.3%	0.03	0.18	1	0	2.0	2	2
EPI CRUE	54	25	83.3%	1.80	1.32	6	0	7.5	2	15
EPI FULV	2	1	3.3%	0.07	0.37	2	0	5.0	5	5
EPI GUTT	2	2	6.7%	0.07	0.25	1	0	7.0	4	10
EQU ACUM	1	1	3.3%	0.03	0.18	1	0	1.0	1	1
GYM MORI	2	2	6.7%	0.07	0.25	1	0	35.0	30	40
HAE STRI	1	1	3.3%	0.03	0.18	1	0	6.0	6	6
HAL BIVI	84	21	70.0%	2.80	2.46	8	0	6.5	4	12
HAL GARN	83	19	63.3%	2.77	4.08	16	0	4.0	1	10
HAL SPE.	4	3	10.0%	0.13	0.43	2	0	4.3	3	6
HOL BERM	3	2	6.7%	0.10	0.40	2	0	9.7	2	25
HOL CILI	5	5	16.7%	0.17	0.38	1	0	3.6	2	5
HOL TRIC	2	2	6.7%	0.07	0.25	1	0	6.5	3	10
IOG HELE	2	2	6.7%	0.07	0.25	1	0	3.0	2	4
KYP SECT	1	1	3.3%	0.03	0.18	1	0	20.0	20	20
LAC BICA	4	4	13.3%	0.13	0.35	1	0	15.5	15	16
LAC MAXI	37	24	80.0%	1.23	0.90	3	0	25.5	14	35
LAC QUAD	2	2	6.7%	0.07	0.25	1	0	28.0	26	30
LUT ANAL	5	5	16.7%	0.17	0.38	1	0	57.0	30	80
LUT BUCC	37	8	26.7%	1.23	3.60	18	0	4.5	2	10
LUT CYAN	1	1	3.3%	0.03	0.18	1	0	110.0	110	110
LUT GRIS	154	19	63.3%	5.13	6.89	26	0	31.1	12	60
MIC CHRY	1	1	3.3%	0.03	0.18	1	0	1.0	1	1
MON CILI	1	1	3.3%	0.03	0.18	1	0	2.0	2	2

Table 21. Combined summary of monitoring on 2 deep fabricated units from June 1988 - June 1990.

Species	SAMPLE FREQUENCY		Mean % Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
	Total Indiv. (N = 30)				High	Low	Mean	Min.	Max.
MYC BONA	1	1	3.3%	0.03	0.18				
MYC SPE.	4	2	6.7%	0.13	0.51	1	0	4.0	4
OCY CHRY	231	21	70.0%	7.70	10.62	2	0	2.5	4
PAR FURC	7	6	20.0%	0.23	0.50	49	0	24.5	14
PAR MARM	10	7	23.3%	0.33	0.66	2	0	9.6	40
POM ARCU	17	10	33.3%	0.57	0.86	2	0	4.1	16
POM PART	157	15	50.0%	5.23	8.23	2	0	30.4	9
POM PARU	11	8	26.7%	0.37	0.67	26	0	3.0	40
POM VARI	2	2	6.7%	0.07	0.25	2	0	27.6	1
PSE MACU	1	1	3.3%	0.03	0.18	1	0	4.5	35
RAC CANA	1	1	3.3%	0.03	0.18	1	0	15.0	2
RYP SAPO	3	3	10.0%	0.10	0.31	1	0	120.0	15
SCA CRIS	1	1	3.3%	0.03	0.18	1	0	17.0	6
SCA SPE.	1	1	3.3%	0.03	0.18	1	0	4.0	25
SER BALD	2	1	3.3%	0.07	0.37	1	0	3.0	4
SER DUME	45	9	30.0%	1.50	4.13	2	0	4.0	3
SER TABA	2	2	6.7%	0.07	0.25	21	0	27.2	3
SER TIGR	7	6	20.0%	0.23	0.50	1	0	3.0	15
SPH BARR	4	4	13.3%	0.13	0.35	2	0	3.4	2
THA BIFA	375	25	83.3%	12.50	13.83	1	0	95.0	5
TRA FALC	3	3	10.0%	0.10	0.31	56	0	4.1	80
						1	0	50.0	10
								50	50
NO. SAMPLES	=	30							
NO. SPECIES	=	69							
TOT. INDIVIDUALS	=	3092							

Table 21a. Ranking of the 15 most frequent and 15 most abundant species on the deep fabricated units from June 1988 - June 1990.

Deep Fabricated Unit 1 (N=15)

Species	% Frequency	Species	Total No.
Graysby	93.3%	Bluehead wrasse	200
Bluehead wrasse	93.3%	Bicolor damselfish	129
Hogfish	73.3%	Masked goby	120
Sharpnose puffer	73.3%	Twospot cardinalfish	81
Bicolor damselfish	60.0%	Gray snapper	77
Masked goby	60.0%	Yellowtail snapper	64
Slippery dick	60.0%	Yellowhead wrasse	43
Gray snapper	60.0%	Slippery dick	34
Yellowhead wrasse	53.3%	Graysby	33
Yellowtail snapper	53.3%	Sharpnose puffer	29
Twospot cardinalfish	53.3%	Blackfin snapper	28
Spotfin butterflyfish	46.7%	Doctorfish	22
Reef butterflyfish	40.0%	Spotfin butterflyfish	14
Blackfin snapper	40.0%	Hogfish	14
Doctorfish	40.0%	Bar jack	12

Deep Fabricated Unit 2 (N=15)

Species	% Frequency	Species	Total No.
Hogfish	86.7%	Round scad	1000
Yellowtail snapper	86.7%	Masked goby	178
Slippery dick	80.0%	Bluehead wrasse	175
Doctorfish	80.0%	Yellowtail snapper	167
Spotfin butterflyfish	80.0%	Gray snapper	77
Bluehead wrasse	73.3%	Doctorfish	52
Graysby	73.3%	Slippery dick	50
Yellowhead wrasse	73.3%	Yellowhead wrasse	40
Sharpnose puffer	66.7%	Greater amberjack	36
Gray snapper	66.7%	Twospot cardinalfish	36
Masked goby	60.0%	Sharpnose puffer	31
Reef butterflyfish	60.0%	Bicolor damselfish	28
Twospot cardinalfish	53.3%	Hogfish	23
Gray angelfish	46.7%	Spotfin butterflyfish	21
Bicolor damselfish	40.0%	Graysby	21

Table 22. Summary of censuses on the deep natural reef (DNR) from September 1988 to May 1990.

Species	Total Indiv. (N = 68)	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
			%			High	Low	Mean	Min.	Max.
ACA BAH1	34	21	30.9%	0.50	0.95	5	0	16.7	10	30
ACA CHIR	38	22	32.4%	0.56	0.95	4	0	17.2	10	25
ACA COER	19	11	16.2%	0.28	0.86	6	0	18.2	10	25
AMB PINO	2	2	2.9%	0.03	0.17	1	0	5.5	5	0
ANI SURI	3	1	1.5%	0.04	0.36	3	0	30.0	25	35
ANI VIRG	12	11	16.2%	0.18	0.42	2	0	19.8	15	25
AP0 SPE.	80	1	1.5%	1.18	9.70	80	0	4.0	2	5
AUL MACU	2	2	2.9%	0.03	0.17	1	0	31.5	25	38
BAL CAPR	2	2	2.9%	0.03	0.17	1	0	30.0	30	30
BOD PULC	159	52	76.5%	2.34	2.06	9	0	8.6	2	24
BOD RUFU	24	19	27.9%	0.35	0.62	2	0	7.2	3	18
CAL CALA	21	10	14.7%	0.31	0.89	5	0	21.8	14	35
CAN MACR	2	2	2.9%	0.03	0.17	1	0	27.5	25	30
CAN ROST	88	45	66.2%	1.29	1.19	4	0	4.9	2	9
CAR BART	58	8	11.8%	0.85	3.04	15	0	28.6	15	40
CAR CRY5	1	1	1.5%	0.01	0.12	1	0	24.0	24	24
CAR RUBE	9	4	5.9%	0.13	0.75	6	0	23.8	14	30
CHA CAPI	111	46	67.6%	1.63	1.38	5	0	7.2	4	14
CHA FABE	2	2	2.9%	0.03	0.17	1	0	36.0	27	45
CHA OCEL	49	25	36.8%	0.72	0.97	3	0	12.0	6	18
CHA SEDE	129	57	83.8%	1.90	1.20	6	0	9.3	4	16
CHA STRI	4	3	4.4%	0.06	0.29	2	0	8.8	7	10
CHR CYAN	226	61	89.7%	3.32	2.91	12	0	6.5	1	12
CHR ENCH	89	23	33.8%	1.31	2.46	10	0	2.7	1	5
CHR INSO	460	53	77.9%	6.76	8.16	41	0	3.7	1	7
CHR MULT	20	5	7.4%	0.29	1.95	16	0	3.7	2	10
CHR SCOT	1396	48	70.6%	20.53	39.93	275	0	2.8	1	8
CLE PARR	64	11	16.2%	0.94	2.59	14	0	3.6	1	22
COR GLAU	34	7	10.3%	0.50	1.64	8	0	3.8	3	5
COR PERS	874	39	57.4%	12.85	20.50	125	0	2.9	1	5
DAS AMER	1	1	1.5%	0.01	0.12	1	0	80.0	80	80
DEC PUNC	2500	2	2.9%	36.76	217.11	1500	0	16.0	15	17
DIO HOLO	1	1	1.5%	0.01	0.12	1	0	14.0	14	14
DIO HYST	1	1	1.5%	0.01	0.12	1	0	30.0	30	30
ECH NAUC	2	2	2.9%	0.03	0.17	1	0	16.5	15	18
EMB PAND	1	1	1.5%	0.01	0.12	1	0	3.0	3	3
EPI ADSC	25	12	17.6%	0.37	0.88	4	0	14.4	6	28
EPI CRUE	105	48	70.6%	1.54	1.43	9	0	14.5	5	22
EPI FULV	5	4	5.9%	0.07	0.31	2	0	15.0	12	20
EPI GUTT	5	3	4.4%	0.07	0.40	3	0	12.4	6	15
EPI STRI	2	2	2.9%	0.03	0.17	1	0	40.0	30	50
EQU ACUM	88	26	38.2%	1.29	2.53	10	0	10.7	6	15
EQU LANC	12	10	14.7%	0.18	0.46	2	0	16.2	12	22
FIS SPE.	1	1	1.5%	0.01	0.12	1	0	20.0	20	20
GER CINE	12	2	2.9%	0.18	1.15	9	0	18.8	15	20
GOB OCEA	32	14	20.6%	0.47	1.19	6	0	3.3	2	5
GYM FUNE	4	4	5.9%	0.06	0.24	1	0	105.0	60	140

Table 22. Summary of censuses on the deep natural reef (DNR) from September 1988 to May 1990.

Species	SAMPLE FREQUENCY			Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
	Total Indiv. (N = 68)		%			High	Low	Mean	Min.	Max.
GYM MORI	2	2	2.9%	0.03	0.17	1	0	47.5	45	50
GYM VICI	1	1	1.5%	0.01	0.12	1	0	80.0	80	80
HAE AURO	3630	22	32.4%	53.38	126.50	600	0	15.8	4	22
HAE FLAV	202	47	69.1%	2.97	3.75	18	0	14.6	2	22
HAE MELA	13	3	4.4%	0.19	1.08	8	0	16.7	13	25
HAE PLUM	603	35	51.5%	8.87	20.61	100	0	18.0	10	28
HAE SCIU	182	25	36.8%	2.68	6.86	45	0	20.0	12	26
HAE SPE.	2591	8	11.8%	38.10	244.63	2000	0	2.9	2	3
HAL BIVI	3	2	2.9%	0.04	0.27	2	0	11.0	7	15
HAL GARN	197	54	79.4%	2.90	2.65	15	0	9.7	2	20
HAL MACU	1	1	1.5%	0.01	0.12	1	0	6.0	6	6
HOL ASCE	1	1	1.5%	0.01	0.12	1	0	13.0	13	13
HOL BERM	15	14	20.6%	0.22	0.45	2	0	21.3	8	35
HOL CILI	7	4	5.9%	0.10	0.46	3	0	11.4	4	25
HOL CORU	9	9	13.2%	0.13	0.34	1	0	15.8	10	20
HOL MARI	2	2	2.9%	0.03	0.17	1	0	10.0	10	10
HOL RUFU	1	1	1.5%	0.01	0.12	1	0	13.0	13	13
HOL TRIC	187	67	98.5%	2.75	1.32	7	0	10.7	2	25
HYP GEMM #	7	4	5.9%	0.10	0.46	3	0	9.3	5	11
HYP NIGR #	1	1	1.5%	0.01	0.12	1	0	8.0	8	8
HYP PUEL #	3	2	2.9%	0.04	0.27	2	0	9.3	7	12
HYP UNIC	87	55	80.9%	1.28	0.88	3	0	8.3	4	15
IOG SPE.	11	2	2.9%	0.16	1.22	10	0	2.2	1	4
LAC BICA	4	4	5.9%	0.06	0.24	1	0	14.3	12	15
LAC MAXI	43	31	45.6%	0.63	0.81	3	0	23.9	6	50
LAC QUAD	2	2	2.9%	0.03	0.17	1	0	23.5	17	30
LUT ANAL	5	3	4.4%	0.07	0.36	2	0	44.2	25	80
LUT APOD	5	1	1.5%	0.07	0.61	5	0	15.0	12	18
LUT BUCC	263	39	57.4%	3.87	5.95	30	0	14.1	8	25
LUT GRIS	76	15	22.1%	1.12	4.47	35	0	35.9	15	50
LUT SYNA	544	28	41.2%	8.00	16.25	90	0	17.0	10	43
MON HISP	1	1	1.5%	0.01	0.12	1	0	18.0	18	18
MON SETI	5	3	4.4%	0.07	0.36	2	0	17.2	14	18
MUL MART	51	7	10.3%	0.75	3.02	20	0	14.6	10	20
MYC BONA	10	8	11.8%	0.15	0.43	2	0	42.9	12	80
MYC SPE.	2	2	2.9%	0.03	0.17	1	0	20.0	10	30
OCY CHRY	118	40	58.8%	1.74	2.39	12	0	21.9	8	45
ODO DENT	50	1	1.5%	0.74	6.06	50	0	4.0	3	5
OPI AURI	2	1	1.5%	0.03	0.24	2	0	7.0	7	8
PAR MARM	1	1	1.5%	0.01	0.12	1	0	6.0	6	6
POM ARCU	22	14	20.6%	0.32	0.74	3	0	28.0	20	40
POM FUSC	16	13	19.1%	0.24	0.52	2	0	6.4	3	10
POM LEUC	5	3	4.4%	0.07	0.40	3	0	5.6	3	10
POM PART	1566	67	98.5%	23.03	12.54	55	0	4.0	1	9
POM PARU	8	7	10.3%	0.12	0.37	2	0	17.8	10	35
POM PLAN	4	4	5.9%	0.06	0.24	1	0	7.8	5	12
POM VARI	77	40	58.8%	1.13	1.20	4	0	5.2	2	9

Table 22. Summary of censuses on the deep natural reef (DNR) from September 1988 to May 1990.

Species	SAMPLE FREQUENCY			Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
	Total Indiv. (N = 68)		%			High	Low	Mean	Min.	Max.
PSE MACU	165	49	72.1%	2.43	2.35	10	0	16.4	10	26
RYP SAPO	1	1	1.5%	0.01	0.12	1	0	25.0	25	25
SCA CRIS	2	2	2.9%	0.03	0.17	1	0	5.5	5	6
SCA CROI	212	61	89.7%	3.12	2.34	12	0	10.6	2	22
SCA TAEN	3	3	4.4%	0.04	0.21	1	0	16.7	10	20
SCA VETU	2	2	2.9%	0.03	0.17	1	0	8.0	4	12
SCO PLUM	5	4	5.9%	0.07	0.31	2	0	24.4	12	30
SCO REGA	7	4	5.9%	0.10	0.46	3	0	39.0	28	50
SER DUME	14	5	7.4%	0.21	0.96	7	0	40.2	10	60
SER TABA	16	9	13.2%	0.24	0.67	3	0	9.0	5	13
SER TIGR	2	2	2.9%	0.03	0.17	1	0	4.0	4	4
SPA AURO	118	56	82.4%	1.74	1.22	5	0	11.6	4	20
SPA SPE.	1	1	1.5%	0.01	0.12	1	0	12.0	12	12
SPA VIRI	6	5	7.4%	0.09	0.33	2	0	19.2	15	32
SYN SPE.	1	1	1.5%	0.01	0.12	1	0	20.0	20	20
THA BIFA	453	54	79.4%	6.66	6.70	33	0	5.7	2	12
TRA GOOD	3	1	1.5%	0.04	0.36	3	0	40.0	40	40
URO JAMA	1	1	1.5%	0.01	0.12	1	0	60.0	60	60

= color variants of H. unicolor

NO. SAMPLES = 68
 NO. SPECIES = 109
 TOT. INDIVIDUALS = 18457

Table 23. Summary of monitoring at the Bahia Honda bridge rubble reefs from June to August 1989.

Species	Total Indiv.	SAMPLE FREQUENCY			Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N = 26)	% Abund.	Mean		High	Low	Mean	Min.	Max.
ABU SAXA	14	6	23.1%	0.54	1.33	6	0	3.4	2	5
ACA BAH1	14	5	19.2%	0.54	1.36	6	0	14.9	10	20
ACA CHIR	75	23	88.5%	2.88	1.82	6	0	16.3	2	25
ACA COER	79	24	92.3%	3.04	1.87	7	0	12.9	3	25
AMB PINO	1	1	3.8%	0.04	0.20	1	0	6.0	6	6
ANI VIRG	130	26	100.0%	5.00	4.05	15	1	11.8	2	29
APO MACU	1	1	3.8%	0.04	0.20	1	0	5.0	5	5
APO PSEU	11	3	11.5%	0.42	1.33	6	0	3.7	2	6
ARC PROB	3	3	11.5%	0.12	0.33	1	0	31.7	25	35
CAL BAJO	1	1	3.8%	0.04	0.20	1	0	25.0	25	25
CAL CALA	3	1	3.8%	0.12	0.59	3	0	22.0	20	23
CAN ROST	35	15	57.7%	1.35	1.41	4	0	5.8	4	9
CAR BART	1	1	3.8%	0.04	0.20	1	0	50.0	50	50
CAR CRY	3	1	3.8%	0.12	0.59	3	0	5.0	5	6
CAR RUBE	13	3	11.5%	0.50	1.42	5	0	8.7	6	10
CAR SPE.	2	1	3.8%	0.08	0.39	2	0	30.0	30	30
CEN UNDE	76	8	30.8%	2.92	7.38	35	0	71.3	35	90
CHA CAPI	3	2	7.7%	0.12	0.43	2	0	6.3	6	7
CHA FABE	1	1	3.8%	0.04	0.20	1	0	50.0	50	50
CHA OCEL	23	12	46.2%	0.88	1.07	3	0	11.5	6	14
CHA SEDE	4	4	15.4%	0.15	0.37	1	0	5.8	5	7
CLU SPE.	300	1	3.8%	11.54	58.83	300	0	4.0	3	5
COR GLAU	174	15	57.7%	6.69	7.91	25	0	4.4	2	6
DEC SPE.	300	3	11.5%	11.54	41.37	200	0	5.9	4	8
EPI ADSC	2	2	7.7%	0.08	0.27	1	0	16.5	15	18
EPI CRUE	14	12	46.2%	0.54	0.65	2	0	12.4	8	20
EPI FULV	2	2	7.7%	0.08	0.27	1	0	8.0	8	8
EPI GUTT	1	1	3.8%	0.04	0.20	1	0	12.0	12	12
EPI MORI	1	1	3.8%	0.04	0.20	1	0	50.0	50	50
EPI STRI	3	2	7.7%	0.12	0.43	2	0	43.3	30	60
EQU ACUM	5	3	11.5%	0.19	0.57	2	0	9.6	8	11
EQU UMBR	2	2	7.7%	0.08	0.27	1	0	10.0	10	10
GOB OCEA	1	1	3.8%	0.04	0.20	1	0	4.0	4	4
GYM MORI	1	1	3.8%	0.04	0.20	1	0	40.0	40	40
HAE ALBU	4	3	11.5%	0.15	0.46	2	0	21.8	18	25
HAE AURO	19955	26	100.0%	767.50	870.73	3500	30	9.0	2	22
HAE FLAV	10	4	15.4%	0.38	1.02	4	0	11.7	10	14
HAE PLUM	154	22	84.6%	5.92	8.10	37	0	15.7	6	25
HAE SCIU-	157	13	50.0%	6.04	10.75	35	0	18.2	12	25
HAE SPE.	325	2	7.7%	12.50	58.84	300	0	6.7	2	8
HAE STRI	4	1	3.8%	0.15	0.78	4	0	16.0	15	17
HAL BIVI	139	21	80.8%	5.35	6.05	25	0	7.6	3	15
HAL RAD1	5	3	11.5%	0.19	0.57	2	0	7.6	6	10
HAL SPE.	1	1	3.8%	0.04	0.20	1	0	8.0	8	8
HAR SPE.	670	3	11.5%	25.77	117.58	600	0	7.0	6	7
HOL BERM	31	17	65.4%	1.19	1.17	4	0	15.7	2	32
HOL CILI	35	20	76.9%	1.35	1.32	6	0	13.8	3	25
HOL TRIC	1	1	3.8%	0.04	0.20	1	0	8.0	8	8

Table 23. Summary of monitoring at the Bahia Honda bridge rubble reefs from June to August 1989.

Species	SAMPLE FREQUENCY			Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
	Total Indiv.	(N=26)	%			High	Low	Mean	Min.	Max.
HYP GEMM #	1	1	3.8%	0.04	0.20	1	0	8.0	8	8
HYP PUEL #	6	3	11.5%	0.23	0.65	2	0	8.3	7	10
HYP UNIC	14	11	42.3%	0.54	0.71	2	0	5.6	4	8
IOG CALL	3	1	3.8%	0.12	0.59	3	0	6.0	5	8
LAC MAXI	46	17	65.4%	1.77	3.27	17	0	19.0	4	40
LAC QUAD	1	1	3.8%	0.04	0.20	1	0	30.0	30	30
LUT ANAL	1	1	3.8%	0.04	0.20	1	0	35.0	35	35
LUT GRIS	164	20	76.9%	6.31	6.18	20	0	24.7	12	40
LUT SYNA	89	12	46.2%	3.42	5.79	22	0	16.5	10	30
MUL MART	1	1	3.8%	0.04	0.20	1	0	9.0	9	9
MYC BONA	30	14	53.8%	1.15	1.41	5	0	47.0	6	100
MYC MICR	71	21	80.8%	2.73	2.32	11	0	18.0	6	40
MYC PHEN	1	1	3.8%	0.04	0.20	1	0	16.0	16	16
MYC SPE.	13	3	11.5%	0.31	1.57	8	0	17.9	5	45
MYR JACO	3	1	3.8%	0.12	0.59	3	0	8.0	8	8
OCY CHRY	10	3	11.5%	0.38	1.27	6	0	17.2	4	25
ODO DENT	3276	16	61.5%	126.00	303.31	1400	0	5.5	2	15
PAR MARM	7	3	11.5%	0.27	0.87	4	0	5.0	4	6
POM ARCU	34	21	80.8%	1.31	1.05	5	0	27.7	12	50
POM FUSC	42	15	57.7%	1.62	2.43	12	0	5.4	3	8
POM LEUC	1	1	3.8%	0.04	0.20	1	0	4.0	4	4
POM PART	5	4	15.4%	0.19	0.49	2	0	4.4	4	6
POM PARU	8	7	26.9%	0.31	0.55	2	0	20.9	12	28
POM PLAN	1	1	3.8%	0.04	0.20	1	0	2.0	2	2
POM VARI	250	26	100.0%	9.62	5.57	19	1	4.3	2	10
PRI AREN	3	2	7.7%	0.12	0.43	2	0	33.3	14	45
SCA COEL	4	3	11.5%	0.15	0.46	2	0	28.0	7	40
SCA COER	3	2	7.7%	0.12	0.43	2	0	26.7	6	40
SCA CROI	156	24	92.3%	6.00	4.57	15	0	7.2	2	16
SCA GUAC	25	8	30.8%	0.96	2.11	9	0	47.2	35	60
SCA VETU	1	1	3.8%	0.04	0.20	1	0	18.0	18	18
SCO PLUM	1	1	3.8%	0.04	0.20	1	0	15.0	15	15
SCO REGA	6	3	11.5%	0.23	0.71	3	0	30.3	30	32
SER BALD	4	2	7.7%	0.15	0.61	3	0	5.5	5	7
SER SUBL	3	2	7.7%	0.12	0.43	2	0	5.7	5	7
SER TIGR	3	2	7.7%	0.12	0.43	2	0	6.7	6	8
SPA AURO	29	12	46.2%	1.12	1.73	6	0	9.5	4	24
SPA CHRY	7	3	11.5%	0.27	1.00	5	0	18.3	15	25
SPA SPE.	6	2	7.7%	0.23	0.99	5	0	6.7	5	8
SPA VIRI	5	4	15.4%	0.19	0.49	2	0	8.6	7	10
SPH BARR	5	5	19.2%	0.19	0.40	1	0	81.0	40	125
SPH SPEN	1	1	3.8%	0.04	0.20	1	0	7.0	7	7
THA BIFA	20	11	42.3%	0.77	0.99	3	0	6.7	4	10
TRA FALC	1	1	3.8%	0.04	0.20	1	0	40.0	40	40

NO. SAMPLES = 26
 NO. SPECIES = 90
 TOT. INDIVIDUALS = 27151

= color variants of *H. unicolor*

Table 24. Summary of monitoring at the American Shoal bridge rubble reefs in July and August 1989.

Species	Total Indiv.	SAMPLE FREQUENCY			Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N = 24)	%	Mean Abund.		High	Low	Mean	Min.	Max.
ACA BAH1	36	15	62.5%	1.50	1.50	5	0	17.7	10	25
ACA CHIR	32	16	66.7%	1.33	1.40	5	0	16.8	12	25
ACA COER	15	10	41.7%	0.63	0.88	3	0	11.9	6	18
ANI VIRG	102	19	79.2%	4.25	6.33	29	0	15.6	2	25
APD PSEU	4	2	8.3%	0.17	0.64	3	0	4.5	3	5
AUL MACU	3	3	12.5%	0.13	0.34	1	0	34.0	22	40
CAL CALA	2	2	8.3%	0.08	0.28	1	0	12.0	6	18
CAN ROST	35	17	70.8%	1.46	1.50	6	0	6.0	3	9
CAR BART	11	2	8.3%	0.46	2.04	10	0	23.6	20	40
CAR CRY5	1	1	4.2%	0.04	0.20	1	0	18.0	18	18
CAR RUBE	38	8	33.3%	1.58	2.65	8	0	9.6	6	14
CEN UNDE	8	6	25.0%	0.33	0.64	2	0	62.5	55	70
CHA CAPI	3	3	12.5%	0.13	0.34	1	0	7.7	7	8
CHA OCEL	28	17	70.8%	1.17	0.87	2	0	12.6	8	15
CHA SEDE	1	1	4.2%	0.04	0.20	1	0	8.0	8	8
COR GLAU	64	10	41.7%	2.67	3.99	12	0	4.4	3	5
DIO HYST	1	1	4.2%	0.04	0.20	1	0	45.0	45	45
EPI ADSC	3	2	8.3%	0.13	0.45	2	0	12.0	4	18
EPI CRUE	9	8	33.3%	0.38	0.58	2	0	11.8	8	15
EQU ACUM	21	9	37.5%	0.88	2.44	12	0	10.6	8	12
EQU UMBR	17	9	37.5%	0.71	1.20	4	0	12.1	8	15
GER CINE	55	13	54.2%	2.29	3.52	15	0	18.5	12	28
GOB OCEA	12	8	33.3%	0.50	0.78	2	0	4.0	3	5
GYM FUNE	1	1	4.2%	0.04	0.20	1	0	100.0	100	100
HAE ALBU	2	1	4.2%	0.08	0.41	2	0	25.0	25	25
HAE AURO	10207	24	100.0%	425.29	438.18	2000	12	16.0	10	20
HAE FLAV	22	5	20.8%	0.92	3.08	15	0	9.9	6	15
HAE PLUM	3225	24	100.0%	134.38	77.81	300	12	18.2	10	25
HAE SCIU	834	22	91.7%	34.75	30.68	111	0	18.2	10	25
HAL BIVI	97	19	79.2%	4.04	4.12	17	0	7.3	4	16
HAL GARN	11	5	20.8%	0.46	0.98	3	0	8.3	4	15
HAL SPE.	1	1	4.2%	0.04	0.20	1	0	15.0	15	15
HOL BERM	21	12	50.0%	0.88	1.03	3	0	18.0	1	26
HOL CILI	13	9	37.5%	0.54	0.93	4	0	18.8	10	28
HOL RUFU	2	1	4.2%	0.08	0.41	2	0	16.0	15	17
HOL TRIC	9	6	25.0%	0.38	0.77	3	0	6.9	4	10
HYP GEMM #	5	4	16.7%	0.21	0.51	2	0	7.2	5	8
HYP NIGR #	1	1	4.2%	0.04	0.20	1	0	8.0	8	8
HYP PUEL #	9	6	25.0%	0.38	0.77	3	0	7.8	4	10
HYP UNIC	12	8	33.3%	0.50	0.83	3	0	9.1	4	20
IOG CALL	5	1	4.2%	0.21	1.02	5	0	7.0	6	8
IOG SPE.	2	1	4.2%	0.08	0.41	2	0	6.0	6	6
LAC BICA	1	1	4.2%	0.04	0.20	1	0	22.0	22	22
LAC MAXI	18	12	50.0%	0.75	0.90	3	0	23.2	14	40
LUT GRIS	56	7	29.2%	2.33	5.22	20	0	22.1	12	45
LUT SYNA	249	20	83.3%	10.38	10.75	30	0	16.7	10	22
MAL TRIA	1	1	4.2%	0.04	0.20	1	0	5.0	5	5

Table 24. Summary of monitoring at the American Shoal bridge rubble reefs in July and August 1989.

Species	SAMPLE FREQUENCY			Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
	Total Indiv. (N = 24)		%			High	Low	Mean	Min.	Max.
MUL MART	22	3	12.5%	0.92	3.06	14	0	23.4	15	28
MYC BONA	1	1	4.2%	0.04	0.20	1	0	50.0	50	50
MYC MICR	15	8	33.3%	0.63	1.06	4	0	15.1	6	25
OCY CHRY	34	13	54.2%	1.42	1.69	5	0	21.6	12	35
ODO DENT	32	10	41.7%	1.33	2.14	8	0	13.3	6	18
OPI AURI	1	1	4.2%	0.04	0.20	1	0	6.0	6	6
POM ARCU	22	14	58.3%	0.92	0.93	3	0	27.1	12	40
POM FUSC	24	11	45.8%	1.00	1.50	6	0	7.5	6	9
POM LEUC	4	2	8.3%	0.17	0.56	2	0	5.0	3	6
POM PART	51	15	62.5%	2.13	2.58	10	0	4.3	2	7
POM PARU	3	3	12.5%	0.13	0.34	1	0	14.3	3	20
POM PLAN	3	2	8.3%	0.13	0.45	2	0	7.3	6	8
POM VARI	71	20	83.3%	2.96	2.66	8	0	4.5	2	9
PRI AREN	160	8	33.3%	6.67	17.35	75	0	24.5	14	35
PSE MACU	46	17	70.8%	1.92	2.02	8	0	16.8	12	22
SCA CRIS	1	1	4.2%	0.04	0.20	1	0	5.0	5	5
SCA CROI	190	24	100.0%	7.92	3.89	20	2	9.7	2	20
SCA VETU	1	1	4.2%	0.04	0.20	1	0	15.0	15	15
SCO PLUM	1	1	4.2%	0.04	0.20	1	0	22.0	22	22
SER TIGR	4	2	8.3%	0.17	0.56	2	0	8.5	8	10
SPA AURO	70	21	87.5%	2.92	2.10	8	0	12.6	5	22
SPA CHRY	6	3	12.5%	0.25	0.68	2	0	16.0	12	18
SPA VIRI	6	3	12.5%	0.25	0.68	2	0	11.0	6	15
SPH BARR	3	3	12.5%	0.13	0.34	1	0	101.7	90	125
SPH SPEN	1	1	4.2%	0.04	0.20	1	0	9.0	9	9
SYN FOET	1	1	4.2%	0.04	0.20	1	0	30.0	30	30
THA BIFA	57	12	50.0%	2.38	3.25	12	0	6.5	2	11
TRA FALC	3	2	8.3%	0.13	0.45	2	0	103.3	80	130

= color variants of *H. unicolor*

NO. SAMPLES = 24
 NO. SPECIES = 72
 TOT. INDIVIDUALS = 16138

Table 25. Combined summary of monitoring for Bahia Honda and American Shoal reefs from June to August 1989.

Species	SAMPLE FREQUENCY					SAMP. FREQ. RANGE		FISH LENGTH (cm)		
	Total Indiv. (N = 50)	% Abund.	Mean Abund.	Stand. Dev.		High	Low	Mean	Min.	Max.
ABU SAXA	14	6 12.0%	0.28	0.99		6	0	3.4	2	5
ACA BAH	50	20 40.0%	1.00	1.50		6	0	16.9	10	25
ACA CHIR	107	39 78.0%	2.14	1.80		6	0	16.5	2	25
ACA COER	94	34 68.0%	1.88	1.90		7	0	12.8	3	25
AMB PINO	1	1 2.0%	0.02	0.14		1	0	6.0	6	6
ANI VIRG	232	45 90.0%	4.64	5.23		29	0	13.4	2	29
APO MACU	1	1 2.0%	0.02	0.14		1	0	5.0	5	5
APO PSEU	15	5 10.0%	0.30	1.05		6	0	3.9	2	6
ARC PROB	3	3 6.0%	0.06	0.24		1	0	31.7	25	35
AUL MACU	3	3 6.0%	0.06	0.24		1	0	34.0	22	40
CAL BAJO	1	1 2.0%	0.02	0.14		1	0	25.0	25	25
CAL CALA	5	3 6.0%	0.10	0.46		3	0	18.0	6	23
CAN ROST	70	32 64.0%	1.40	1.44		6	0	5.9	3	9
CAR BART	12	3 6.0%	0.24	1.42		10	0	25.8	20	50
CAR CRY	4	2 4.0%	0.08	0.44		3	0	8.3	5	18
CAR RUBE	51	11 22.0%	1.02	2.15		8	0	9.4	6	14
CAR SPE.	2	1 2.0%	0.04	0.28		2	0	30.0	30	30
CEN UNDE	84	14 28.0%	1.68	5.45		35	0	70.4	35	90
CHA CAPI	6	5 10.0%	0.12	0.39		2	0	7.0	6	8
CHA FABI	1	1 2.0%	0.02	0.14		1	0	50.0	50	50
CHA OCEL	51	29 58.0%	1.02	0.98		3	0	12.1	6	15
CHA SEDE	5	5 10.0%	0.10	0.30		1	0	6.2	5	8
CLU SPE.	300	1 2.0%	6.00	42.43		300	0	4.0	3	5
COR GLAU	238	25 50.0%	4.76	6.59		25	0	4.4	2	6
DEC SPE.	300	3 6.0%	6.00	30.12		200	0	5.9	4	8
DIO HYST	1	1 2.0%	0.02	0.14		1	0	45.0	45	45
EPI ADSC	5	4 8.0%	0.10	0.36		2	0	13.8	4	18
EPI CRUE	23	20 40.0%	0.46	0.61		2	0	12.2	8	20
EPI FULV	2	2 4.0%	0.04	0.20		1	0	8.0	8	8
EPI GUTT	1	1 2.0%	0.02	0.14		1	0	12.0	12	12
EPI MORI	1	1 2.0%	0.02	0.14		1	0	50.0	50	50
EPI STRI	3	2 4.0%	0.06	0.31		2	0	43.3	30	60
EQU ACUM	26	12 24.0%	0.52	1.75		12	0	10.4	8	12
EQU UMBR	19	11 22.0%	0.38	0.90		4	0	11.8	8	15
GER CINE	55	13 26.0%	1.10	2.67		15	0	18.5	12	28
GOB OCEA	13	9 18.0%	0.26	0.60		2	0	4.0	3	5
GYM FUNE	1	1 2.0%	0.02	0.14		1	0	100.0	100	100
GYM MORI	1	1 2.0%	0.02	0.14		1	0	40.0	40	40
HAE ALBU	6	4 8.0%	0.12	0.44		2	0	22.8	18	25
HAE AURO	30162	50 100.0%	603.24	711.88		3500	12	11.4	2	22
HAE FLAV	32	9 18.0%	0.64	2.25		15	0	10.4	6	15
HAE PLUM	3379	46 92.0%	67.58	84.13		300	0	18.0	6	25
HAE SCIU	991	35 70.	17.82	24.15		111	0	19.0	10	25
HAE SPE.	325	2 4.0%	6.50	42.50		300	0	6.7	2	8
HAE STRI	4	1 2.0%	0.08	0.57		4	0	16.0	15	17
HAL BIVI	236	40 80.0%	4.72	5.20		25	0	7.5	3	16
HAL GARN	11	5 10.0%	0.22	0.71		3	0	8.3	4	15

Table 25. Combined summary of monitoring for Bahia Honda and American Shoal reefs from June to August 1989.

Species	SAMPLE FREQUENCY			Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
	Total Indiv. (N = 50)	%				High	Low	Mean	Min.	Max.
HAL RADI	5	3	6.0%	0.10	0.42	2	0	7.6	6	10
HAL SPE.	2	2	4.0%	0.04	0.20	1	0	11.5	8	15
HAR SPE.	670	3	6.0%	13.40	84.99	600	0	7.0	6	7
HOL BERM	52	29	58.0%	1.04	1.11	4	0	16.6	1	32
HOL CILI	48	29	58.0%	0.96	1.21	6	0	15.2	3	28
HOL RUFU	2	1	2.0%	0.04	0.28	2	0	16.0	15	17
HOL TRIC	10	7	14.0%	0.20	0.57	3	0	7.0	4	10
HYP GEMM #	6	5	10.0%	0.12	0.39	2	0	7.3	5	8
HYP NIGR #	1	1	2.0%	0.02	0.14	1	0	8.0	8	8
HYP PUEL #	15	9	18.0%	0.30	0.71	3	0	8.0	4	10
HYP UNIC	26	19	38.0%	0.52	0.76	3	0	7.2	4	20
IOG CALL	8	2	4.0%	0.16	0.82	5	0	6.6	5	8
IOG SPE.	2	1	2.0%	0.04	0.28	2	0	6.0	6	6
LAC BICA	1	1	2.0%	0.02	0.14	1	0	22.0	22	22
LAC MAXI	64	29	58.0%	1.28	2.47	17	0	20.2	4	40
LAC QUAD	1	1	2.0%	0.02	0.14	1	0	30.0	30	30
LUT ANAL	1	1	2.0%	0.02	0.14	1	0	35.0	35	35
LUT GRIS	220	27	54.0%	4.40	6.03	20	0	24.0	12	45
LUT SYNA	338	32	64.0%	6.76	9.15	30	0	16.6	10	30
MAL TRIA	1	1	2.0%	0.02	0.14	1	0	5.0	5	5
MUL MART	23	4	8.0%	0.46	2.15	14	0	22.7	9	28
MYC BONA	31	15	30.0%	0.62	1.16	5	0	47.1	6	100
MYC MICR	86	29	58.0%	1.72	2.10	11	0	17.5	6	40
MYC PHEN	1	1	2.0%	0.02	0.14	1	0	16.0	16	16
MYC SPC.	8	1	2.0%	0.16	1.13	8	0	17.9	5	45
MYR JACO	3	1	2.0%	0.06	0.42	3	0	8.0	8	8
OCY CHRY	44	16	32.0%	0.88	1.56	6	0	20.6	4	35
ODO DENT	3308	26	52.0%	66.16	225.61	1400	0	5.6	2	18
OPI AURI	1	1	2.0%	0.02	0.14	1	0	6.0	6	6
PAR MARM	7	3	6.0%	0.14	0.64	4	0	5.0	4	6
POM ARCU	56	35	70.0%	1.12	1.00	5	0	27.5	12	50
POM FUSC	66	26	52.0%	1.32	2.04	12	0	6.2	3	9
POM LEUC	5	3	6.0%	0.10	0.42	2	0	4.8	3	6
POM PART	56	19	38.0%	1.12	2.05	10	0	4.3	2	7
POM PARU	11	10	20.0%	0.22	0.46	2	0	19.1	3	28
POM PLAN	4	3	6.0%	0.08	0.34	2	0	6.0	2	8
POM VARI	321	46	92.0%	6.42	5.52	19	0	4.3	2	10
PRI AREN	163	10	20.0%	3.26	12.34	75	0	24.7	14	45
PSE MACU	46	17	34.0%	0.92	1.69	8	0	16.8	12	22
SCA COEL	4	3	6.0%	0.08	0.34	2	0	28.0	7	40
SCA COER	3	2	4.0%	0.06	0.31	2	0	26.7	6	40
SCA CRIS	1	1	2.0%	0.02	0.14	1	0	5.0	5	5
SCA CROI	346	48	96.0%	6.92	4.32	20	0	8.6	2	20
SCA GUAC	25	8	16.0%	0.50	1.58	9	0	47.2	35	60
SCA VETU	2	2	4.0%	0.04	0.20	1	0	16.5	15	18
SCO PLUM	2	2	4.0%	0.04	0.20	1	0	18.5	15	22
SCO REGA	6	3	6.0%	0.12	0.52	3	0	30.3	30	32

Table 25. Combined summary of monitoring for Bahia Honda and American Shoal reefs from June to August 1989.

Species	Total Indiv.	SAMPLE FREQUENCY		Mean Abund.	Stand. Dev.	SAMP. FREQ. RANGE		FISH LENGTH (cm)		
		(N = 50)	%			High	Low	Mean	Min.	Max.
SER BALD	4	2	4.0%	0.08	0.44	3	0	5.5	5	7
SER SUBL	3	2	4.0%	0.06	0.31	2	0	5.7	5	7
SER TIGR	7	4	8.0%	0.14	0.50	2	0	7.7	6	10
SPA AURO	99	33	66.0%	1.98	2.10	8	0	11.7	4	24
SPA CHRY	13	6	12.0%	0.26	0.85	5	0	17.2	12	25
SPA SPE.	6	2	4.0%	0.12	0.72	5	0	6.7	5	8
SPA VIRI	11	7	14.0%	0.22	0.58	2	0	9.9	6	15
SPH BARR	8	8	16.0%	0.16	0.37	1	0	88.8	40	125
SPH SPEN	2	2	4.0%	0.04	0.20	1	0	8.0	7	9
SYN FOET	1	1	2.0%	0.02	0.14	1	0	30.0	30	30
THA BIFA	77	23	46.0%	1.54	2.48	12	0	6.5	2	11
TRA FALC	4	3	6.0%	0.08	0.34	2	0	87.5	40	130

= color variants of H. unicolor

NO. SAMPLES = 50
 NO. SPECIES = 103
 TOT. INDIVIDUALS = 43289

Table 26. Summary of settler and colonizer species at the shallow fabricated units from June 1988 to June 1990.

SETTLER SPECIES					COLONIZER SPECIES				
Species	Total Indiv.	% Freq. (N=42)	Biomass kg	1 Value	Species	Total Indiv.	% Freq. (N=42)	Biomass kg	1 Value
1 THA BIFA	724	92.9%	0.58	ML	1 ACA CHIR	79	61.9%	4.10	ml
2 HAL BIVI	389	95.2%	1.47	ml	2 LAC MAXI	15	31.0%	5.16	P,R
3 PAR MARM	99	57.1%	0.05	ml	3 CHA OCEL	12	14.3%	0.77	ML
4 HAE SPE.	82	19.0%	0.01	S	4 HAL RAD	8	16.7%		ML
5 ACA BAH	68	57.1%	1.27	ml	5 HEM SPE.	7	7.1%	0.01	ml
6 HAE AURO	64	14.3%	0.02	S	6 OPI AURI	7	4.8%	0.01	ML
7 ANI VIRG	61	61.9%	2.55	S,R,ml	7 HOL SPE.	6	4.8%	0.01	ml
8 APO PSEU	60	54.8%	0.07	ML	8 CAR RUBE	6	7.1%	0.51	
9 CAN ROST	59	66.7%	0.05	ML	9 BOD RUFU	5	7.1%		ML
10 POM ARCU	46	69.0%	44.02	ML	10 DIP FORM	5	9.5%	0.05	
11 ACA COER	42	50.0%	0.53	ML	11 EPI ADSC	4	9.5%	0.09	S,ml
12 POM PART	31	26.2%	0.02	ML	12 HAE MELA	4	9.5%	0.02	S
13 HAE STRI	16	4.8%			13 CHA SEDE	3	7.1%		ML
14 GOB OCEA	9	11.9%		ML	14 HOL MARI	3	2.4%	0.03	ml
15 SCA CRIS	8	14.3%	0.01	ml	15 GIN CIR	3	7.1%	174.64	ml
16 MAL TRIA	8	11.9%		ML	16 LUT ANAL	3	7.1%	2.84	P,R
17 CHR MULT	7	14.3%	0.01	ml	17 ECH NAUC	3	4.8%	0.19	
18 POM VARI	4	9.5%		ML	18 MYC SPE.	2	4.8%		ml
19 SCA SPE.	4	2.4%		ml	19 ABU SAXA	2	4.8%		ml
20 EMB PAND	4	9.5%		ml	20 CAR BART	2	2.4%	1.02	R
21 HOL BERM	3	7.1%	0.93	ML	21 MYC MICR	1	2.4%	8.61	P,R
22 HAL GARN	3	7.1%		ML	22 SYN INTE	1	2.4%	0.01	
23 SCA CROI	2	2.4%		ML	23 CAL CALA	1	2.4%	1.32	P,R
24 EPI CRUE	2	4.8%	0.05	ml	24 POM PARU	1	2.4%	0.84	ML
25 POM LEUC	2	2.4%		ML	25 HAE ALBU	1	2.4%	1.25	S,R
26 OCY CHRY	2	4.8%	0.01	P,R	26 LAC BICA	1	2.4%	0.02	ml
27 EQU ACUM	2	4.8%		ML	27 SYN FOET	1	2.4%		
28 COR GLAU	2	4.8%		ml	28 HAE PLUM	1	2.4%		S,R
29 MAL SPE.	2	2.4%			29 LAC QUAD	1	2.4%	0.08	ml
30 CHR SCOT	1	2.4%		ML	30 HOL CILI	1	2.4%	0.53	ML
31 SER TIGR	1	2.4%		ML	31 MON SPE.	1	2.4%		ml
32 CHR ENCH	1	2.4%		ML	32 AST STEL	1	2.4%		
33 HOL CORU	1	2.4%			33 URO JAMA	1	2.4%	0.15	
34 SPH BARR	1	2.4%		R					
Total	1810		51.65		Total	192		202.26	

1 Economic value: P, primary commercial; S, secondary commercial; R, recreational;
ML, primary marine life; ml, secondary marine life

Table 27. Summary of settler and colonizer species at the mid-depth fabricated units from June 1988 to June 1990.

SETTLER SPECIES					COLONIZER SPECIES				
Species	Total Indiv.	% Freq (N=32)	Biomass kg	1 Value	Species	Total Indiv.	% Freq. (N=32)	Biomass kg	1 Value
1 ACA COER	121	96.9%	10.94	ML	1 ACA BAH1	223	96.9%	35.37	ml
2 CAN ROST	83	81.3%	0.13	ML	2 HAL BIVI	108	78.1%	0.67	ml
3 THA BIFA	659	81.3%	0.43	ML	3 ACA CHIR	92	62.5%	14.52	ml
4 ANI VIRG	34	71.9%	5.12	S,R,ml	4 LAC MAXI	37	62.5%	9.07	P,R
5 CHA SEDE	37	65.6%	0.63	ML	5 POM ARCU	32	62.5%	23.57	ML
6 EPI CRUE	37	62.5%	0.36	ml	6 CHA OCEL	32	53.1%	1.93	ML
7 COR GLAU	273	56.3%	0.14	ml	7 ABU SAXA	39	53.1%	0.89	ml
8 APO PSEU	109	50.0%	0.10	ML	8 OCY CHRY	337	46.9%	94.67	P,R
9 HAE MELA	150	50.0%	2.39	S	9 CAR RUBE	104	25.0%	12.69	
10 POM PART	67	43.8%	0.03	ML	10 GYM MORI	8	21.9%	0.68	ML
11 HAL GARN	111	40.6%	0.09	ML	11 PSE MACU	6	15.6%	0.11	ml
12 HAE AURO	639	28.1%	0.64	S	12 POM PARU	7	12.5%	3.82	ML
13 HAE FLAV	43	21.9%	0.34	S	13 SPH BARR	4	12.5%	23.93	R
14 LUT BUCC	7	18.8%	0.02	P,R	14 DIP FORM	9	12.5%	0.05	
15 SER TIGR	7	18.8%	0.01	ML	15 LAC BICA	3	9.4%	0.43	ml
16 HOL BERM	9	15.6%	4.56	ML	16 RYP SAPO	3	9.4%	0.63	
17 EQU ACUM	6	15.6%	0.02	ML	17 DEC PUNC	20	6.3%	0.46	
18 HAE SPE.	159	12.5%	0.10	S	18 DEC MACA	300	6.3%	22.46	
19 PAR MARM	6	12.5%		ML	19 HEM SPLE	3	6.3%	0.02	ml
20 GOB OCEA	6	9.4%		ML	20 HOL CORU	7	6.3%	0.04	ml
21 HAE STRI	308	9.4%	0.79		21 EPI GUTT	3	6.3%	0.02	S,ml
22 HOL CILI	4	9.4%	1.06	ML	22 MON HISP	3	6.3%	0.17	ml
23 EQU LANC	2	6.3%		ML	23 DEC SPE.	100	6.3%	24.20	
24 SPA AURO	3	6.3%	0.21	ml	24 HAL RAD1	2	6.3%	0.12	ML
25 CHR INSO	2	6.3%		ML	25 HAE ALBU	2	6.3%	0.41	S,R
26 MYC SPE.	3	6.3%		P,R	26 CAL CALA	2	6.3%	0.17	P,R
27 MAL SPE.	1	3.1%		ml	27 SER DUME	22	6.3%	28.19	P,R
28 MAL TRIA	1	3.1%		ML	28 URO JAMA	1	3.1%	0.07	ml
29 POM PLAN	1	3.1%		ML	29 LUT ANAL	1	3.1%	1.54	P,R
30 MYC BONA	1	3.1%	0.61	P,R	30 CHA STRI	1	3.1%	0.05	ML
31 CHR MULT	1	3.1%		ml	31 ALU SCHO	1	3.1%	0.02	ml
Total	2890		28.7		32 SPA CHRY	1	3.1%	0.03	ml
					33 SCA CROI	1	3.1%		ML
					34 ALU SCRI	1	3.1%	0.39	ml
					35 SCO REGA	8	3.1%	2.85	P,R
					36 SYN FOET	1	3.1%	0.13	
					37 LAC QUAD	1	3.1%	0.39	ml
					38 LUT GRIS	1	3.1%	0.96	P,R
					39 SCO PLUM	1	3.1%	0.17	ml
					40 LAC TRIQ	1	3.1%	0.25	ml
					41 ECH NAUC	1	3.1%	0.01	ml
					42 APO SPE.	2	3.1%	0.01	ml
					Total	1531		306.16	

1 Economic value: P, primary commercial; S, secondary commercial; R, recreational;
ML, primary marine life; ml, secondary marine life

Table 28. Summary of settler and colonizer species at the deep fabricated units from June 1988 to June 1990.

SETTLER SPECIES					COLONIZER SPECIES				
Species	Total Indiv. (N=30)	% Freq.	Biomass kg	1 Value	Species	Total Indiv. (N=30)	% Freq.	Biomass kg	1 Value
1 EPI CRUE	54	83.3%	0.34	ml	1 LAC MAXI	37	80.0%	11.99	P,R
2 THA BIFA	375	83.3%	0.25	ML	2 HAL BIVI	84	70.0%	0.28	ml
3 CAN ROST	60	70.0%	0.06	ML	3 OCY CHRY	231	70.0%	55.79	P,R
4 HAL GARN	83	63.3%	0.05	ML	4 LUT GRIS	154	63.3%	71.29	P,R
5 COR GLAU	298	60.0%	0.14	ml	5 CHA OCEL	35	63.3%	1.89	ML
6 APO PSEU	117	53.3%	0.09	ml	6 ACA CHIR	74	60.0%	18.21	ml
7 POM PART	157	50.0%	0.09	ML	7 POM ARCU	17	33.3%	14.71	ML
8 CHA SEDE	20	50.0%	0.15	ML	8 SER DUME	45	30.0%	15.62	P,R
9 LUT BUCC	37	26.7%	0.02	P,R	9 POM PARU	11	26.7%	7.15	ML
10 PAR MARM	10	23.3%	0.01	ml	10 LUT ANAL	5	16.7%	15.65	P,R
11 SER TIGR	7	20.0%		ML	11 CAL CALA	4	13.3%	1.84	P,R
12 BOD PULC	11	20.0%	0.01	ML	12 LAC BICA	4	13.3%	0.56	ml
13 CHR ENCH	23	20.0%	0.01	ML	13 SPH BARR	4	13.3%	24.8	R
14 PAR FURC	7	20.0%	0.09	ML	14 HAL SPE.	4	10.0%		ml
15 HOL CILI	5	16.7%	0.01	ML	15 CAR CRYC	7	10.0%	1.01	R
16 CHR INSO	10	16.7%		ML	16 CAR RUBE	20	10.0%	3.67	
17 CHR SCOT	5	13.3%		ML	17 ACA BAH1	7	10.0%	1.38	ml
18 APO SPE.	7	10.0%		ml	18 TRA FALC	3	10.0%	11.39	R
19 HOL TRIC	2	6.7%	0.02	ML	19 CAR BART	5	10.0%	9.93	R
20 POM VARI	2	6.7%		ML	20 ACA COER	8	10.0%	0.46	ML
21 BOD RUFU	2	6.7%		ML	21 RYP SAPO	3	10.0%	0.16	
22 EPI GUTT	2	6.7%	0.01	S,ml	22 LAC QUAD	2	6.7%	0.66	ml
23 MYC SPE.	4	6.7%		P,R	23 IOG HELE	2	6.7%		
24 HOL BERM	3	6.7%	0.07	ML	24 GYM MORI	2	6.7%	0.15	ML
25 SER TABA	2	6.7%		ML	25 LUT CYAN	1	3.3%	26.73	P,R
26 MON CILI	1	3.3%		ml	26 PSE MACU	1	3.3%	0.06	ml
27 MIC CHRY	1	3.3%		ML	27 DEC PUNC	1000	3.3%	89.11	
28 CLE PARR	1	3.3%		ML	28 RAC CANA	1	3.3%	1.92	P,R
29 SER BALD	2	3.3%		ML	29 ECH NAUC	1	3.3%	0.02	
30 SCA SPE.	1	3.3%		ml	30 KYP SECT	1	3.3%	0.18	
31 EQU ACUM	1	3.3%		ML	31 BLE CRIS	1	3.3%		ml
32 EPI ADSC	1	3.3%		S,ml	32 EPI FULV	2	3.3%		ml
33 MYC BONA	1	3.3%		P,R	33 CAL SPE.	1	3.3%	0.35	R,S
34 ANI VIRG	1	3.3%		S,R,ml	34 ALU SCRI	1	3.3%	0.99	ml
					35 HAE STRI	1	3.3%		S
Total	1313		1.42		Total	1779		387.95	

1 Economic value: P, primary commercial; S, secondary commercial; R, recreational;
ML, primary marine life; ml, secondary marine life

Table 29. Summary of settler and colonizer species at the Bahia Honda bridge rubble reefs from June to August 1989.

SETTLER SPECIES					COLONIZER SPECIES				
Species	Total Indiv.	% Freq. (N=26)	Biomass kg	1 Value	Species	Total Indiv.	% Freq. (N=26)	Biomass kg	1 Value
1 HAE AURO	19955	100.0%	163.61	S	1 HAE PLUM	154	84.6%	11.24	S
2 POM VARI	250	100.0%	0.51	ML	2 HAE SCIU	157	50.0%	18.35	S
3 ANI VIRG	130	100.0%	9.11	S,R,ml	3 HYP UNIC	14	42.3%	0.04	ml
4 ACA COER	79	92.3%	4.61	ML	4 CEN UNDE	76	30.8%	452.51	R
5 SCA CROI	156	92.3%	0.95	ml	5 SCA GUAC	25	30.8%	51.97	ml
6 ACA CHIR	75	88.5%	5.82	ML	6 SPH BARR	5	19.2%	18.96	R
7 POM ARCU	34	80.8%	22.37	ML	7 ACA BAH	14	19.2%	1.03	ml
8 MYC MICR	71	80.8%	5.87	P,R	8 HAE FLAV	10	15.4%	0.31	S
9 HAL BIVI	139	80.8%	0.72	ml	9 SPA VIRI	5	15.4%	0.07	ml
10 LUT GRIS	164	76.9%	39.11	P,R	10 SCO REGA	6	11.5%	1.39	P,R
11 HOL CILI	35	76.9%	2.38	ML	11 CAR RUBE	13	11.5%	0.11	R
12 LAC MAXI	46	65.4%	6.25	P,R	12 DEC SPE.	300	11.5%	0.57	
13 HOL BERM	31	65.4%	2.91	ML	13 HYP PUEL #	6	11.5%	0.06	ml
14 ODO DENT	3276	61.5%	5.91		14 HAE ALBU	4	11.5%	0.79	S,R
15 CAN ROST	35	57.7%	0.28	ML	15 PAR MARM	7	11.5%	0.01	ML
16 POM FUSC	42	57.7%	0.20	ml	16 ARC PROB	3	11.5%	2.46	S,R
17 COR GLAU	174	57.7%	0.19	ml	17 HAL RAD	5	11.5%	0.03	ML
18 MYC BONA	30	53.8%	46.97	P,R	18 HAR SPE.	670	11.5%	2.74	
19 CHA OCEL	23	46.2%	1.07	ML	19 SPA CHRY	7	11.5%	0.71	ml
20 EPI CRUE	14	46.2%	0.41	ml	20 MYC SPE.	13	11.5%	1.81	P,R
21 SPA AURO	29	46.2%	0.41	ml	21 PRI AREN	3	7.7%	1.65	S
22 LUT SYNA	89	46.2%	7.00	P,R	22 EPI STRI	3	7.7%	3.75	P,R
23 THA BIFA	20	42.3%	0.05	ML	23 EQU UMBR	2	7.7%	0.03	ml
24 POM PARU	8	26.9%	2.18	ML	24 SPA SPE.	6	7.7%	0.04	
25 ABU SAXA	14	23.1%	0.02	ml	25 EPI ADSC	2	7.7%	0.14	S,ml
26 POM PART	5	15.4%	0.01	ML	26 EPI GUTT	1	3.8%	0.03	S,ml
27 CHA SEDE	4	15.4%	0.02	ML	27 CAR CRY	3	3.8%	0.01	R
28 OCY CHRY	10	11.5%	0.92	P,R	28 GYM MORI	1	3.8%	0.11	ML
29 SCA COEL	4	11.5%	1.65	ml	29 CAR BART	1	3.8%	2.26	R
30 APO PSEU	11	11.5%	0.01	ML	30 CAR SPE.	2	3.8%	1.02	
31 EQU ACUM	5	11.5%	0.06	ML	31 CAL CALA	3	3.8%	0.74	P,R
32 CHA CAPI	3	7.7%	0.02	ML	32 LUT ANAL	1	3.8%	0.72	P,R
33 SER BALD	4	7.7%	0.01	ML	33 CAL BAJ	1	3.8%	0.38	P,R
34 HAE SPE.	325	7.7%	1.46		34 CHA FAB	1	3.8%	0.07	S
35 EPI FULV	2	7.7%	0.02	ml	35 SCA VETU	1	3.8%	0.01	ml
36 SER SUBL	3	7.7%	0.02	ml	36 HYP GEMM #	1	3.8%	0.01	ml
37 SER TIGR	3	7.7%	0.01	ML	37 MYC PHEN	1	3.8%	0.05	P,R
38 SCA COER	3	7.7%	1.02	ml	38 EPI MORI	1	3.8%	1.76	P,R
29 APO MACU	1	3.8%		ML	39 SCO PLUM	1	3.8%	0.07	ml
40 GOB OCEA	1	3.8%		ML	40 SPH SPEN	1	3.8%	0.01	
41 POM PLAN	1	3.8%		ML	41 HOL TRIC	1	3.8%	0.02	ML
42 MUL MART	1	3.8%	0.07	S	42 IOG CALL	3	3.8%	0.01	
43 POM LEUC	1	3.8%		ML	43 HAE STRI	4	3.8%	0.38	
Total	25306		334.21		44 MYR JACO	3	3.8%	0.05	ml
					45 LAC QUAD	1	3.8%	0.39	ml

Table 29. Summary of settler and colonizer species at the Bahia Honda bridge rubble reefs from June to August 1989.

SETTLER SPECIES

Species	Total Indiv.	% Freq. (N=26)	Biomass kg	1 Value
=====				

COLONIZER SPECIES

Species	Total Indiv.	% Freq. (N=26)	Biomass kg	1 Value
=====				

46 HAL SPE.	1	3.8%	0.01	
47 CLU SPE.	300	3.8%	0.27	
48 AMB PINO	1	3.8%		ML
49 TRA FALC	1	3.8%	1.96	R

Total	1845		581.11	
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1 Economic value: P, primary commercial; S, secondary commercial; R, recreational;
 ML, primary marine life; ml, secondary marine life
 * = color variants of H. unicolor

Table 30. Summary of settler and colonizer species at the American Shoal bridge rubble reefs in July and August 1989.

SETTLER SPECIES					COLONIZER SPECIES				
Species	Total Indiv.	% Freq. (N=24)	Biomass kg	1 Value	Species	Total Indiv.	% Freq. (N=24)	Biomass kg	1 Value
1 SCA CROI	190	100.0%	2.66	ml	1 HAE PLUM	3225	100.0%	359.24	S
2 HAE AURO	10207	100.0%	735.66	S	2 HAE SCIU	834	91.7%	94.32	S
3 SPA AURO	70	87.5%	1.91	ml	3 CHA OCEL	28	70.8%	1.51	ML
4 POM VARI	71	83.3%	0.16	ML	4 PSE MACU	46	70.8%	3.66	ml
5 LUT SYNA	249	83.3%	19.95	P,R	5 ACA BAH1	36	62.5%	4.09	ml
6 ANI VIRG	102	79.2%	9.10	S,R,ml	6 GER CINE	55	54.2%	8.19	
7 HAL BIVI	97	79.2%	0.39	ml	7 LAC MAXI	18	50.0%	4.40	P,R
8 CAN ROST	35	70.8%	0.13	ML	8 POM FUSC	24	45.8%	0.27	ml
9 ACA CHIR	32	66.7%	2.68	ml	9 ODO DENT	32	41.7%	0.80	
10 POM PART	51	62.5%	0.09	ML	10 EQU UMBR	17	37.5%	0.43	ml
11 POM ARCU	22	58.3%	13.56	ML	11 PRI AREN	160	33.3%	34.95	S
12 OCY CHRY	34	54.2%	5.83	P,R	12 CAR RUBE	38	33.3%	0.42	
13 THA BIFA	57	50.0%	0.10	ML	13 EPI CRUE	9	33.3%	0.22	S
14 HOL BERM	21	50.0%	2.74	ML	14 LUT GRIS	56	29.2%	9.69	P,R
15 COR GLAU	64	41.7%	0.06	ml	15 CEN UNDE	8	25.0%	35.15	R
16 ACA COER	15	41.7%	0.70	ML	16 HAE FLAV	22	20.8%	0.40	S
17 HOL CILI	13	37.5%	1.97	ML	17 HYP GEMM #	5	16.7%	0.03	ml
18 EQU ACUM	21	37.5%	0.36	ML	18 SPH BARR	3	12.5%	22.95	R
19 MYC MICR	15	33.3%	0.73	P,R	19 CHA CAPI	3	12.5%	0.04	ML
20 HYP UNIC	12	33.3%	0.13	ml	20 AUL MACU	3	12.5%	0.29	
21 GOB OCEA	12	33.3%	0.05	ML	21 MUL MART	22	12.5%	4.82	S
22 HYP PUEL #	9	25.0%	0.05	ml	22 SPA CHRY	6	12.5%	0.39	ml
23 HOL TRIC	9	25.0%	0.10	ML	23 CAR BART	11	8.3%	2.08	R
24 HAL GARN	11	20.8%	0.07	ML	24 CAL CALA	2	8.3%	0.09	P,R
25 POM PARU	3	12.5%	0.25	ML	25 TRA FALC	3	8.3%	32.80	R
26 SPA VIRI	6	12.5%	0.17	ml	26 SER TIGR	4	8.3%	0.04	ML
27 APO PSEU	4	8.3%	0.01	ML	27 OPI AURI	1	4.2%		ML
28 POM PLAN	3	8.3%	0.03	ML	28 SPH SPEN	1	4.2%	0.01	
29 EPI ADSC	3	8.3%	0.08	S,ml	29 HAE ALBU	2	4.2%	0.60	S,R
30 POM LEUC	4	8.3%	0.01	ML	30 IOG SPE.	2	4.2%		
31 CHA SEDE	1	4.2%	0.02	ML	31 SYN FOET	1	4.2%	0.22	
Total	11443		799.75		32 GYM FUNE	1	4.2%	2.11	ml
1 Economic value: P, primary commercial; S, secondary commercial; R, recreational; ML, primary marine life; ml, secondary marine life					33 SCA CRIS	1	4.2%		ml
# = color variants of H. unicolor					34 SCA VETU	1	4.2%	0.06	ml
					35 MAL TRIA	1	4.2%		ML
					36 MYC BONA	1	4.2%	1.91	P,R
					37 LAC BICA	1	4.2%	0.29	ml
					38 HAL SPE.	1	4.2%	0.05	
					39 IOG CALL	5	4.2%	0.01	
					40 CAR CRYC	1	4.2%	0.13	R
					41 SCO PLUM	1	4.2%	0.22	ml
					42 HYP NIGR #	1	4.2%	0.01	ml
					43 HOL RUFU	2	4.2%	0.15	ml
					44 DIO HYST	1	4.2%	3.09	ml
					Total	4695		630.13	

Table 31. Comparison of 15 most frequent, abundant, and heaviest species at shallow fabricated units to the shallow natural reef, June 1988 to June 1990.

SAR Combined (N=42)

Species	% Frequency	Species	Total No.	Species	Biomass (kg)
Slippery dick	95.2	Bluehead wrasse	724	Nurse shark	174.64
Bluehead wrasse	92.9	Slippery dick	389	Gray angelfish	44.02
Gray angelfish	69.0	Seaweed blenny	99	Gag grouper	8.61
Sharpnose puffer	66.7	Unid. grunt	82	Hogfish	5.16
Doctorfish	61.9	Doctorfish	79	Doctorfish	4.10
Porkfish	61.9	Ocean surgeon	68	Mutton snapper	2.84
Ocean surgeon	57.1	Tomtate	64	Porkfish	2.55
Seaweed blenny	57.1	Porkfish	61	Ocean surgeon	1.70
Twospot cardinalfish	54.8	Twospot cardinalfish	60	Slippery dick	1.47
Blue tang	50.0	Sharpnose puffer	59	Saucereye porgy	1.32
Hogfish	31.0	Gray angelfish	46	Margate	1.25
Bicolor damselfish	26.2	Blue tang	42	Yellow jack	1.02
Unid. grunt	19.0	Bicolor damselfish	31	Blue angelfish	0.93
Puddingwife	16.7	Striped grunt	16	French angelfish	0.84
Four species	14.3	Hogfish	15	Spotfin butterflyfish	0.77

Shallow Natural Reef (N=111)

Species	% Frequency	Species	Total No.
Striped parrotfish	95.5	Bicolor damselfish	4493
Yellowhead wrasse	94.6	Bluehead wrasse	2731
Bicolor damselfish	93.7	White grunt	1821
Bluehead wrasse	91.9	Blue tang	1011
Blue tang	85.6	Tomtate	806
Foureye butterflyfish	84.7	Yellowhead wrasse	660
Ocean surgeon	82.0	Bluestriped grunt	634
Redband parrotfish	74.8	Striped parrotfish	538
Harlequin bass	73.0	Slippery dick	484
White grunt	72.1	Ocean surgeon	381
Cocoa damsel	70.3	Doctorfish	253
Slippery dick	68.5	Redband parrotfish	231
Doctorfish	66.7	Foureye butterflyfish	228
Clown wrasse	53.2	Striped grunt	213
Hogfish	47.7	Cocoa damselfish	150

Table 32. Comparison of the 15 most frequent, abundant, and heaviest species at mid-depth units to the mid-depth natural reef, June 1988 to June 1990.

MAR Combined (N=32)

Species	% Frequency	Species	Total No.	Species	Biomass (kg)
Blue tang	96.9	Bluehead wrasse	659	Yellowtail snapper	94.67
Ocean surgeon	96.9	Tomtate	639	Ocean surgeon	35.37
Bluehead wrasse	81.3	Yellowtail snapper	337	Greater amberjack	28.19
Sharpnose puffer	81.3	Striped grunt	308	Unid. scad	24.20
Slippery dick	78.1	Mackeral scad	300	Barracuda	23.93
Porkfish	71.9	Bridled goby	273	Gray angelfish	23.57
Reef butterflyfish	65.6	Ocean surgeon	223	Mackeral scad	22.46
Graysby	62.5	Unid. grunt	159	Doctorfish	14.52
Doctorfish	62.5	Cottonwick	150	Bar jack	12.69
Hogfish	62.5	Blue tang	121	Blue tang	10.94
Gray angelfish	62.5	Yellowhead wrasse	111	Hogfish	9.07
Bridled goby	56.3	Twospot cardinalfish	109	Porkfish	5.12
Spotfin butterflyfish	53.1	Slippery dick	108	Blue angelfish	4.56
Sergeant major	53.1	Bar jack	104	French angelfish	3.82
Twospot cardinalfish	50.0	Unid. scad	100	Cero mackeral	2.85
Cottonwick	50.0				

Mid-depth Natural Reef (N=78)

Species	% Frequency	Species	Total No.
Bicolor damselfish	100.0	Bicolor damselfish	3699
Bluehead wrasse	98.7	Unid. grunt	3500
Yellowhead wrasse	94.9	Bluehead wrasse	2255
Blue chromis	89.7	Tomtate	2140
Striped parrotfish	83.3	Unid. scad	725
Foueye butterflyfish	83.3	Yellowhead wrasse	477
Redband parrotfish	82.1	Blue chromis	453
Ocean surgeon	82.1	French grunt	316
Cocoa damselfish	70.5	Striped parrotfish	246
Reef butterflyfish	70.5	Brown chromis	240
Sharpnose puffer	67.9	Neon goby	209
Harlequin bass	66.7	Foueye butterflyfish	187
Graysby	64.1	Ocean surgeon	175
Blue tang	62.8	Redband parrotfish	162
Rock beauty	59.0	Yellowtail snapper	150

Table 33. Comparison of the 15 most frequent, abundant, and heaviest species at the deep fabricated units to the deep natural reef, June 1988 to June 1990.

DAR Combined (N=30)

Species	% Frequency	Species	Total No.	Species	Biomass (kg)
Bluehead wrasse	83.3	Round scad	1000	Round scad	89.10
Graysby	83.3	Bluehead wrasse	375	Gray snapper	68.49
Hogfish	80.0	Bridled goby	298	Yellowtail snapper	55.55
Slippery dick	70.0	Yellowtail snapper	231	Cubera snapper	26.73
Yellowtail snapper	70.0	Bicolor damselfish	157	Barracuda	25.43
Sharpnose puffer	70.0	Gray snapper	154	Doctordfish	18.46
Yellowhead wrasse	63.3	Twospot cardinalfish	117	Greater amberjack	16.54
Spotfin butterflyfish	63.3	Slippery dick	84	Mutton snapper	16.37
Gray snapper	63.3	Yellowhead wrasse	83	Gray angelfish	14.82
Doctordfish	60.0	Doctordfish	74	Hogfish	11.95
Bridled goby	60.0	Sharpnose puffer	60	Permit	11.76
Twospot cardinalfish	53.3	Graysby	54	Yellow jack	10.43
Bicolor damselfish	50.0	Greater amberjack	45	French angelfish	7.21
Reef butterflyfish	50.0	Blackfin snapper	37	Bar jack	3.67
Greater amberjack	30.0	Hogfish	37	Ocean surgeon	2.16

Deep Natural Reef (N=68)

Species	% Frequency	Species	Total No.	Species	Biomass (kg)
Bicolor damselfish	98.5	Tomtate	3630	Tomtate	257.30
Rock beauty	98.5	Unid. grunt	2591	Round scad	155.60
Striped parrotfish	89.7	Round scad	2500	White grunt	67.21
Blue chromis	89.7	Bicolor damselfish	1566	Gray snapper	53.20
Reef butterflyfish	83.8	Purple reefish	1396	Greater amberjack	53.12
Redband parrotfish	82.4	Masked goby	874	Lane snapper	47.08
Butter hamlet	80.9	White grunt	603	Blue-striped grunt	28.23
Yellowhead wrasse	79.4	Lane snapper	544	Yellow jack	25.86
Bluehead wrasse	79.4	Sunshinefish	460	Yellowtail snapper	20.93
Sunshinefish	77.9	Bluehead wrasse	263	Gray angelfish	14.96
Spotfin hogfish	76.5	Blackfin snapper	263	Spotted goatfish	12.70
Spotted goatfish	72.1	Blue chromis	226	French grunt	12.42
Graysby	70.6	Striped parrotfish	212	Hogfish	12.19
Purple reefish	70.6	French grunt	202	Green moray	9.69
French grunt	69.1	Yellowhead wrasse	197	Black grouper	8.47

Table 34. Comparison of the 15 most frequent, abundant, and heaviest species at the American Shoal and Bahia Honda bridge rubble reefs, June to August 1989.

American Shoal bridge rubble reefs (N=24)					
Species	% Frequency	Species	Total No.	Species	Biomass (kg)
Tomtate	100.0%	Tomtate	10207	Tomtate	735.66
Striped parrotfish	100.0%	White grunt	3225	White grunt	359.24
White grunt	100.0%	Bluestriped grunt	834	Bluestriped grunt	94.32
Bluestriped grunt	91.7%	Lane snapper	249	Snook	35.15
Redband parrotfish	87.5%	Striped parrotfish	190	Bigeye	34.95
Cocoa damselfish	83.3%	Bigeye	160	Permit	32.80
Lane snapper	83.3%	Porkfish	102	Barracuda	22.95
Slippery dick	79.2%	Slippery dick	97	Lane snapper	19.95
Porkfish	79.2%	Cocoa damselfish	71	Gray angelfish	13.56
Spotfin butterflyfish	70.8%	Redband parrotfish	70	Gray snapper	9.69
Spotted goatfish	70.8%	Bridled goby	64	Porkfish	9.10
Sharpnose puffer	70.8%	Bluehead wrasse	57	Yellowfin mojarra	8.19
Doctorfish	66.7%	Gray snapper	56	Yellowtail snapper	5.83
Ocean surgeon	62.5%	Yellowfin mojarra	55	Yellow goatfish	4.82
Bicolor damselfish	62.5%	Bicolor damselfish	51	Hogfish	4.40

Bahia Honda bridge rubble reefs (N=26)					
Species	% Frequency	Species	Total No.	Species	Biomass (kg)
Porkfish	100.0%	Tomtate	19955	Snook	452.51
Cocoa damselfish	100.0%	Reef croaker	3276	Tomtate	163.61
Tomtate	100.0%	Unid. Harengula	670	Rainbow parrotfish	51.97
Blue tang	92.3%	Unidentified grunt	325	Black grouper	46.97
Striped parrotfish	92.3%	Unid. scad	300	Gray snapper	39.11
Doctorfish	88.5%	Unid. clupeid	300	Gray angelfish	22.37
White grunt	84.6%	Cocoa damselfish	250	Barracuda	18.96
Gray angelfish	80.8%	Bridled goby	174	Bluestriped grunt	18.35
Slippery dick	80.8%	Gray snapper	164	White grunt	11.24
Black grouper	80.8%	Bluestriped grunt	157	Porkfish	9.11
Queen angelfish	76.9%	Striped parrotfish	156	Lane snapper	7.00
Gray snapper	76.9%	White grunt	154	Hogfish	6.25
Blue angelfish	65.4%	Slippery dick	139	Reef croaker	5.91
Hogfish	65.4%	Porkfish	130	Gag	5.87
Reef croaker	61.5%	Lane snapper	89	Doctorfish	5.82

Table 35. Comparison of the 15 most frequent and abundant species on artificial and natural reefs at similar depths; Hawk Channel rubble reefs (June-August 1989) and the mid-depth natural reef (September 1988-June 1990).

Hawk Channel rubble reefs combined (N=50)			
Species	% Frequency	Species	Total No.
Tomtate	100.0	Tomtate	30162
Striped parrotfish	96.0	White grunt	3379
Cocoa damselfish	92.0	Reef croaker	3308
White grunt	92.0	Bluestriped grunt	991
Porkfish	90.0	Unid. clupeid	670
Slippery dick	80.0	Striped parrotfish	346
Doctordfish	78.0	Lane snapper	338
Gray angelfish	70.0	Unid. grunt	325
Bluestriped grunt	70.0	Cocoa damselfish	321
Blue tang	68.0	Unid. clupeid	300
Redband parrotfish	66.0	Unid. scad	300
Sharpnose puffer	64.0	Bridled goby	238
Lane snapper	64.0	Slippery dick	236
Blue angelfish	58.0	Porkfish	232
Spotfin butterflyfish	58.0	Gray snapper	220
Queen angelfish	58.0		
Gag	58.0		
Hogfish	58.0		

Mid-depth Natural Reef (N=78)			
Species	% Frequency	Species	Total No.
Bicolor damselfish	100.0	Bicolor damselfish	3699
Bluehead wrasse	98.7	Unid. grunt	3500
Yellowhead wrasse	94.9	Bluehead wrasse	2255
Blue chromis	89.7	Tomtate	2140
Striped parrotfish	83.3	Unid. scad	725
Foueye butterflyfish	83.3	Yellowhead wrasse	477
Redband parrotfish	82.1	Blue chromis	453
Ocean surgeon	82.1	French grunt	316
Cocoa damselfish	70.5	Striped parrotfish	246
Reef butterflyfish	70.5	Brown chromis	240
Sharpnose puffer	67.9	Neon goby	209
Harlequin bass	66.7	Foueye butterflyfish	187
Graysby	64.1	Ocean surgeon	175
Blue tang	62.8	Redband parrotfish	162
Rock beauty	59.0	Yellowtail snapper	150

Table 36. Occurrence and rank of the 15 most frequent species at artificial reefs.

Species	SARC	MARC	DARC	BH	AMS	N=5
1 Doctorfish	5	8	10	5	13	5
2 Slippery dick	1	5	4	7	8	5
3 Hogfish	11	8	3	13		4
4 Porkfish	5	6		1	8	4
5 Sharpnose puffer	4	3	4		10	4
6 Bicolor damselfish	12		13		14	3
7 Blue tang	10	1		4		3
8 Bluehead wrasse	2	3	1			3
9 Gray angelfish	3	8		7		3
10 Ocean surgeon	7	1			14	3
11 Spotfin butterflyfish		13	7		10	3
12 Twospot cardinalfish	9	15	12			3
13 Cocoa damselfish				1	6	2
14 Gray snapper			7	11		2
15 Graysby		8	1			2
16 Reef butterflyfish		7	13			2
17 Striped parrotfish				4	1	2
18 Tomtate				1	1	2
19 White grunt				6	1	2
20 Black grouper				7		1
21 Blue angelfish				13		1
22 Bluestriped grunt					4	1
23 Bridled goby			10			1
24 Cottonwick		15				1
25 Greater amberjack			15			1
26 Lane snapper					6	1
27 Puddingwife	14					1
28 Queen angelfish				11		1
29 Redband parrotfish					5	1
30 Reef croaker				15		1
31 Sergeant major		13				1
32 Seaweed blenny	7					1
33 Spotted goatfish					10	1
34 Unid. grunt	13					1
35 Yellowhead wrasse				7		1
36 Yellowtail snapper				4		1

Table 37. Occurrence and rank of the 15 most abundant species at artificial reefs.

	SARC	MARC	DARC	BH	AMS	N=5
1 Slippery dick	2	13	8	13	8	5
2 Bluehead wrasse	1	1	2		12	4
3 Bridled goby		6	3	8	11	4
4 Tomtate	7	2		1	1	4
5 Bicolor damselfish	13		5		15	3
6 Gray snapper			6	9	13	3
7 Lane snapper			15	15	4	3
8 Porkfish	8			14	7	3
9 Twospot cardinalfish	9	12	7			3
10 Unid. grunt	4	8		4		3
11 Blue tang	12	10				2
12 Bluestriped grunt				10	3	2
13 Cocoa damselfish				7	9	2
14 Doctorfish	5		10			2
15 Ocean surgeon	6	7				2
16 Sharpnose puffer	10		11			2
17 Striped grunt	14	4				2
18 Striped parrotfish				11	5	2
19 Unid. scad		15		5		2
20 White grunt				12	2	2
21 Yellowhead wrasse		11	9			2
22 Yellowtail snapper		3	4			2
23 Bar jack		14				1
24 Bigeye					6	1
25 Blackfin snapper			14			1
26 Cottonwick		9				1
27 Gray angelfish	11					1
28 Graysby			12			1
29 Greater amberjack			13			1
30 Hogfish	15					1
31 Mackeral scad		5				1
32 Redband parrotfish				10		1
33 Reef croaker				2		1
34 Round scad			1			1
35 Seaweed blenny	3					1
36 Unid. clupeid				6		1
37 Unid. herring				3		1
38 Yellowfin mojarra				14		1

Table 38. Occurrence and rank of the 15 heaviest species at artificial reefs.

Species	SARC	MARC	DARC	BH	AMS	N=5
1 Gray angelfish	2	6	9	6	9	5
2 Hogfish	4	11	10	12	15	5
3 Barracuda		5	5	7	7	4
4 Doctorfish	5	8	6	15		4
5 Porkfish	7	12		10	11	4
6 French angelfish	14	14	13			3
7 Gray snapper			2	5	10	3
8 Ocean surgeon	8	2	15			3
9 Yellowtail snapper		1	3		13	3
10 Mutton snapper	6		8			2
11 Bar jack		9	14			2
12 Blue angelfish	13	13				2
13 Bluestriped grunt				8	3	2
14 Gag	3			14		2
15 Greater amberjack		3	7			2
16 Lane snapper				11	8	2
17 Permit			11		6	2
18 Snook				1	4	2
19 Tomtate				2	1	2
20 White grunt				9	2	2
21 Yellow jack	12		12			2
22 Bigeye					5	1
23 Black grouper				4		1
24 Blue tang		10				1
25 Cero mackerel		15				1
26 Cubera snapper			4			1
27 Mackerel scad		7				1
28 Margate	11					1
29 Nurse shark	1					1
30 Rainbow parrotfish				3		1
31 Reef croaker					15	1
32 Round scad			1			1
33 Saucereye porgy	10					1
34 Slippery dick	9					1
35 Spotfin butterflyfish	15					1
36 Unid. scad			4			1
37 Yellow goatfish					14	1
38 Yellowfin mojarra					12	1

Table 39. Summary of species by trophic level at mid-depth fabricated units, June 1988 to June 1990.

Species	1 Trophic Level	% Freq. (N=32)	Total No.	Biomass (kg)	2 Value
BROWSERS					
CAN ROST	B,H	81.3%	83	0.13	ML
POM ARCU	B	62.5%	32	23.57	ML
HOL BERM	B	15.6%	9	4.56	ML
POM PARU	B	12.5%	7	3.82	ML
LAC BICA	B	9.4%	3	0.43	ml
HOL CILI	B	9.4%	4	1.06	ML
LAC TRIQ	B	3.1%	1	0.25	ml
LAC QUAD	B	3.1%	1	0.39	ml
Subtotal			140	34.21	
FISHES					
OCY CHRY	F,Ma	46.9%	337	94.67	P,R
GYM MORI	F,Ma	21.9%	8	0.68	ML
DIP FORM	F,Mi,Ma	12.5%	9	0.05	
SPH BARR	F	12.5%	4	23.93	R
MYC SPE.	F	6.3%	3		P,R
SER DUME	F	6.3%	22	28.19	P,R
SCO REGA	F	3.1%	8	2.85	P,R
LUT GRIS	F,Ma	3.1%	1	0.96	P,R
MYC BONA	F	3.1%	1	0.61	P,R
SYN FOET	F	3.1%	1	0.13	
SCO PLUM	F	3.1%	1	0.17	ml
Subtotal			395	152.24	
HERBIVORES					
ACA COER	H	96.9%	121	10.94	ML
ACA BAHI	H	96.9%	223	35.37	ml
ACA CHIR	H	62.5%	92	14.52	ml
COR GLAU	H	56.3%	273	0.14	ml
SPA AURO	H	6.3%	3	0.21	ml
SCA CROI	H	3.1%	1		ML
POM PLAN	H	3.1%	1		ML
ALU SCHO	H	3.1%	1	0.02	ml
SPA CHRY	H	3.1%	1	0.03	ml
ALU SCRI	H	3.1%	1	0.39	ml
Subtotal			717	61.62	
MICRO & MACROINVERTIVORE					
HAL BIVI	Mi,Ma	78.1%	108	0.67	ml
ANI VIRG	Ma	71.9%	34	5.12	P,R,ml
CHA SEDE	Mi	65.6%	37	0.63	ML
LAC MAXI	Ma	62.5%	37	9.07	P,R
EPI CRUE	Ma	62.5%	37	0.36	ml

Table 39. Summary of species by trophic level at mid-depth fabricated units, June 1988 to June 1990.

Species	¹ Trophic Level	% Freq. (N=32)	Total No.	Biomass (kg)	² Value
CHA OCEL	Mi	53.1%	32	1.93	ML
HAL GARN	Mi, Ma	40.6%	111	0.09	ML
SER TIGR	Mi	18.8%	7	0.01	ML
LUT BUCC	Mi, Ma, F	18.8%	7	0.02	P, R
PSE MACU	Mi	15.6%	6	0.11	ml
EQU ACUM	Mi	15.6%	6	0.02	ML
RYP SAPO	Ma, F	9.4%	3	0.63	
GOB OCEA	Mi	9.4%	6		ML
EQU LANC	Mi	6.3%	2		ML
HOL CORU	Ma, Mi	6.3%	7	0.04	ml
CAL CALA	Ma	6.3%	2	0.17	S, R
EPI GUTT	Ma	6.3%	3	0.02	S, ml
HAE ALBU	Ma, Mi	6.3%	2	0.41	S, R
HAL RAD1	Mi, Ma	6.3%	2	0.12	ML
MON HISP	Mi, Ma	6.3%	3	0.17	ml
HEM SPLE	Mi, Ma	6.3%	3	0.02	ml
CHA STRI	Mi	3.1%	1	0.05	ML
LUT ANAL	Ma, F	3.1%	1	1.54	P, R
URO JAMA	Ma	3.1%	1	0.07	ml
Subtotal			458	21.3	
PLANKTIVORES					
THA BIFA	P, Mi	81.3%	659	0.43	ML
ABU SAXA	P	53.1%	39	0.89	ml
APO PSEU	P	50.0%	109	0.10	ML
HAE MELA	P, Mi	50.0%	150	2.39	S
POM PART	P, H	43.8%	67	0.03	ML
HAE AURO	P, Mi	28.1%	639	0.04	S
CAR RUBE	P, F	25.0%	104	12.69	
HAE FLAV	P, Mi, Ma	21.9%	43	0.33	S
HAE SPE.	P, Mi	12.5%	159	0.10	S
PAR MARM	?	12.5%	6		ml
HAE STRI	P, Mi	9.4%	308	0.79	S
DEC SPE.	P	6.3%	100	24.21	
CHR INSO	P	6.3%	2		ML
DEC PUNC	P	6.3%	20	0.46	
DEC MACA	P	6.3%	300	22.46	
MAL SPE.	P, Mi	3.1%	1		ml
APO SPE.	P	3.1%	2	0.01	ml
MAL TRIA	P, Mi	3.1%	1		ml
ECH NAUC	P	3.1%	1	0.01	
CHR MULT	P	3.1%	1		ML
Subtotal			2711	64.94	
Total			4421	334.31	

Trophic level: B, browser; F, piscivore; H, herbivore; Mi, microinvertebrate;
Ma, macroinvertebrate; P, planktivore
Value: P, primary commercial; S, secondary commercial; R, recreational
ML, primary marine life; ml, secondary marine life

Table 40. Summary of species by trophic level at deep fabricated units, June 1988 to June 1990.

Species	Trophic Level	% Freq (N=30)	Total No.	Biomass (kg)	Value
BROWSERS					
CAN ROST	B,H	70.0%	60	0.05	ML
POM ARCU	B	33.3%	17	14.82	ML
POM PARU	B	26.7%	11	7.21	ML
HOL CILI	B	16.7%	5	0.01	ML
LAC BICA	B	13.3%	4	0.56	ml
LAC QUAD	B	6.7%	2	0.66	ml
HOL TRIC	B	6.7%	2	0.02	ML
HOL BERM	B	6.7%	3	0.36	ML
Subtotal			104	23.69	
PISCIVORES					
OCY CHRY	F,Ma	70.0%	231	55.55	P,R
LUT GRIS	F,Ma	63.3%	154	68.49	P,R
SER DUME	F	30.0%	45	16.54	P,R
SPH BARR	F	13.3%	4	25.43	R
CAR BART	F	10.0%	5	10.43	R
CAR CRYC	F	10.0%	7	1.05	R
MYC SPE.	F,Ma	6.7%	4		P,R
GYM MORI	F,Ma	6.7%	2	0.16	ML
MYC BONA	F,Ma	3.3%	1		P,R
EPI ADSC	F,Ma	3.3%	1		S,ml
LUT CYAN	F,Ma	3.3%	1	26.73	P,R
RAC CANA	F,Ma	3.3%	1	1.92	P,R
Subtotal			456	206.3	
HERBIVORES					
COR GLAU	H	60.0%	298	0.14	ml
ACA CHIR	H	60.0%	74	18.46	ml
ACA COER	H	10.0%	8	0.46	ML
ACA BAH1	H	10.0%	7	2.16	ml
POM VARI	H	6.7%	2		ML
SCA SPE.	H	3.3%	1		ml
ALU SCRI	H	3.3%	1	0.99	ml
KYP SECT	H	3.3%	1	0.18	
MIC CHRY	H	3.3%	1		ML
SCA CRIS	H	3.3%	1		ml
Subtotal			394	22.39	
MICRO & MACROINVERTIVORES					
EPI CRUE	Ma	83.3%	54	0.34	ml
LAC MAXI	Ma	80.0%	37	11.95	P,R
HAL BIVI	Mi,Ma	70.0%	84	0.28	ml

Table 40. Summary of species by trophic level at deep fabricated units, June 1988 to June 1990.

Species	¹ Trophic Level	% Freq. (N=30)	Total No.	Biomass (kg)	² Value
HAL GARN	Mi, Ma	63.3%	83	0.07	ML
CHA OCEL	Mi	63.3%	35	1.96	ML
CHA SEDE	Mi	50.0%	20	0.15	ML
LUT BUCC	Ma	26.7%	37	0.02	P, R
SER TIGR	Mi	20.0%	7		ML
BOD PULC	Mi, Ma	20.0%	11	0.01	ML
LUT ANAL	Ma, F	16.7%	5	16.37	P, R
CAL CALA	Ma	13.3%	4	1.85	P, R
RYP SAPO	Ma, F	10.0%	3	0.16	
TRA FALC	Ma	10.0%	3	11.76	R
HAL SPE.	Mi	10.0%	4		ml
BOD RUFU	Mi, Ma	6.7%	2		ML
SER TABA	Mi	6.7%	2		ML
EPI GUTT	Ma	6.7%	2	0.01	S, ml
EQU ACUM	Mi	3.3%	1		ML
EPI FULV	Ma, F	3.3%	2		ml
CAL SPE.	Ma	3.3%	1	0.35	P, R
PSE MACU	Mi	3.3%	1	0.06	ml
SER BALD	Mi	3.3%	2		ML
ECH NAUC	Mi	3.3%	1	0.02	ml
ANI VIRG	Ma	3.3%	1		S, R, ml
MON CILI	Mi, Ma	3.3%	1		ml
Subtotal			403	45.36	
PLANKTIVORES					
THA BIFA	P, Mi	83.3%	375	0.25	ML
APO PSEU	P	53.3%	117	0.08	ML
POM PART	P, H	50.0%	157	0.10	ML
PAR MARM	?	23.3%	10	0.01	ML
CHR ENCH	P	20.0%	23	0.01	ML
PAR FURC	?	20.0%	7	0.09	ML
CHR INSO	P	16.7%	10		ML
CHR SCOT	P	13.3%	5		ML
APO SPE.	P	10.0%	7		ml
CAR RUBE	P	10.0%	20	3.67	
IOG HELE	P	6.7%	2		ml
CLE PARR	P	3.3%	1		ML
HAE STRI	P, Mi	3.3%	1		
DEC PUNC	P	3.3%	1000	89.1	
Subtotal			1735	93.31	
Total			3092	391.05	

1 Trophic level: B, browser; F, piscivore; H, herbivore

Mi, microinvertebrate; Ma, macroinvertebrate; P, planktivore

2. Economic value: P, primary commercial; S, secondary commercial; R, recreational;

ML, primary marine life; ml, secondary marine life

Table 41. Summary of species by trophic level at the deep natural reef from September 1988 to May 1990.

Species	¹ Trophic Level	Freq. (N=68)	Total Indiv.	Biomass (kg)	² Value
BROWSERS					
HOL TRIC	B	98.5%	187	7.10	ML
CAN ROST	B,H	66.2%	88	0.18	ML
HOL BERM	B	20.6%	15	3.40	ML
POM ARCU	B	20.6%	22	14.96	ML
POM PARU	B	10.3%	8	1.32	ML
LAC BICA	B	5.9%	4	0.48	ml
HOL CILI	B	5.9%	7	0.27	ML
LAC QUAD	B	2.9%	2	0.44	ml
Subtotal			333	28.15	
PISCIVORES					
OCY CHRY	F,Ma	58.8%	118	20.93	P,R
LUT GRIS	F,Ma	22.1%	76	53.20	P,R
MYC BONA	F	11.8%	10	8.47	P,R
CAR BART	F	11.8%	58	25.86	R
SER DUME	F	7.4%	14	53.12	P,R
GYM FUNE	F,Ma	5.9%	4	9.69	ML
EPI FULV	F,Ma	5.9%	5	0.25	ml
SCO REGA	F	5.9%	7	3.44	P,R
SCO PLUM	F	5.9%	5	1.50	ml
EPI GUTT	F,Ma	4.4%	5	0.14	S
AUL MACU	F	2.9%	2	0.16	
MYC SPE.	F	2.9%	2	0.20	P,R
EPI STRI	F,Ma	2.9%	2	1.94	P,R
GYM MORI	F,Ma	2.9%	2	0.40	ML
GYM VICI	F	1.5%	1	1.26	ml
SYN SPE.	F	1.5%	1	0.06	
LUT APOD	F,Ma	1.5%	5	0.31	S,R
CAR CRY5	F	1.5%	1	1.29	R
TRA GOOD	F	1.5%	3	5.88	
Subtotal			321	188.1	
HERBIVORES					
SCA CROI	H	89.7%	212	4.35	ML
SPA AURO	H	82.4%	118	2.47	ml
POM VARI	H	58.8%	77	0.28	ML
ACA CHIR	H	32.4%	38	3.56	ml
ACA BAHI	H	30.9%	34	3.58	ml
ACA COER	H	16.2%	19	2.94	ML
COR GLAU	H	10.3%	34	0.02	ml
SPA VIRI	H	7.4%	6	0.84	ml
POM PLAN	H	5.9%	4	0.05	ML

Table 41. Summary of species by trophic level at the deep natural reef from September 1988 to May 1990.

Species	¹ Trophic Level	Freq. (N=68)	Total Indiv.	Biomass (kg)	² Value
POM LEUC	H	4.4%	5	0.02	ML
SCA TAEN	H	4.4%	3	0.21	ml
SCA CRIS	H	2.9%	2		ml
SCA VETU	H	2.9%	2	0.02	ml
CAN MACR	H,B	2.9%	2	0.74	ml
SPA SPE.	H	1.5%	1	0.02	ml
Subtotal			557	19.1	
MICRO & MACROINVERTIVORES					
CHA SEDE	Mi	83.8%	129	3.30	ML
HYP UNIC	Mi	80.9%	87	0.79	ml
HAL GARN	Mi,Ma	79.4%	197	2.31	ML
BOD PULC	Mi,Ma	76.5%	159	1.64	ML
PSE MACU	Mi	72.1%	165	12.70	ml
EPI CRUE	Ma	70.6%	105	4.97	ml
HAE FLAV	Mi,Ma,P	69.1%	202	12.42	S
CHA CAPI	Mi	67.6%	111	1.43	ML
LUT BUCC	Mi,Ma,F	57.4%	263	4.80	P,R
HAE PLUM	Mi,Ma,P	51.5%	603	67.21	S
LAC MAXI	Ma	45.6%	43	12.19	P,R
LUT SYNA	Ma,F	41.2%	544	47.08	P,R
EQU ACUM	Mi	38.2%	88	1.58	ML
CHA OCEL	Mi	36.8%	49	2.58	ML
HAE SCTU	Mi,Ma,P	36.8%	182	28.23	S
HAE AURO	Mi,P	32.4%	3630	257.3	S
BOD RUFU	Mi,Ma	27.9%	24	0.16	ML
GOB OCEA	Mi	20.6%	32	0.01	ML
EPI ADSC	Ma	17.6%	25	1.14	S,ml
ANI VIRG	Ma	16.2%	12	2.28	S,R,ml
EQU LANC	Mi	14.7%	12	0.65	ML
CAL CALA	Ma	14.7%	21	5.05	P,R
HOL CORU	Ma,Mi	13.2%	9	0.70	ml
SER TABA	Mi	13.2%	16	0.23	ML
MUL MART	Mi	10.3%	51	1.99	S
HYP GEMM #	Mi	5.9%	7	0.11	ml
CHA STRI	Mi	4.4%	4	0.08	ML
MON SETI	Mi,Ma	4.4%	5	0.43	ml
LUT ANAL	Ma,F	4.4%	5	7.27	P,R
HAE MELA	Mi,P	4.4%	13	1.20	S
CHA FABE	Ma	2.9%	2	2.78	S
GER CINE	Mi	2.9%	12	2.42	
HAL BIVI	Mi,Ma	2.9%	3	0.05	ml
HYP PUEL #	Mi	2.9%	3	0.06	ml
HOL MARI	Ma	2.9%	2	0.06	ml
BAL CAPR	Ma	2.9%	2	1.09	P,R
SER TIGR	Mi	2.9%	2		ML
AMB PINO	Mi	2.9%	2		ML

Table 41. Summary of species by trophic level at the deep natural reef from September 1988 to May 1990.

Species	¹ Trophic Level	Freq. (N=68)	Total Indiv.	Biomass (kg)	² Value
HYP NIGR #	Mi	1.5%	1		ml
RYP SAPO	Ma,F	1.5%	1	0.26	
ODO DENT	Mi	1.5%	50	0.03	
HOL RUFU	Ma	1.5%	1	0.04	ml
DIO HYST	Ma	1.5%	1	1.20	ml
HAL MACU	Mi, Ma	1.5%	1		ML
ANI SURI	Ma	1.5%	3	1.81	P,R
URO JAMA	Ma	1.5%	1	2.19	ml
MON HISP	Mi, Ma	1.5%	1	0.10	ml
HOL ASCE	Ma, Mi	1.5%	1	0.06	ml
DAS AMER	Ma	1.5%	1	0.17	
DIO HOLO	Ma	1.5%	1	0.09	ml
Subtotal			6884	494.24	
PLANKTIVORES					
POM PART	P,H	98.5%	1566	2.28	ML
CHR CYAN	P	89.7%	226	0.66	ML
THA BIFA	P,Mi	79.4%	453	0.88	ML
CHR INSO	P	77.9%	460	0.54	ML
CHR SCOT	P	70.6%	1396	0.66	ML
COR PERS	?	57.4%	874	0.17	ml
CHR ENCH	P	33.8%	89	0.05	ML
POM FUSC	P,H	19.1%	16	0.12	ml
CLE PARR	P	16.2%	64	0.03	ML
HAE SPE.	P	11.8%	2591	0.39	S
CHR MULT	P	7.4%	20	0.01	ml
CAR RUBE	P,F	5.9%	9	1.90	
IOG SPE.	P	2.9%	11		ml
ECH NAUC	P	2.9%	2	0.09	ml
DEC PUNC	P	2.9%	2500	155.60	
FIS SPE.	?	1.5%	1	0.02	
APD SPE.	P	1.5%	80	0.09	
OPI AURI	P	1.5%	2	0.01	ML
EMB PAND	?	1.5%	1		ml
PAR MARM	?	1.5%	1		ML
Subtotal			10362	163.50	
Total			18457	893.09	

1 Trophic level: B, browser; F, piscivore; H, herbivore; Mi, microinvertivore; Ma, macroinvertivore; P, planktivore

2 Economic value: P, primary commercial; S, secondary commercial; R, recreational; ML, primary marine life; ml, secondary marine life

= color variants of H. unicolor

Table 42. Summary of species by trophic level at Bahia Honda rubble reefs from June to August 1989.

Species	1		Total No.	Biomass (kg)	2 Value
	Trophic level	% Freq. (N=26)			
=====					
BROWSERS					
POM ARCU	B	80.8%	34	22.37	ML
HOL CILI	B	76.9%	35	2.38	ML
HOL BERM	B	65.4%	31	2.91	ML
CAN ROST	B,H	57.7%	35	0.28	ML
POM PARU	B	26.9%	8	2.18	ML
LAC QUAD	B	3.8%	1	0.39	ml
HOL TRIC	B	3.8%	1	0.02	ML
SPH SPEN	B,Mi	3.8%	1	0.01	
Subtotal			146	30.54	
FISHES					
MYC MICR	F,Ma	80.8%	71	5.87	P,R
LUT GRIS	F,Ma	76.9%	164	39.11	P,R
MYC BONA	F	53.8%	30	46.97	P,R
CEN UNDE	F,Ma	30.8%	76	452.51	R
SPH BARR	F	19.2%	5	18.96	R
SCO REGA	F	11.5%	6	1.39	P,R
OCY CHRY	F,Ma	11.5%	10	0.92	P,R
MYC SPE.	F,Ma	11.5%	13	1.81	P,R
EPI STRI	F,Ma	7.7%	3	3.75	P,R
EPI ADSC	F,Ma	7.7%	2	0.14	S,ml
GYM MORI	F,Ma	3.8%	1	0.11	ML
SCO PLUM	F	3.8%	1	0.07	ml
CAR SPE.	F	3.8%	2	1.02	
CAR BART	F	3.8%	1	2.26	R
CAR CRYC	F	3.8%	3	0.01	R
Subtotal			388	574.9	
HERBIVORES					
POM VARI	H	100.0%	250	0.51	ML
ACA COER	H	92.3%	79	4.61	ML
SCA CROI	H	92.3%	156	0.95	ml
ACA CHIR	H	88.5%	75	5.82	ML
COR GLAU	H	57.7%	174	0.19	ml
SPA AURO	H	46.2%	29	0.41	ml
SCA GUAC	H	30.8%	25	51.97	ml
ACA BAH1	H	19.2%	14	1.03	ml
SPA VIRI	H	15.4%	5	0.07	ml
SCA COEL	H	11.5%	4	1.65	ml
SPA CHRY	H	11.5%	7	0.71	ml

Table 42. Summary of species by trophic level at Bahia Honda rubble reefs from June to August 1989.

Species	1		Total No.	Biomass (kg)	2 Value
	Trophic level	% Freq. (N=26)			
SCA COER	H	7.7%	3	1.02	ml
SPA SPE.	H	7.7%	6	0.04	
SCA VETU	H	3.8%	1	0.01	ml
POM LEUC	H	3.8%	1		ML
POM PLAN	H	3.8%	1		ML
Subtotal			830	68.99	
MICRO & MACROINVERTIVORES					
ANI VIRG	Ma	100.0%	130	9.11	S,R,ml
HAE AURO	Mi,P	100.0%	19955	163.61	S
HAE PLUM	Mi,Ma,P	84.6%	154	11.24	S
HAL BIVI	Mi,Ma	80.8%	139	0.72	ml
LAC MAXI	Ma	65.4%	46	6.25	P,R
ODO DENT	Mi,P	61.5%	3276	5.91	
HAE SCIU	Mi,Ma,P	50.0%	157	18.35	S
CHA OCEL	Mi	46.2%	23	1.07	ML
EPI CRUE	Ma	46.2%	14	0.41	ml
LUT SYNA	Ma	46.2%	89	7.00	P,R
HYP UNIC	Mi	42.3%	14	0.04	ml
CHA SEDE	Mi	15.4%	4	0.02	ML
HAE FLAV	Mi,Ma,P	15.4%	10	0.31	S
EQU ACUM	Mi	11.5%	5	0.06	ML
HYP PUEL #	Mi	11.5%	6	0.06	ml
HAE ALBU	Ma	11.5%	4	0.79	S,R
HAL RAD1	Mi,Ma	11.5%	5	0.03	ML
ARC PROB	Ma	11.5%	3	2.46	S,R
EPI FULV	Ma,F	7.7%	2	0.02	ml
EQU UMBR	Mi	7.7%	2	0.03	ml
CHA CAPI	Mi	7.7%	3	0.02	ML
SER BALD	Mi	7.7%	4	0.01	ML
SER TIGR	Mi	7.7%	3	0.01	ML
SER SUBL	Mi	7.7%	3	0.02	ml
HAE SPE.	Mi	7.7%	325	1.46	
PRI AREN	Ma	7.7%	3	1.65	S
AMB PINO	Mi	3.8%	1		ML
LUT ANAL	Ma,F	3.8%	1	0.72	P,R
MYR JACO	Mi	3.8%	3	0.05	ml
HAL SPE.	Mi,Ma	3.8%	1	0.01	
MUL MART	Mi	3.8%	1	0.07	S
MYC PHEN	Ma,F	3.8%	1	0.05	P,R
HYP GEMM #	Mi	3.8%	1	0.01	ml
TRA FALC	Ma	3.8%	1	1.96	R
EPI GUTT	Ma,F	3.8%	1	0.03	S,ml
CAL BAJO	Ma	3.8%	1	0.38	P,R
GOB OCEA	Mi	3.8%	1		ML

Table 42. Summary of species by trophic level at Bahia Honda rubble reefs from June to August 1989.

Species	1		Total No.	Biomass (kg)	2 Value
	Trophic level	% Freq. (N=26)			
HAE STRI	Mi	3.8%	4	0.38	
EPI MORI	Ma,F	3.8%	1	1.76	P,R
CHA FABE	Ma	3.8%	1	0.07	S
CAL CALA	Ma	3.8%	3	0.74	P,R
Subtotal			24401	236.89	
PLANKTIVORES					
POM FUSC	P,H	57.7%	42	0.20	ml
THA BIFA	P,Mi	42.3%	20	0.05	ML
ABU SAXA	P	23.1%	14	0.02	ml
POM PART	P,H	15.4%	5	0.01	ML
HAR SPE.	P	11.5%	670	2.74	
CAR RUBE	P,F	11.5%	13	0.11	R
DEC SPE.	P	11.5%	300	0.57	
PAR MARM	?	11.5%	7	0.01	ML
APO PSEU	P	11.5%	11	0.01	ML
APO MACU	P	3.8%	1		ML
CLU SPE.	P	3.8%	300	0.27	
IOG CALL	P	3.8%	3	0.01	
Subtotal			1386	4.00	
Total			27151	915.32	

1 Trophic level: B, browser; F, piscivore; H, herbivore; Mi, micoinvertivore;

Ma, macroinvertivore; P, planktivore

2 Economic value: P, primary commercial; S, secondary commercial; R, recreational;

ML, primary marine life; ml, secondary marine life

= color variants of H. unicolor

Table 43. Summary of close-up fouling community photography at fabricated units.

DATE	1 SAR UNITS	TOTAL IMAGES	2 MAR UNITS	TOTAL IMAGES	2 DAR UNITS	TOTAL IMAGES
=====	=====	=====	=====	=====	=====	=====
9/18/88	1,2,3	24	1E,1W,2E,2W	23	1E,1W	12
12/31/88	1,2,3	23	1E,1W,2E,2W	24	1E,1W,2E,2W	24
5/6/89	1,2,3	22	1E,1W,2E,2W	24	1E,1W,2E,2W	24
9/2/89	1,2,3	24	1E,1W,2E,2W	23	1E,1W,2E,2W	24
1/11/90			1E,1W,2E,2W	24	1E,1W,2E,2W	24
6/30/90			2E,2W	11	1E	6
8/90	1,2	9	1E,1W,2E,2W	24	1E,1W,2E,2W	24
Total		102		153		138 = 393

E = east

W = west

1 = 6 frames/unit with additional frames at SAR1

2 = 6 frames/side/unit

Table 44. Comparison of artificial reefs in Hawaii and Florida (from Bohnsack et al. 1989).
 Stone et al. (1979) included a 12m dia x 2m high natural reef and a 20m dia x 1m high tire reef.

Source Reef Type	Brock (1987)		Stone et al. (1979)		Bohnsack et al. (1989)				This Study Artificial			Natural				
	Natural	Artificial	Natural	Artificial	Natural	Natural	Artificial	Small Units SAR	Large Units MAR	Large Units DAR	Bahia Honda	American Shoal	Shallow	Mid	Deep	
					Small	Large	Block (1)									Block (8)
Location	Hawaii		Florida		Florida				Florida							
Number/m2	1.6	8.9	6.8	2.1	1.02	1.45	71	24	1.6	5.1	3.8	5.9	3.8	0.9	1.2	1.5
Number/m3		6.8	3.4	2.1			56	19	2.3	3.4	2.6					72
Biomass (g/m2)	46	1267			72	47	390	701	212	387	483	199	340			
Biomass (g/m3)		975					309	555	290	260	324					48
Mean size (g)	29	137			71	133	6	29	127	76	126	33	90			12.7
Sample biomass (kg)	2.76	76.02			2.02	7.09	0.71	10.21	6.05	10.46	13.03	35.20	60.22			
Total Species	81	125	85	98	36	85	74	96	67	73	69	90	72	104	114	109
Reef area (m2) ²	60	60	113	113-315	28	175	1.75	14	29	27	27	177	177	177	177	177
Reef Volume (m3)		78	226	314			2.3	18.4	20.4	40.2	40.2					
Composition	coral	concrete	coral	tires	coral	coral	concrete	concrete	concrete	concrete	conc	conc/stl	concrete	coral	coral	coral
No. Modules/Patches		38		500			1	8	3	2	2	19	4			
Depth (m)	19-20	Same	14	Same	10-12	Same	Same	Same	7	14	24	9-10	11-12	6-8	10-12	26-31
Location	Maunaloa Bay, Oahu		Biscayne Nat'l Park		Key Biscayne				Big Pine Key, Florida Keys							
Latitude	21 15'		25 23'		25 42'				24 34'		24 37'		24 33'		24 34'	
Longitude	157 46'		80 06'		80 06'				81 20'		81 17'		81 28'		81 20'	
Study Duration	13 mo		30 mo		21 mo				24 mo		3 mo		24 mo		24 mo	
Total Samples	47	47	8	8	11	72	119	62	42	32	30	26	24	111	78	68

1 SAR biomass includes 3 large nurse sharks (69%)

2 Stationary census area = 177 m2

FIGURES

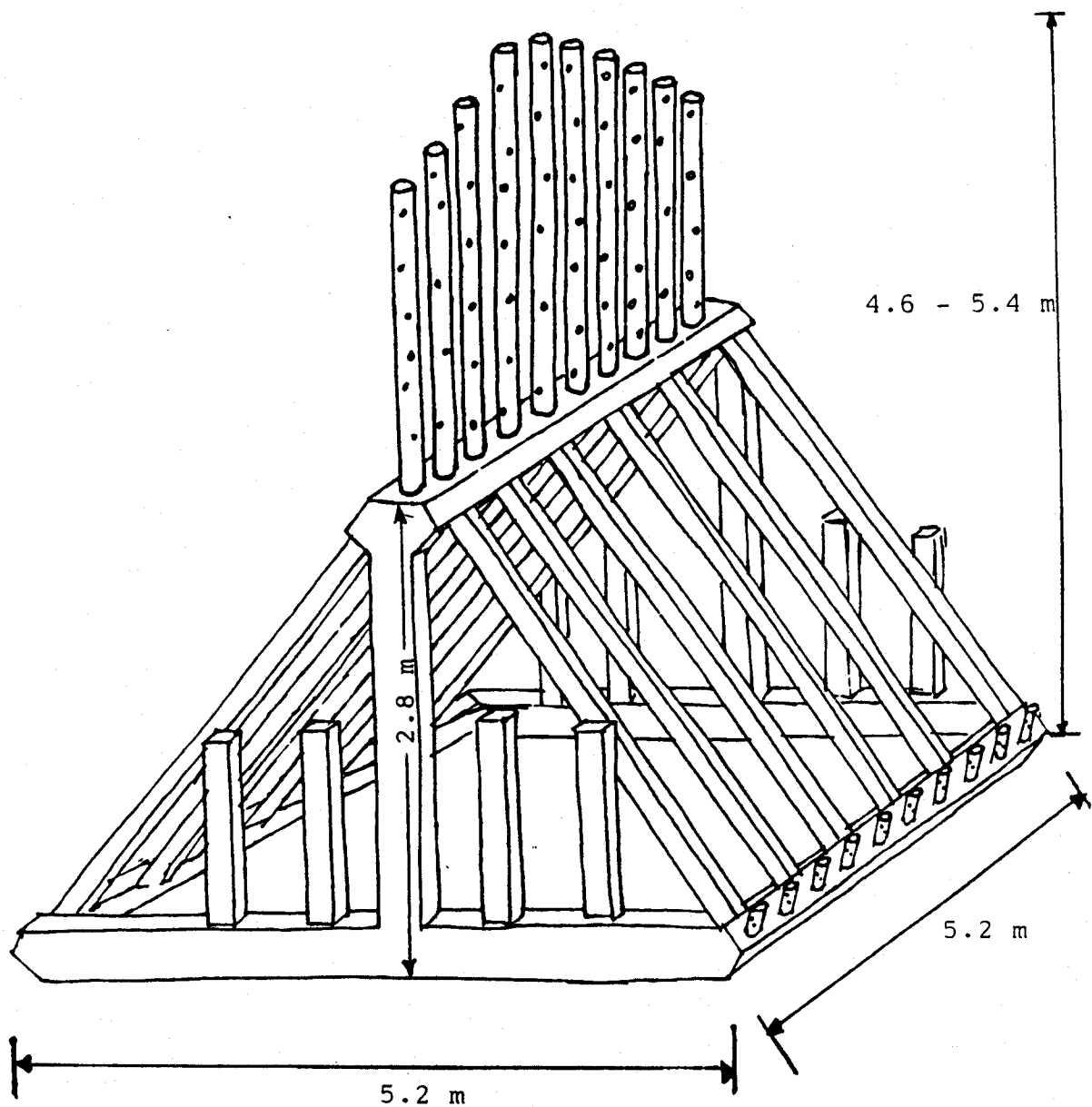


Figure 1. High profile prefabricated unit design.

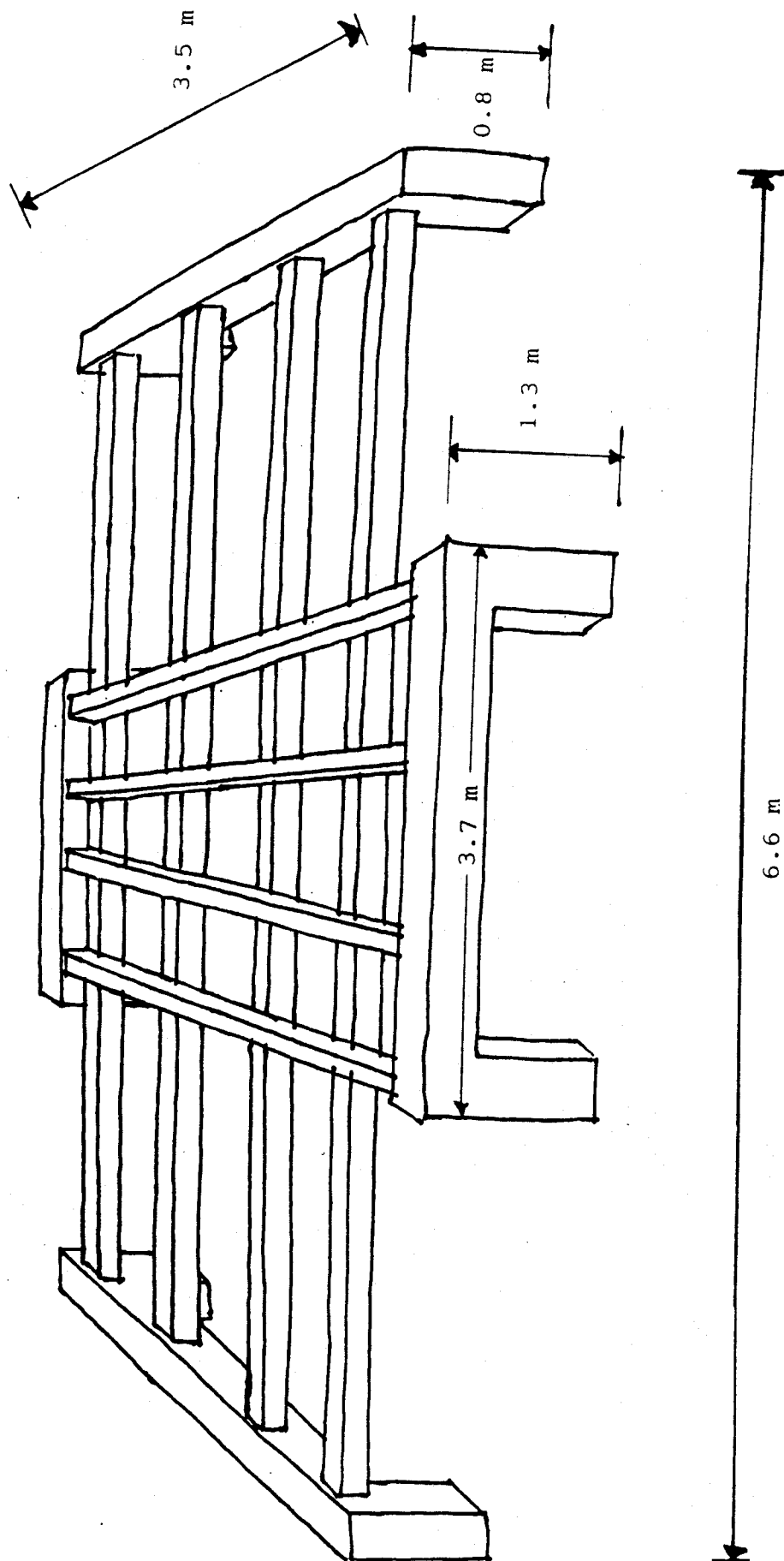


Figure 2. Low profile prefabricated unit design.

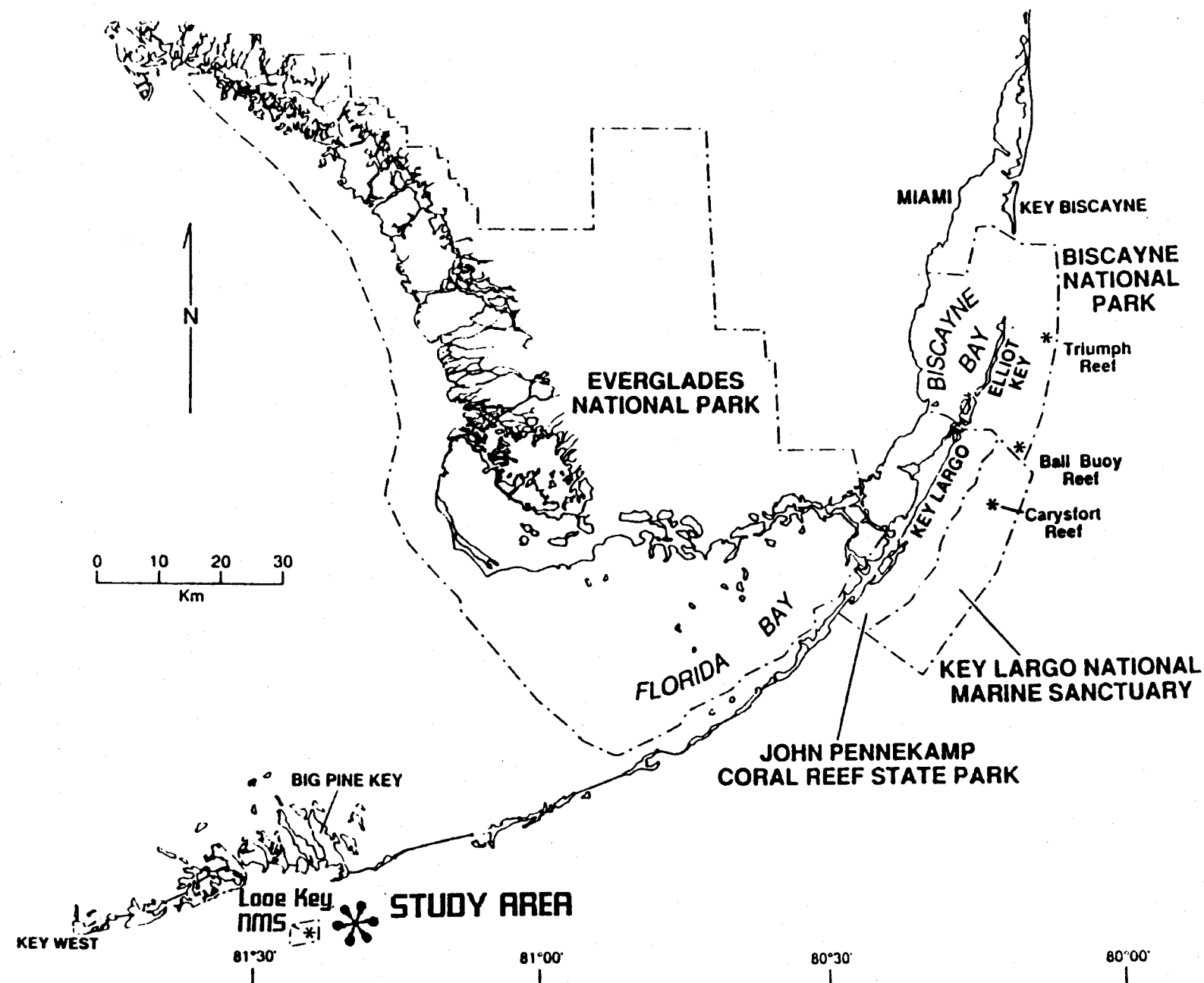


Figure 3. Study site location in South Florida.

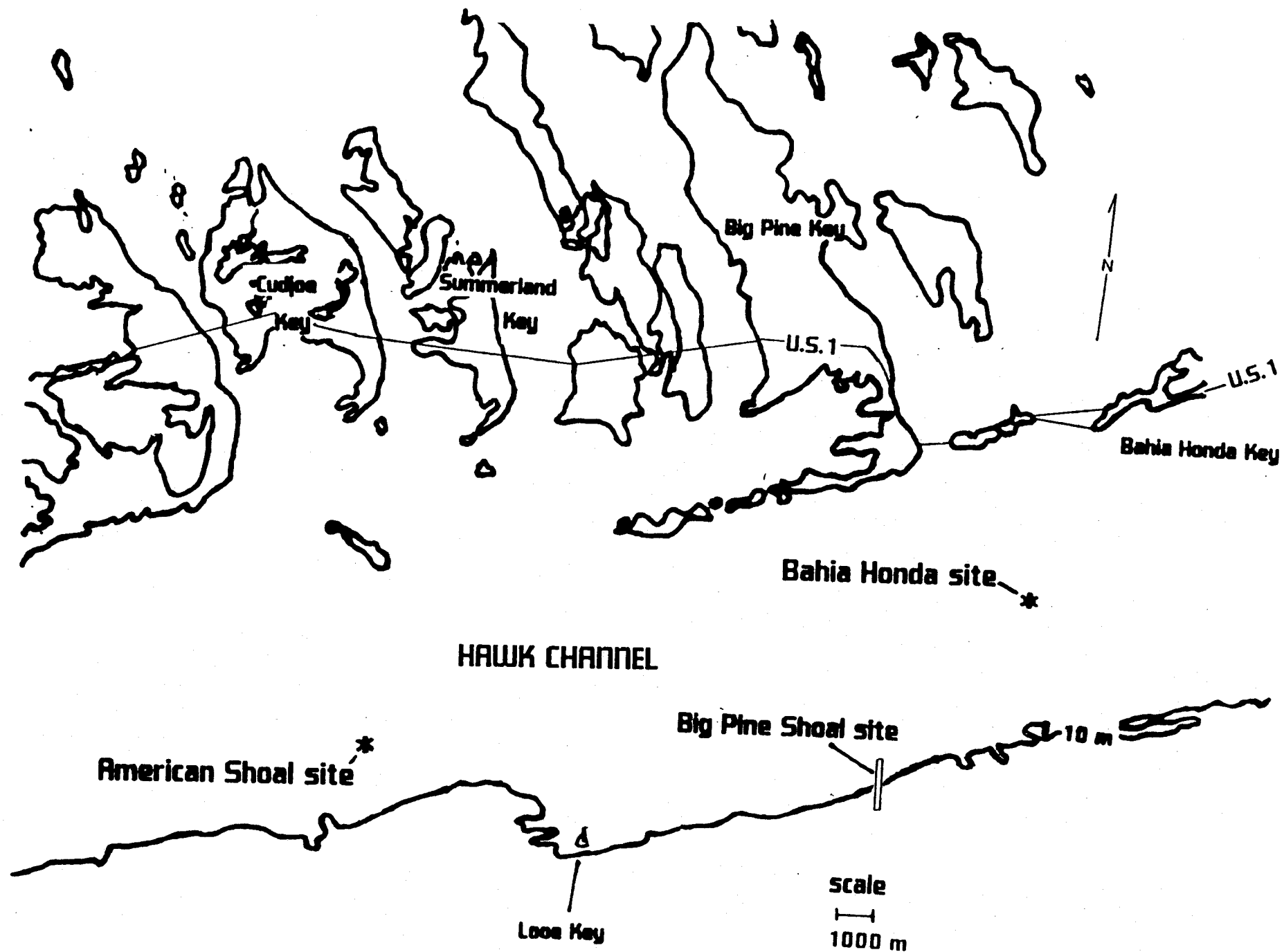


Figure 4. Location of the study site near Big Pine Shoal and the Bahia Honda and American Shoal bridge rubble reefs.

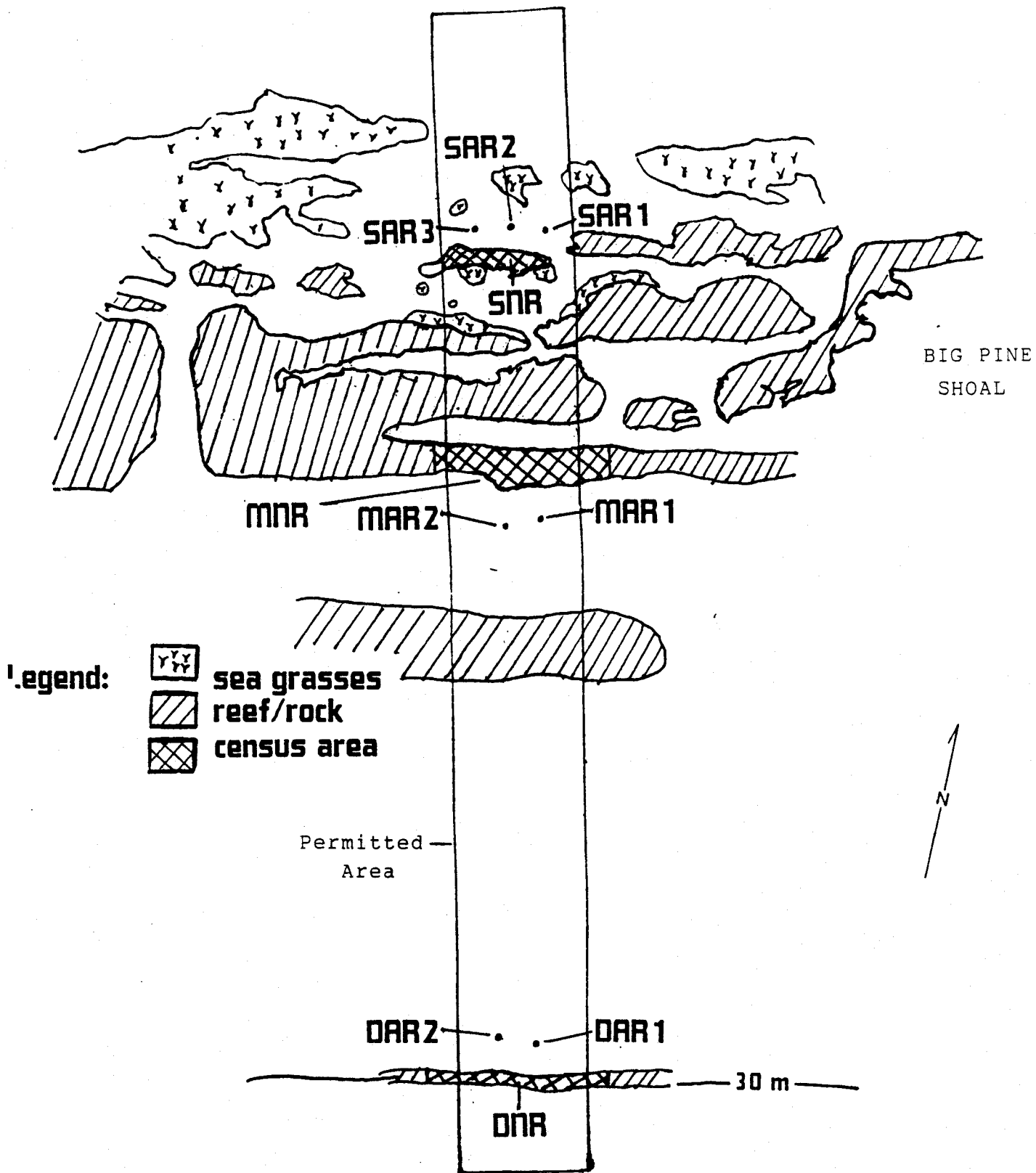


Figure 5. Approximate location of prefabricated units and natural reefs within the study area.

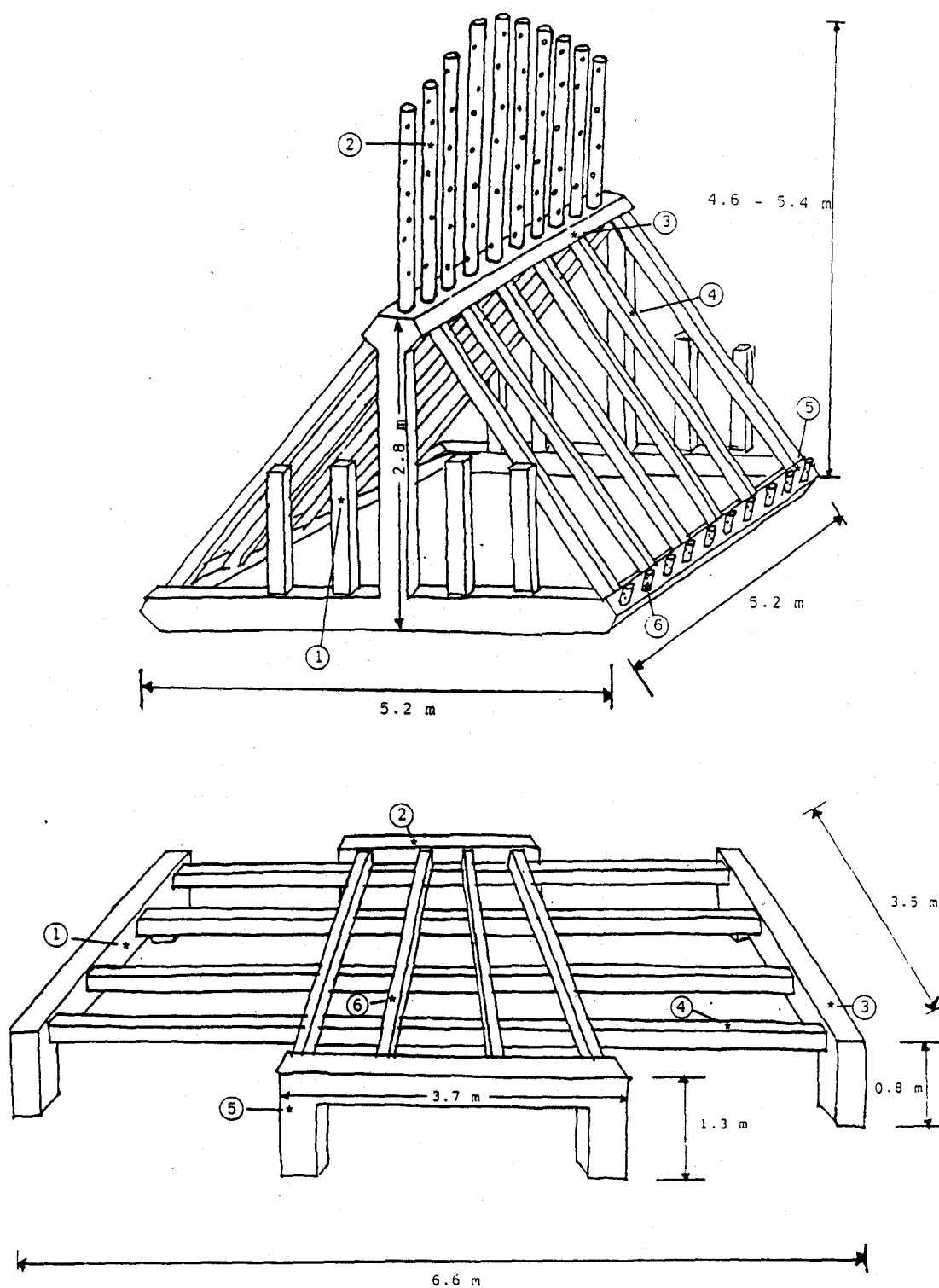


Figure 6. Points of fouling community close-up photography.

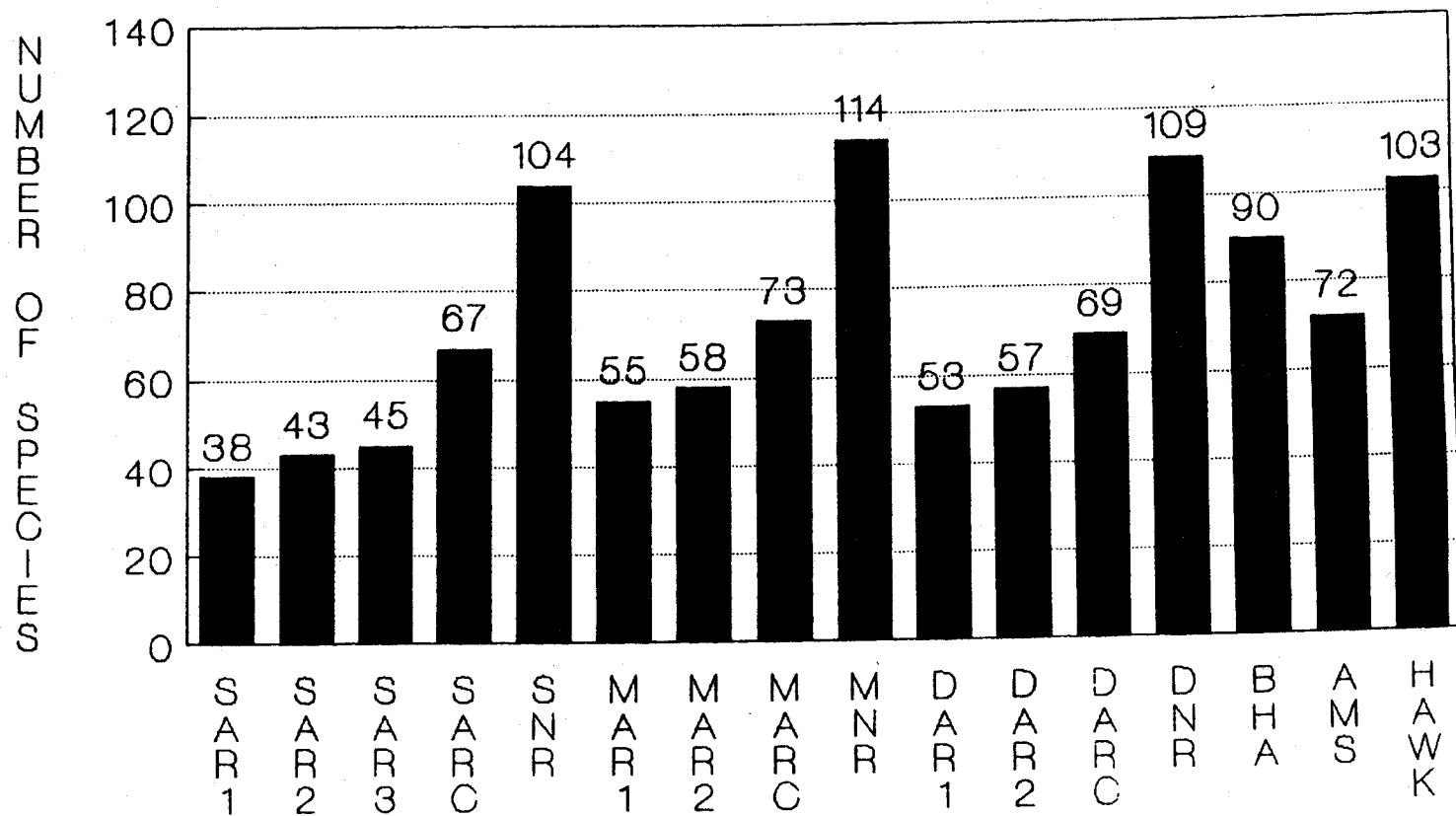


Figure 7. Total number of species recorded at censused artificial and natural reefs.

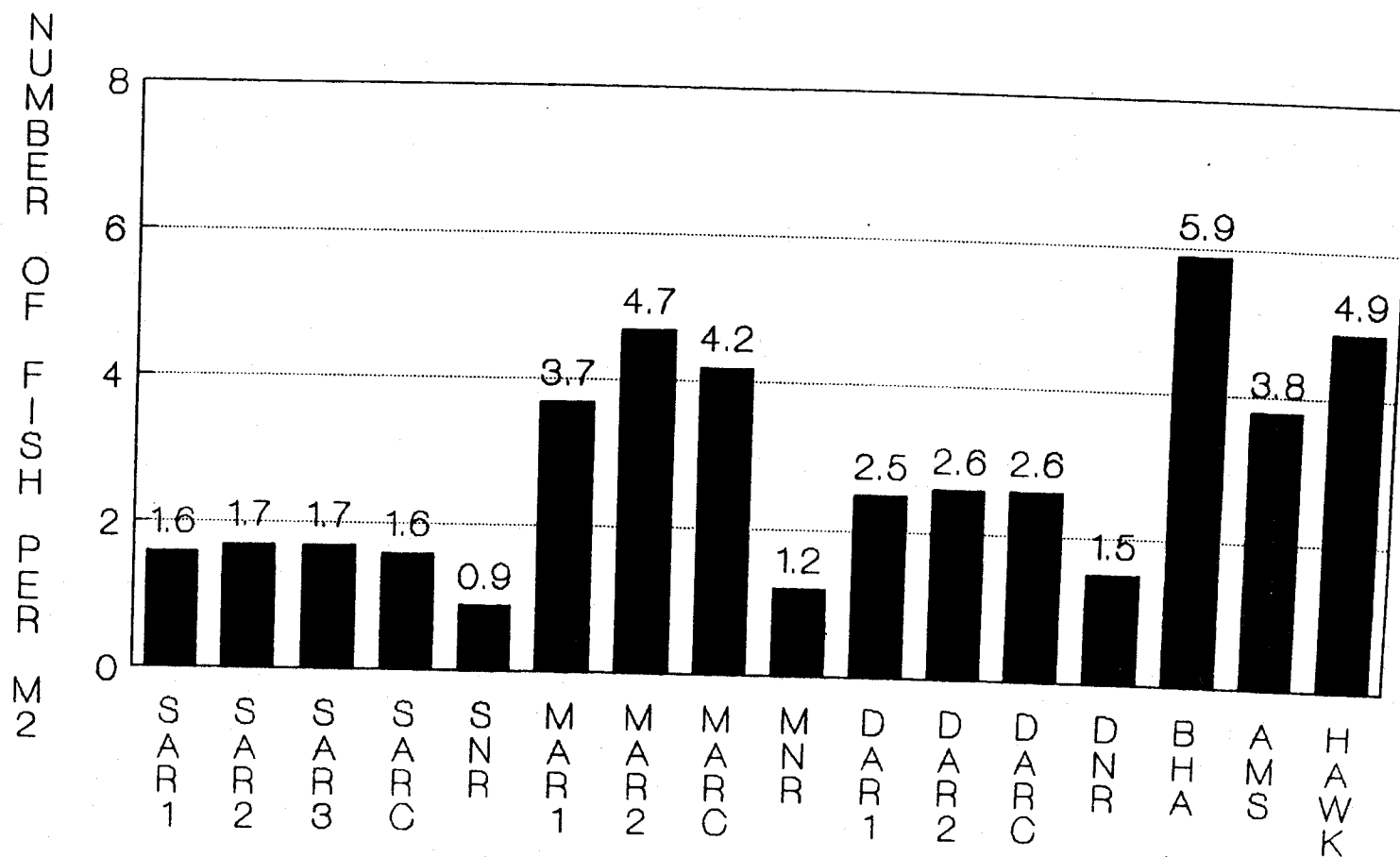


Figure 8. Relative density of fishes recorded at censused artificial and natural reefs. Excluded are 1,000 round scad in one DAR2 sample and 800 juvenile grunts in one MAR1 sample.

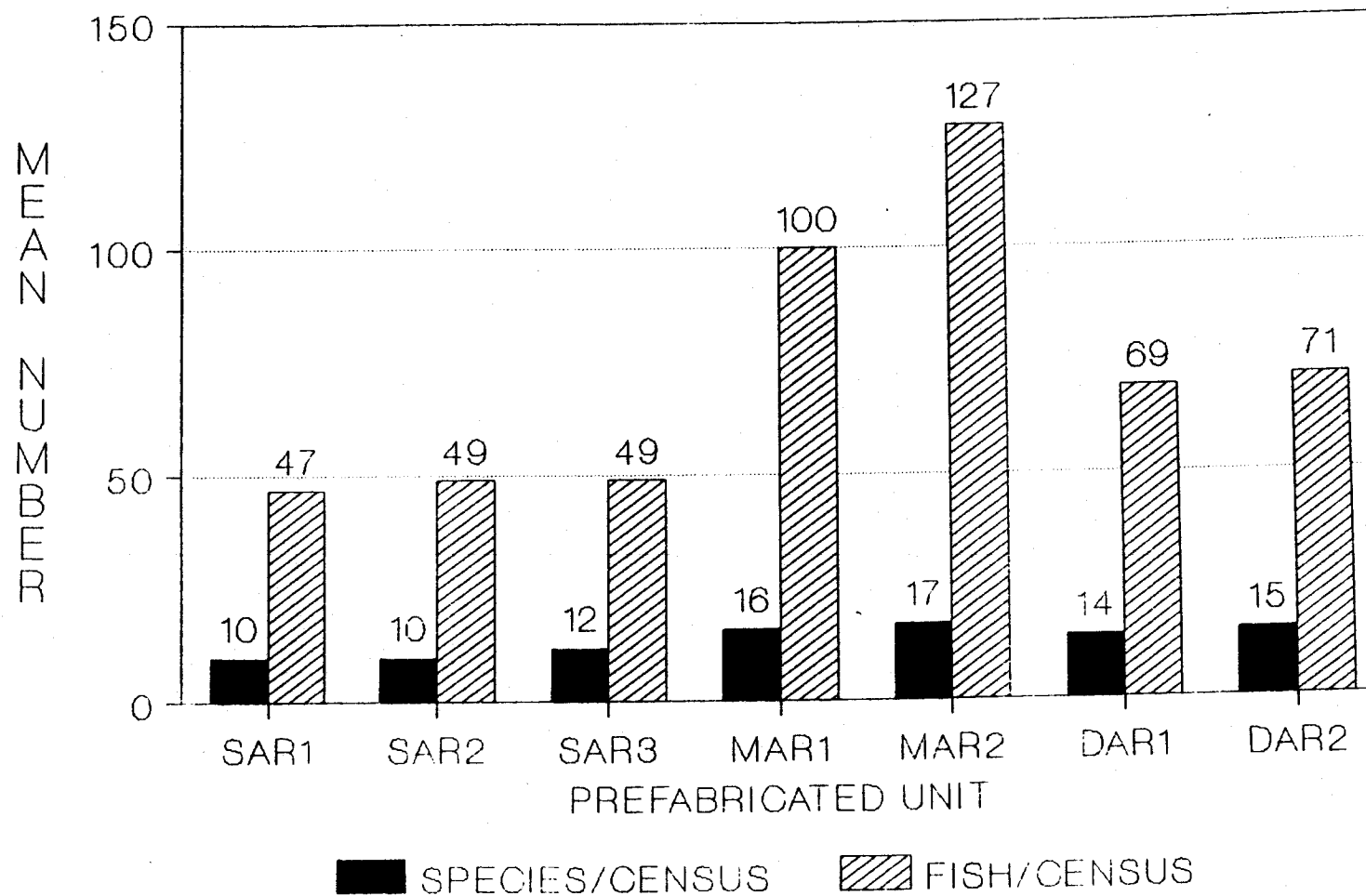


Figure 9. Mean number of species and fishes per census at units. Excluded are 1,000 round scad in one DAR2 sample and 800 juvenile grunts in one MAR1 sample.

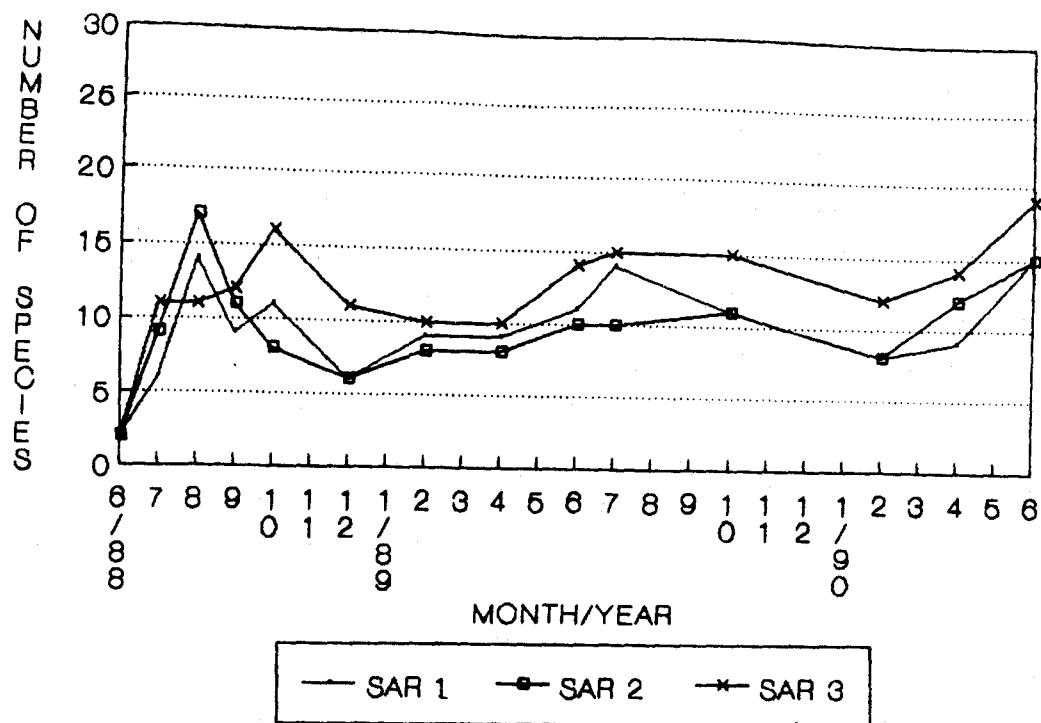


Figure 10. Monthly number of species at each low profile unit.

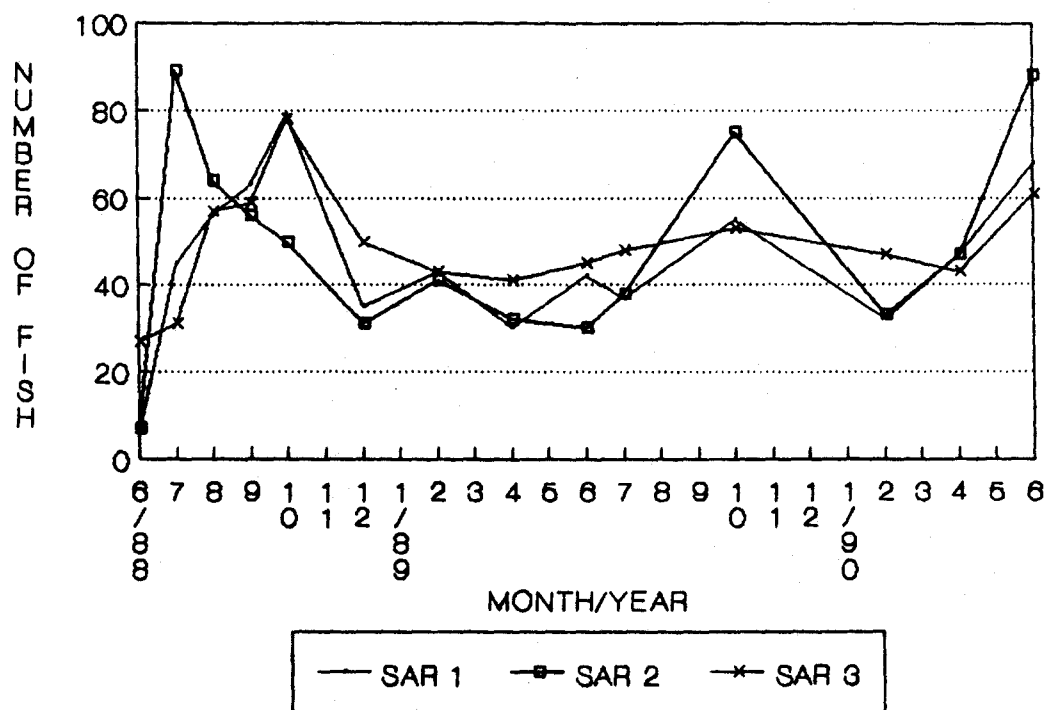


Figure 11. Monthly number of fishes at each low profile unit.

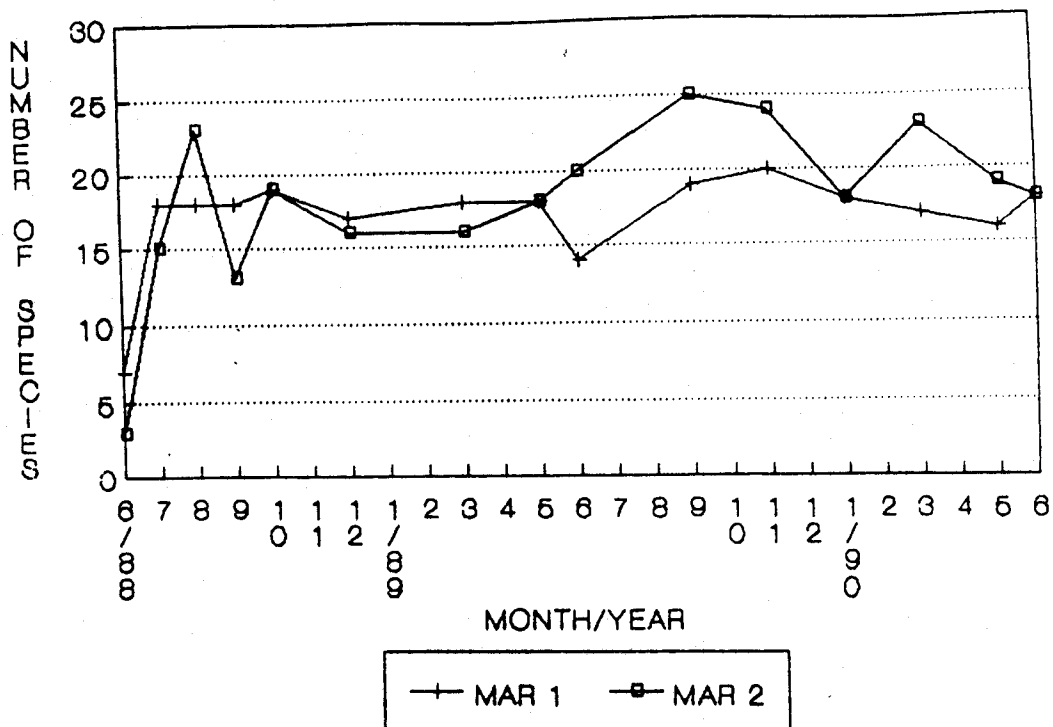


Figure 12. Monthly number of species at each mid-depth high profile unit.

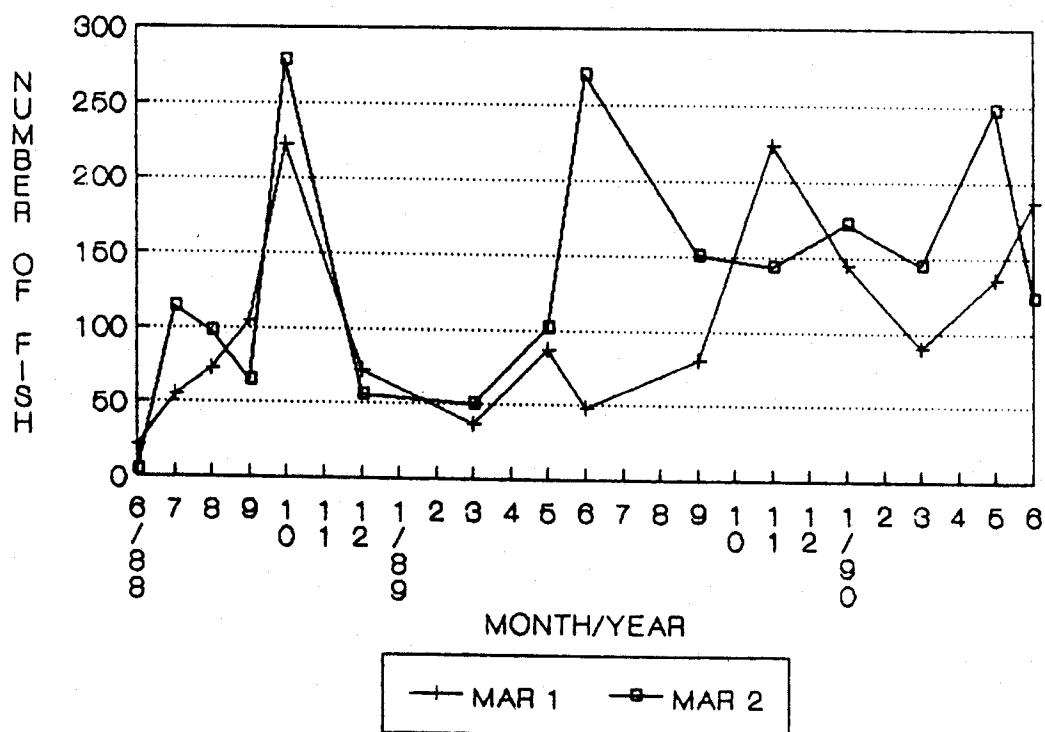


Figure 13. Monthly number of fishes at each mid-depth high profile unit. Excludes 800 MAR1 (8/88) grunts.

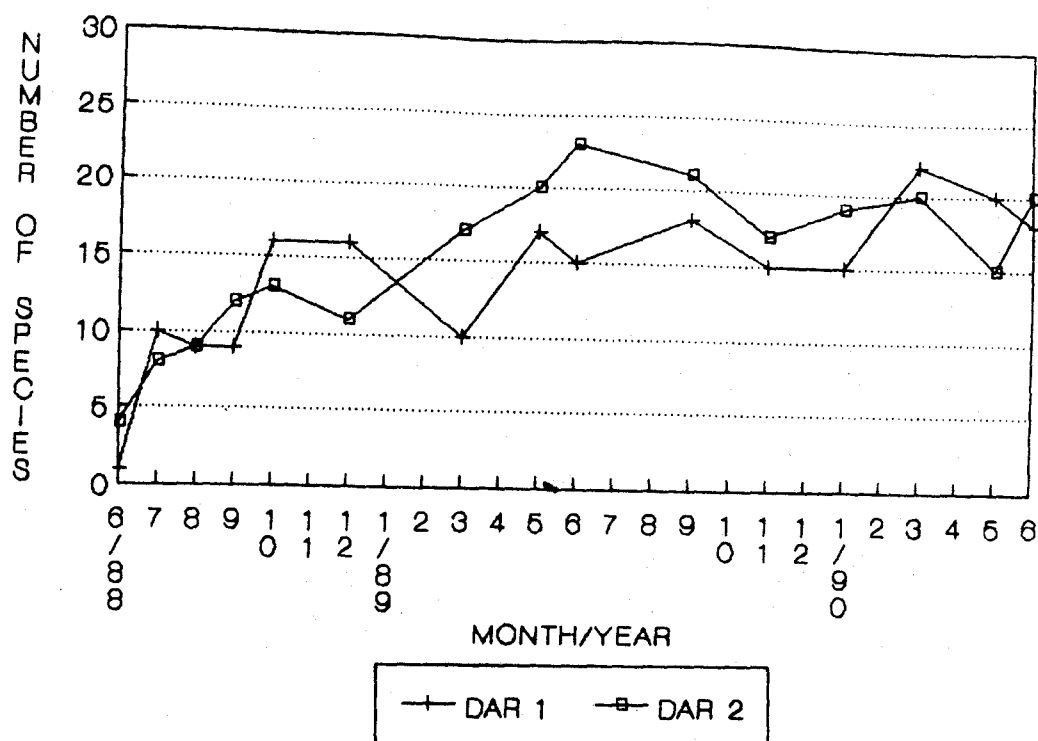


Figure 14. Monthly number of species at each deep high profile unit.

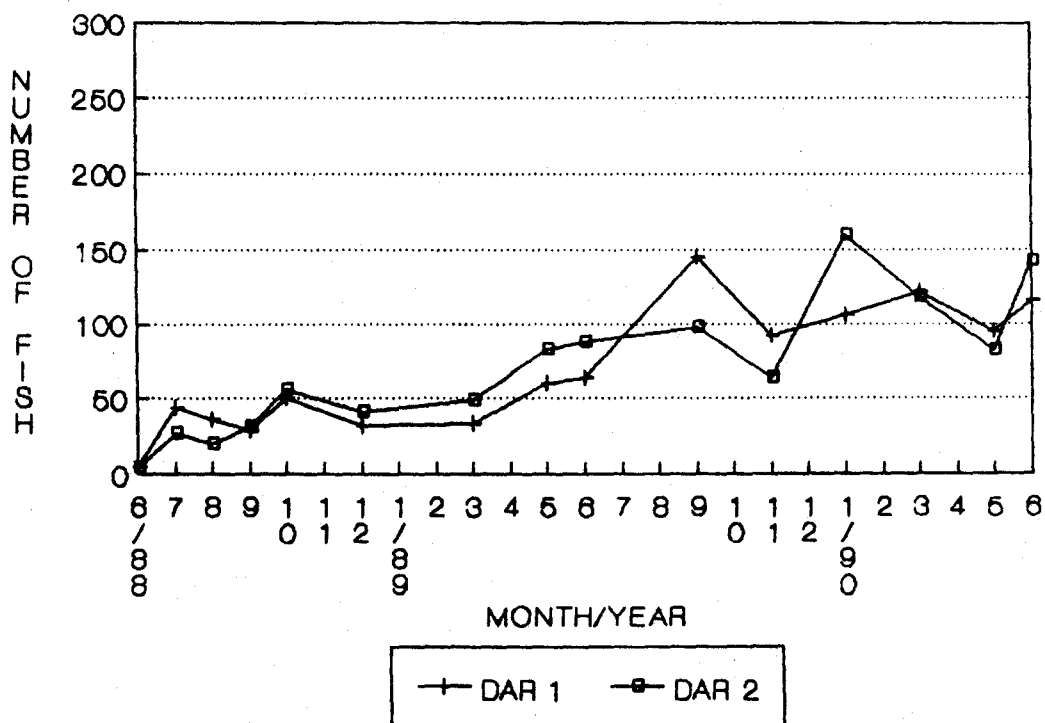


Figure 15. Monthly number of fishes at each deep high profile unit. Excludes 1,000 DAR2 (10/88) round scad.

SETTLER SPECIES

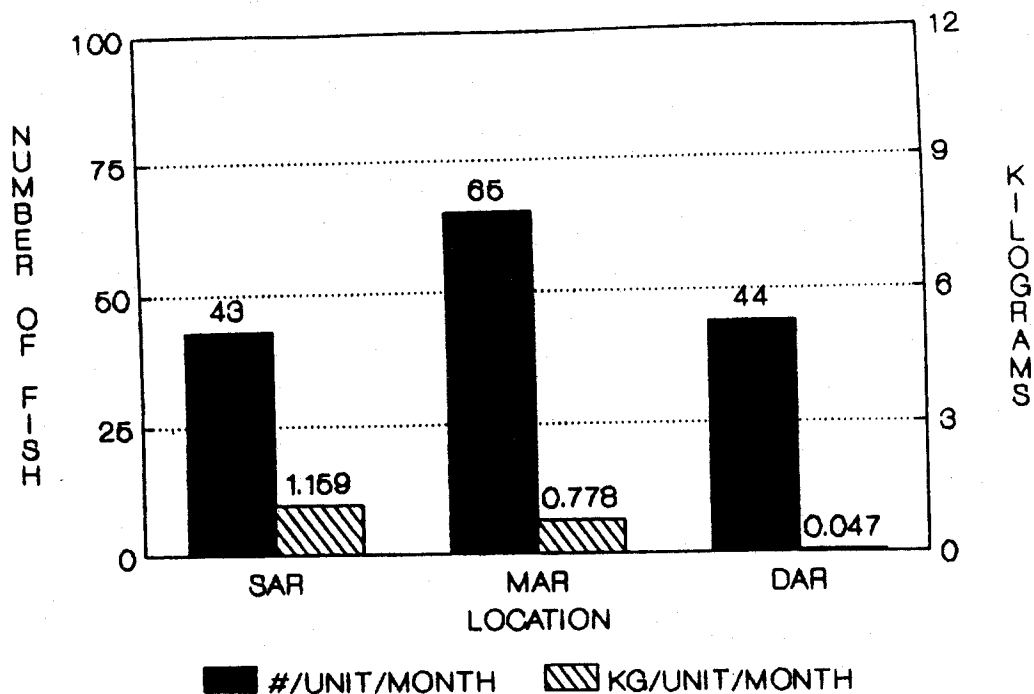


Figure 16. Potential contribution of settler species to numbers and biomass at units. Excludes 800 juvenile grunts at MAR.

COLONIZER SPECIES

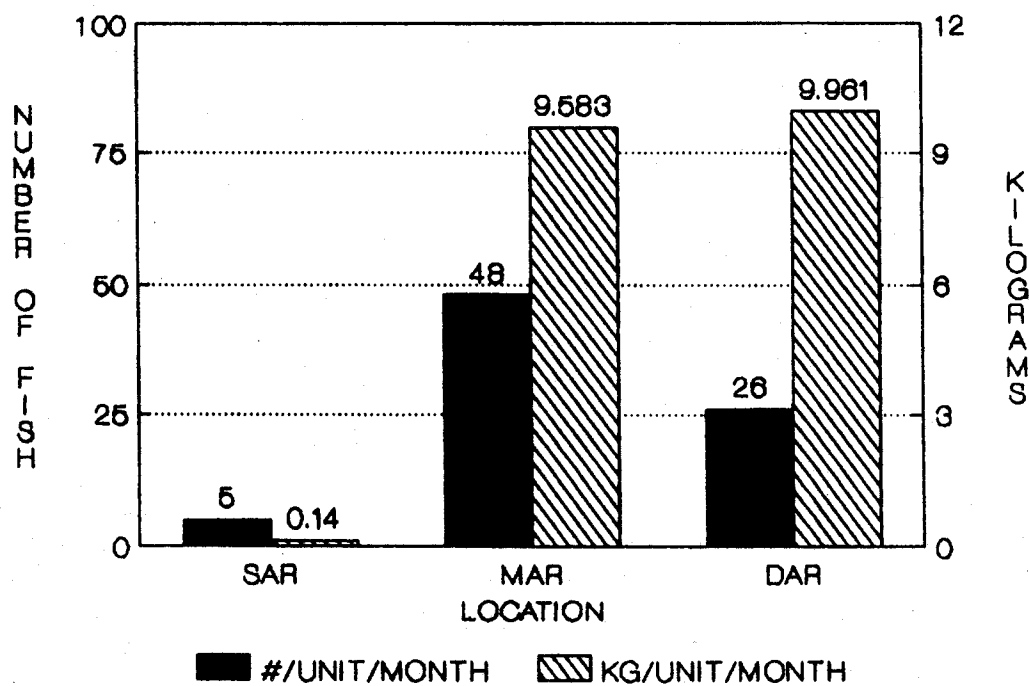


Figure 17. Potential contribution of colonizer species to fish numbers and biomass at units. Excludes 3 nurse sharks at SAR and 1,000 round scad at DAR.

SETTLER SPECIES

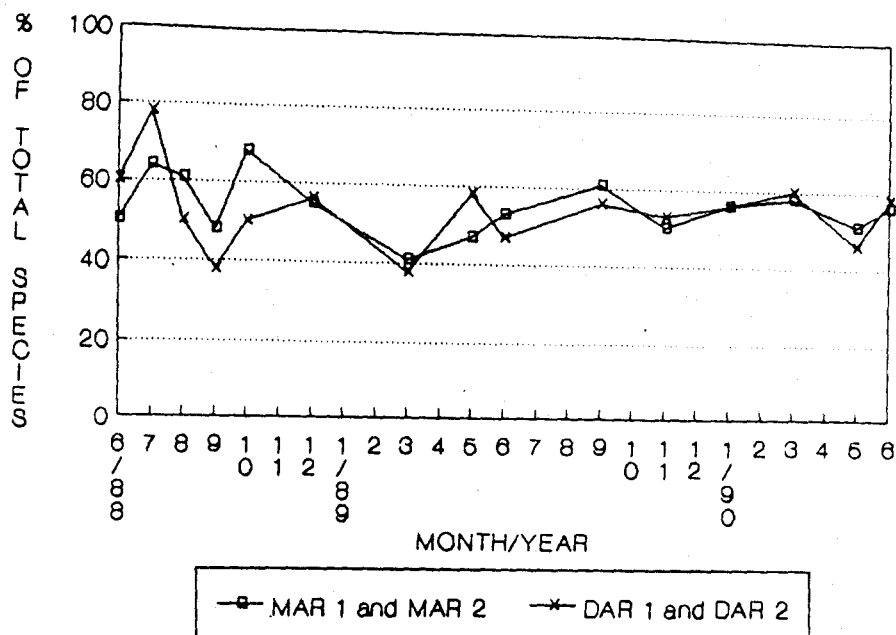


Figure 18. Monthly comparison of settler species as a proportion of total species at mid-depth and deep units.

SETTLER SPECIES

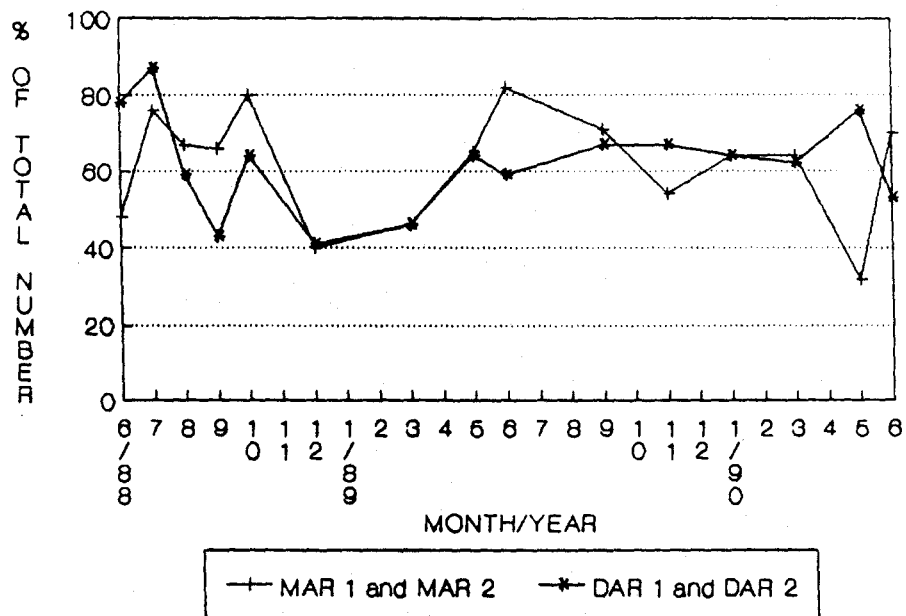


Figure 19. Monthly comparison of potential settler numbers as a proportion of total numbers at mid-depth and deep units.

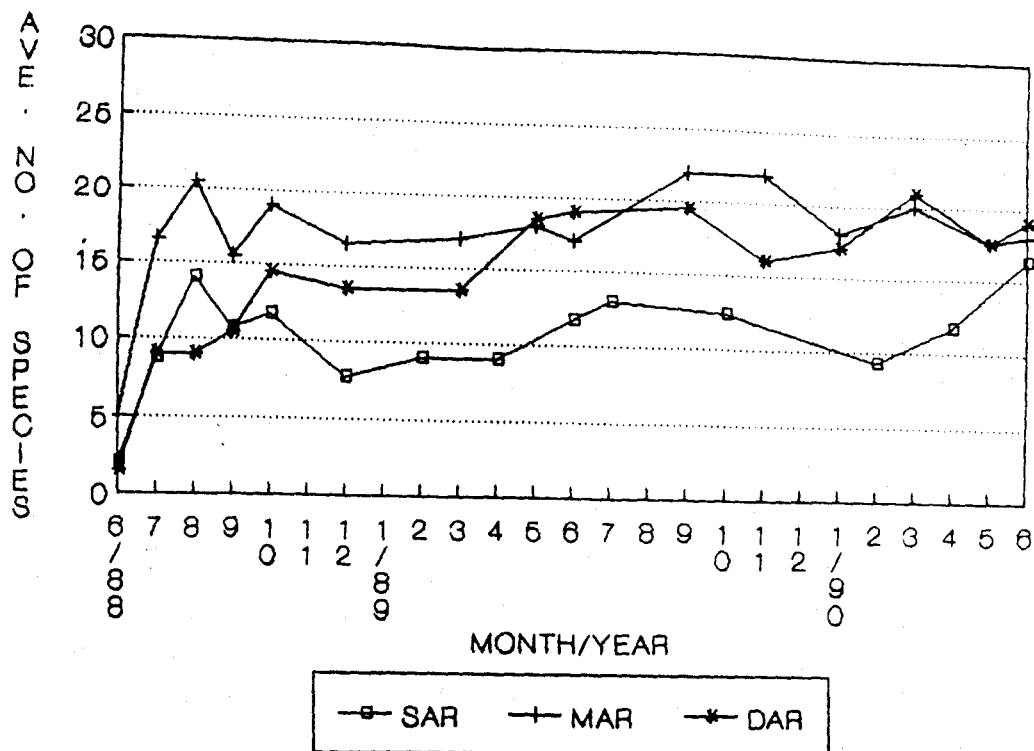


Figure 20. Monthly mean number of species at units in 3 depths.

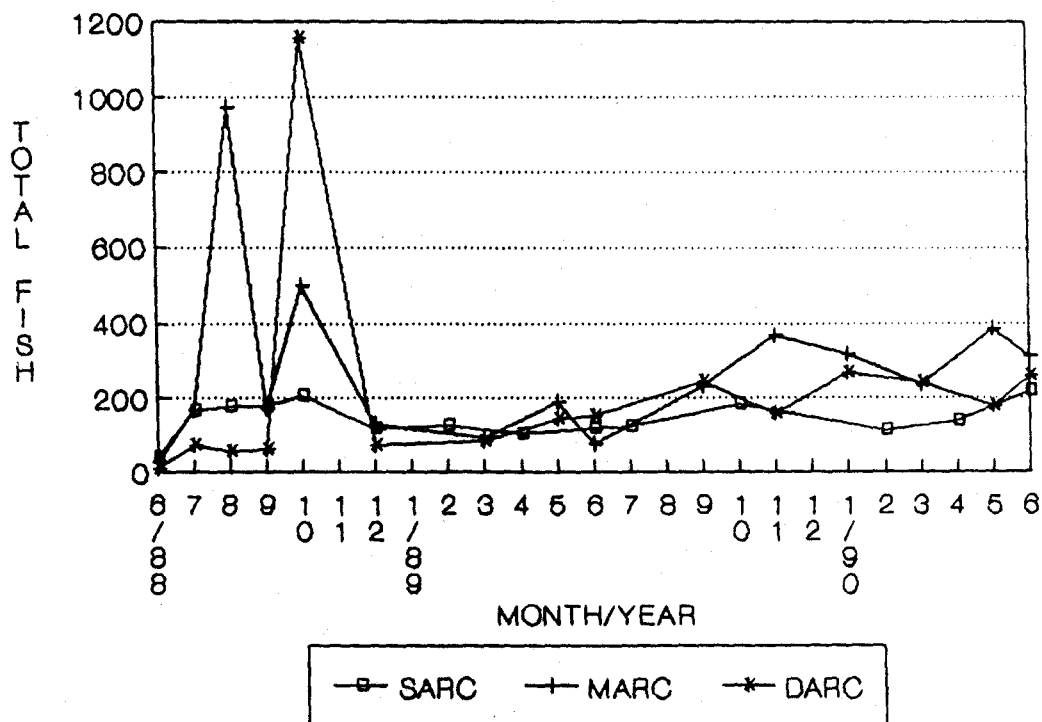


Figure 21. Monthly total of fishes at units in 3 depths. Numbers are from 3 shallow units and 2 units at mid-depth and deep sites.

Trophic Level as % of Total Biomass

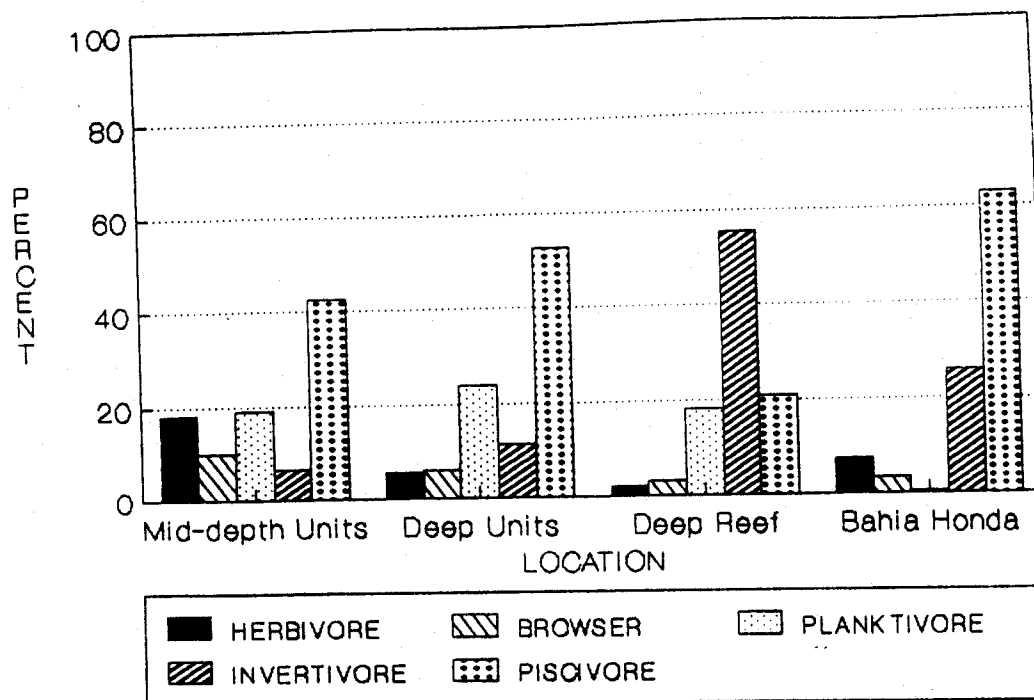


Figure 22. Trophic level as a proportion of total biomass at four sites.

Trophic Level as % of Total Number

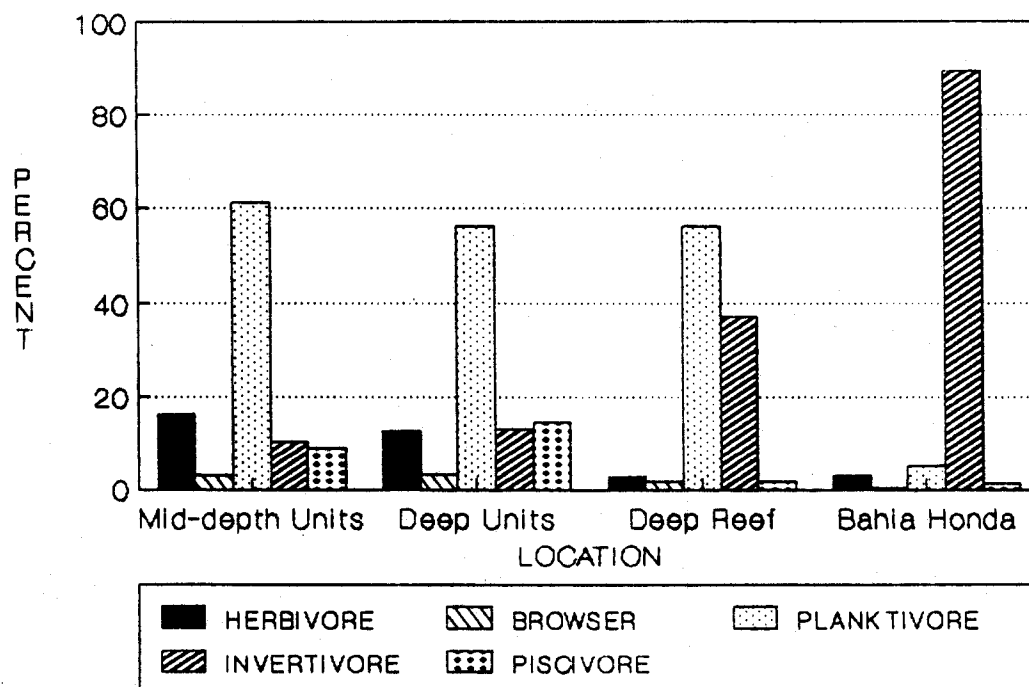


Figure 23. Trophic level as a proportion of total numbers at four sites.

YELLOWTAIL SNAPPER

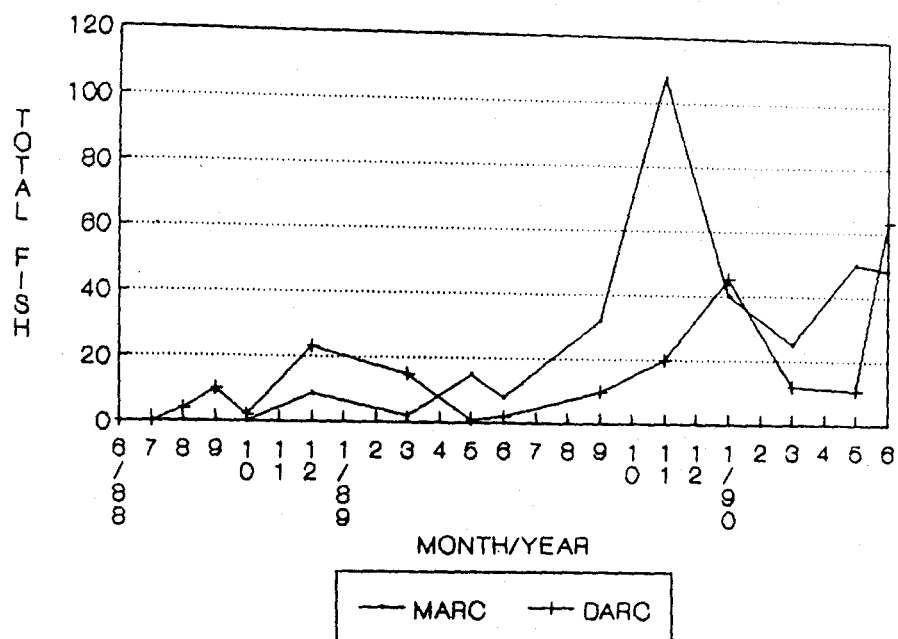


Figure 24. Monthly numbers of yellowtail snapper at mid-depth and deep units.

DEEP UNITS

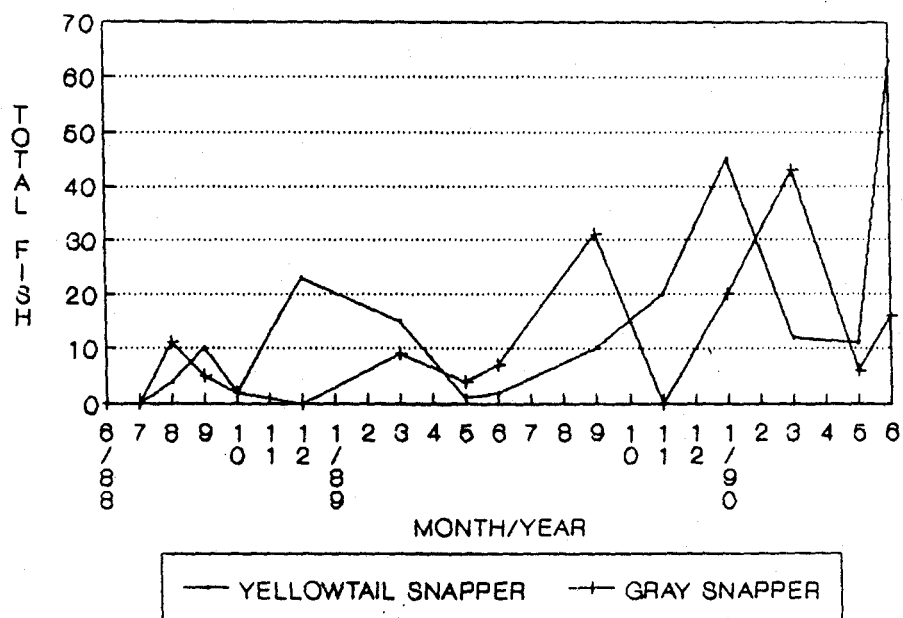


Figure 25. Monthly numbers of yellowtail snapper and gray snapper at deep units.

PLATES

PLATE 1

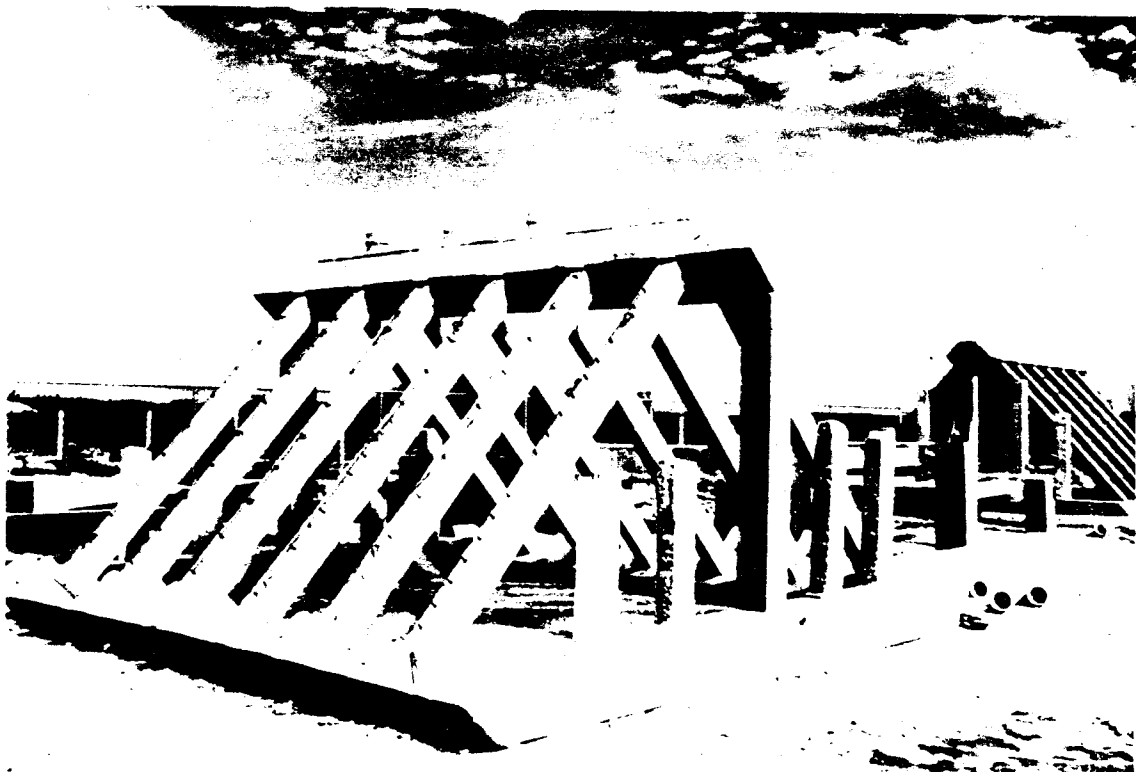


Plate 1. Construction yard view of low profile (top) and high profile (bottom) prefabricated units. The view of the high units is prior to placement of the PVC "stacks" on top.

PLATE 2

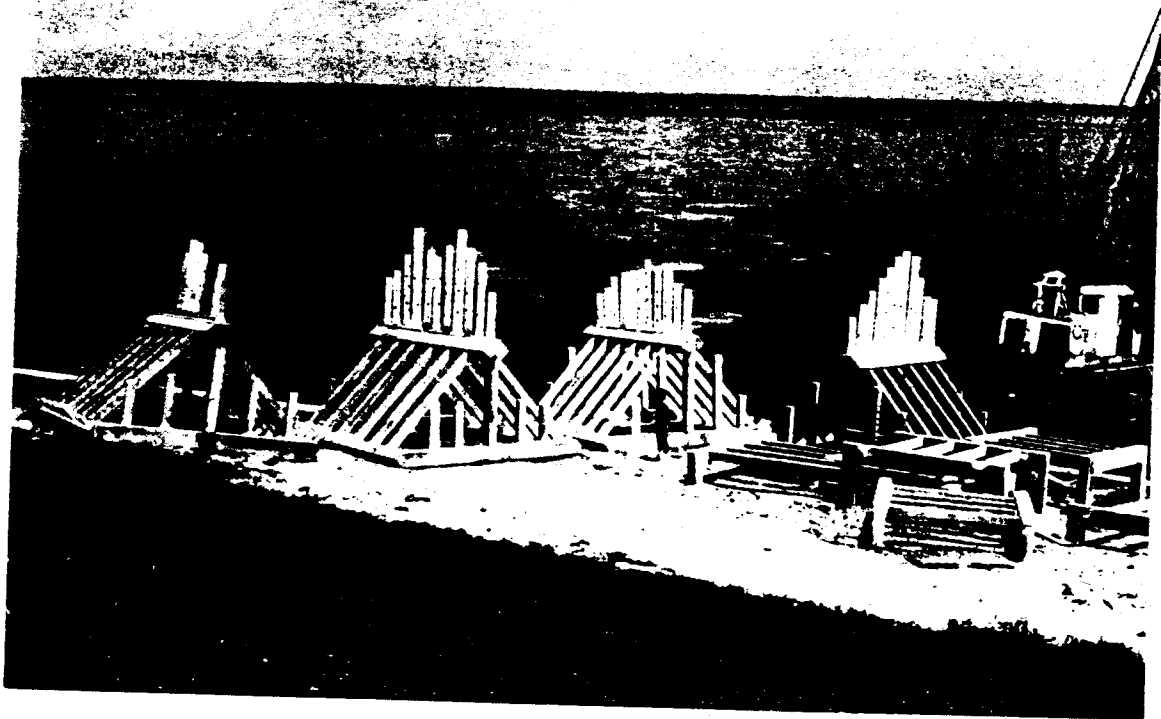
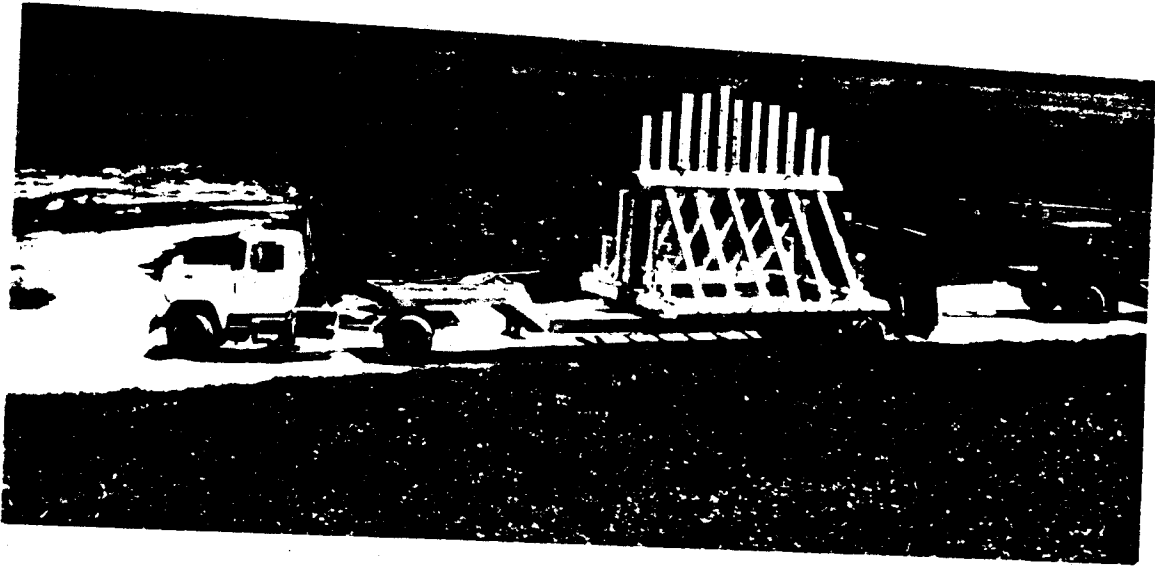


Plate 2. Transportation of the prefabricated units (top) and units at the staging area at the west end of the old Bahia Honda Bridge (bottom).

PLATE 3

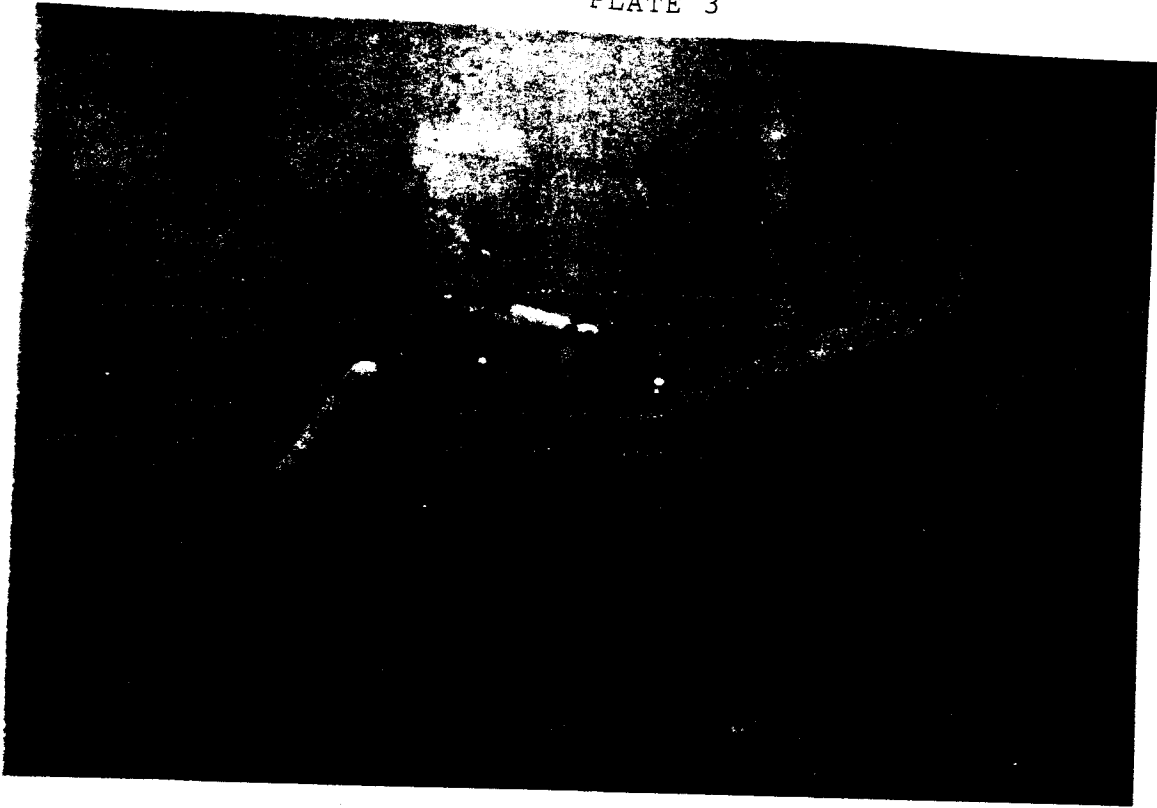


Plate 3. Underwater views of a mid-depth prefabricated unit about 90 days after placement.

PLATE 4

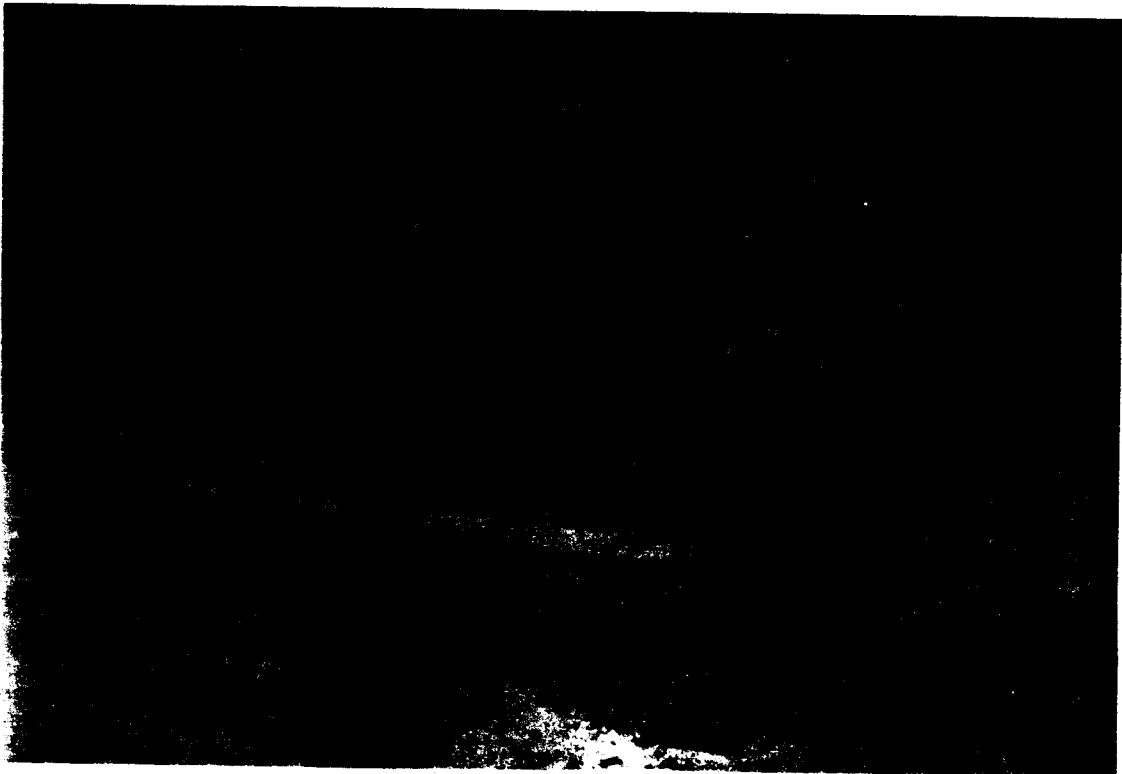
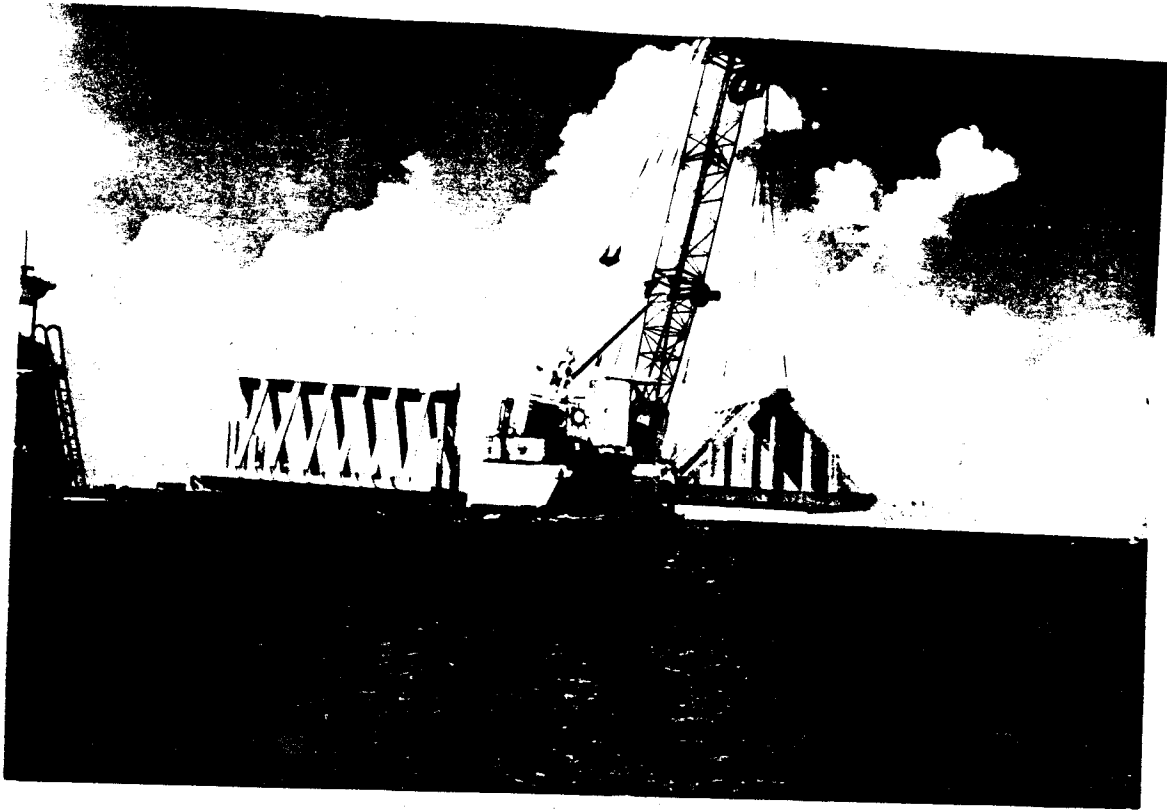


Plate 4. Deliberate placement of a mid-depth prefabricated unit in June, 1988 (top) and an underwater view of a low profile shallow prefabricated unit (bottom).

PLATE 5

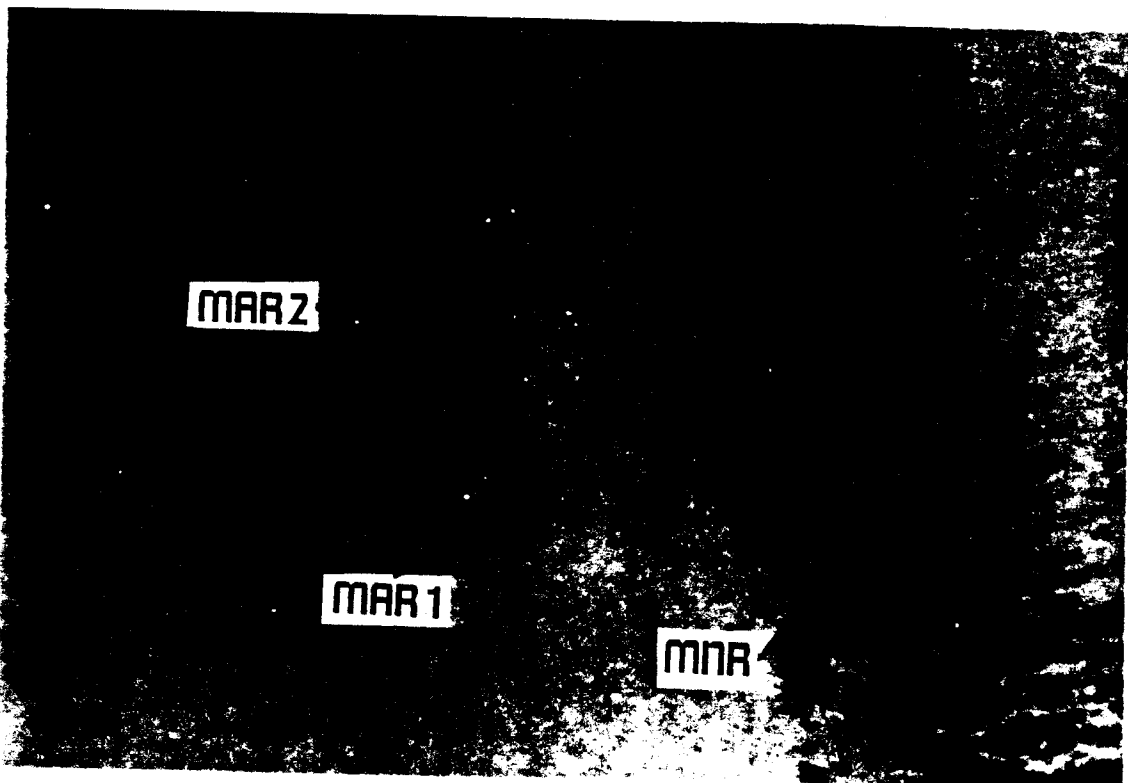
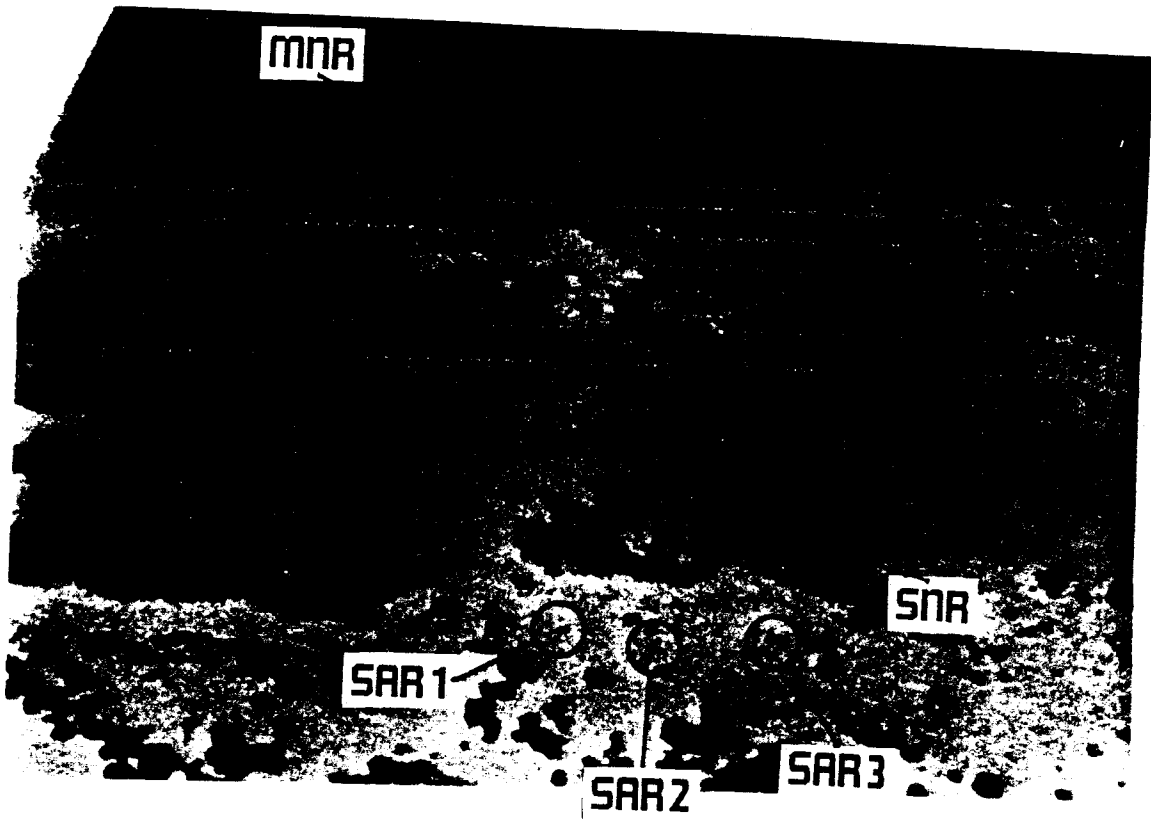


Plate 5. 1988 Oblique aerial photographs of the shallow prefabricated units (SAR), the shallow natural reef (SNR), the mid-depth prefabricated units (MAR), and the mid-depth natural reef (MNR). The top photo was taken from about 185 m (600') altitude with a view to the south. The bottom photo is from about 90 m (300') altitude with a view to the west.

PLATE 6

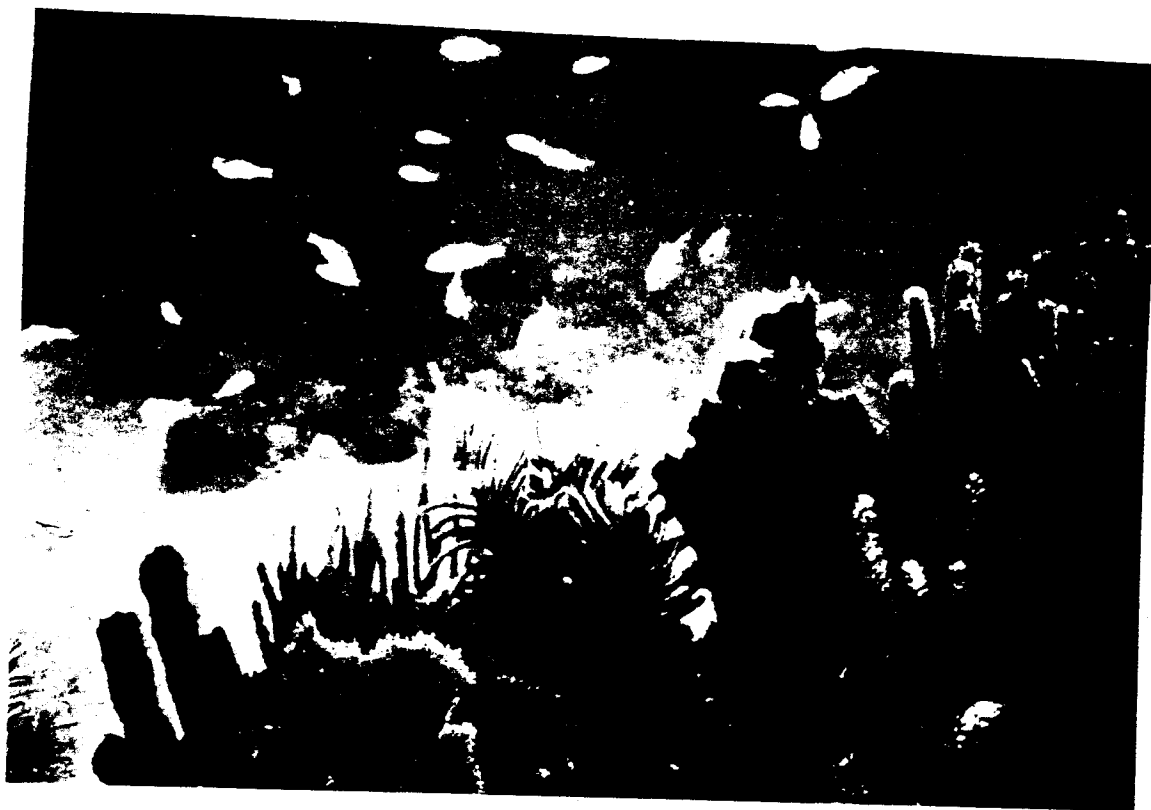


Plate 6. Underwater view of the shallow natural reef including a school of juvenile tomtate grunts (Haemulon aurolineatum) feeding in the water column (top), and the mid-depth natural reef (bottom).

PLATE 7

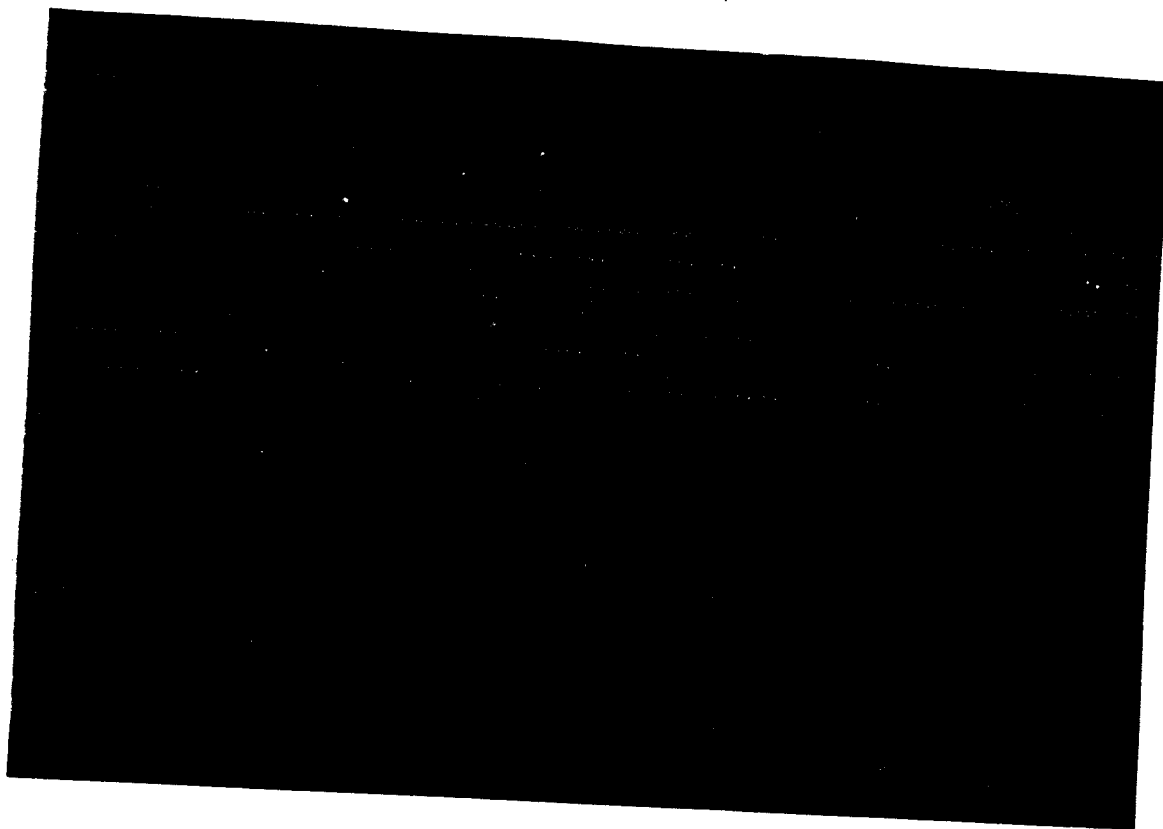


Plate 7. Underwater views of the deep natural reef and a school of gray snapper (Lutjanus griseus).

PLATE 8

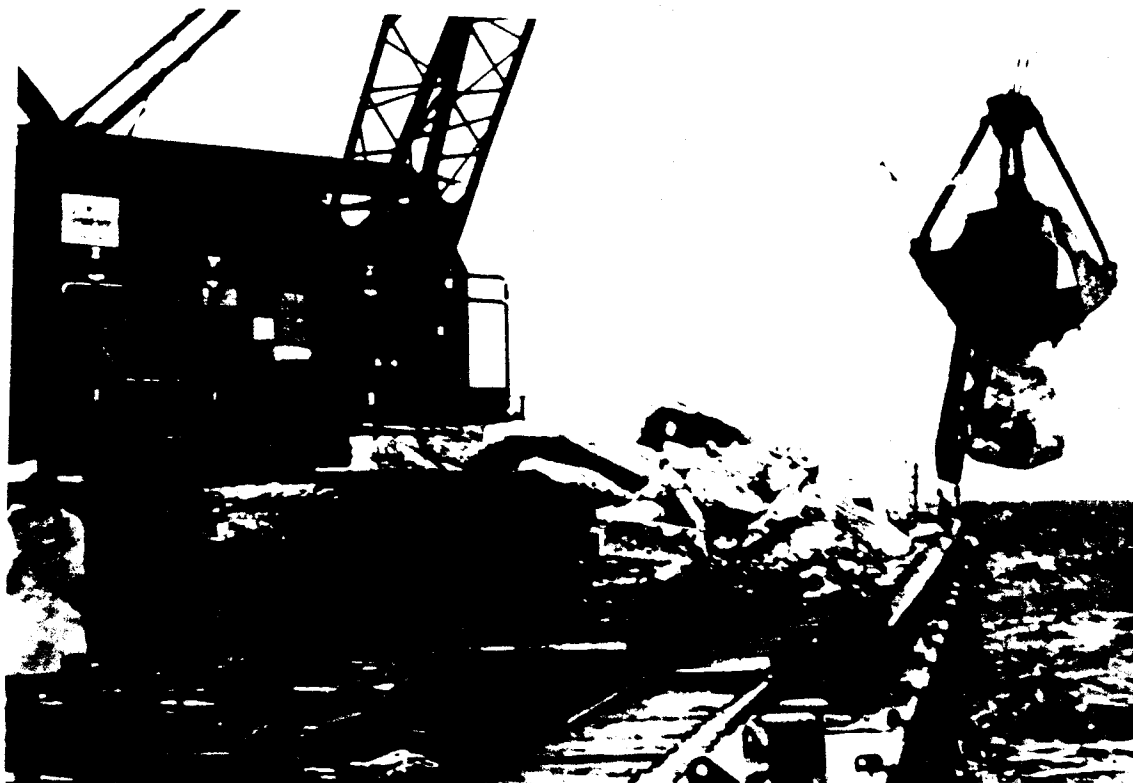
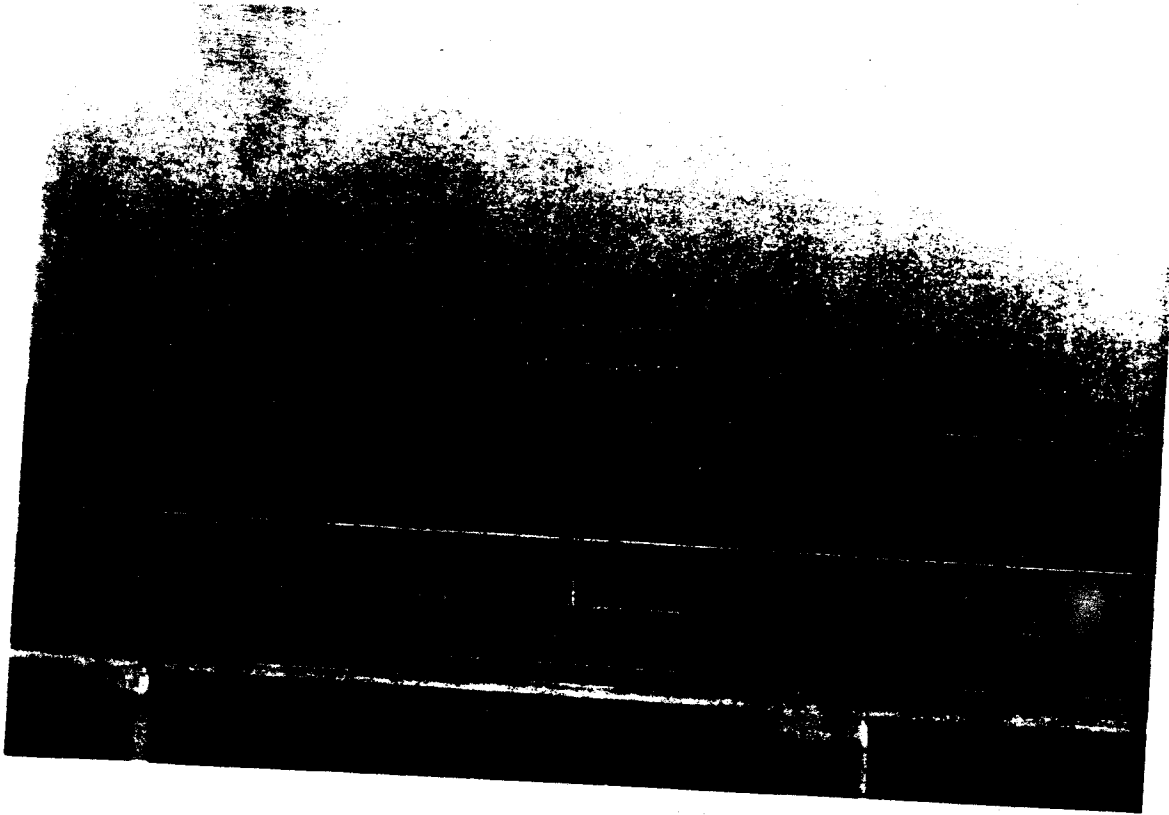


Plate 8. Steel girders of the Bahia Honda artificial reef being removed from the old Bahia Honda bridge in 1985 (top); more typical concrete construction of Keys bridges is in the foreground. Placement of large concrete rubble onto "patches" of the Bahia Honda artificial reef is shown in the bottom photograph.

PLATE 9

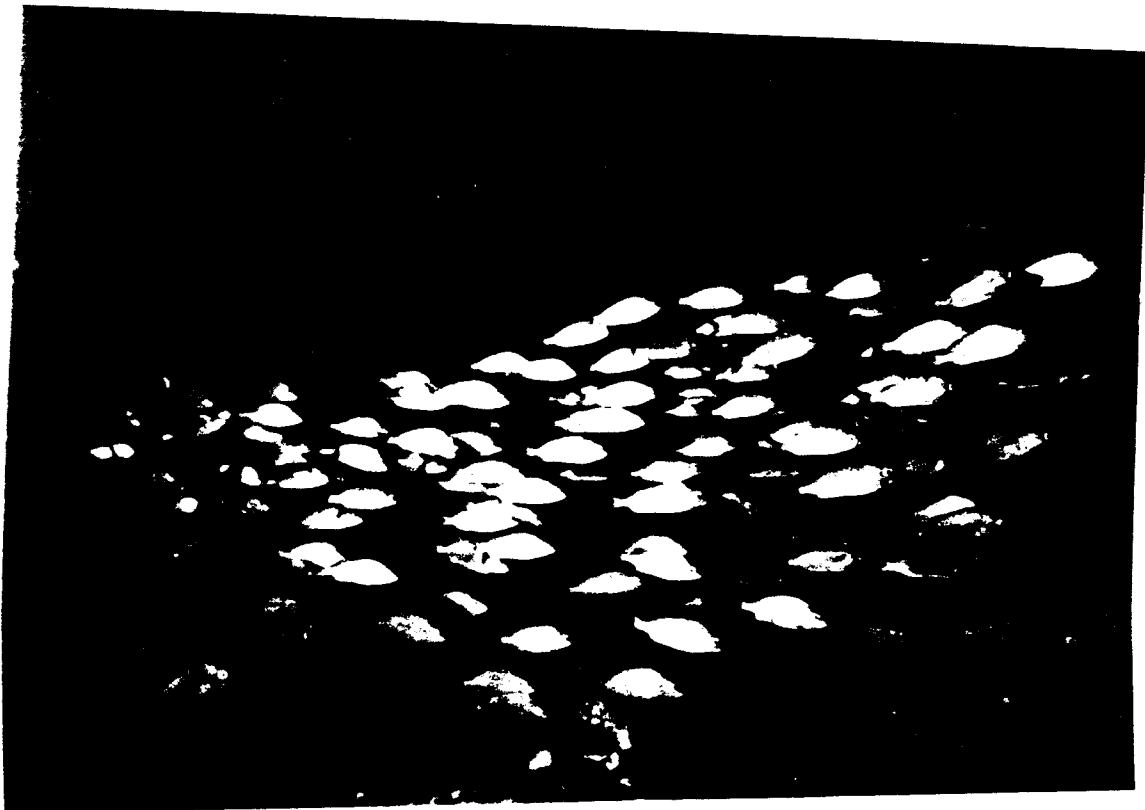


Plate 9. Underwater views of octocorals and a school of mixed grunts (Haemulon sciurus and H. plumieri) at the American Shoal bridge rubble reef.

PLATE 10



Plate 10. Underwater views of PVC and concrete surfaces of a mid-depth prefabricated unit 3 months (top) and 17 months (bottom) after placement.

PLATE 11

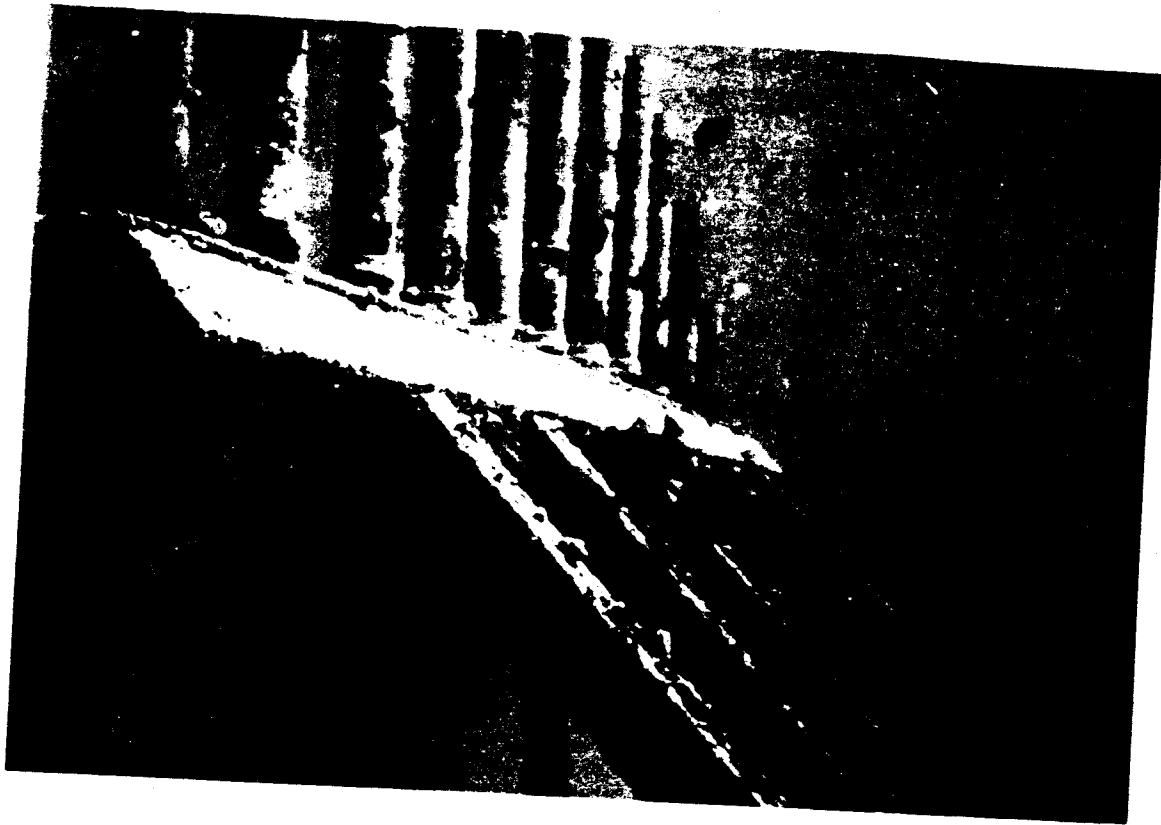


Plate 11. Underwater view of a mid-depth prefabricated unit 17 months after placement (top) with browsing gray angelfish (Pomacanthus arcuatus). The bottom photo is of the lower concrete and PVC edge of a deep prefabricated units 17 months after placement.

PLATE 12

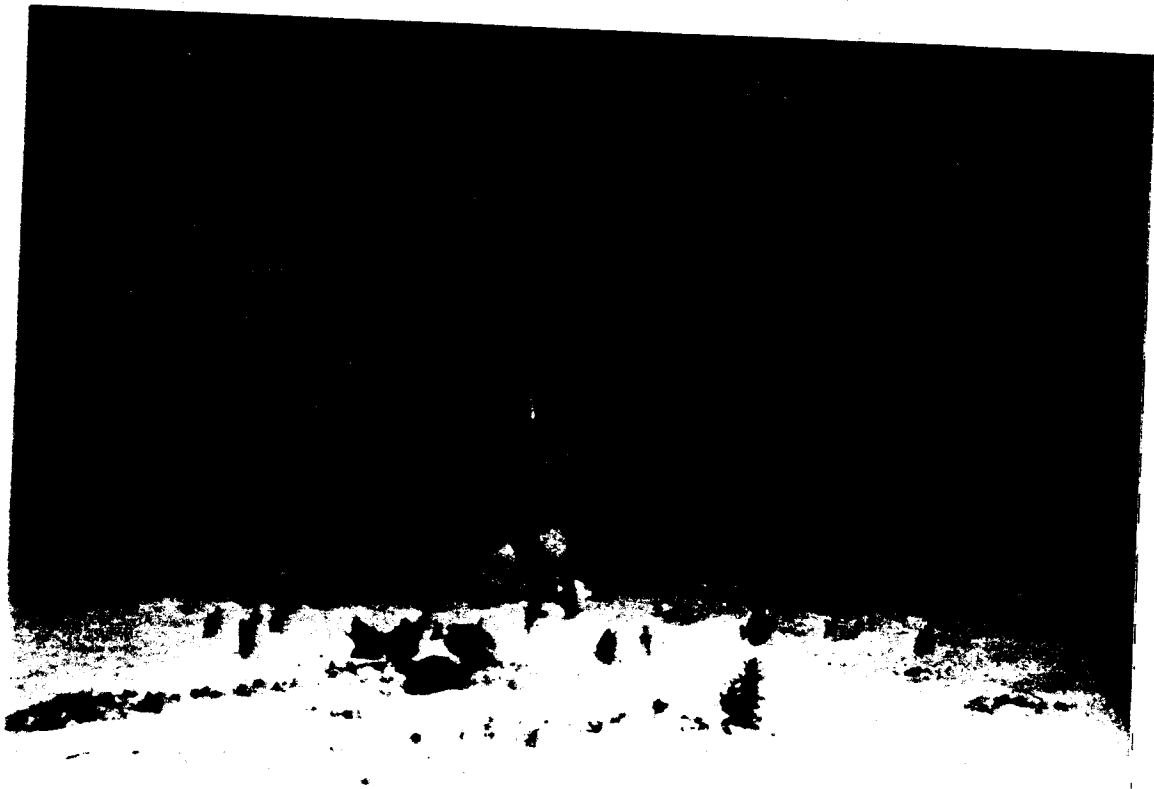


Plate 12. Aggregation of yellowtail snapper (Ocyurus chrysurus) over a mid-depth prefabricated unit (top) and aggregation of doctorfish (Acanthurus chirurgus), ocean surgeon (A. bahianus), and hogfish (Lachnolaimus maximus) near a mid-depth unit (bottom) 17 months after placement.

PLATE 13



Plate 13. Underwater view of a fish trap containing black grouper (Mycteroperca bonaci), gray snapper (Lutjanus griseus), and gray angelfish (Pomacanthus arcuatus) photographed in the study area.