

## A Survey of Fishes from Various Coral Reef Habitats within the Cayos Cochinos Marine Reserve, Honduras

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**Abstract:** This paper describes reef fish populations within the recently established Cayos Cochinos Biological Reserve (November 1993), a small archipelago of islands and reefs lying 10 km north of the Honduran coast. After years of commercial exploitation, only subsistence-artisanal level hand-line fishing is now permitted in the Reserve. Three census methods (random swims, stationary counts, and transect surveys) were employed using SCUBA and snorkel to determine overall species richness and abundance within five habitat types (shallow semi-protected reef; shallow exposed reef; shallow back reef comprising areas of grass, sand, and rubble; deep reef; and offshore reef). These surveys revealed a diverse reef fish community, with a total of 226 species reported for the area. These data provide the first quantitative assessment of fish populations in the area and the necessary baseline information for subsequent studies in the preserve. The densities reported here suggest that historical fishing pressure has reduced the diversity and abundance of commercially important species, and has had an important impact upon various aspects of the reef community structure.

**Key words:** Coral reef fishes, population census, abundance, density, diversity.

The fish populations of the Cayos Cochinos reef complex (10 km north of the Honduran mainland) have historically suffered heavy fishing pressure from a variety of sources. In 1993, the Honduran government moved to protect these populations by establishing the Cayos Cochinos Biological Reserve. Effective in November of that year, all commercial harvests of marine life, except for the most basic, artisanal, fishing practices, were banned within a 460 km<sup>2</sup> area centered on the archipelago. This prohibition is effectively enforced day and night via regular boat patrols by the Honduran Navy.

To monitor the effects of this change in fishing pressure, a census of reef fish populations was undertaken just as enforcement of the fishing ban began. This paper describes the results of that work. Not only does this represent the first rigorous cataloging of the diverse and abundant fishes living in the region, it also provides the necessary baseline data for future surveys of a population of fishes released from fishing pressure.

### MATERIALS AND METHODS

**Sites:** Fifteen sites within the Reserve were chosen for their habitat type and accessi-

bility (Fig. 1). For analysis, sites were grouped by depth and environment within one of five habitat categories: "S" = shallow, semi-exposed reef (< 10 m depth, dominant coral cover in areas of typically low to moderate wave energy); "D" = deep reef (> 15 m depth, dominant coral cover); "E" = exposed reef (< 7 m depth, coral and sand patches often exposed to high

wave energy); "P" = protected reef/sand/grass (< 10 m depth, habitat of scattered reef, rubble, sand and seagrass in areas of typically low wave energy); and "O" = offshore reefs (> 15 m depth, dominant hard and soft coral cover, occasionally strong currents, and oceanic water) that included sites at the Roatan Banks (see Table 1 for the habitat designation of each site).

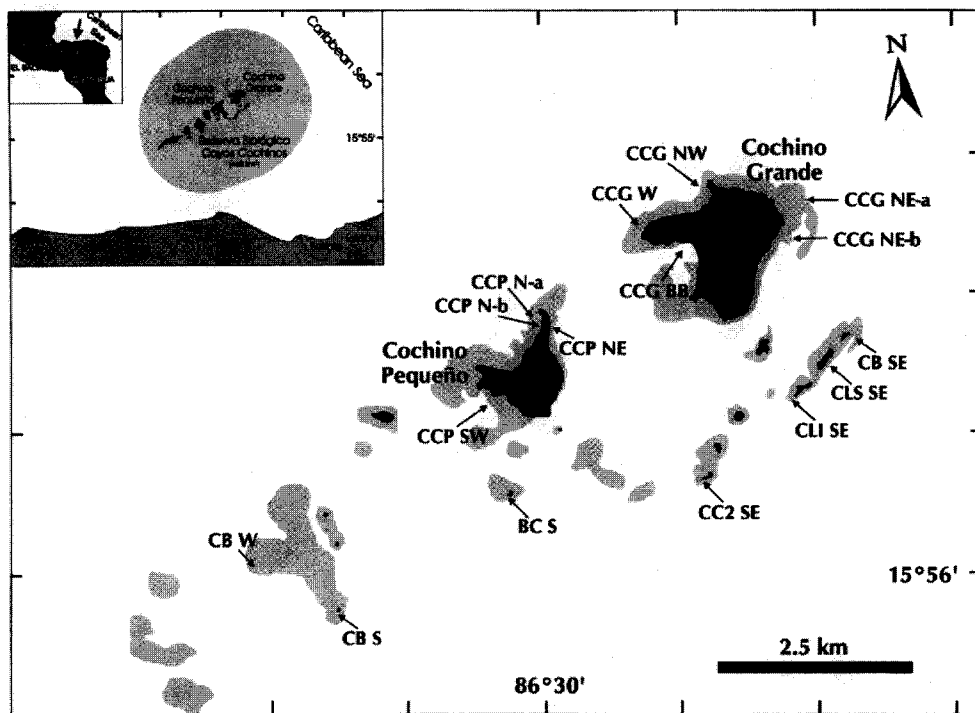


Fig. 1. Cayos Cochinos: 16 sites surveyed. Shadow areas represent reef depths from 0 - 15 m.

**Fish Censuses:** In an attempt to characterize both the diversity and abundance of fish populations within Cayos Cochinos, three census techniques (random swims, transect surveys, and stationary counts; reviewed by Rogers *et al.* (1994) were employed in various reef habitats between 9/23/95 and 10/7/95 using both snorkel and scuba between 09:00 and 16:00. The details of each technique are described below. Fish identifications were made

using Randall (1983), Böhlke & Chaplin (1992), and Humann (1994).

A) Random swim censuses: Random swims (adapted from Jones & Thompson 1978, Kimmel 1985) provide information on species richness and relative abundances but lack information on fish density. Each census began at an arbitrarily chosen point within a specific habitat. Divers (separated by at least 8 m) swam slowly through the habitat for 25 min, noting

TABLE 1

Sites of fish surveys in Cayos Cochinos Marine Preserve. Habitat types as follows: S = shallow, semi-exposed reef; D = deep reef; E = exposed reef; P = protected reef; O = oceanic reef (see figure 1 for locations, and text for further description)

| Location Site                      | Description   | Habitat | Comments                                       |
|------------------------------------|---|---------|--|
| <b>Cayo Cochinos Grande (CCG)</b>  |   |         |  |
| CCG NW                             | Fringing reef to 30 m with extensive soft and hard coral/boulder habitat  | S, D    | Two depths (< 1.5 & 20-25 m) surveyed          |
| CCG W                              | Sheep coral wall dropping from 5 to 30 m. Extensive coral cover   | S, D    | Two depths (< 1.5 & 20-25 m) surveyed          |
| CCG BB                             | Shallow (1-4 m) rubble, sand, and seagrass  | P       | Protected from all but southwest swell         |
| CCG NE-a                           | Exposed shelf (5-7 m) soft corals and massive, low relief corals  | E       | Potential for heavy surge and currents.        |
| CCG NE-b                           | Shallow (1-2 m) rubble, sand, and seagrass with scattered corals  | P       | Very protected, many juvenile fishes           |
| <b>Cayo Cochinos Pequeño (CCP)</b> |   |         |  |
| CCP NE:                            | Semi-exposed patch reef (1-4 m) surrounded by sand and grassbed   | S       | High coral reef fish diversity.                |
| CCP N-a:                           | Fringing reef, many massive corals and high coral cover (3-7 m) depth   | S       | High relief environment.                       |
| CCP N-b:                           | Shallow (1-2 m) lagoonal habitat of rubble, algal turf, and seagrass  | P       | Many juvenile fishes. Similar CCGNE-b.         |
| CCP SW:                            | Shallow (1-4 m) lagoonal seagrass habitat with sand patches and rubble  | P       | Many juvenile fishes.                          |
| <b>Cayo Balfate (CB)</b>           |   |         |  |
| CB SE:                             | Fringing reef (4-10 m) with extensive soft coral cover  | S       | Many herbivorous fishes                        |
| <b>Cayo Largo Superior (CLS)</b>   |   |         |  |
| CLS SE:                            | Groove and spur fringing reef habitat (4-10 m) with heavy coral cover   | S       | Extensive sand habitat below 15 m east         |
| <b>Cayo Largo Inferior (CLI)</b>   |   |         |  |
| CLI SE:                            | Shallow (2-4 m) fringing reef becoming spur and groove to east  | S       | Heavy macroalgal cover to southwest            |
| <b>Cayo Chechemate das (CC2)</b>   |   |         |  |
| CC2 SE:                            | Shallow (5-8 m), low relief, fringing reef, with scattered small coral heads  | S       | Loss of soft corals.                           |
| <b>Cayo Bobe (BCS)</b>             |   |         |  |
|                                    | Shallow (5-7 m) fringing reef; coral cover increases with depth. Extensive grassbed habitat to north.   | S       | Abrupt reef drop (to 25 m) with sand bottom.   |
| <b>Cayo Bolón (CB)</b>             |   |         |  |
| CB W:                              | Exposed fringing reef dominated by <i>Milipora</i> at reef crest. Shallow (3 m) fore-reef drops to 25 m. Sand channels and coral buttresses from 15-25 m. | D       | All surveys done below 15 m.                   |
| CB S:                              | Shallow (5 m) fringing reef with sand and rubble. Coral cover increases with depth. Extensive soft coral cover and sand areas to the west.                | S       | Sand and isolated deep patch reefs             |
| <b>Raetan Banks (RB)</b>           |   |         |  |
|                                    | Deep (15-30 m) reef outcrops ~ 15 km NW of the Cochinos archipelago. Oceanic conditions (clear water, strong currents)                                    | O       | Diverse fish fauna (oceanic and reef species). |

TABLE 2

A species list of fishes from the Cayos Cochinos Marine Reserve. Relative abundance and rank based on random swim surveys within five habitat types (total number of species/column given below each heading; number of surveys/habitat in parenthesis). Numbers left of slash (/) reflect average abundance score (max=5, see text for details). Numbers to right of slash denote proportional rank, within column, of species encountered during random swim surveys (1=highest rank). \* = species observed by the author outside of survey periods; d = species reported by local divers; f = species reported by local fishermen

| Family   | Total       | Shallow reef | Deep reef   | Exposed reef | Back reef   | Offshore    |
|--|-------------|--------------|-------------|--------------|-------------|-------------|
| Genus species                                    | 226 (45)    | 157 (20)     | 142 (10)    | 44 (4)       | 74 (6)      | 105 (5)     |
| <i>Acanthuridae</i> ( <i>surgonfishes</i> )      |             |              |             |              |             |             |
| <i>Acanthurus bahianus</i>                       | 3.82 / 0.96 | 3.75 / 0.89  | 3.30 / 0.82 | 5.00 / 1.00  | 3.67 / 0.96 | 4.40 / 0.79 |
| <i>Acanthurus chirurgus</i>                      | 1.88 / 0.79 | 2.15 / 0.69  | 1.00 / 0.48 | 3.00 / 0.44  | 2.33 / 0.79 | 1.60 / 0.34 |
| <i>Acanthurus coeruleus</i>                      | 4.40 / 0.99 | 4.50 / 0.95  | 4.20 / 0.93 | 5.00 / 1.00  | 3.67 / 0.96 | 4.80 / 0.88 |
| <i>Albulidae</i> ( <i>bonefishes</i> )           |             |              |             |              |             |             |
| <i>Albula vulpes</i>                             | 1           |              |             |              | f,d         |             |
| <i>Asteronariidae</i> ( <i>frogfishes</i> )      |             |              |             |              |             |             |
| <i>Antennarius multilineatus</i>                 | 1           | d            |             |              |             |             |
| <i>Antennarius striatus</i>                      | 1           | d            |             |              |             |             |
| <i>Apogonidae</i> ( <i>cardinalfishes</i> )      |             |              |             |              |             |             |
| <i>Apogon lucifer</i>                            | 0.16 / 0.26 | 0.10 / 0.00  | 0.30 / 0.20 |              | 0.67 / 0.37 |             |
| <i>Apogon maculatus</i>                          | 1           | *            |             |              |             |             |
| <i>Apogon planifrons</i>                         | 1           | *            |             |              |             |             |
| <i>Apogon pseudomaculatus</i>                    | 1           | *            |             |              |             |             |
| <i>Apogon robbinsi</i>                           | 1           | *            |             |              |             |             |
| <i>Apogon townsendi</i>                          | 0.51 / 0.52 |              | 1.20 / 0.57 |              |             | 2.20 / 0.64 |
| <i>Astronotus puncticulatus</i>                  | 0.40 / 0.43 | *            | 1.10 / 0.50 |              |             |             |
| <i>Phaeoptyx xenus</i>                           | 1           | 0.35 / 0.27  |             |              |             |             |
| <i>Atherinidae</i> ( <i>silverfishes</i> )       |             |              |             |              |             |             |
| <i>Allanetta harringtonensis</i>                 | 1           | 0.75 / 0.48  | 0.50 / 0.29 |              |             |             |
| <i>Atherinomorrus nigrus</i>                     |             |              |             |              |             |             |
| <i>Aulostomus maculatus</i>                      | 1.80 / 0.77 | 2.35 / 0.70  | 1.40 / 0.62 | 1.50 / 0.09  | 0.33 / 0.18 | 2.40 / 0.64 |
| <i>Balistridae</i> ( <i>triggerfishes</i> )      |             |              |             |              |             |             |
| <i>Balistes vetula</i>                           | 0.33 / 0.42 | 0.40 / 0.31  | 1.20 / 0.57 |              |             |             |
| <i>Canthidermis nagflamen</i>                    | 0.58 / 0.56 |              |             |              |             | 4.80 / 0.88 |
| <i>Melichthys niger</i>                          | 0.44 / 0.48 |              |             |              |             | 4.00 / 0.74 |
| <i>Xanthichthys ringens</i>                      | 0.11 / 0.18 |              |             |              |             | 2.00 / 0.44 |
| <i>Batrachoididae</i> ( <i>toadfishes</i> )      |             |              |             |              |             |             |
| <i>Batrachoides gilberti</i>                     | 0.22 / 0.33 |              | 0.20 / 0.16 |              |             |             |
| <i>Batrachoides</i> sp.                          | 0.04 / 0.07 | 0.25 / 0.19  |             |              |             |             |
| <i>Belontiidae</i> ( <i>needlefishes</i> )       |             |              |             |              |             |             |
| <i>Polybelone argalis</i>                        | 1           | *            |             |              |             |             |
| <i>Tylosurus crocodilus</i>                      | 1           | *            |             |              |             |             |
| <i>Blepharidae</i> ( <i>combtooth blennies</i> ) |             |              |             |              |             |             |
| <i>Ophioblennius atlanticus</i>                  | 0.62 / 0.58 | 0.60 / 0.40  | 0.10 / 0.06 | 3.25 / 0.47  |             | 0.80 / 0.22 |
| <i>Scorpaenidae</i>                              | 1           | *            |             |              |             |             |
| <i>Scorpaenopsis</i>                             |             |              |             |              |             |             |



|                                     |             |             |             |             |             |             |
|-------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <i>Chilomycterus antennatus</i>     | 0.07 / 0.09 |             |             |             | 0.50 / 0.26 |             |
| <i>Diodon hystrix</i>               | 0.09 / 0.16 | 0.20 / 0.10 | 0.20 / 0.16 |             |             | 0.80 / 0.22 |
| <i>Diodon holocentrus</i>           | 0.13 / 0.25 |             |             |             |             |             |
| <i>Echeneidae (remoras)</i>         |             |             |             |             |             |             |
| <i>Echeneis naucrates</i>           | 0.09 / 0.15 | 0.10 / 0.00 | 0.20 / 0.16 |             |             |             |
| <i>Elopiidae (tarpon)</i>           |             |             |             |             |             |             |
| <i>Megalops atlanticus</i>          | 1           |             |             |             |             |             |
| <i>Engraulidae (anchovies)</i>      |             |             |             |             |             |             |
| <i>Anchoa lyolepis</i>              | 0.87 / 0.67 |             | 1.70 / 0.67 |             |             | 3.00 / 0.64 |
| <i>Epithippidae (spadefishes)</i>   |             |             |             |             |             |             |
| <i>Chaetodipterus jaber</i>         | 0.33 / 0.39 |             |             |             |             |             |
| <i>Fistulariidae (cornetfishes)</i> |             |             |             |             |             |             |
| <i>Fistularia tubacarra</i>         | 1           |             |             |             |             |             |
| <i>Gerridae (mojarras)</i>          |             |             |             |             |             |             |
| <i>Eucinostomus melanopterus</i>    | 1           |             |             |             |             |             |
| <i>Eucinostomus jonesi</i>          | 1           |             |             |             |             |             |
| <i>Gerrus cinereus</i>              | 1           |             |             |             |             |             |
| <i>Gobiatoxidae (clingfishes)</i>   | 0.09 / 0.14 | 0.20 / 0.10 |             |             |             |             |
| <i>Arcus rubiginosus</i>            | 1           |             |             |             |             |             |
| <i>Gobiidae (gobies)</i>            |             |             |             |             |             |             |
| <i>Coryphopterus dicrus</i>         | 0.09 / 0.16 | 0.50 / 0.36 | 0.50 / 0.29 |             |             | 0.60 / 0.15 |
| <i>Coryphopterus eidolon</i>        | 0.56 / 0.55 | 0.90 / 0.52 | 1.20 / 0.57 |             |             | 0.80 / 0.22 |
| <i>Coryphopterus lipernes</i>       | 0.40 / 0.44 |             | 0.40 / 0.23 |             |             | 2.40 / 0.64 |
| <i>Coryphopterus glaucofraenum</i>  | 1.20 / 0.72 | 3.90 / 0.90 | 2.00 / 0.72 |             |             | 1.80 / 0.38 |
| <i>Coryphopterus personatus</i>     | 3.38 / 0.92 | 0.25 / 0.19 | 3.70 / 0.88 | 2.85 / 0.90 |             | 3.80 / 0.70 |
| <i>Logosoma helena</i>              | 0.31 / 0.38 | 0.35 / 0.27 | 0.70 / 0.38 |             |             |             |
| <i>Gnatholepis thompsoni</i>        | 0.20 / 0.29 |             | 1.00 / 0.48 |             |             | 0.80 / 0.22 |
| <i>Gobiosoma dilepis</i>            | 0.13 / 0.25 | 0.10 / 0.00 | 0.50 / 0.29 |             |             | 3.00 / 0.64 |
| <i>Gobiosoma oceanops</i>           | 2.07 / 0.82 | 0.30 / 0.21 | 2.20 / 0.74 |             | 0.67 / 0.37 | 0.40 / 0.11 |
| <i>Gobiosoma xanthopyra</i>         | 1.02 / 0.69 | 2.50 / 0.73 | 1.80 / 0.69 |             |             | 4.60 / 0.82 |
| <i>Grammididae (basilias)</i>       |             |             |             |             |             |             |
| <i>Gramma loreto</i>                | 2.78 / 0.87 | 1.40 / 0.58 | 3.70 / 0.88 |             |             | 0.20 / 0.06 |
| <i>Gramma melacara</i>              | 0.62 / 0.60 | 2.40 / 0.72 | 3.30 / 0.82 |             |             |             |
| <i>Grammididae (soopfishes)</i>     |             |             |             |             |             |             |
| <i>Rypitcus saponaceus</i>          | 0.07 / 0.08 |             |             | 0.50 / 0.02 |             |             |
| <i>Esoxocetidae (flycatchers)</i>   |             |             |             |             |             |             |
| <i>Hemiramphus brasiliensis</i>     | 1           |             |             |             |             |             |
| <i>Haemulidae (grunts)</i>          |             |             |             |             |             |             |
| <i>Anisotremus surinamensis</i>     | 0.40 / 0.45 |             | 0.20 / 0.16 |             |             | 0.60 / 0.15 |
| <i>Anisotremus virginicus</i>       | 0.78 / 0.65 | 0.55 / 0.38 | 1.70 / 0.67 |             |             |             |
| <i>Haemulon aurolineatum</i>        | 1.73 / 0.76 | 1.40 / 0.58 | 4.00 / 0.91 |             | 1.67 / 0.70 |             |
| <i>Haemulon carbonarium</i>         | 0.58 / 0.57 | 0.70 / 0.46 | 0.60 / 0.35 | 1.50 / 0.09 |             |             |
| <i>Haemulon chrysargyreum</i>       | 0.53 / 0.53 | 0.40 / 0.31 | 1.00 / 0.48 |             |             | 0.20 / 0.06 |
| <i>Haemulon flavolineatum</i>       | 2.93 / 0.88 | 3.60 / 0.85 | 3.70 / 0.88 | 3.75 / 0.56 | 1.00 / 0.47 |             |
| <i>Haemulon macrostomum</i>         | 0.71 / 0.63 | 1.25 / 0.55 | 0.20 / 0.16 |             | 1.67 / 0.70 |             |
| <i>Haemulon plumieri</i>            | 2.67 / 0.86 | 2.80 / 0.77 | 3.70 / 0.88 | 4.00 / 0.60 |             | 1.00 / 0.26 |
| <i>Haemulon sciurus</i>             | 1.27 / 0.72 | 1.50 / 0.59 | 1.40 / 0.62 | 1.50 / 0.09 | 1.17 / 0.49 | 2.20 / 0.64 |
| <i>Haemulon striatum</i>            | 1           |             |             |             |             |             |

|                                       |             |             |             |             |             |             |             |  |  |  |
|---------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--|--|--|
| <b>Holocentridae (squirrelfishes)</b> |             |             |             |             |             |             |             |  |  |  |
| <i>Adiorx cornutus</i>                | 0.44        | 0.47        | 1.40 / 0.62 | 1.75        | 0.14        | 0.33 / 0.18 | 0.20 / 0.06 |  |  |  |
| <i>Adiorx ventralis</i>               | 0.33 / 0.40 | 0.35 / 0.27 | 0.50 / 0.29 | 0.50 / 0.29 | 0.33 / 0.18 | 0.33 / 0.18 | 0.20 / 0.06 |  |  |  |
| <i>Holocentrus aderseni</i>           | 1.02 / 0.69 | 0.70 / 0.46 | 0.40 / 0.23 | 2.50        | 0.37        | 0.83 / 0.42 | 2.60 / 0.64 |  |  |  |
| <i>Holocentrus marinus</i>            | 1.47 / 0.74 | 0.70 / 0.46 | 2.40 / 0.76 | 2.00        | 0.23        | 1.17 / 0.49 | 4.00 / 0.74 |  |  |  |
| <i>Holocentrus rufus</i>              | 2.96 / 0.89 | 3.20 / 0.82 | 3.30 / 0.82 | 1.75        | 0.14        | 1.17 / 0.49 | 4.40 / 0.79 |  |  |  |
| <i>Myripristis jacobus</i>            | 0.56 / 0.55 | 0.65 / 0.42 | 0.60 / 0.35 | 1.75        | 0.14        | 1.17 / 0.49 | 1.20 / 0.30 |  |  |  |
| <b>Inermittidae (bonnetmouths)</b>    |             |             |             |             |             |             |             |  |  |  |
| <i>Enmellichthys atlanticus</i>       | 0.44 / 0.49 | 0.50 / 0.36 | 0.80 / 0.40 | 0.80 / 0.40 | 0.40 / 0.11 | 0.40 / 0.11 | 0.40 / 0.11 |  |  |  |
| <i>Inermia viata</i>                  | 0.62 / 0.59 | 0.80 / 0.21 | 1.10 / 0.50 | 1.10 / 0.50 | 2.20 / 0.64 | 2.20 / 0.64 | 2.20 / 0.64 |  |  |  |
| <b>Kyphosidae (chubs)</b>             |             |             |             |             |             |             |             |  |  |  |
| <i>Kyphosus sectatrix</i>             | 0.96 / 0.68 | 0.85 / 0.49 | 1.20 / 0.57 | 1.20 / 0.57 | 2.80 / 0.64 | 2.80 / 0.64 | 2.80 / 0.64 |  |  |  |
| <b>Labridae (wrasses)</b>             |             |             |             |             |             |             |             |  |  |  |
| <i>Bodianus rufus</i>                 | 3.69 / 0.95 | 4.10 / 0.91 | 3.90 / 0.90 | 4.50        | 0.74        | 0.83 / 0.42 | 4.40 / 0.79 |  |  |  |
| <i>Clepticus parri</i>                | 2.40 / 0.84 | 2.60 / 0.75 | 3.10 / 0.79 | 3.10 / 0.79 | 5.00 / 1.00 | 5.00 / 1.00 | 5.00 / 1.00 |  |  |  |
| <i>Halichoeres bivittatus</i>         | 1.98 / 0.81 | 1.55 / 0.60 | 0.80 / 0.40 | 5.00 / 1.00 | 1.00        | 5.00 / 1.00 | 5.00 / 1.00 |  |  |  |
| <i>Halichoeres garnoti</i>            | 4.11 / 0.97 | 4.50 / 0.95 | 5.00 / 1.00 | 5.00 / 1.00 | 1.00        | 1.67 / 0.70 | 5.00 / 1.00 |  |  |  |
| <i>Halichoeres maculipinna</i>        | 2.49 / 0.85 | 3.00 / 0.80 | 1.20 / 0.57 | 5.00 / 1.00 | 1.00        | 1.67 / 0.70 | 2.00 / 0.44 |  |  |  |
| <i>Halichoeres pictus</i>             | 0.71 / 0.62 | 1.00 / 0.53 | 1.20 / 0.57 | 2.00 / 0.23 | 2.83 / 0.90 | 2.83 / 0.90 | 0.20 / 0.06 |  |  |  |
| <i>Halichoeres poeyi</i>              | 0.71 / 0.62 | 0.45 / 0.33 | 0.70 / 0.38 | 2.00 / 0.23 | 2.50 / 0.86 | 2.50 / 0.86 | 0.40 / 0.11 |  |  |  |
| <i>Halichoeres radiatus</i>           | 1.71 / 0.75 | 2.70 / 0.76 | 0.20 / 0.16 | 5.00 / 1.00 | 1.67 / 0.70 | 1.67 / 0.70 | 5.00 / 1.00 |  |  |  |
| <i>Lachnolaima maximum</i>            | 1.40 / 0.73 | 1.70 / 0.62 | 0.90 / 0.43 | 5.00 / 1.00 | 1.00 / 0.47 | 1.00 / 0.47 | 5.00 / 1.00 |  |  |  |
| <i>Thalassoma bifasciatum</i>         | 3.27 / 0.91 | 4.15 / 0.92 | 0.60 / 0.35 | 5.00 / 1.00 | 1.00 / 0.47 | 1.00 / 0.47 | 5.00 / 1.00 |  |  |  |
| <i>Xyrichtys martinicensis</i>        | 0.38 / 0.42 | 0.45 / 0.33 | 0.60 / 0.35 | 5.00 / 1.00 | 1.00 / 0.47 | 1.00 / 0.47 | 5.00 / 1.00 |  |  |  |
| <i>Xyrichtys novacula</i>             | 0.22 / 0.30 | 0.45 / 0.33 | 0.60 / 0.35 | 5.00 / 1.00 | 1.00 / 0.47 | 1.00 / 0.47 | 5.00 / 1.00 |  |  |  |
| <i>Xyrichtys splendens</i>            | 0.47 / 0.49 | 0.35 / 0.27 | 0.60 / 0.35 | 2.50 / 0.37 | 0.67 / 0.37 | 0.67 / 0.37 | 0.67 / 0.37 |  |  |  |
| <b>Labrisomidae (scaled blennies)</b> |             |             |             |             |             |             |             |  |  |  |
| <i>Lucyablennius zingaro</i>          | 0.20 / 0.28 | 0.15 / 0.04 | 0.60 / 0.35 | 0.60 / 0.35 | 0.60 / 0.35 | 0.60 / 0.35 | 0.60 / 0.35 |  |  |  |
| <i>Malacoctenus triangulatus</i>      | 0.13 / 0.23 | 0.15 / 0.04 | 0.60 / 0.35 | 0.60 / 0.35 | 0.60 / 0.35 | 0.60 / 0.35 | 0.60 / 0.35 |  |  |  |
| <i>Malacoctenus macropterus</i>       | 0.07 / 0.09 | 0.07 / 0.09 | 0.20 / 0.16 | 0.20 / 0.16 | 0.50 / 0.26 | 0.50 / 0.26 | 0.50 / 0.26 |  |  |  |
| <i>Malacoctenus boehlkei</i>          | 0.04 / 0.03 | 0.04 / 0.03 | 0.20 / 0.16 | 0.20 / 0.16 | 0.50 / 0.26 | 0.50 / 0.26 | 0.50 / 0.26 |  |  |  |
| <i>Malacoctenus versicolor</i>        | 1           | 1           | 0.20 / 0.16 | 0.20 / 0.16 | 0.50 / 0.26 | 0.50 / 0.26 | 0.50 / 0.26 |  |  |  |
| <i>Labrisomus filamentosus</i>        | 0.09 / 0.13 | 0.20 / 0.10 | 0.20 / 0.16 | 0.20 / 0.16 | 0.50 / 0.26 | 0.50 / 0.26 | 0.50 / 0.26 |  |  |  |
| <i>Labrisomus machipinnus</i>         | 1           | 1           | 0.20 / 0.16 | 0.20 / 0.16 | 0.50 / 0.26 | 0.50 / 0.26 | 0.50 / 0.26 |  |  |  |
| <i>Coralliozetes bahamensis</i>       | 0.09 / 0.17 | 0.10 / 0.00 | 0.20 / 0.16 | 0.20 / 0.16 | 0.50 / 0.26 | 0.50 / 0.26 | 0.50 / 0.26 |  |  |  |
| <b>Leiostomidae (snappers)</b>        |             |             |             |             |             |             |             |  |  |  |
| <i>Leiostomus xanthurus</i>           | 0.73 / 0.64 | 0.70 / 0.46 | 1.60 / 0.66 | 1.60 / 0.66 | 2.00 / 0.44 | 2.00 / 0.44 | 2.00 / 0.44 |  |  |  |
| <i>Leiostomus apodus</i>              | 1.47 / 0.74 | 1.30 / 0.56 | 2.20 / 0.74 | 2.20 / 0.74 | 1.33 / 0.53 | 1.33 / 0.53 | 1.33 / 0.53 |  |  |  |
| <i>Leiostomus buccanella</i>          | 1           | 1           | 0.90 / 0.43 | 0.90 / 0.43 | 3.80 / 0.70 | 3.80 / 0.70 | 3.80 / 0.70 |  |  |  |
| <i>Leiostomus xanthurus</i>           | 0.27 / 0.35 | 0.15 / 0.04 | 0.90 / 0.43 | 0.90 / 0.43 | 3.80 / 0.70 | 3.80 / 0.70 | 3.80 / 0.70 |  |  |  |
| <i>Leiostomus griseus</i>             | 0.33 / 0.41 | 0.50 / 0.36 | 0.50 / 0.29 | 0.50 / 0.29 | 3.80 / 0.70 | 3.80 / 0.70 | 3.80 / 0.70 |  |  |  |
| <i>Leiostomus joca</i>                | 0.78 / 0.65 | 0.50 / 0.36 | 0.60 / 0.35 | 0.60 / 0.35 | 3.80 / 0.70 | 3.80 / 0.70 | 3.80 / 0.70 |  |  |  |
| <i>Leiostomus mahogoni</i>            | 0.58 / 0.56 | 1.20 / 0.54 | 0.20 / 0.16 | 0.20 / 0.16 | 1.67 / 0.70 | 1.67 / 0.70 | 1.67 / 0.70 |  |  |  |
| <i>Leiostomus xanthurus</i>           | 0.22 / 0.32 | 1.20 / 0.54 | 0.20 / 0.16 | 0.20 / 0.16 | 1.67 / 0.70 | 1.67 / 0.70 | 1.67 / 0.70 |  |  |  |
| <i>Ocyurus chrysurus</i>              | 3.33 / 0.92 | 3.70 / 0.88 | 4.00 / 0.91 | 4.00 / 0.91 | 4.60 / 0.82 | 4.60 / 0.82 | 4.60 / 0.82 |  |  |  |
| <b>Monacanthidae (filefishes)</b>     |             |             |             |             |             |             |             |  |  |  |
| <i>Aluterus scripius</i>              | 0.09 / 0.11 | 0.09 / 0.11 | 0.10 / 0.06 | 0.10 / 0.06 | 0.60 / 0.15 | 0.60 / 0.15 | 0.60 / 0.15 |  |  |  |
| <i>Cuntherhes macrocerus</i>          | 0.29 / 0.37 | 0.29 / 0.37 | 0.10 / 0.06 | 0.10 / 0.06 | 2.60 / 0.64 | 2.60 / 0.64 | 2.60 / 0.64 |  |  |  |

|  |             |             |             |             |             |             |
|--|-------------|-------------|-------------|-------------|-------------|-------------|
| <i>Cuntherinus pilius</i>                      | 1.71 / 0.75 | 1.95 / 0.65 | 1.50 / 0.59 | 4.00 / 0.60 | 2.00 / 0.75 | 1.80 / 0.38 |
| <i>Monacanthus ciliatus</i>                    | 0.27 / 0.35 |             |             |             |             |             |
| <i>Monacanthus tuckeri</i>                     | 0.16 / 0.26 | 0.25 / 0.19 | 0.20 / 0.16 |             |             |             |
| <b>Mugilidae (mullets)</b>                     |             |             |             |             | f, d        |             |
| <i>Muxil cephalus</i>                          | 1           |             |             |             |             |             |
| <b>Mullidae (goatfishes)</b>                   |             |             |             |             |             |             |
| <i>Mullidichthys murina</i>                    | 1.87 / 0.79 | 1.65 / 0.61 | 3.70 / 0.88 |             | 1.67 / 0.70 | 0.30 / 0.22 |
| <i>Pseudupeneus maculatus</i>                  | 2.11 / 0.82 | 1.90 / 0.65 | 3.50 / 0.83 | 2.50 / 0.37 | 0.50 / 0.26 | 1.80 / 0.38 |
| <b>Muraenidae (moray eels)</b>                 |             |             |             |             |             |             |
| <i>Echidna catenata</i>                        | 0.11 / 0.21 | 0.25 / 0.19 |             |             |             |             |
| <i>Enchelycore nigricans</i>                   | 1           | d           |             |             |             |             |
| <i>Gymnothorax funebris</i>                    | 0.02 / 0.01 |             | 1.00 / 0.48 |             |             | 0.20 / 0.06 |
| <i>Gymnothorax moringa</i>                     | 0.13 / 0.24 |             |             |             |             | 0.60 / 0.15 |
| <i>Gymnothorax miliaris</i>                    | 0.09 / 0.10 | 0.10 / 0.00 | 0.20 / 0.16 |             |             |             |
| <b>Myliobatidae (eagle rays)</b>               |             |             |             |             |             |             |
| <i>Aetobatus narnari</i>                       | 0.16 / 0.27 | 0.25 / 0.19 |             |             | 0.33 / 0.18 |             |
| <b>Ogcocephalidae (headfishes)</b>             |             |             |             |             |             |             |
| <i>Ogcocephalus parvus</i>                     | 1           | d           |             |             |             |             |
| <i>Ogcocephalus nasutus</i>                    | 1           | d           |             |             |             |             |
| <b>Ophichthidae (snake eels)</b>               |             |             |             |             |             |             |
| <i>Myrichthys breviceps</i>                    | 1           |             |             |             |             |             |
| <i>Myrichthys ocellatus</i>                    | 1           |             |             |             |             |             |
| <i>Ophichthus ophi</i>                         | 0.11 / 0.18 |             | 0.50 / 0.29 |             |             |             |
| <b>Opistognathidae (jowfishes)</b>             |             |             |             |             |             |             |
| <i>Opistognathus aurifrons</i>                 | 0.60 / 0.57 | 0.25 / 0.19 | 0.70 / 0.38 |             |             | 3.00 / 0.64 |
| <i>Opistognathus macrognathus</i>              | 0.11 / 0.19 | 0.10 / 0.00 | 0.50 / 0.29 |             |             |             |
| <b>Ostraciidae (trunkfishes and cowfishes)</b> |             |             |             |             |             |             |
| <i>Lucioperca bicaudalis</i>                   | 0.09 / 0.13 | 0.20 / 0.10 | 2.70 / 0.77 |             |             | 2.40 / 0.64 |
| <i>Lucioperca polygona</i>                     | 0.27 / 0.36 |             |             |             |             |             |
| <i>Lucioperca quadricornis</i>                 | 0.67 / 0.61 | 0.90 / 0.52 |             |             |             |             |
| <i>Lucioperca triquetra</i>                    | 0.62 / 0.59 | 0.25 / 0.19 | 1.20 / 0.57 |             |             | 1.00 / 0.26 |
| <i>Lucioperca trigonus</i>                     | 0.13 / 0.24 | 0.15 / 0.04 | 1.80 / 0.69 |             |             |             |
| <b>Pempheridae (sweepers)</b>                  |             |             |             |             |             |             |
| <i>Pempheris schomburgkii</i>                  | 0.20 / 0.28 | 0.40 / 0.31 | 0.10 / 0.06 |             |             |             |
| <b>Pomacanthidae (tangelfishes)</b>            |             |             |             |             |             |             |
| <i>Centropyge argi</i>                         | 0.22 / 0.33 |             |             |             |             | 2.00 / 0.44 |
| <i>Holocentrus ciliatus</i>                    | 2.44 / 0.84 | 2.85 / 0.79 | 2.90 / 0.79 | 2.25 / 0.28 | 0.35 / 0.18 | 2.60 / 0.64 |
| <i>Holocentrus tricolor</i>                    | 3.67 / 0.94 | 3.80 / 0.90 | 4.60 / 0.96 | 4.50 / 0.74 |             | 5.00 / 1.00 |
| <i>Pomacanthus arcuatus</i>                    | 2.04 / 0.81 | 2.05 / 0.67 | 3.90 / 0.90 |             |             | 2.40 / 0.64 |
| <i>Pomacanthus paru</i>                        | 1.82 / 0.78 | 2.00 / 0.66 | 2.70 / 0.77 |             |             | 2.60 / 0.64 |
| <b>Pomacenteridae (damselfishes)</b>           |             |             |             |             |             |             |
| <i>Abudefduf saxatilis</i>                     | 1.16 / 0.70 | 1.90 / 0.65 | 1.00 / 0.48 |             |             | 5.00 / 1.00 |
| <i>Chromis cyaneus</i>                         | 3.76 / 0.95 | 4.70 / 0.97 | 5.00 / 1.00 |             |             | 2.00 / 0.44 |
| <i>Chromis insularis</i>                       | 0.89 / 0.67 | 0.10 / 0.00 | 2.80 / 0.78 |             |             | 5.00 / 1.00 |
| <i>Chromis multilineatus</i>                   | 2.44 / 0.85 | 2.60 / 0.75 | 3.30 / 0.82 |             |             | 5.00 / 1.00 |
| <i>Microspathodon chrysurus</i>                | 2.93 / 0.88 | 3.35 / 0.85 | 0.90 / 0.43 | 3.75 / 0.56 | 2.17 / 0.77 | 4.80 / 0.88 |
| <i>Stegastes diemacrus</i>                     | 1.84 / 0.78 | 2.85 / 0.79 | 0.80 / 0.40 | 0.90 / 0.02 | 2.50 / 0.86 | 0.20 / 0.06 |
| <i>Stegastes dorsopinnatus</i>                 | 1.76 / 0.76 | 2.30 / 0.69 | 0.70 / 0.38 | 3.00 / 0.44 | 2.33 / 0.79 |             |



|   |             |             |             |             |             |             |
|---|-------------|-------------|-------------|-------------|-------------|-------------|
| <i>Stegastes leucostictus</i>               | 0.53 / 0.53 | 0.20 / 0.10 | 4.90 / 0.98 | 5.00 / 1.00 | 3.33 / 0.93 | 5.00 / 1.00 |
| <i>Stegastes partitus</i>                   | 4.60 / 0.99 | 4.65 / 0.96 | 2.10 / 0.72 | 5.00 / 1.00 | 3.33 / 0.93 | 5.00 / 1.00 |
| <i>Stegastes planifrons</i>                 | 3.47 / 0.93 | 4.95 / 0.98 | 4.70 / 0.96 | 2.00 / 0.23 | 1.83 / 0.71 | 5.00 / 1.00 |
| <i>Stegastes planifrons</i>                 | 3.09 / 0.90 | 3.70 / 0.88 |             |             | 1.67 / 0.70 |             |
| <i>Prisacanthidae (bigeyes)</i>             |             |             |             |             |             |             |
| <i>Prisacanthus arenatus</i>                | 0.04 / 0.02 |             | 0.20 / 0.16 |             |             |             |
| <i>Prisacanthus cruentatus</i>              | 0.20 / 0.27 | 0.40 / 0.31 | 0.10 / 0.06 |             |             |             |
| <i>Rachycentridae (cobies)</i>              |             |             |             |             |             |             |
| <i>Rachycentron canadum</i>                 |             |             |             |             |             |             |
| <i>Rhincodontidae (nurse sharks)</i>        |             |             |             |             |             |             |
| <i>Rhincodon typus</i>                      | 0.22 / 0.32 |             | 0.30 / 0.20 |             |             |             |
| <i>Ginglymostoma cirratum</i>               |             |             |             |             |             |             |
| <i>Scorpaenidae (parrotfishes)</i>          |             |             |             |             |             |             |
| <i>Cryptonomus roseus</i>                   | 0.87 / 0.66 | 0.70 / 0.46 | 1.00 / 0.48 |             | 2.50 / 0.36 | 2.00 / 0.44 |
| <i>Scarus coelestis</i>                     | 0.67 / 0.61 |             | 2.00 / 0.72 |             |             | 0.40 / 0.11 |
| <i>Scarus coelestis</i>                     | 0.33 / 0.41 |             | 1.30 / 0.59 |             |             |             |
| <i>Scarus guacamaia</i>                     |             |             |             |             |             |             |
| <i>Scarus iserti</i>                        | 5.00 / 1.00 | 5.00 / 1.00 | 5.00 / 1.00 | 5.00 / 1.00 | 5.00 / 1.00 | 5.00 / 1.00 |
| <i>Scarus taeniopieris</i>                  | 0.56 / 0.54 |             | 0.10 / 0.06 |             |             | 4.80 / 0.88 |
| <i>Scarus vetula</i>                        | 1.18 / 0.71 | 1.90 / 0.63 |             |             |             | 3.00 / 0.64 |
| <i>Sparisoma atomarium</i>                  | 0.47 / 0.50 | 0.60 / 0.40 | 0.90 / 0.43 | 5.00 / 1.00 | 1.67 / 0.70 | 4.80 / 0.88 |
| <i>Sparisoma aurofrenatum</i>               | 4.40 / 0.99 | 5.00 / 1.00 | 4.40 / 0.94 | 2.50 / 0.37 | 4.00 / 0.97 | 1.40 / 0.32 |
| <i>Sparisoma chrysopterygum</i>             | 2.16 / 0.83 | 1.65 / 0.61 | 2.30 / 0.74 | 2.25 / 0.38 | 2.67 / 0.88 |             |
| <i>Sparisoma radians</i>                    | 0.49 / 0.51 |             |             | 3.50 / 0.49 | 2.50 / 0.86 | 0.60 / 0.15 |
| <i>Sparisoma rubripinne</i>                 | 2.22 / 0.83 | 2.80 / 0.77 | 1.20 / 0.57 | 5.00 / 1.00 | 1.67 / 0.70 | 5.00 / 1.00 |
| <i>Sparisoma viride</i>                     | 4.20 / 0.98 | 4.75 / 0.98 | 3.90 / 0.90 |             |             |             |
| <i>Sciænidae (croakers and drums)</i>       |             |             |             |             |             |             |
| <i>Equetus lanceolatus</i>                  | 0.27 / 0.36 |             | 1.20 / 0.57 |             |             |             |
| <i>Equetus acuminatus</i>                   | 0.60 / 0.58 | 0.75 / 0.48 | 1.20 / 0.57 |             |             |             |
| <i>Equetus punctatus</i>                    | 0.09 / 0.15 | 0.20 / 0.10 |             |             |             |             |
| <i>Odonotocion dentex</i>                   | 0.33 / 0.38 | 0.25 / 0.19 | 1.00 / 0.48 |             |             |             |
| <i>Scorpaenidae (mackerel and tunas)</i>    |             |             |             |             |             |             |
| <i>Acanthocybium solandri</i>               |             |             |             |             |             |             |
| <i>Euthynnus alleiteratus</i>               | 0.09 / 0.14 | 0.15 / 0.04 | 0.10 / 0.06 |             |             | 2.00 / 0.44 |
| <i>Scomberomorus cavalla</i>                | 0.22 / 0.31 |             |             |             |             |             |
| <i>Scomberomorus maculatus</i>              | 0.42 / 0.46 | 0.60 / 0.40 | 0.70 / 0.38 |             |             |             |
| <i>Scomberomorus regalis</i>                |             |             |             |             |             |             |
| <i>Scorpaenidae (scorpaeniformes)</i>       |             |             |             |             |             |             |
| <i>Scorpaena grandicornis</i>               | 0.04 / 0.02 |             |             |             | 0.33 / 0.18 |             |
| <i>Scorpaena plumieri</i>                   | 0.04 / 0.01 | 0.10 / 0.00 |             |             |             |             |
| <i>Serranidae (sea basses and groupers)</i> |             |             |             |             |             |             |
| <i>Alphesioses aff.</i>                     | 0.04 / 0.08 |             |             |             | 0.33 / 0.18 |             |
| <i>Epinephelus adscensionis</i>             |             |             |             |             |             |             |
| <i>Epinephelus cruentatus</i>               | 2.96 / 0.89 | 3.70 / 0.88 | 3.70 / 0.88 |             | 0.83 / 0.42 | 3.40 / 0.67 |
| <i>Epinephelus fulvus</i>                   | 2.56 / 0.86 | 2.45 / 0.73 | 1.60 / 0.66 | 4.25 / 0.65 | 1.67 / 0.70 | 4.60 / 0.82 |
| <i>Epinephelus guttatus</i>                 | 0.33 / 0.39 | 0.35 / 0.27 | 0.40 / 0.23 |             |             | 0.80 / 0.22 |
| <i>Epinephelus itajara</i>                  |             |             |             |             |             |             |
| <i>Epinephelus striatus</i>                 | 0.71 / 0.63 | 0.35 / 0.27 |             |             |             | 5.00 / 1.00 |

|                                       |             |             |             |             |             |             |
|---------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <i>Hypoplectrus unicolor</i>          | 3.89 / 0.96 | 4.45 / 0.94 | 4.90 / 0.98 | 1.00 / 0.00 | 1.50 / 0.56 | 4.80 / 0.88 |
| <i>Liopropoma carnabi</i>             | 0.04 / 0.03 |             | 0.30 / 0.20 |             |             | 1.20 / 0.30 |
| <i>Liopropoma rubre</i>               | 0.20 / 0.29 | 0.15 / 0.04 | 0.20 / 0.16 |             |             | 3.60 / 0.68 |
| <i>Mycioperca bonaci</i>              | 0.40 / 0.44 |             |             |             |             | 1.20 / 0.30 |
| <i>Mycioperca interstitialis</i>      | 0.13 / 0.23 |             |             |             |             | 1.20 / 0.30 |
| <i>Mycioperca rubra</i>               | 0.13 / 0.22 | 0.55 / 0.38 | 0.30 / 0.20 |             |             | 2.40 / 0.64 |
| <i>Mycioperca iterns</i>              | 0.51 / 0.52 | 0.95 / 0.52 |             |             |             | 4.00 / 0.74 |
| <i>Mycioperca venenosa</i>            | 0.93 / 0.68 |             |             |             |             | 2.20 / 0.64 |
| <i>Paranibius fulciflor</i>           | 0.24 / 0.34 |             |             |             |             | 3.00 / 0.64 |
| <i>Serranus balidwini</i>             | 0.44 / 0.47 | 0.25 / 0.19 | 0.60 / 0.35 |             | 1.50 / 0.56 |             |
| <i>Serranus tabacarius</i>            | 1.20 / 0.71 | 1.40 / 0.58 | 1.50 / 0.64 |             | 0.35 / 0.18 |             |
| <i>Serranus tigrinus</i>              | 1.78 / 0.77 | 2.40 / 0.72 | 1.50 / 0.64 |             | 1.35 / 0.53 |             |
| <i>Serranus tigrisvarum</i>           | 0.56 / 0.54 | 0.65 / 0.42 | 0.40 / 0.23 |             |             |             |
| <i>Spartidae (porgies)</i>            |             |             |             |             |             |             |
| <i>Calamus calamus</i>                | 3.40 / 0.93 | 3.30 / 0.82 | 4.60 / 0.96 | 4.25 / 0.65 | 1.35 / 0.53 | 3.20 / 0.66 |
| <i>Sphyraenidae (barracuadas)</i>     |             |             |             |             |             |             |
| <i>Sphyraena barracuda</i>            | 1.29 / 0.73 | 0.90 / 0.52 | 1.10 / 0.50 | 2.00 / 0.23 |             | 4.20 / 0.76 |
| <i>Sphyraena picuailia</i>            | 1           |             |             |             |             | d.f         |
| <i>Syngnathidae (pipefishes)</i>      |             |             |             |             |             |             |
| <i>Hypocampus retuli</i>              | 1           | d           |             |             |             |             |
| <i>Micropogonias aeneoides</i>        | 1           | *           |             |             |             |             |
| <i>Cosmocampus elucens</i>            | 1           | *           |             |             |             |             |
| <i>Cosmocampus albirostris</i>        | 1           | d           |             |             |             |             |
| <i>Symodonidae (lizardfishes)</i>     |             |             |             |             |             |             |
| <i>Symodus intermedius</i>            | 0.82 / 0.66 | 0.20 / 0.10 | 1.90 / 0.70 | 1.25 / 0.02 |             | 1.80 / 0.38 |
| <i>Symodus symodus</i>                | 0.02 / 0.00 |             |             |             |             | 0.20 / 0.06 |
| <i>Tetraodonidae (puffers)</i>        |             |             |             |             |             |             |
| <i>Canthigaster rasirata</i>          | 3.16 / 0.91 | 3.35 / 0.83 | 3.60 / 0.84 | 3.75 / 0.56 | 1.00 / 0.47 | 4.20 / 0.76 |
| <i>Sphaeroides spengleri</i>          | 0.09 / 0.12 |             |             |             | 0.67 / 0.37 |             |
| <i>Sphaeroides testudineus</i>        | 1           |             |             |             | d           |             |
| <i>Torpidiidae (electric rays)</i>    |             |             |             |             |             |             |
| <i>Narcine brasiliensis</i>           | 1           |             |             |             | d           |             |
| <i>Tripterygiidae (triple fins)</i>   |             |             |             |             |             |             |
| <i>Enneanectes sp.</i>                | 0.04 / 0.04 | 0.10 / 0.00 |             |             |             |             |
| <i>Uranoscopusidae (stargazers)</i>   |             |             |             |             |             |             |
| <i>Uranoscopus guianus</i>            | 1           |             |             |             | d           |             |
| <i>Urophoridae (yellow stingrays)</i> |             |             |             |             |             |             |
| <i>Urolophus jamaicensis</i>          | 0.22 / 0.31 | 0.35 / 0.27 |             |             | 0.50 / 0.26 |             |

TABLE 3.

Mean density  $\pm$  SE (fish/m<sup>2</sup>) of the eighty most common species (density > 0.001 fish/m<sup>2</sup>) in four habitats of the Cayos Cochinos archipelago. Age distribution, given as percent of three age classes (adult, juvenile, recruit) within parenthesis following means

| Species                            | Shallow reef                 | Back reef                    | Deep reef                    | Exposed reef                 |
|------------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
| <i>Coryphopterus personatus</i>    | 3.350 $\pm$ 1.435 (70.20.10) |                              | 7.898 $\pm$ 3.127 (80.10.10) |                              |
| <i>Scorpaenidae</i>                | 0.372 $\pm$ 0.097 (33.52.15) | 1.732 $\pm$ 0.459 (71.23.61) | 0.242 $\pm$ 0.302 (50.60.10) | 0.070 $\pm$ 0.070 (95.0.5)   |
| <i>Stegastes partitus</i>          | 0.208 $\pm$ 0.047 (50.24.26) | 0.064 $\pm$ 0.034 (33.40.27) | 0.022 $\pm$ 0.012 (60.40.0)  | 0.155 $\pm$ 0.096 (58.21.11) |
| <i>Chromis cyanus</i>              | 0.119 $\pm$ 0.055 (67.13.20) |                              | 0.006 $\pm$ 0.003 (50.50.0)  | 0.010 $\pm$ 0.010 (1.0.0)    |
| <i>Clepticus parvus</i>            | 0.111 $\pm$ 0.062 (31.17.52) |                              |                              |                              |
| <i>Thalassoma bifasciatum</i>      | 0.111 $\pm$ 0.027 (76.14.10) | 0.125 $\pm$ 0.034 (44.15.41) | 0.013 $\pm$ 0.024 (1.0.0)    | 0.404 $\pm$ 0.159 (87.13.0)  |
| <i>Curatx ruber</i>                | 0.101 $\pm$ 0.081 (82.18.0)  | 0.006 $\pm$ 0.006 (1.0.0)    | 0.057 $\pm$ 0.029 (67.33.0)  |                              |
| <i>Stegastes planifrons</i>        | 0.095 $\pm$ 0.020 (73.20.7)  | 0.053 $\pm$ 0.034 (80.20.0)  | 0.051 $\pm$ 0.021 (50.44.6)  | 0.003 $\pm$ 0.003 (0.1.0)    |
| <i>Ocyurus chrysurus</i>           | 0.082 $\pm$ 0.058 (94.6.0)   |                              | 0.096 $\pm$ 0.050 (1.0.0)    |                              |
| <i>Sparisoma aurofrenatum</i>      | 0.072 $\pm$ 0.017 (37.57.6)  | 0.015 $\pm$ 0.015 (14.71.15) | 0.048 $\pm$ 0.012 (53.47.0)  | 0.051 $\pm$ 0.043 (44.43.13) |
| <i>Halichoeres garnoti</i>         | 0.060 $\pm$ 0.010 (74.26.0)  |                              | 0.006 $\pm$ 0.003 (1.0.0)    | 0.029 $\pm$ 0.029 (33.33.34) |
| <i>Anchoa hepsetus</i>             | 0.058 $\pm$ 0.058 (1.0.0)    | 5.308 $\pm$ 5.308 (0.1.0)    | 17.520 $\pm$ 12.38 (1.0.0)   | 0.006 $\pm$ 0.004 (0.50.50)  |
| <i>Stegastes dorsopinacatus</i>    | 0.045 $\pm$ 0.021 (99.1.0)   | 0.209 $\pm$ 0.077 (89.5.5)   |                              |                              |
| <i>Stegastes diadematus</i>        | 0.034 $\pm$ 0.010 (76.22.2)  | 0.053 $\pm$ 0.027 (65.12.23) |                              |                              |
| <i>Stegastes variabilis</i>        | 0.033 $\pm$ 0.008 (36.39.4)  | 0.013 $\pm$ 0.007 (0.50.50)  | 0.045 $\pm$ 0.012 (86.14.0)  | 0.003 $\pm$ 0.003 (0.1.0)    |
| <i>Sparisoma viride</i>            | 0.033 $\pm$ 0.011 (40.49.11) | 0.004 $\pm$ 0.004 (0.50.50)  | 0.019 $\pm$ 0.003 (33.67.0)  | 0.006 $\pm$ 0.004 (50.50.0)  |
| <i>Sparisoma chrysopteron</i>      | 0.028 $\pm$ 0.024 (94.6.0)   | 0.036 $\pm$ 0.026 (29.71.0)  | 0.032 $\pm$ 0.013 (80.20.0)  | 0.003 $\pm$ 0.003 (0.1.0)    |
| <i>Hypoplectrus unicolor</i>       | 0.027 $\pm$ 0.005 (93.7.0)   | 0.002 $\pm$ 0.002 (1.0.0)    | 0.025 $\pm$ 0.010 (50.50.0)  | 0.010 $\pm$ 0.010 (1.0.0)    |
| <i>Gobiosoma oceanops</i>          | 0.024 $\pm$ 0.008 (83.17.0)  |                              |                              | 0.006 $\pm$ 0.006 (50.50.0)  |
| <i>Halichoeres maculipinna</i>     | 0.023 $\pm$ 0.006 (98.2.0)   | 0.066 $\pm$ 0.020 (74.13.13) | 0.010 $\pm$ 0.020 (1.0.0)    | 0.035 $\pm$ 0.018 (64.27.9)  |
| <i>Acanthurus coeruleus</i>        | 0.022 $\pm$ 0.005 (71.26.3)  | 0.023 $\pm$ 0.008 (45.46.9)  |                              |                              |
| <i>Coryphopterus glaucofraenum</i> | 0.020 $\pm$ 0.009 (79.21.0)  | 0.051 $\pm$ 0.021 (88.12.0)  | 0.010 $\pm$ 0.006 (1.0.0)    |                              |
| <i>Microspathodon chrysurus</i>    | 0.019 $\pm$ 0.006 (88.9.3)   | 0.028 $\pm$ 0.012 (85.15.0)  |                              |                              |
| <i>Acanthurus bahianus</i>         | 0.015 $\pm$ 0.004 (77.23.0)  | 0.104 $\pm$ 0.021 (43.47.10) |                              |                              |
| <i>Coryphopterus dactylus</i>      | 0.014 $\pm$ 0.008 (83.17.0)  | 0.017 $\pm$ 0.008 (1.0.0)    |                              |                              |
| <i>Epinephelus cruentatus</i>      | 0.013 $\pm$ 0.003 (1.0.0)    | 0.002 $\pm$ 0.002 (0.1.0)    | 0.019 $\pm$ 0.007 (83.17.0)  |                              |
| <i>Gobiosoma xanthurus</i>         | 0.012 $\pm$ 0.009 (76.24.0)  | 0.005 $\pm$ 0.002 (1.0.0)    |                              |                              |
| <i>Chaetodon capistratus</i>       | 0.012 $\pm$ 0.003 (1.0.0)    | 0.004 $\pm$ 0.003 (50.50.0)  | 0.013 $\pm$ 0.006 (75.25.0)  | 0.022 $\pm$ 0.013 (1.0.0)    |
| <i>Canthigaster rostrata</i>       | 0.010 $\pm$ 0.003 (83.11.6)  |                              | 0.022 $\pm$ 0.008 (43.57.0)  |                              |
| <i>Amblycirrhitus pinus</i>        | 0.010 $\pm$ 0.006 (94.6.0)   |                              |                              |                              |
| <i>Acanthurus chirurgus</i>        | 0.009 $\pm$ 0.007 (94.6.0)   |                              |                              |                              |
| <i>Halichoeres bivittatus</i>      | 0.008 $\pm$ 0.005 (1.0.0)    | 0.338 $\pm$ 0.113 (58.30.12) |                              | 0.038 $\pm$ 0.016 (92.8.0)   |
| <i>Gramma loreto</i>               | 0.008 $\pm$ 0.007 (86.14.0)  |                              |                              |                              |
| <i>Serranus nigricans</i>          | 0.008 $\pm$ 0.003 (71.29.0)  |                              |                              |                              |
| <i>Epinephelus fulvus</i>          | 0.008 $\pm$ 0.003 (1.0.0)    | 0.008 $\pm$ 0.004 (1.0.0)    |                              | 0.006 $\pm$ 0.006 (1.0.0)    |
| <i>Holocentrus tricolor</i>        | 0.008 $\pm$ 0.003 (85.15.0)  |                              | 0.010 $\pm$ 0.003 (1.0.0)    | 0.019 $\pm$ 0.011 (1.0.0)    |
| <i>Gnatholepis thompsoni</i>       | 0.006 $\pm$ 0.005 (82.18.0)  | 0.066 $\pm$ 0.029 (90.10.0)  |                              | 0.006 $\pm$ 0.004 (0.1.0)    |
| <i>Holocentrus nigrus</i>          | 0.006 $\pm$ 0.002 (1.0.0)    | 0.002 $\pm$ 0.002 (1.0.0)    | 0.010 $\pm$ 0.003 (1.0.0)    | 0.000 $\pm$ 0.000            |
| <i>Calamus colaninus</i>           | 0.006 $\pm$ 0.002 (1.0.0)    |                              |                              | 0.003 $\pm$ 0.003 (1.0.0)    |
| <i>Chromis multilineatus</i>       | 0.006 $\pm$ 0.005 (73.0.27)  |                              |                              |                              |
| <i>Huemulon aurolineatum</i>       | 0.006 $\pm$ 0.003 (80.20.0)  | 0.340 $\pm$ 0.340 (0.81.19)  |                              | 0.003 $\pm$ 0.003 (1.0.0)    |

|                                  |                       |                        |                       |                       |
|----------------------------------|-----------------------|------------------------|-----------------------|-----------------------|
| <i>Chaetodon striatus</i>        | 0.006±0.002 (1.0,0)   | 0.015±0.004 (1.0,0)    | 0.006±0.005 (1.0,0)   | 0.010±0.006 (1.0,0)   |
| <i>Aulostomus maculatus</i>      | 0.006±0.002 (60,40.0) |                        | 0.006±0.003 (50,50.0) | 0.003±0.003 (1.0,0)   |
| <i>Coryphopterus eidolon</i>     | 0.006±0.005 (80,20.0) |                        |                       |                       |
| <i>Holocentrus ciliatus</i>      | 0.005±0.003 (89,11.0) |                        |                       |                       |
| <i>Spatsoma rubripinnae</i>      | 0.005±0.002 (1.0,0)   | 0.013±0.010 (50,50.0)  |                       | 0.093±0.003 (0.1,0)   |
| <i>Scarus vetula</i>             | 0.004±0.004 (1.0,0)   |                        |                       |                       |
| <i>Pomacanthus arcuatus</i>      | 0.003±0.002 (1.0,0)   |                        |                       |                       |
| <i>Spatsoma atomarium</i>        | 0.003±0.002 (67,33.0) |                        |                       |                       |
| <i>Haemulon flavolineatum</i>    | 0.003±0.001 (67,33.0) | 0.017±0.005 (87,13.0)  |                       | 0.003±0.003 (1.0,0)   |
| <i>Halicentrus radiatus</i>      | 0.003±0.002 (80,20.0) | 0.015±0.005 (29,57,14) |                       | 0.003±0.003 (0.1,0)   |
| <i>Malacoctenus boefferi</i>     | 0.003±0.002 (1.0,0)   |                        |                       |                       |
| <i>Acanthemblemaria aspera</i>   | 0.003±0.003 (1.0,0)   |                        |                       |                       |
| <i>Pseudupeneus maculatus</i>    | 0.003±0.002 (80,20.0) |                        |                       |                       |
| <i>Halicentrus poeyi</i>         | 0.002±0.002 (1.0,0)   |                        |                       |                       |
| <i>Haemulon plumieri</i>         | 0.002±0.001 (1.0,0)   |                        |                       |                       |
| <i>Holocentrus adcaenionis</i>   | 0.002±0.002 (1.0,0)   | 0.011±0.007 (1.0,0)    |                       | 0.033±0.015 (60,40.0) |
| <i>Caranx bartholomaei</i>       | 0.002±0.001 (1.0,0)   | 0.002±0.002 (1.0,0)    |                       | 0.003±0.003 (0.1,0)   |
| <i>Chaetodon ocellatus</i>       | 0.002±0.002 (1.0,0)   | 0.002±0.002 (1.0,0)    |                       |                       |
| <i>Cuntherhines pullus</i>       | 0.002±0.001 (1.0,0)   | 0.002±0.002 (1.0,0)    |                       |                       |
| <i>Lachnolaimus maximus</i>      | 0.002±0.002 (1.0,0)   | 0.002±0.002 (1.0,0)    |                       |                       |
| <i>Acanthemblemaria maria</i>    | 0.002±0.001 (1.0,0)   |                        |                       |                       |
| <i>Gobiosoma dilepsis</i>        | 0.001±0.001 (50,50.0) |                        |                       |                       |
| <i>Bodianus rufus</i>            | 0.001±0.001 (50,50.0) |                        |                       |                       |
| <i>Halicentrus pictus</i>        | 0.001±0.001 (0.1,0)   |                        |                       | 0.006±0.006 (1.0,0)   |
| <i>Kyphosus sepioides</i>        | 0.001±0.001 (1.0,0)   |                        |                       |                       |
| <i>Pomacanthus nuckeri</i>       | 0.001±0.001 (1.0,0)   |                        |                       |                       |
| <i>Holocentrus marianus</i>      | 0.001±0.001 (1.0,0)   |                        |                       |                       |
| <i>Lutjanus apodus</i>           | 0.001±0.001 (1.0,0)   |                        |                       |                       |
| <i>Mulloidichthys martinicus</i> | 0.001±0.001 (1.0,0)   | 0.008±0.008 (1.0,0)    |                       |                       |
| <i>Haemulon microstomum</i>      | 0.001±0.001 (1.0,0)   |                        |                       |                       |
| <i>Lutjanus griseus</i>          | 0.001±0.001 (1.0,0)   |                        |                       |                       |
| <i>Abudefduf saxatilis</i>       | 0.119±0.119 (0.5,95)  |                        |                       | 0.016±0.010 (60,40.0) |
| <i>Ophioblennius atlanticus</i>  | 0.013±0.013 (1.0,0)   |                        |                       |                       |
| <i>Malacoctenus triangulus</i>   | 0.013±0.013 (83,17.0) |                        |                       |                       |
| <i>Malacoctenus macropterus</i>  | 0.008±0.006 (1.0,0)   |                        |                       |                       |
| <i>Spatsoma radians</i>          | 0.004±0.004 (1.0,0)   |                        |                       | 0.003±0.003 (1.0,0)   |
| <i>Stegastes leucostictus</i>    | 0.004±0.004 (0.1,0)   |                        |                       |                       |
| <i>Scomberomorus regalis</i>     |                       |                        |                       |                       |
| <i>Anisotremus surinamensis</i>  |                       |                        |                       |                       |
| <i>Sphyraena barracuda</i>       |                       |                        |                       | 0.003±0.003 (0.1,0)   |
| <i>Synodus intermedius</i>       |                       |                        |                       |                       |

TABLE 4

Mean density (fish/hectare) and size (cm)  $\pm$  1 SE of fishes potentially impacted by fishing pressure in four reef habitats within the Cayos Cochinos Marine Reserve based on transect surveys (number of surveys in each habitat given in parentheses). Percent of surveys in which each species was encountered given before each mean density.

|                                 | Shallow (20) |                  |                | Deep (4) |                   |                 | Exposed (4) |                  |                | Back (6) |                  |                |
|---------------------------------|--------------|------------------|----------------|----------|-------------------|-----------------|-------------|------------------|----------------|----------|------------------|----------------|
|                                 | %            | density          | size           | %        | density           | size            | %           | density          | size           | %        | density          | size           |
| <i>Curax ruber</i>              | 45           | 171.3 $\pm$ 95.6 | 9.5 $\pm$ 1.4  | 75       | 518.8 $\pm$ 278.3 | 20.0 $\pm$ 2.9  | 25          | 3.1 $\pm$ 3.1    | 17.5           | 33       | 10.4 $\pm$ 8.2   | 15.0 $\pm$ 5.0 |
| <i>Spartanoma viride</i>        | 90           | 78.1 $\pm$ 13.4  | 25.3 $\pm$ 1.1 | 75       | 28.1 $\pm$ 10.7   | 22.7 $\pm$ 3.5  | 100         | 109.4 $\pm$ 52.1 | 25.7 $\pm$ 2.3 | 50       | 35.4 $\pm$ 34.2  | 23.3 $\pm$ 9.6 |
| <i>Ocyurus chrysurus</i>        | 75           | 40.0 $\pm$ 11.8  | 15.4 $\pm$ 1.5 | 100      | 131.3 $\pm$ 86.2  | 16.4 $\pm$ 1.2  | 25          | 3.1 $\pm$ 3.1    | 15.0 $\pm$ 0.1 | 17       | 2.1 $\pm$ 2.1    | 2.0            |
| <i>Haemulon flavolineatum</i>   | 70           | 38.1 $\pm$ 9.3   | 13.5 $\pm$ 0.7 |          |                   |                 | 50          | 9.4 $\pm$ 9.4    | 3.8 $\pm$ 3.8  | 83       | 100.0 $\pm$ 61.7 | 13.8 $\pm$ 1.5 |
| <i>Lutjanus malinchei</i>       | 30           | 23.8 $\pm$ 10.0  | 18.3 $\pm$ 1.7 |          |                   |                 |             |                  |                |          |                  |                |
| <i>Callanx calamus</i>          | 80           | 21.9 $\pm$ 3.8   | 14.6 $\pm$ 0.8 | 75       | 12.5 $\pm$ 5.1    | 9.4 $\pm$ 3.1   | 25          | 3.1 $\pm$ 3.1    | 10.0           | 17       | 2.1 $\pm$ 2.1    | 20.0           |
| <i>Spartanoma rubripinne</i>    | 55           | 21.3 $\pm$ 6.0   | 27.3 $\pm$ 1.6 | 100      | 25.0              | 5.1             | 100         | 46.9 $\pm$ 13.9  | 22.6 $\pm$ 5.1 | 33       | 25.0 $\pm$ 17.1  | 12.1 $\pm$ 0.9 |
| <i>Epinephelus cruentatus</i>   | 35           | 20.6 $\pm$ 9.6   | 10.6 $\pm$ 0.9 |          |                   |                 | 10.3        | 1.0              |                |          |                  |                |
| <i>Lutjanus synagris</i>        | 15           | 18.1 $\pm$ 12.0  | 9.7 $\pm$ 2.3  |          |                   |                 |             |                  |                |          |                  |                |
| <i>Haemulon plumieri</i>        | 70           | 13.1 $\pm$ 3.2   | 18.1 $\pm$ 1.4 | 50       | 9.4 $\pm$ 6.0     | 20.0 $\pm$ 10.0 | 25          | 3.1 $\pm$ 3.1    | 15.0           |          |                  |                |
| <i>Haemulon macrostomum</i>     | 35           | 8.1 $\pm$ 2.9    | 24.7 $\pm$ 1.1 |          |                   |                 | 50          | 6.3 $\pm$ 3.6    | 16.3 $\pm$ 1.3 | 67       | 110.4 $\pm$ 52.5 | 16.5 $\pm$ 2.7 |
| <i>Lachnolaimus maximus</i>     | 45           | 5.0 $\pm$ 1.4    | 25.6 $\pm$ 5.7 | 25       | 3.1 $\pm$ 3.1     | 25.0            | 75          | 6.3 $\pm$ 6.3    | 5.3 $\pm$ 5.3  |          |                  |                |
| <i>Spartanoma chrysopictum</i>  | 15           | 4.4 $\pm$ 2.8    | 27.9 $\pm$ 2.3 |          |                   |                 |             |                  |                |          |                  |                |
| <i>Epinephelus fulvus</i>       | 20           | 3.1 $\pm$ 1.5    | 18.3 $\pm$ 2.4 |          |                   |                 |             |                  |                |          |                  |                |
| <i>Haemulon carbonarium</i>     | 10           | 2.5 $\pm$ 1.9    | 23.8 $\pm$ 3.8 |          |                   |                 | 100         | 25.0 $\pm$ 8.8   | 10.8 $\pm$ 3.9 | 100      | 160.4 $\pm$ 70.4 | 20.0 $\pm$ 1.5 |
| <i>Haemulon sciurus</i>         | 20           | 2.5 $\pm$ 1.1    | 21.6 $\pm$ 3.0 | 25       | 3.1 $\pm$ 3.1     | 20.0            |             |                  |                | 50       | 35.4 $\pm$ 26.1  | 13.3 $\pm$ 4.4 |
| <i>Lutjanus apodus</i>          | 15           | 2.5 $\pm$ 1.5    | 28.3 $\pm$ 1.7 |          |                   |                 |             |                  |                | 33       | 4.2 $\pm$ 2.6    | 25.0 $\pm$ 5.0 |
| <i>Haemulon aurolineatum</i>    | 10           | 1.9 $\pm$ 1.4    | 13.3 $\pm$ 0.3 |          |                   |                 |             |                  |                | 17       | 4.2 $\pm$ 4.2    | 20.0           |
| <i>Curax burholomaei</i>        | 10           | 1.3 $\pm$ 1.3    | 20.0 $\pm$ 0.0 | 25       | 93.8 $\pm$ 93.8   | 25.0            |             |                  |                | 50       | 12.5 $\pm$ 12.5  | 20.0           |
| <i>Alectis crotinis</i>         | 5            | 1.3 $\pm$ 1.3    | 90.0           |          |                   |                 |             |                  |                | 17       | 14.6 $\pm$ 14.6  | 37.5           |
| <i>Balistes vela</i>            | 5            | 0.6 $\pm$ 0.6    | 30.0           |          |                   |                 | 50          | 6.3 $\pm$ 3.6    | 17.5 $\pm$ 2.5 | 5        | 6.3 $\pm$ 3.8    | 9.3 $\pm$ 0.7  |
| <i>Holocentrus adersoniis</i>   | 5            | 1.3 $\pm$ 1.3    | 12.5           |          |                   |                 |             |                  |                |          |                  |                |
| <i>Lutjanus analis</i>          | 5            | 1.3 $\pm$ 1.3    | 50.0           |          |                   |                 |             |                  |                |          |                  |                |
| <i>Lutjanus griseus</i>         | 5            | 1.3 $\pm$ 1.3    | 13.5           |          |                   |                 |             |                  |                |          |                  |                |
| <i>Antistremus virginicus</i>   | 5            | 0.6 $\pm$ 0.6    | 20.0           |          |                   |                 |             |                  |                |          |                  |                |
| <i>Boiua lunata</i>             | 5            | 0.6 $\pm$ 0.6    | 35.0           |          |                   |                 |             |                  |                |          |                  |                |
| <i>Mycteroperca rubra</i>       | 5            | 0.6 $\pm$ 0.6    | 40.0           |          |                   |                 |             |                  |                |          |                  |                |
| <i>Mycteroperca tigris</i>      | 5            | 0.6 $\pm$ 0.6    | 30.0           |          |                   |                 |             |                  |                |          |                  |                |
| <i>Scomberomorus regalis</i>    | 5            | 0.6 $\pm$ 0.6    | 60.0           |          |                   |                 |             |                  |                |          |                  |                |
| <i>Trachinotus falcatus</i>     | 5            | 0.6 $\pm$ 0.6    | 80.0           | 75       | 34.4 $\pm$ 17.2   | 22.9 $\pm$ 2.7  |             |                  |                |          |                  |                |
| <i>Curax cryps</i>              |              |                  |                | 25       | 3.1 $\pm$ 3.1     | 60.0            |             |                  |                |          |                  |                |
| <i>Antistremus surinamensis</i> |              |                  |                | 25       | 93.8 $\pm$ 93.8   | 25.0            |             |                  |                |          |                  |                |
| <i>Mycteroperca venenosus</i>   |              |                  |                | 25       | 3.1 $\pm$ 3.1     | 35.0            |             |                  |                |          |                  |                |
| <i>Sphyraena barracuda</i>      |              |                  |                | 25       | 3.1 $\pm$ 3.1     | 55.0            | 25          | 3.1 $\pm$ 3.1    | 35.0           | 33       | 2.1 $\pm$ 2.1    | 62.5           |
|                                 |              |                  |                | 25       | 3.1 $\pm$ 3.1     | 45.0            |             |                  |                |          |                  |                |

all fish seen at any distance within the predefined depth zone of the habitat. The initial sighting of each species was noted according to time and assigned to one of five numerical categories (5 = first five minutes, 4 = second five minutes, etc). A fish not observed during the 25 min survey received no score.

For data analyses, scores for each species were averaged within habitat (fish not encountered within a habitat received no score and were not considered further). To produce a relative measure of abundance within habitat, the average score was multiplied by the proportion of surveys in which the species received a score (e.g. a fish observed twice during a total of five surveys, once in the first five minutes (score = 5) and once in the second five minutes (score = 4) would receive an average score of  $(5+4)/2 = 4.5$ . When multiplied by the proportion of surveys observed ( $2/5 = 0.4$ ) this species would receive an abundance score of  $4.5 \times 0.4 = 1.8$ . Note, the maximum abundance score of 5.0 represents a fish that was seen within the first five minutes of every survey conducted within a habitat. These scores were then ranked ordinally (tie scores received the same rank) within habitat types. A proportional rank derived by using the formula:  $(\text{total \# of spp.} - \text{rank}) / (\text{total \# of spp.} - 1)$  for data from each habitat type generated ranks that can be compared between habitat types. A total of 43 random swim surveys, totaling 17.1 hours of observation were made.

**B) Stationary counts:** Stationary counts (adapted from Bannerot & Bohsack 1986, Kimmel 1993) generate estimates of species richness, density, relative abundance within a habitat, and size distributions. With moderate sampling, they can provide very accurate information on uniformly dispersed, sedentary species. They may, however, under or overestimate the presence of species that are patchily distributed (e.g. species that are spatially clustered within a habitat or mobile species whose abundance at one location varies through time). Stationary counts are also relatively good for detecting more cryptic species, although, as with most non-destructive survey techniques, the density of such species will generally be underestimated. For the present study, stationary counts were made from the center of a 10 m radius "cylinder" extending from the bottom up to the surface (when visible). Divers were sepa-

rated by at least 15 m to prevent overlapping surveys.

During the first ten minutes of each stationary count, all species (transient and resident) occurring within the survey "cylinder" were noted; both species identification and age class (Recruit = an individual that has settled on the reef within the last month; Juvenile = a nonreproductive individual of relatively small size; Adult = a potentially reproductive individual of relatively large size) were recorded. Similar data were collected between minutes 10-15, but only for fish residing within the survey area (i.e. transient fish entering the survey "cylinder" after ten minutes were not recorded). During the last five min of the survey (minutes 15-20) the observer would leave the center observation point and swim over the survey area looking for small or cryptic individuals that might have been missed during the first 15 min. Stationary counts were conducted in all but offshore habitat types. A total of 34 stationary surveys, totaling 11.3 hours of observation and covering 2 669 m<sup>2</sup> of reef surface were conducted.

**C) Transect surveys:** Transect surveys (Brock 1954) were designed to assess the potential effects of changing fishing pressure by specifically targeting those species of fish regularly taken by fishermen in Cayos Cochinos before the reserve was established. These are listed in Table 3. Surveys were made along a 100 m transect tape played out during a slow swim (mean time to completion  $\pm 1$  SE:  $8.16 \pm 0.28$  min). The number and estimated size (to the nearest cm) of all target species occurring in front and within 4 m of either side of the observer were recorded, for a total coverage/survey of 800 m<sup>2</sup> per observer. Paired, parallel transects by buddy teams were separated by at least 12 m (i.e. a minimum 4 m buffer zone between areas of coverage). A total of 38 transect surveys, totaling 5.6 hours of observation and covering 30 400 m<sup>2</sup> of reef surface, were made. As with the stationary counts, transect surveys were not conducted on offshore reefs.

**Local interviews:** To supplement the survey work we also questioned local "experts": two dive masters from a nearby dive resort and fishermen from Cayo Bolaños were interviewed for their knowledge of local fish populations. They reported a number of species not observed during the survey work, primarily cryptic or

rare fish (by the dive masters), or offshore species (fishermen). These are noted within the tables.

## RESULTS

A total of 214 species of fish were observed during more than 66 hours of observation comprising all aspects of the survey work (Table 2). Over 90 % of these species were encountered at least once during the random swim surveys. An additional 22 species were reported by local divers and fishermen, for a total of 226 fish species reported for the area. Overall, the most ubiquitous and abundant species in the region was the striped parrotfish, *Scarus iserti*, which was observed during the first five minutes of every random swim at every site, as well as during most stationary counts and transects. The next nine most abundant species, from six different families, were, respectively: *Stegastes partitus* (Pomacentridae), *Acanthurus coeruleus* (Acanthuridae), *Sparisoma aurofrenatum* (Scaridae), *Sparisoma viride* (Scaridae), *Chaetodon capistratus* (Chaetodontidae), *Halichoeres gamoti* (Labridae), *Hypoplectrus unicolor* (Serranidae), *Acanthurus bahianus* (Acanthuridae), and *Chromis cyaneus* (Pomacentridae). Certain species received a top rank only within specific habitats. These included: shallow reef: *Stegastes planifrons*; deep reef: *Holocentrus tricolor*, *Stegastes variabilis*; exposed reef: *Halichoeres bivittatus*, *Thalassoma bifasciatum*; back reef: *Halichoeres bivittatus*; and offshore reef: *Caranx ruber*, *Chromis multilineatus*, *Clepticus parrai*, *Epinephelus striatus*, *Holocentrus tricolor*, *Thalassoma bifasciatum*.

More than 80 species of fish were observed during stationary counts. Densities of only the most common species (density > 0.001 fish/m<sup>2</sup>) are listed in Table 3. The small goby, *Coryphopterus personatus* was the most abundant species in both shallow and deep reef habitats, but did not occur in back reef or exposed habitats.

A total of 34 species considered to be potentially influenced by historical fishing pressure were observed during transect surveys. The mean density and size of these fish in four reef habitats is given in Table 4. Of the target species, moderate sized (10-20 cm) bar jacks, *Caranx ruber*, occurred at the highest abun-

dances in both shallow and deep reef habitats, although the mid-water snapper, *Ocyurus chrysurus*, and adult stoplight parrotfish, *Sparisoma viride*, were also quite common and occurred in all habitat types. Two grunts, *Haemulon flavolineatum* and *H. macrostomum*, and the parrotfish *Sparisoma chrysopterum* occurred at high abundances in the back reef habitat.

## DISCUSSION

The reefs of Cayos Cochinos currently support diverse and abundant populations of reef fish. The total of 226 species representing 69 families reported here compares favorably to lists from other parts of the Caribbean (e.g. 232 spp in 59 families from Panama, Clifton *et al.* submitted). Several species that are considered uncommon or rare in the western Caribbean (e.g. *Cantherines macrocenus*, *Echiophis interinctus*, *Equetus lanceolatus*, *Granma melacara*, and *Ioglossus helenae*; Humann 1994), while not common in Cayos Cochinos, were regularly encountered during surveys in the area. Additionally, several species not reported here (e.g. *Doratonotus megalepis*, *Malacoctenus aurolineatus*) probably also occur in the region, but were not detected because of their cryptic habits. Positive identification of several triplefins within the genus *Enneanectes* await specimen collections, and the finding of a possibly undescribed toadfish (with distinctive yellow blotches on the snout, probably in the genus *Batrochoides*) invites further study. The report by divers (confirmed by photograph) of at least one specimen of the northern stargazer, *Astroscopus guttatus*, represents a considerable range extension for this species.

Species historically taken by fishermen in the Cayos Cochinos generally received low relative abundance scores from the random swim data, and many were not encountered during transect surveys that specifically targeted this group. Although many of these species are top trophic level predators and, thus, never present in great numbers; the densities reported here suggest that fishing pressure has reduced their numbers even further. In turn, the absence of these fish almost certainly has had an important impact upon various aspects of the reef community in Cayos Cochinos and changes in community structure seem likely as the pre-

serve becomes a refuge for previously harvested adult fishes. Recovery of such populations can occur in less than two years given a total ban on fishing (e.g. McClanahan *et al.* 1994), although the extent to which the populations of Cayos Cochinos recover will ultimately depend upon the recruitment of juveniles from the protected population, as well as from sources outside the preserve (Humann 1994). Conversely, as the populations of previously harvested fishes recover within the preserve, they may become an important source of recruits to exploited areas elsewhere. Subsequent surveys in the area may track the recovery of these fish in the region, providing a unique and valuable opportunity to monitor the preserve's effects upon the reef community of Cayos Cochinos.

#### ACKNOWLEDGMENTS

This study was encouraged and supported by H. Guzmán, the Smithsonian Tropical Research Institute, and the Government of Honduras. D. Higbie, R. Remington, and the management of Plantation Beach Resort supported work at the offshore banks and provided detailed information on species encountered by the resort diving community. The staff of the Cayos Cochinos field station provided superb logistical support throughout the study.

O. Barrio and H.M. Guzmán edited and reviewed the manuscript. This study was partially sponsored by the Honduras Coral Reef Fund, AVINA Foundation, and the Tropical Research Institute.

#### RESUMEN

Este trabajo describe la población de peces arrecifales dentro de la recientemente establecida Reserva Biológica de Cayos Cochinos, un pequeño archipiélago de islas y arrecifes situado a unos 10 km al norte de la costa hondureña. Después de años de explotación comercial, únicamente la pesca a línea es permitida a un nivel artesanal y las demás artes están prohibidas. Tres métodos

de censo (nados al azar, conteo estacionario y transectos) fueron empleados utilizando SCUBA y buceo libre para determinar de forma general la riqueza de especies y la abundancia dentro de cinco hábitats (arrecifes semi protegidos de poca profundidad, arrecifes expuestos de poca profundidad, arrecifes de poca profundidad conteniendo áreas de hierba, arena y piedra; arrecifes profundos y arrecifes alejados de la costa). Estos estudios revelaron una alta diversidad en la comunidad de peces, con un total de 226 especies reportadas en el área. Esta información provee la primera evaluación cuantitativa de poblaciones de peces en el área, que facilita la información de línea de base necesaria para otros estudios subsecuentes en la Reserva. Las densidades de especies de importancia comercial reportadas sugieren que la pesca histórica a reducido la diversidad y abundancia de estas especies, y ha tenido un importante impacto en varios aspectos de la estructura de la comunidad arrecifal.

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