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THE ECOLOGICAL BASIS OF FISHERY YIELD OF THE PUERTO RICO - VIRGIN ISLANDS INSULAR SHELF

1987 Assessment

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by

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Cover photograph: Red mangrove (*Rhizophora mangle*) prop roots with gray snapper (*Lutjanus griseus*), seagrass, and attached fire sponge (*Tedania ignis*). (Credit: Jiangang Luo, Cooperative Institute for Marine and Atmospheric Science, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Coral Gables, FL.

PREFACE

[PREPARED IN 2006]

There are a significant number of documents and data related to the marine environment of South Florida that have never been published, and are thus not used by scientific community and academia. These documents and data are important because they can help characterize the state of the coastal environment in the past, and thus are essential when evaluating the current state of degradation and setting restoration goals. Due to the nature of the paper and electronic media on which they exist, and in some cases the conditions in which they are housed, the data and documents are in jeopardy of being irretrievably lost. These materials cannot be located using electronic and manual bibliographic searches because they have not been catalogued or archived in libraries.

The purpose of the Coastal and Estuarine Data Document Archeology and Rescue (CEDAR) for South Florida is to collect unpublished data and documents on the South Florida coastal and estuarine ecosystem; convert and restore information judged valuable to the South Florida restoration effort into electronic and printed form, and distribute it electronically to the scientific community, academia and the public. "Data Archaeology" is used to describe the process of seeking out, restoring, evaluating, correcting, and interpreting historical data sets. "Data Rescue" refers to the effort to save data at risk of being lost to the science community.

This report was originally prepared for the NOAA National Marine Fisheries Service to support development of an ecosystem model for use in preparation of Puerto Rico and Virgin Islands Ecosystem Plan.

NOAA/National Ocean Service/National Centers for Coastal Ocean Science (NCCOS) is not responsible for the accuracy of the findings or the quality of the data in rescued documents.

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ABSTRACT

A literature review was conducted to locate information on the flow of energy from primary producers to the fishery stocks of the Puerto Rican-Virgin Islands insular shelf. This report uses site-specific information to describe the major ecological subsystems, or habitats, of the region, to identify the more common species and the subsystems in which they occur, to quantify productivity and biomass, and to outline trophic relationships. Discussions on each topic and subsystem vary in substance and detail, being limited by the availability and accessibility of information.

Seven distinct subsystems are described: mangrove estuary, seagrass bed, coral reef, algal plain, sand/mud bottom, shelf break, and overlying pelagic. Over 50 tables provide lists of species found in each habitat on various surveys dating back to 1956. Estimates of density, relative abundance, and productivity are provided when possible.

We evaluated whether sufficient information exists to support an analysis of the energy basis of fishery production in the area, beginning with the design and development of an ecosystem model. Data needs in three categories - species lists, biomass, and trophic relations - were examined for each subsystem and for each of three species groups - primary producers, invertebrates, and fish. We concluded that adequate data, sufficient for modeling purposes, are available in 16 (25%) of 64 categories; limited data, those requiring greater extrapolation, are available in 35 (55%) categories; and no data are available in 13 (20%) categories. The best-studied subsystems are seagrass beds and coral reefs, with at least limited data in all categories. Invertebrates, the intermediate link in the food web between primary producers and fishes, are the least quantified group in the region. Primary production and fishes, however, are relatively well-studied, providing sufficient data to support an ecosystem-level analysis and to initiate a modeling effort.

1. INTRODUCTION

A literature review was conducted as the first phase of an investigation of the ecologicai bases of the fisheries yield of the Puerto Rican - Virgin Islands (PRVI) insular shelf. The purpose of the review was (1) to locate site-specific information that would support an analysis of the flow of energy from primary producers to fishery stocks, (2) to identify deficiencies in current knowledge on this topic, and (3) to evaluate the feasibility of developing an energy-flow model. Including over 200 citations, this report summarizes readily-available information from both published and unpublished literature. Its preparation represents the first step toward developing an understanding of the PRVI area as an ecosystem supporting fisheries.

Information we reviewed suggested that the insular shelf ecosystem surrounding Puerto Rico and the Virgin islands consists of distinct subsystems, or habitats, each with its own characteristic species composition, density, biomass, and trophic structure. Animal species, plankton, detritus, and nutrients moving between - and thereby connecting - these subsystems provide pathways over which neighboring subsystems may interact to influence species diversity, biomass, and secondary productivity. We have recognized the distinctiveness of the various subsystems in the organization of this report. As shown conceptually in Figure 1, we have delineated seven major subsystems - mangrove estuaries, seagrass beds, coral reefs, algal plains, sand/mud expanses, the shelf break, and the overlying pelagic zone. What follows is a description of the PRVI shelf area and the boundaries of interest in our study. We then give a broad description of each subsystem, and provide specific data on species occurrence, biomass and primary productivity, trophic relations, and areal extent. Known examples of the ways in which various subsystems are connected are also given.

A major feature of this report is the inclusion of over 50 tables containing species lists that were adapted from various survey reports. Where possible, quantitative density estimates were added to the original lists. Several lists were prepared especially for this report; for instance, we compiled Randall's list of common reef fish species from his 1983 book. As a starting point for defining the components of major trophic groups, the lists are an essential first step in analyzing energy flow through the ecosystem. Compilation of such lists is particularly important in spatially heterogeneous systems where large numbers of species occur. These lists, published as a unit, will be invaluable in an ecosystem study of the area, facilitating an analysis of the species differences and commonalities among systems. Both the distinctiveness and connectedness of the subsystems will be further clarified by the occurrence or lack of species on various lists.

The specific goal of this review is to evaluate whether enough site-specific information exists to pursue an ecosystem approach, With such a goal, the scope of our review was necessarily limited, and not everything that has been published on the biology of marine areas of the PRVI area was included. Considerable applicable information from other geographic areas such as South Florida, exists, and may be used in future modeling and analysis to fill gaps in site-specific information. Additional information of interest may yet exist in locations presently inaccessible to us and may be uncovered in future work.

[NOTE ADDED IN 2006: Data used in this study are compiled in the attached spreadsheet. Photographs of ecological systems and species were added at the end of the document.]

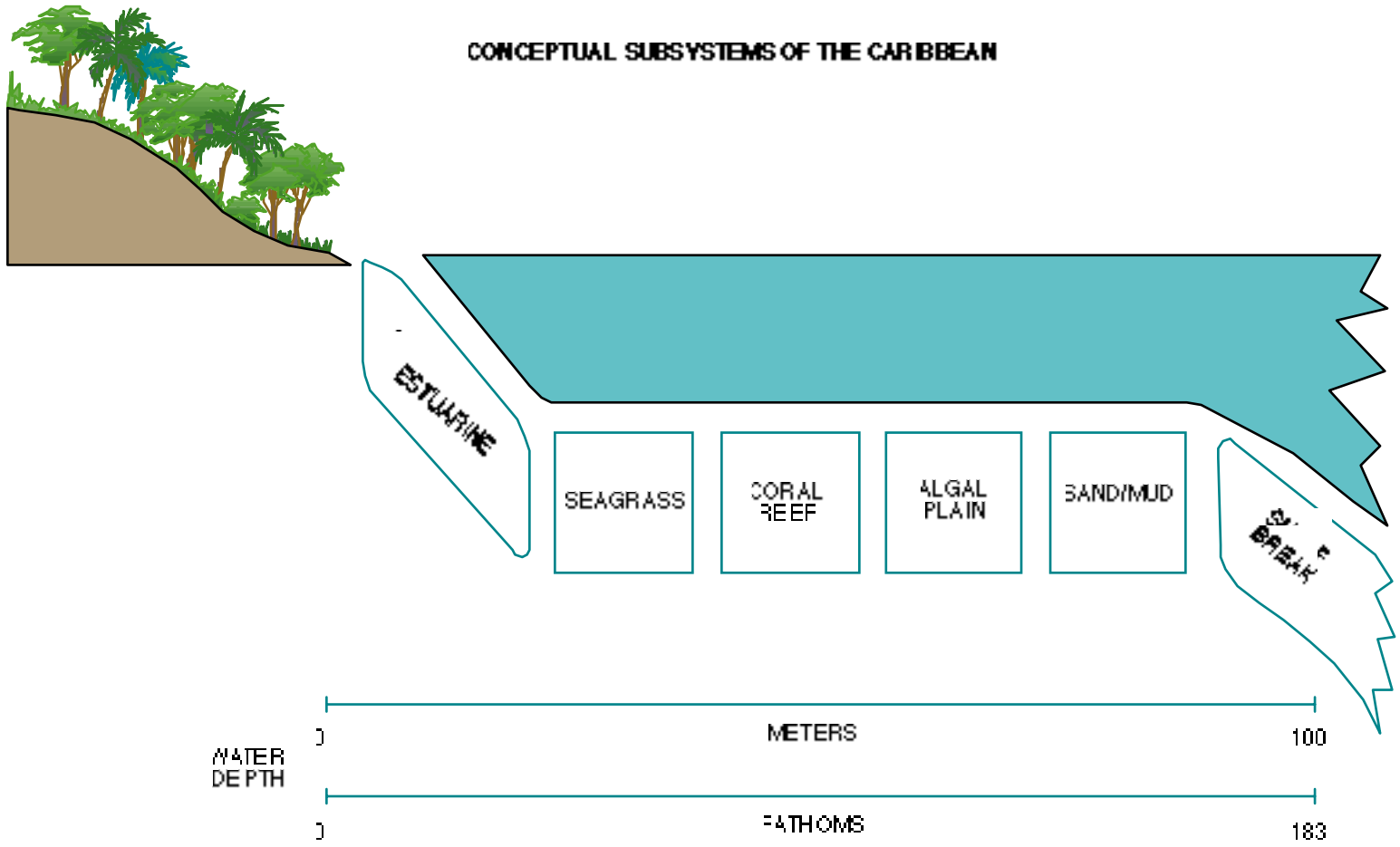

Figure 1. Conceptual diagram of seven major ecological subsystems of the Puerto Rican-Virgin Islands insular shelf ecosystem.

2. THE PUERTO RICO - VIRGIN ISLAND INSULAR SHELF

The insular platform of interest in this study contains 1,093,419 ha, about half of which (553,779 ha) surrounds Puerto Rico, with lesser areas surrounding the British Virgin Islands (342,990 ha), St. Thomas and St. John (162,450 ha), and St. Croix (34,200 ha) (Fig. 2) (CFMC, 1983). The area under study extends seaward from the shorelines to the 100-fathom contour.

Puerto Rico, the smallest and easternmost of the major islands of the Greater Antillies, is 160 km long, 56 km wide, and has a land area of 5,473.6 km^2 (Anonymous, 1978). Offshore island include Mona, Culebra, Vieques, Desecho, Caja de Muertos, and numerous smaller cays. The insular shelf break occurs at 75 - 200 m off the north and southwestern coasts, whereas the break off the south-central and eastern regions is more gradual, occurring at 25 - 50 m. At the edges of the insular shelf, Puerto Rico is isolated by deep-water channels. To the east, the Anegada Passage separates Puerto Rico from the Lesser Antilles. The Puerto Rico trench to the north is the deepest part of the Atlantic Ocean, with depths of 8,200 m just 120 km from the coast. The Mona Passage to the west separates Puerto Rico and Hispaniola (Anonymous, 1976).

The United States Virgin Islands, located 64 km east of Puerto Rico, comprise 68 islands and cays, the largest of these being St. Croix, St. Thomas, and St. John. St. Croix is, 95.2 km long, 9.6 km wide, is 218.4 km^2 in area (Anonymous, 1979), and is separated from the rest of the Virgin Islands by the Anegada Passage. The insular shelf is very narrow, dropping to 100 fathoms very close to shore. The coastline is regular with only three indentations at Christianstead Harbor, Salt River, and Krause Lagoon. Offshore islands include Green Cay and Buck Island. St. Thomas, the commercial and tourist center of the area, is 19.2 km long, 3.2 km wide, and 83.2 km^2 in area. The smallest island of the US Virgin Islands, St. John, is located 4.8 km east of St. Thomas, is 13.8 km Icing, 6.4 km wide, and 52 km^2 in area (Anonymous, 1979). The British Virgin Islands, with total land area of 94 km^2, are a British Crown colony situated 104 km east of Puerto Rico, and are, comprised of 60 islands, rocks and cays (Walters, 1983a and 1983b). The largest islands in the group are Tortola, Virgin Gorda, and Anegada, and smaller islands include Jost Van Dyke, Tobago, Salt island, Peter Island, Cooper Island, and Norman Island.

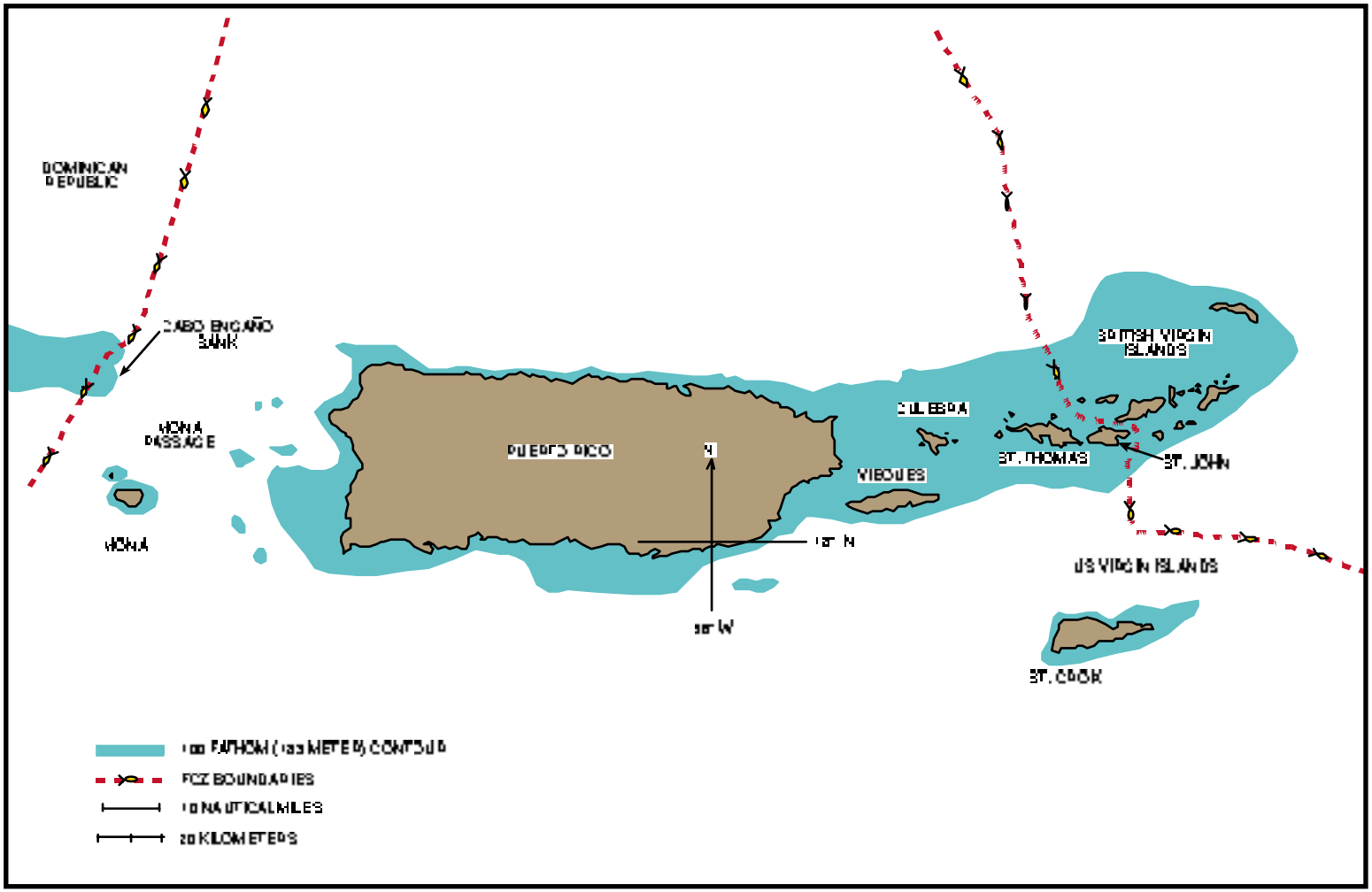

Figure 2. Boundaries of interest in an ecosystem study of the insular shelf of the Puerto Rico-Virgin

3. MANGROVE ESTUARIES

Mangroves and associated estuaries are productive coastal features of the tropics, with mangroves covering an estimated 60 to 70 percent of tropical shorelines (Martinez *et al.*, 1979). The estuarine subsystem extends from the coastline inland to the point of deepest seawater intrusion, including lower parts of freshwater rivers. In the PRVI area, large estuaries occur only in Puerto Rico; the compressed shoreline of smaller islands restricts the extent of tidally-influenced habitat. Many commercially-valuable fishes that occur offshore as adults spend their juvenile life stages in mangrove estuaries, and thus these few tidal areas are valuable with regard to fisheries (VIERS, 1969). Mangrove litter from Puerto Rican shorelines may contribute to coastal and offshore food webs (Golley *et al.*, 1962).

3.1. Species Occurrence

A taxonomic study of algae of mangrove lagoons in the Virgin Islands (Borgesen, 1911) is one of the earliest reports dealing with this habitat (Almodovar and Pagan, 1971). Four species of mangroves occur in the Caribbean: red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia nitida*), white mangrove (*Laguncularia racemosa*), and buttonwood (*Conocarpus erecta*). Species occurrence and growth forms are determined by topography and water circulation. Red mangroves, for example, typically occupy wetter, shallower, and more open sites (Heatwole, 1985).

Five types of mangrove forests are recognized: fringe, riverine, overwash, basin, and dwarf (Lugo and Snedaker, 1974). In Puerto Rico, all five forest types can be found (Martinez *et al.*, 1979). Studies by Heatwole (1970; 1985), Saenger *et al.* (1983), Pool *et al.* (1977), Cintron *et al.* (1978), Golley *et al.* (1962), Almodovar and Pagan (1971), Martinez *et al.* (1979), and Lugo and Cintron (1975) have provided ecological and distributional information on mangroves in Puerto Rico. Earlier studies and legal policies regarding mangroves are summarized in CZMP (1978).

One study has described invertebrate species occurring in mangrove estuaries of the PRVI area: Mercado and Caprilles (1982) described invertebrate species in commensal anemone complexes in shallow lagoons of southwestern Puerto Rico.

Several studies have provided species lists for fishes in mangrove estuaries. Fourteen species were noted by Randall (1983) to occur in estuarine habitats (Table 1), as indicated by their use of 'shallow brackish lagoons', 'shallow brackish pools', 'brackish water', and by their penetration into fresh water areas. Eighteen species of adult fishes characterized the mangroves of St. Croix (Table 2) (Clavijo *et al.*, 1980). Seven species were common or very common in mangroves as adults: needlefish or timucu (*Strongylura timucu*), mosquitofish (*Gambusia* spp.), silver jenny (*Eucinostomus gula*), yellowfin mojarra (*Gerres cinereus*), reef croaker (*Odontoscion dentex*), white mullet (*Mugil curema*), and checkered puffer (*Sphoeroides testudineus*).

Commercially important, diurnally active fishes censused in mangrove shoreline areas of St. John included 25 species (Table 3) (Boulon, 1985a). The most numerous fishes were French grunts (*Haemulon flavolineatum)*, tomtate (*H. aurolineatum*), unidentified juvenile grunts, dog snapper (*Lutjanus jocu*), mahogany snapper (*L. mahogoni*), and dwarf herring (*Jenkinsia lamprotaenia*). The largest fishes were snook (*Centropomus undecimalis*), bar jack (*Caranx ruber*), and gray snapper (*L. griseus*). Fishes found exclusively in the mangrove habitat were sea bream (*Archosargus rhomboidalis*), snook, and redear sardine (*Harengula humeralis*).

Surveys of mangroves outside the Virgin Island Biosphere Reserve (VIBR) (i.e., Hurricane Hole, St. John, and two sites in the British Virgin Islands, on Tortola and on Norman Island) showed a species composition similar to other surveys of St. John (Boulon, 1985b). Several taxa previously undocumented in other mangrove surveys were recorded (Table 4): adult coney (*Epinephelus fulvus*), adult Nassau grouper (*E. striatus*), trunkfish, and unidentified juvenile porgies. Total numbers of species in all of Boulon's surveys were similar throughout St. John, with 25 species in VIBR, and 21 species in Hurricane Hole. Total species numbers were lower in the British Virgin islands, with 11 species in Tortola and 15 species on Norman Island.

In southwestern Puerto Rico, Kimmel (1985) described a statistically distinct group of sixteen fish species that occurred consistently in the mangroves (Table 5), and also listed the ten most abundant fish species he observed (Table 6). Sixty fish species taken by Austin (1971) in mangrove estuaries of Puerto Rico (Table 7) included predominantly juveniles. Austin (1971) explained that many adult fishes do not occur in mangrove areas because of the shallowness, the restricted space of the roots, and the frequent salinity extremes. Another study in Puerto Rico listed just thirty estuarine fish species (Table 8) (Bejarano, 1979, in Negron and Cintron, 1979). Erdman (1956) listed at least eleven species from enclosed lagoons there, and included gray

snapper, tarpon (*Megalops atlanticus*), snook, unidentified gobies, small unidentified eels, jewfish (*E. itajara*), and young of several species, including hogfish (*Lachnolaimus maximus*), sea bream, yellowtail snapper ((*Ocyurus chrysurus*), unidentified snappers (*Lutjanus* spp.), and unidentified parrotfishes (Scaridae). Wagner and Wolf (1974) surveyed eight bays of Puerto Rico for bait fishes, and reported three taxa as common - thread herring (*Opisthonema* sp.), unidentified anchovies (Engraulidae) and dwarf herring.

Stoner (1986) recorded 41 fish species in 18 families from trawl studies of Laguna Joyuda, Puerto Rico (Table 9). Ten of the most abundant species accounted for about 90% of the total catch. Juveniles of most of the Laguna Joyuda species were also common in seagrass beds and unembayed mangroves. Abundance of fishes was highly seasonal, with peaks correlating with high levels of allochthonous inputs and the enhanced availability of foods within the lagoon basin. Species richness was low in comparison with temperate estuaries, and Stoner suggested that the general lack of estuarine habitats in the Caribbean may explain the occurrence of few truly estuarine species.

Several studies of fish species occurrence in mangrove estuaries have shown how nearby habitats can influence the species composition of an estuarine area, particularly through changing patterns of habitat use accompanying ontogenetic or seasonal changes. For example, Stoner (1986) found that just 12.2% of fish species in Laguna Joyuda, Puerto Rico, were residents, whereas 56.1% were cyclical or seasonal visitors. Austin and Austin (1971) suggested that, for many fish species, occurrence in mangrove estuaries is related largely to proximity of other habitats, such as reefs, grassbeds, and sand/mud systems. The abundance of typical reef species in Kimmel's (1985) estuarine areas may further support this suggestion. The small sizes of fishes observed led Boulon to confirm that the mangrove habitat acts as a nursery ground for offshore fishes. For example, juvenile mahogany snapper were reported in mangrove estuaries and seagrass beds of St. John; Randall (1983) considered this a "coral reef species", and the inshore presence of juvenile mahogany snapper may reflect the proximity of reefs. Local variations in density and species composition of the mangrove fish community may therefore be attributed to the effects of the larger system of which the mangrove subsystem is a part. The further delineation of mangrove estuaries occurring near to reefs, for example, should be of future interest with regard to the productivity potential of these areas. These considerations further suggest that species lists from any one study may be influenced greatly by the timing (both ontogenetic and seasonal) of the study, and should be interpreted with care.

Sampling techniques have varied among studies, and as a result each study provides different types of data. For example, Austin's (1971) comprehensive listing of 82 species reflects the collecting techniques used in his study (seines, poisoning, gill nets), which discriminate less against rare and cryptic species than visual census techniques.

3.2. Biomass and Primary Productivity

The biomass of mangrove forests varies widely throughout the world and even within small regions. Variability in biomass data may be attributed to age, stand history, structure and/or hurricane frequency. A summary of biomass estimates for various mangrove ecosystems, including data for Puerto Rico (from Golley *et al.*, 1962) is given in Lugo and Snedaker (1974). Dry weight estimates for Puerto Rico averaged 62,850 kg/ha, intermediate, between extreme estimates for Florida successional stands (8,123 kg/ha) and Panamanian forests (279,212 kg/ha) . Heatwole (1985) gave densities of live mangroves in eight swamps of Puerto Rico (Table 10) .

Mangroves are most productive where tides transport nutrients, remove metabolic products, and ventilate roots (Carter *et al.*, 1979; Lugo and Snedaker, 1974). A summary of mangrove data can be found in Lugo and Snedaker (1974), and parameters used by Lugo *et al.* (1976) in modeling a mangrove ecosystem are shown in Table 11. Gross productivity for mangrove systems has ranged from 1.4 to 13.9 g C/m^2/day, depending on tidal factors and water chemistry. Data from La Parguera, Puerto Rico, were intermediate to all values, averaging 8.2 g C/m^2/day. Mangrove respiration rates have ranged overall from 0.6 to 9.1 g C/m^2/day, with a value of 9.1 reported for La Parguera. Annual leaf fall rates for mangrove forests in La Parguera, averaging 2.0 g C/m^2/day, were similar to those reported in other areas. Export of mangrove litter to surrounding estuarine waters has been measured at 2.27 particulate matter/m^2 forested area/day (Golley *et al.*, 1962) and 0.5 g/m^2/day, or 26% leaf fall (Snedaker and Lugo, 1973). Mangrove soil respiration rate (reflecting bacterial metabolism) have been reported as 0.2 and 0.37 g C/m^2/day by Lugo *et al.* (1975) and Golley *et al.* (1962), respectively.

Phytoplankton blooms are common in shallow waters of protected bays and mangrove lagoons, where primary production has ranged from 0.8 to 8.3 g C/m^2/day (nine times that of offshore waters) (Burkholder *et al.*, 1967). Net production in Joyuda Lagoon, Puerto Rico, was measured as 0.9 and 1.7 g C/m^2/day (Table 12.) (Owen and Tilly, 1985). Margalef (1971) reported that annual net production in bays and mangrove

areas of the Caribbean may exceed 1,000 g C/m^2. Plankton density and physical and chemical aspects of the Caño Corazones estuary in Puerto Rico were studied by Cham and Seda del Toro (1980). Additional productivity data for estuarine areas may be available in Cintron *et al.* (1978) and Golley *et al.* (1962), which have not been reviewed .

Biomass estimates of fishes of mangrove estuaries are not common. Quantitative values, in fact, are available only in Boulon (1985a) (Table 5). Qualitative information from four studies includes rank abundance data (Tables 5, 7 and 9), distinction of adult and juvenile forms (Table 4), and indication of common or uncommon (Tables 2 and 7).

3.3. Trophic Relations

Studies of trophic habits of estuarine invertebrates are limited to temperate areas, and no site-specific information on this topic has been located for the PRVI area.

Food habits of fishes in coastal bays of the Caribbean have been described by Beebe and Tee-Van (1928) and in less detail by Randall (1983). Limited food habits data from the PRVI area is available for three species of Acanthuridae (Clavijo, 1974), larval and young tarpon (Harrington and Harrington, 1960), lane snapper (*Lutjanus synagris*) (Rodriguez-Pino, 1962), bonefish (*Albula vulpes*) (Erdman, 1960), and mojarras (Gerreidae) (Austin, 1968). Many fish species in the mangrove community, particularly mullet, use detritus directly, while others, such as the mojarras (Gerreidae), use detritus indirectly by feeding on crustaceans (Austin, 1968; Austin and Austin, 1971; Negron and Cintron, 1979). Austin and Austin (1971) described the food habits of selected juvenile fishes (15 families, 26 species) in the mangroves of Puerto Rico. Small fishes feed on organisms that are low in the trophic web, with only 2.62% of the overall diet including other fishes (4 families) (Table 13); 23% of the juvenile species were at least partly piscivorous. The most frequent prey taken were crustaceans (49.8% of total diet), which were used by 77% of the species surveyed. Ontogenetic changes in diets of mangrove fishes are common; many juvenile fishes of the mangroves, particularly Elopidae and most Carangidae, are predators of benthic invertebrates, while their adult forms, are midwater piscivores (Austin and Austin, 1971). In contrast, diet changes very little with growth in great barracuda (*Sphyraena barracuda*), mullet, and porgies (Sparidae) (Austin and Austin, 1971). Small schooling fishes such as dwarf herring feed on zooplankton throughout their lives (Randall, 1983).

Top predators have been studied very little in Caribbean estuaries (Beebe and Tee-Van, 1928), and no site-specific ecological data have been located.

3.4. Areal Extent

The distribution of mangrove swamps in Puerto Rico has been documented by Heatwole (1970), Lugo and Cintron (1975), and Martinez *et al.* (1979). Lugo and Cintron (1975) grouped the mangrove formations of Puerto Rico into two broad categories - the north coast type and the south coast type - based on wave energy and precipitation regimes characterizing each coast (see Martinez *et al.*, 1979). Northeastern Puerto Rico has the highest concentration of mangrove swamps (Heatwole, 1985). The north coast receives year-round rainfall and has an indented coastline with several major rivers (Austin, 1971). Fifty-eight percent of the total island runoff drains into six north coast estuaries (Negron and Cintron, 1979), which comprise a total area of 15,358 ha, of which 1,825 ha, or 11.9%, are mangroves (Negron and Cintron, 1979). Despite this, most of the northern coast lacks significant stands of mangroves (Heatwole, 1985). The eastern tip, and the south-central and southwestern coasts have extensive mangrove swamps (Heatwole, 1985). Along the south coast there are several mangrove areas that have freshwater inputs only during the rainy months, having high salinities at other times (Austin, 1971). The west coast, with heavy mountain rainfall, has numerous river and streams (Austin, 1971). Mangrove forests border almost the entire western coastline from Punto Jorobado to Punta Pitahaya (Gonzalez-Liboy, 1979), and mangrove islets are common inside the inner shelf (Cintron *et al.*, 1978). The coastal area near La Parguera has extensive mangrove forests, especially along the western shores (Almodovar and Pagan, 1971). Austin (1971) provides detailed descriptions of mangrove extent in several areas of Puerto Rico, including Playa Papayo, El Marimba, Guanica Harbor, Guayanilla Bay, Guanajibo River, Joyuda Lagoon, Anarco River, and Cabo Tiburones. Additional detail is available in Martinez *et al.* (1979). Detailed maps and descriptions of the watersheds of the north coast of Puerto Rico can be found in Negron and Cintron (1979).

Puerto Rico now retains only slightly more than a quarter (6,405 ha) of the original mangrove cover (24,300 ha) estimated in 1959 by Wadsworth (1959). The quality and areal extent of estuarine areas in Puerto Rico have declined with increased demand for recreation, encroachment by development, and declining water quality (Negron and Cintron, 1979). By 1968, 13 of 62 estuarine areas in Puerto Rico were eliminated, while many others became polluted (Wadsworth, 1969). All estuarine zones along the north coast had undergone changes in dominant land use, with 762 ha (25% of total) having been deforested. The total area occupied

by mangroves in Puerto Rico in the 1960's was 16,600 acres (Heatwole, 1985), although Wadsworth (1959) reported 7,190 ha. By 1968, mangroves covered 6,596 ha, a loss of 594 ha since 1959 (Martinez *et al.*, 1979). This coverage had been reduced to 6,405 ha by 1974; of these, about 25 ha were in Culebra and 225 ha in Vieques (Martinez *et al.*, 1979).

Mangrove shorelines occur in several of the deeper, more protected embayments of St. John, including Fish Bay, Great Lameshur, Coral Bay, Hurricane Hole, and Mary's Point Creek, with small strands in Haulover Day, Little Lameshur, and Brown Bay (Boulon, 1985a). The largest mangrove communities on St. John are found in its largest and most protected bay, Coral Bay (Boulon, 1985b). Hurricane Hole, at the northern end of Coral Bay, includes many smaller bays and creeks lined with red mangroves (Boulon, 1985b). Beets and Lewand (1984) qualitatively described the extent of mangrove habitat in the shallow bays of St. John. On St. Croix, Ogden (1980) reported that industrial development has destroyed much of the mangroves, which remain only along Salt River; scattered black mangrove occurs at Great Pond, Western Pond, and Altona lagoon.

In the British Virgin islands, Boulon (1985b) reported a small mangrove area at the head of the Bight on Norman island and a small, disturbed area in Soper's Hole, Tortola, and along Frenchman's Cay. The mangroves along the Tortola coastline east of Soper's Hole did not have sufficiently submerged prop roots to provide fish habitat, and the road along the south coast of Tortola in Soper's Hole displaced most of the mangroves that previously occurred there (Boulon, 1985b)

4. SEAGRASS BEDS

Extensive meadows of seagrasses are found along most coastlines in the Caribbean, widely scattered at depths of less than five meters, over well-illuminated shallow bays, channels, and inner margins of coral reefs (Burkholder *et al.*, 1959). Leaf structure of the grasses and cave-like habitats, or blowouts, at the edge of many grassbeds provide habitat complexity for a wide range of prey organisms. Kimmel (1985) considered seagrasses an integral part of the coral reef subsystem with regard to fish production and species diversity.

4.1. Species Occurrence

Marine spermatophytes comprising Caribbean seagrass beds include turtle grass (*Thalassia testudinum* König), manatee grass (*Syringodium filiforme* Kutzing), shoal grass (*Halodule wrightii* Ascherson) (den Hartog, 1970), *Halophila decipiens* Ostenfeld (Josselyn *et al.*, 1986), and *H. bailloinis* (Ogden, 1980). Though seagrasses often occur as mixed stands, *Thalassia* most often dominates in biomass and standing stock (Thayer *et al.*, 1984). Macroalgal clumps (including primarily *Halimeda opuntia*) are often interspersed with seagrasses. A list of macroalgal species occurring in seagrass beds of St. Thomas can be found in Rogers (1982).

Invertebrate species occurring in seagrass beds of Puerto Rico have been listed by Bauer (1985). Caridean shrimp are numerically-dominant invertebrates in *Thalassia* beds, and on the north coast of Puerto Rico, Bauer (1985) found that nine species of caridean shrimp - *Latreutes fucorum*, *Periclimenes americanus*, *Thor manningi*, A*lpheus normanni*, *Hippolyte curacaoensis*, *Latreutes parvulus*, *Processa bermudensis*, *P. riversi* and *Leander tenuicornis* - accounted for 99.9% of the total shrimp abundance in seagrass meadows. Conch (*Strombus* spp.) were once abundant in grassbeds of southern and western inshore areas of Puerto Rico, although fishing has depleted these populations (Ballantine and Appeldoorn, 1983). Juvenile conch were observed by Boulon (1985a) in grassbeds of most of the bays of St. John in 1982 (Boulon, 1985b).

Several studies have provided lists of fish species found in seagrass beds of the PRVI area. Nineteen species were described by Randall (1983) as 'commonly observed' in seagrass beds (Table 14). Ten species and five families of fishes characterized the grassbeds of southwestern Puerto Rico (Table 15) (Kimmel, 1985). Five species of fishes occurring in the 'shallow bay grass' habitat of St. John were given in Boulon (1985a) (Table 16). Common fishes included trunkfishes (Ostraciontidae), bar jack (*Caranx ruber*), and bucktooth parrotfish (*Sparisoma radians*). Mahogany snapper and barracuda were present in lower numbers. Fishes observed by Boulon (1985a) were primarily juveniles.

In St. Croix, Clavijo *et al.* (1980) reported 27 fish species that use seagrass beds as 'typical habitat' while adults (Table 17). Ten families (12 species) were common or very common. Gladfelter *et al.* (1977) listed 24 fish species in seagrasses of Buck Island Reef National Monument (BIRNM), St. Croix (Table 18). Nocturnal and diurnal surveys of fishes in seagrass beds of Tague Bay, St. Croix, included 56 species (Table 19) (Robblee, 1987), whereas less comprehensive night surveys conducted earlier in that area had revealed just eight species (Table 20) (Ogden and Zieman, 1977). White grunt *(Haemulon plumieri*) and bucktooth parrotfish were the most abundant species on night surveys.

Further information regarding fish fauna of seagrass habitats in the Caribbean can be found in Ogden (1980). Gonzalez-Liboy (1979) compiled a list of 100 fish species occurring in seagrass beds of Puerto Rico. McFarland (1979) reported that post larval (age 30 days, size 12 mm SSL, life stage III) French grunts (*Haemulon plumieri*) occurred in grass bed habitats. Randall (1983) reported the lemon shark, (*Negaprion brevirostris*), an a 'common inshore species' in the Caribbean.

As in mangrove estuaries, the species composition of seagrass beds, particularly with regard to fishes, appears to be influenced by neighboring subsystems, For example, a majority of species observed in seagrasses by Kimmel (1985) used the reef as adults (e.g., gobies, grunts, snappers), suggesting that the species composition of the La Parguera area is influenced by the proximity of reefs. Randall (1983) described seagrass beds as common habitat for many fish species often seen on reefs. Seagrass beds of St. John were used by juveniles of certain species (e.g.. mahogany snapper) that again reflect the proximity of reefs (Table 16). The occurrence of patch reefs in Tague Bay, St. Croix, was reflected by the presence in its seagrass beds of reef species such as squirrelfishes and grunts (Tables 19 and 20).

Sampling techniques limited the comprehensiveness of many species lists for seagrass beds. The bias in visual censusing is particularly evident in complex seagrass beds (Randall, 1983). For example, Kimmel (1985) observed few typical seagrass species in his surveys, overlooking cryptic species such as pipefishes and puffers.

4.2. Biomass and Primary Productivity

Research on seagrass productivity in the PRVI area has emphasized *Thalassia* and been conducted largely near La Parguera, Puerto Rico (for review, see Gonzalez-Liboy, 1979). At La Parguera, Odum *et al.* (1959) studied oxygen production, Burkholder *et al* (1959) reported standing stocks and chemical constituents, Odum *et al.* (1958) and Margalef (1962) studied chlorophyll 'a' concentrations, and Stevenson and Ufret (1966) reported elemental concentrations. Gonzalez-Liboy (1979) reported an average standing stock of *Thalassia* at La Parguera of 142 g/m^2 and summarized results of other studies reporting standing stocks in that area (Table 21). Total biomass and above ground standing stocks from 29 sites around Puerto Rico are presented in Table 22. The impact of heated effluents and detailed ecology of *Thalassia* beds in Puerto Rico was investigated by Schroeder (1975), Vicente (1975, 1977, 1979), and Vicente and Rivera (1982).

Studies of seagrasses at Vieques, St. Thomas, and St. Croix have also been conducted. Zieman (1978) reported on the condition of the seagrass ecosystems of Vieques. Standing crop biomass of seagrass beds was reported by Rogers (1982) at six sites near St. Thomas. Mean annual *Thalassia* standing crop ranged from 35.9 to 63.7 g dry wt./m^2, and productivity ranged from 0.6 to 28.0 g dry wt/m^2/day. *Syringodium* standing crop ranged from 3.6 to 67.0 g dry wt/m^2 and productivity ranged from 0.1 to 2.2 g dry wt/m^2/day. Rogers (1982) also reported biomass of macroscopic algae of seagrass beds, which averaged <1 g/m^2 and <1% cover. Williams (1981) studied successional stages of seagrass beds in Tague Bay, St. Croix, and reported productivity and standing stock data. Zieman *et al.* (1979) studied production and export of seagrasses at the same site. *Halophila decipiens* was found to be the dominant macrophyte on the floor of the Salt River Canyon, St. Croix, contributing significantly to down-canyon export of detritus; biomass and productivity of this species is given in Josselyn *et al.* (1986).

Invertebrate densities were measured in seagrass beds of BIRNM (Table 23) (Gladfelter *et al.*, 1977), Bauer (1985) found that abundances of the nine most numerous caridean species in Puerto Rican seagrass beds averaged 16 shrimps/m^2 (daytime) and 49/m^2 (night). Abundances were markedly seasonal, with peaks in late spring-summer and December-January. (No biomass or productivity estimates were provided.)

Regarding fish biomass, two studies provided qualitative density information, one giving relative abundances (Table 15) and one listing common and uncommon species (Table 17). Four studies provided quantitative information (Tables 16, 18, 19, and 20). In seagrasses of St. John, five diurnal visual censuses, each covering an area of 201 m^2, revealed a low fish density (Table 16). Night-time surveys of seagrass beds of St. Croix revealed extremely low densities, ranging from less than 1.2 fish/1,000 m^2 to 26 fish/1,000 m^2 (Tables 19 and 20).

4.2. Trophic relations

Despite the high number of species of seagrass herbivores in the Caribbean (Thayer *et al.*, 1984), just 5-10% of the net productivity of *Thalassia* is consumed directly (Zieman *et al.*, 1979). Among the known grazing species, conch (*Strombus gigas*) and starfish (*Oreaster reticulatus*) consume seagrass detritus, live leaves, and epiphytes (see review in Ogden, 1980). Feeding rates of herbivorous invertebrate seagrass consumers are reviewed by Lawrence (1975) and Ogden (1980). Randall (1967) listed over 30 species of Caribbean reef fishes that have seagrasses as part of their diets, and Gonzalez-Liboy (1979) listed 20 such species. Whether many of these fishes consume *Thalassia* deliberately or secondarily is not known. Ogden (1980) reviewed studies of herbivorous fishes in seagrasses.

Food habits of fishes in a lagoon in western Puerto Rico are described by Almodovar and Pagan (1971). Food habits of three species of barracuda that are common in seagrasses are given by Gonzalez-Liboy (1979). Randall (1983) suggests general food habits of fishes commonly occurring in seagrass beds (Table 14). McFarland (1979) reported that juvenile grunts were diurnal planktivores.

Green turtles (*Chelonia mydas*) having a diet of 80% *Thalassia* (Mortimer, 1981), were once the primary consumers of seagrasses in the Caribbean, although exploitation has since reduced their impact (Thayer *et al.*, 1984), The shallow bays of St. Croix contain large numbers of actively-feeding juvenile green turtles (Tighe, 1981; Ogden *et al.*, 1983). Nesting species of sea turtles - hawksbills, leatherbacks, and greens - has been documented on St. John (Small, 1982).

4.3. Areal Extent

Seagrasses occupy back-reef areas (Cintron *et al.*, 1974; Gonzalez-Liboy, 1979), and Landsat data for 'shallow inshore and backreef areas' (Armstrong, 1983) can be used to estimate seagrass area in St. Croix (2,322 ha) and Culebra (433 ha). Seagrass beds in selected bays of St. Thomas have been described by

Rogers (1982), although no areal estimates were provided. Beets and Lewand (1984) qualitatively described the extent of seagrass beds in the bays of St. John. Gladfelter *et al.* (1977) provided a map of areal extent of four seagrass communities near Buck island Reef National Monument, St. Croix. Robblee (1987) provided a coarse map of seagrass distribution in Tague Bay, St. Croix. Seagrass distribution in Puerto Rico coincides with major fishing areas, with the greatest development along the southwestern coast, where the highest fish production occurs (Gonzalez-Liboy, 1979). The north coast has fewer seagrass beds because wave energy and sedimentation interfere with bottom stability and light penetration. Additional data on seagrass area in the PRVI area may be found in Odum *et al.* (1959), Grigg and Van Eepoel (1970), Delgado (1978), Carvajal *et al.* (1979), Gonzalez-Liboy (1979), and Vicente and Rivera (1982).

5. CORAL REEFS

Coral reefs are productive ecosystems containing a high diversity of species, many of which are taken in commercial and recreational fisheries. The coral reef subsystems as defined here include fringing, submerged and patch reefs, as well as 'sponge-coral', or 'live bottom' habitats (sensu Struhsaker, 1969). The ecology and distribution of coral reefs in the northeastern Caribbean have been described generally by several publications (Glynn, 1973a; Colin, 1978; Jones and Endean, 1973).

5.1. Species Occurrence

Species of coral and associated organisms inhabiting Caribbean waters have been widely described (e.g., Colin, 1978; Jaap, 1984). The distribution and relative, abundance of hard corals in the area is a result of many factors, including, at the species-level, patterns of larval recruitment, asexual reproduction or fragmentation, mortality, regenerative capabilities, and aggressive interactions among species (Rogers *et al.*, 1982). Large-scale environmental factors such as depth, turbidity, and current velocity may also influence species occurrence. Physiographic areas of Caribbean reef support different species, illustrating the effects of wave energy and other environmental factors on community structure. The major reef framework-building organisms are *Acropora*, *Millepora*, *Poriolithon*, and *Lithophyllum* in shallow water and larger corals, especially *Monastrea*, in deeper waters (Adey *et al.,* 1977).

The reef crest (or flat), algal ridge, back reef, and fore reef are among the subhabitats that can be defined both physiographically and biologically and contain somewhat distinctive but nonetheless integrated ecological communities. The reef flat is typically characterized by tolerant species such as *Siderastrea*, *Porites*, and *Diploria*. Algal ridges are intertidal areas occurring on many scattered reefs in the Caribbean and are built primarily by red coralline algae and other macroalgae (Adey, 1975; Adey and Burke, 1976; Connor and Adey, 1977). The back reef generally lacks substrate and adequate water clarity for coral development (Colin, 1978), has little topographic relief, is relatively barren of plant life (except benthic diatoms), and has sand or silty mud substrate (Kimmel, 1985). Transitional back reef slopes may be intermediate between the lagoon and the reef flat. The fore reef (often further distinguished as shallow or deep) is heterogeneous, often dominated by *Acropora palmata* in shallower, high energy areas and by mixed communities of *A. cervicornis*, *Monastrea cavernosa*, and *M. annularis*, among many others, at greater depths.

Lists of coral species have been made for specific reefs in the PRVI area. Adey *et al.* (1977) described the reefs of St. Croix - including Boiler Bay, Robin Bay, Fancy Point, the shelf edge, Buck Island (northeast end), Tague Bay, Salt River Canyon, and the West End. Sadd (1984) listed major coral species and percent cover in five reef zones of Cane Bay, St. Croix. Gladfelter *et al.* (1977) provided general descriptions of the reef community at Duck Island Reef National Monument (BIRNM), St. Croix. Coral species characterizing reefs at La Parguera, Puerto Rico, were described by Kimmel (1985). Components and physiographic regions of submerged reefs south of Virgin Gorda, St. Thomas, and St. John were described by Macintyre (1972). Boulon (1980) described the reefs of southeastern Puerto Rico.

Ninety-three species of benthic algae were identified at BIRNM (Stanhope, 1980). Steneck (1982) described the predominant algal growth form ('algal turfs') of bank-barrier reefs (e.g., Tague Bay, St. Croix) and deep-wall reefs (e.g., Salt River Canyon, St. Croix), which supported as many as 30 - 50 algal species in an average 4-cm^2 area [see also Steneck (1986)]. Connor and Adey (1977) listed 40 algal species on algal ridges of St. Croix, and Adey *et al.* (1977) listed benthic algae of several St. Croix reefs.

Plankton of Caribbean reef areas were inventoried and censused by Glynn (1973b) and E. Gladfelter (1979, 1980a). At BIRNM, St. Croix, at least 21 groups of zooplankton were identified.

Invertebrate species inhabiting Caribbean coral reefs as given in Colin (1978) are too numerous to list here. Particularly abundant echinoderms at BIRNM included *Diadema antillarum* and *Echinometra lacunter*; crustaceans included *Percnon gibbesi* and *Stenorhynchus hispidus* (crabs) and *Periclemenes pedersoni* (shrimp); molluscs included *Cittarium pica* and *Cyphyma gibbosum* (Adey *et al.*, 1977),

Caribbean reefs support over 500 species of fishes (Ogden and Quinn, 1984) described in specialized texts (Bohlke and Chaplin, 1968; Randall, 1983). Site-specific studies of the PRVI area report fewer than 500 fish species; Parrish (1982) recorded 130 species on a reef off southwest Puerto Rico, and Collette and Talbot (1972) recorded 107 species on a reef off St. John. In studies at BIRNM, W. Gladfelter (1980) listed 128 diurnal species on five reef types (Table 24). Gladfelter *et al.* (1977) listed diurnal and nocturnal fish species in four areas of BIRNM (Table 25). Thirteen species considered abundant at BIRNM were listed in Adey *et al.* (1977) (Table 26). Clavijo *et al.* (1980) listed 212 fish species in 47 families that used reefs off St. Croix as 'typical habitat' while adults (Table 27). Kimmel (1985) surveyed over 200 fish species on reefs off La

Parguera, Puerto Rico (Table 28). The nineteen most abundant species in his line transect samples are listed in Table 29. Boulon (1985a and b) reported 45 species of commercially-important fishes on reef habitats in and around St. John (Table 30) and reported 20 species at three sites in the British Virgin islands (Table 31). Randall (1983) listed the 300 'most common' Caribbean species from shallow reef areas (Table 32). Detailed information covering the larger Caribbean area is available for selected families of reef fishes, including Balistidae (Aiken, 1975a), Chaetodontidae (Aiken, 1975b), Haemulidae (Billings and Munro, 1974), Mullidae (Munro, 1976), and Serranidae (Thompson and Munro, 1978).

Larger vertebrates that occur over reef areas in the Caribbean include rays and sharks. The spotted eagle ray (*Aetobatis narinari*) is 'commonly observed over reef areas' (Clavijo *et al.*, 1980; Randall, 1983). Twenty-four species of sharks (3 families) occur in Caribbean 'inshore' areas (Randall, 1983). These include nurse sharks (*Ginglystoma cirratum*), tiger sharks (*Galeocerdo cuvier*), lemon sharks (*Negaprion brevirostris*), Atlantic sharpnose shark (*Rhizoprionodon terranovae*), reef shark (*Carchirhinus perezi*), black tip shark (*C. limbatus*), bull shark (*C. leucas*), great hammerhead (*Sphyrna mokkaran*), and scalloped hammerhead (S. lewini). Clavijo *et al.* (1980) included the smooth dogfish (*Mustelus canis*) on reefs of St. Croix.

5.2. Biomass and Primary Productivity

Coral reef communities contain a diverse and spatially variable assemblage of coral and algal species. Estimates of standing stock, growth rates, and productivity of reef components and the reef community therefore vary both spatially and temporally. For example, coral growth rate declines with depth (1 - 40 m) (Hubbard and Scaturo, 1985), light level, turbidity, and sedimentation rate (Rogers, 1979; Hubbard and Scaturo, 1985). Physical disturbance by storms call alter species diversity and structural complexity (Rogers *at al.*, 1982), thus creating further variability in productivity rates. Productivity and biomass values of coral reefs are summarized here. Generally, research has emphasized either coral, algae, or the entire reef community.

Productivity or growth rates of various species of Caribbean corals are given in Table 33. Difference in growth forms and rates of calcification result in widely varying growth rates (cm/yr) among coral species, whereas environmental factors, such as turbidity and pollution, influence within-species variation (Dodge and Brass, 1984). Productivity of a dominant coral, *Acropora palmata*, was similar in two studies conducted off St. Croix. The fastest growing species in shallow waters (3 m) off St. Croix was *Monastrea annularis* (0.4 - 1.2 cm/yr) (Hubbard and Scaturo, 1985). Growth rates of six other scleractinean species over all depths varied from 0.12 - 0.45 cm/yr. On a slightly deeper (4 m) reef, San Cristobal Reef off Puerto Rico, Rogers (1979) measured net primary productivity of a reef dominated by *Acropora cervicornis* (0.07 - 6.7 g C/m^2 reef area/day), and estimated growth rates of 8.3 - 8.7 cm/yr (ranging from 0 - 22.8 cm/yr . Similar growth rate for *A. cervicornis* (7.1 cm/yr) were found by Gladfelter (1980b) for St. Croix colonies at 10 m depth, although growth rates varied widely among and within sites (Rogers, 1979).

Shallow water algal turf communities are the major primary producers on many reefs (Adey and Steneck, 1985; Carpenter, 1985). Productivity of algal groups, ecologically distinguished as 'algal', microscopic, turf, benthic, and reef turf, are within the same order of magnitude at diverse sites (Table 34).

Productivity studies of the entire coral reef community are few. On two shallow reefs off St. Croix, community composition included 45% coverage of the reef surface by *Acropora palmata* (the dominant coral), 30% algal turf, and 8% macroscopic algae (Rogers and Salesky, 1981). Correcting for percent cover and structural dimensionality, community gross production, net production, and respiration were estimated as 8.1, 5.5, and 2.6 g C/m^2/day, respectively (Rogers and Salesky, 1981). On San Cristobal Reef, Puerto Rico (4 m depth), 45% cover was by the coral *Acropora cervicornis,* and community net primary production (uncorrected for structure and cover) ranged from 0.04 - 6.7 g C/m^2/day (Rogers, 1979), half the corrected value (total mean value = 14.1 g C/m^2/day found on Tague Bay patch reefs (Rogers and Salesky, 1981). Community gross productivity measurements of a bank reef off St. Croix led Adey *et al.* (1977) to conclude that 27% was due to live coral production, 68% to benthic algal mats, and 5% to corralline algae. Total gross primary production of the back reef was 10.8 g C/m^2/day and the fore reef was 4.1 g C/m^2/day.

Gladfelter (1979) reported zooplankton densities for reefs of BIRNM. Plankton were more diverse and abundant on the fore reef (180 organisms/m^2) than the back reef (84 organisms/m^2) although overall biomasses were similar (E. Gladfelter, 1980a). Seasonal trends suggested that abundance of zooplankton was lowest in winter. The density and biomass of zooplankton off St. Croix were lower than off Puerto Rico, attributed to enrichment from land runoff (E. Gladfelter, 1980a).

Density and biomass estimates of reef fishes are not common in the literature because fishes are difficult to census on reefs, and the community is diverse and dynamic. Reef fish community structure changes

temporally and with environmental parameters (W. Gladfelter, 1980) and geographical locations. Correlates of species occurrence have included reef surface complexity, proximity to oceanic water, and reef height (W. Gladfelter, 1980), timing of recruitment of juveniles (Talbot *et al.*, 1978), and many others. Gladfelter *et al.* (1980) found that major differences in fish fauna of 25 reefs off St. Croix were due to gross structural differences of the reefs; six reefs off Anegada showed a high level of similarity in fish fauna due to structural homogeneity of reefs in that area. Proximity to nursery habitat, such as mangrove estuaries and seagrass beds, may further influence species occurrence and abundance. For example, Gladfelter *et al.* (1980) found that abundance and diversity of Pomadasydae on Anegada reefs were positively correlated with seagrass density; fish biomass and diversity were lowest where seagrass was absent.

Density estimates of shallow water reef fishes of St. John are available in Boulon (1985a) (Table 30), and these can be converted to biomass if weight is estimated from the lengths he recorded. Randall (1963) determined the fish biomass on two shallow (less than 5.5 m) fringing reefs off St. John to be 158 g/m^2 and 160 g/m2 (1,580 and 1,600 kg/ha). A nearby artificial reef had 1,740 g/m^2 (17,4000 kg/ha). The higher biomass on the artificial reef was due to the proximity of seagrass beds. Fast and Pagan-Font (1973) recorded a standing crop of fishes of 218.0 g/m^2 on an artificial reef off Puerto Rico, and a biomass of 23.3 g/m^2 on a nearby natural reef. Kimmel (1985) provided density estimates of the 19 most abundant fish species (84% of total fish abundance) (Table 29) and other species (Table 28) on a reef near La Parguera. Total fish density was 42,448 fish/ha. The most abundant were the bicolor damselfish (*Pomacentrus partitus*) (9,458 fish/ha), bluehead (*Thalassoma bifasciatum*) (5,773 fish/ha), and blue chromis (*Chromis cyaneus*) (3,935 fish/ha). Surveying five reef types off St. Croix, W. Gladfelter (1980) made density estimates of 128 diurnal reef species (Table 24). Adey *et al.* (1977) listed 13 species in 3 families as the most abundant species on BIRNM (Table 26), and Gladfelter *et al.* (1977) gave relative abundances at this site (Table 25). Clavijo *et al.* (1980) indicated relative abundances of reef fish species on St. Croix (Table 27).

5.3. Trophic Relations

Herbivorous fishes dominate tropical reef faunas throughout the world (Bakus, 1969; Ogden and Lobel, 1978). Herbivory accounts for the major flow of energy from primary producers in the coral reef ecosystem (Hatcher, 1981). On Caribbean reefs, there are over 60 species of herbivores, even excluding microinvertebrates (Carpenter, 1986). From 10 - 25% of the fish species are in the families Scaridae, Acanthuridae, and Pomacentridae (Parrish and Zimmermann, 1977; Ogden and Lobel, 1978), which are active in the top 20 m of the water column, where the greatest development and highest productivity of benthic plants occurs (Ogden and Lobel, 1973). Foraging of the herbivorous parrotfish has been described by Lobel and Ogden (1981).

Algal turfs on coral reefs are grazed significantly with 100% or more of the daily algal production removed by herbivores (Carpenter, 1985), whereas producers with more rigid plant structures, including macrophytes and encrusting corallines (sensu Steneck, 1982) may be consumed at lower rates. Grazing sea urchins, such as *Diadema antillarum*, may compete with herbivorous fishes for algal resources; the biomass of herbivorous fishes has increased on reefs where *Diadema* populations were severely reduced by blight (Carpenter, 1986). Studying parrotfishes (Scaridae), surgeonfishes (Acanthuridae), and sea urchins (Echinoidea), Ogden (1976) stated that "herbivores generally take food in proportion to abundance and availability." Atkinson *et al.* (1973) found that *Diadema* consumed plant species in proportion to their relative availability on a patch reef in the Virgin Islands; and, in St. Croix, an inverse relationship between algal biomass and urchin density was demonstrated (Carpenter and Gladfelter, 1979). Carpenter and Gladfelter (1979) found that about 20% of the *Diadema* population fed on live coral, at average feeding rates of 2.28 mm live coral surface/day.

Steneck (1982) presented herbivory rates on reefs of St. Croix; grazing of algal turfs ranged from - 0.79 g dry wt/m^2/day at 40 m depths (i.e. algal growth exceeded consumption) to 2.8 g dry wt/m^2/day at 10 m depths. Densities of grazing invertebrates peaked at 5 and 15 feet, where *Acmaea* and *Diadema* were present at 2 and 17.5 individuals/m^2 respectively (Steneck, 1982). Steneck found the most intense grazing in shallow fore reef sites, decreasing in bank reef and shallow algal ridges, and reaching a minimum in deep wall reef habitat, where benthic productivity was lowest. As in terrestrial grassland systems, herbivory on coral reef algae may result in higher overall ecosystem primary production (Carpenter, 1986).

The occurrence, abundance, feeding habits, and foraging behaviors of coral reef fishes have been summarized for the Caribbean (Randall, 1967) and, in less detail, for Puerto Rico (Parrish and Zimmermann, 1977), St. John (Randall, 1963), and St. Croix (Ogden *et al.*, 1975; Clavijo, 1979) specifically. On a reef in Puerto Rico, major trophic groups other than herbivores included pisivores (10.5% of the total fish fauna); macroinvertebrate carnivores (38%); planktivores (34%); and omnivores (3%) (Parrish and Zimmermann, 1977). W. Gladfelter (1980) described the abundance and distribution of trophic guilds on five reef types off

St. Croix, and found herbivores most abundant at lagoon sites, planktivores at fore-reef sites, and benthic invertebrate feeders at leeward sites (Table 35). Gladfelter and Johnson (1983) described the food habits of seven species of holocentrids, which comprised over 99% of the nocturally-active fishes off St. Croix, feeding primarily on benthic crustaceans. Simpson (1979) reported biomass data for two lagoonal patch reefs on St. Croix.

Robins (1971) suggested that few fishes fill the planktivorous niche in the Virgin islands because few reefs there are washed by steady, plankton-rich ocean currents. Small, recently recruited grunts (*Haemulon* spp.) feed diurnally on plankton above reef sheltering sites (Randall, 1983), and the cooper sweeper (*Pempheris schomburgki*) migrates diurnally from back-reef refuges to feed on meroplanktonic crustaceans (1 - 6 mm in size) along the fore-reef (W Gladfelter, 1980). W. Gladfelter (1980) found that diurnal planktivores comprised over 50% of the fish fauna (by number of individuals) at two fore-reef sites off St. Croix; planktivore density generally reflected zooplankton abundance, which, in turn, reflected nearness to ocean currents. Diurnal plantivores included blue chromis (*Chromis cyanea*), and black durgon (*Melichthys niger*).

The trophic importance of hermatypic corals is largely unknown, as only a limited number of reef species are known to coral tissues (Randall, 1967; Simpson, 1979). In St. Croix, grazing pressure on corals by parrotfishes was seasonal, occurring at low enough levels to allow regeneration of coral tissue (Simpson, 1979).

Sharks are likely top predators on coral reefs. Randall (1983) reported that most sharks consume fishes; nurse sharks also take invertebrates, and manta rays consume primarily molluscs, including conch.

5.4. Areal Extent

Coral reefs occupy 7,584 ha around St. John, St. Thomas, St. Croix, Culebra, and Vieques. There are no Landsat estimates of coral reef area for Puerto Rico, although estimates are available for Culebra (923 ha) and Vieques (245 ha). Bardach (1958) used US Hydrographic Office charts to determine the total coral reef area for Puerto Rico and the Virgin islands inside 30 and 100 fathom (55 - 183 m) contours as 2,500 and 4,250 mi^2 respectively.

In Puerto Rico, coral reefs have been inventoried (Pilkey and Fritz, 1976; Goenaga, 1979) and described (Lugo, 1978). Several shallow fringing reefs and a well-developed submerged reef (Boulon, 1980) occur off the east, south, and west coasts (Almy and Carrion-Torres, 1963). Off La Parguera, where the insular shelf is rather broad (Morelock *et al.*, 1977), two rows of reefs oriented east to west occur between the shelf break and the shore, and a sunken marginal reef occurs at the shelf break at 20 m depth (Gonzalez-Liboy, 1979). Margalef (1962) reported that coral reefs off La Parguera are of the marginal type, while Almy and Carrion-Torres (1963) and Kaye (1959) reported them as 'poorly formed or ribbon reefs" (Gonzalez-Liboy, 1979). The north coast of Puerto Rico has very few reefs, except as isolated coral colonies (Kaye, 1959; Almy and Carrion-Torres, 1963). Maximal reef development occurs along the south coast. where terrestrial runoff is low, the shelf is broad, and currents are stronger (Almy and Carrion-Torres, 1963), Pressick (1970) reported on a fringing reef at Icacos Island off the northeastern coast, and Szmant-Froeblich (1981) described reefs of Jobos Bay on the southeast coast.

Armstrong (1983) reported 3,584 ha of coral reefs surrounding St. Croix (Table 1). The reefs of St. Croix have been well-studied (Ogden *et al.,* 1972; Multer, 1974; Adey, 1975; Adey and Burke, 1976; Adey *et al.*, 1977; MacIntyre, 1972; Gladfelter *et al.*, 1977). Ogden (1980a) described each reef in detail, and reported the best development on the windward, or eastern, end of the island. Similarly Adey and Burke (1976) reported that throughout the eastern Caribbean, shallow reefs occur on the north, west, and south (windward) sides of major islands, whereas no major reef structures occurred on leeward sites. Smaller islands with partly protected lee shores often had horseshoe-shaped or encircling reefs.

The coral reefs of the eastern Virgin Islands, from Anegada southwest to Norman Isiand, were described by Adey and Burke (1976). North and east of Anegada, a well-developed, mixed coral reef and algal ridge system extends for more than 30 km. North of Virgin Gorda, 'several' reefs 'as much as' 3-km long exist. Extending from southeast of Virgin Gorda to Norman Island (35 km), there is little shallow reef development, except in bays and coves, due to the narrow and steeply sloping shelf in this area.

Landsat data in Armstrong (1983) show that coral reefs occupy 1,901 ha around St. Thomas (Table 1). Coral reefs of selected bays of St. Thomas have been described by Rogers (1982), although no areal data were provided. Armstrong (1983) reported 855 ha of coral reefs surrounding St. John (Table 1). Additional areal estimates could be derived form the maps in Kumpf and Randall (1961) using dot-grid calculations, or could be derived from percent cover estimates in Beets and Lewand (1984), given areal estimates of each bay.

Kumpf and Randall (1961) provided maps, but not detailed descriptions, of the marine habitats around St. John. Beets and Lewand (1984) provided more detailed descriptions of marine communities and qualitative descriptions of the extent of coral occurrence within the bays of St. John. They stated that coral reef cover, especially upper fore reef organisms, increased toward the windward (eastern) portion of St. John. Storm damage to corals in 1979 was reportedly extensive, particularly along the southeastern shore. Degradation of specific coral reefs due to visitor damage, sedimentation, or other environmental causes was discussed. Offshore areas (over 20-m depth) were reported to support occasional solitary corals.

Clifton and Phillips (1972), Stoeckle *et al,* (1968), and VIERS (1969) described small areas of St. John in detail, providing species inventories, coral zonation patterns, and percent cover estimates. Investigations conducted on St. John during the Tektite projects (1969 - 1971) were limited to Great Lameshur Bay and vicinity and did not describe areal extent of coral reefs (see Collette and Earle, 1972; Miller *et al.*, 1971; Risk, 1972). An environmental survey by Robinson (1972) presented quantitative data on the soft bottom community within Caneel Bay, while Grigg (1978) produced benthic maps and biological descriptions of Cruz Bay. Brody *et al.* (1970) studied water quality, sediments, and benthic communities of Chocolate Hole and Cruz Bay; and Sigma Environmental Systems (1977) produced similar information for Chocolate Hole. Studies that we did not review may provide further data on coral reefs of St. John (Beets *et al.*, 1984; Hoffman *et al.*, 1974).

6. ALGAL PLAINS

Algal plains are sandy-bottom habitats, with a diverse community of benthic flora and fauna covering 80 - 85% of the bottom (Dahl, 1973). Species composition of the community undergoes periodic changes under the influence of strong tidal currents and winds (Ballantine, 1984; Boulon, 1985b; Kimmel, 1985). Algal plains occur in a wide range of water depths, near coral reefs (Earle, 1972; Dahl, 1973), and in areas of strong currents around small islands (Boulon, 1985b). Sediments of the algal plain are coarse sand and coral rubble (Ballantine, 1977), providing little vertical relief except for an occasional patch reef, coral head, empty conch shell, or sand mound (Boulon, 1985b; Kimmel, 1985).

6.1. Species Occurrence

Sponges comprise the majority of the biomass of major (sedentary) faunal groups on the algal plains (Table 36) (Dahl, 1973), providing microhabitats for a variety of organisms. Tunicates, bryozoans, molluscs, polychaetes, and gorgonians comprise other faunal groups of the plains (Dahl, 1973).

Algal species that stabilize the sediment of algal plains include *Halimeda*, *Udotea*, *Caulerpa*, *Anadyomene*, *Agardhiella*, and *Gracilaria* spp. Large red algae (*Laurencia*, *Gracilaria*, *Halymenia*, *Dasya*, *Chondria*, etc.) are commonly attached to shells or coral rubble. A total of 384 species of benthic algae have been reported from Puerto Rico, Mona, Vieques, Culebra, and Desecheo in references given in Almodovar and Ballantine (1983), which provided an update to the list and noted the emphasis on algae of the La Parguera region. Predominant benthic plants of the algal plain are listed in Table 36 (Dahl, 1973).

Invertebrates are poorly inventoried for the algal plains of the PRVI area. Deep subtidal algal plains off Puerto Rico support many gastropod species, including *Strombus costatus*, *S. gallus*, *S. raninus*, *Xenophora conchyliophora*, *Astraea phoebia*, and numerous smaller species (Berg, 1975). Lobster occur on algal plains, although not as permanent residents (Berg, 1975). Other crustaceans occurring in the habitat include box crabs (*Calappa* sp.).

The low degree of structural complexity of algal plains may limit the sizes and numbers of fishes occurring there. Boulon (1985b) surveyed fishes of 'bank algae' areas in Pillsbury Sound, and concluded that 'the majority of fish (on the algal plain) are small, cryptic species with no commercial value' (with the exception of juvenile queen triggerfish), and that algal plains 'may serve as a nursery habitat for (fishes)... of commercial importance...' but that '-juveniles are hard to detect' on visual surveys. Kimmel (1985) surveyed fishes of the algal plain (his 'rubble/sand biotope'), listed the 10 most abundant fish species (eight families) (Table 37), and described a characteristic species group (Table 38). Six of the species - sand tilefish (*Malacanthus plumieri*), bluelip parrotfish (*Cryptotomus roseus*), yellowhead jawfish (*Opistoganthus aurifrons*), tobaccofish (*Serranus tabacarius*), chalk bass (*S. tortugarum*) and hovering goby (*Ioglossus helana*) - were present in over 95% of the samples taken visually.

6.2. Biomass and Primary Productivity

Dahl (1973) surveyed the macroalgae of the algal plains southwest of Mayaguez, Puerto Rico, at 35 m depth, and provided biomass estimates for major constitutents (Table 39). Both the density and diversity of algae increases with distance from nearby reefs because of grazing by reef fishes. *Halimeda* spp., with a biomass of 281 g wet wt/m^2, was the dominant component by percent cover and wet weight on algal plains surveyed. Qualitative abundances of other algae are given in Table 36 (Dahl, 1973). Sponges dominated the sedentary faunal group of the algal plain. Estimates of invertebrate and fish densities on algal plains are few. Berg (1975) reported a mean density of 1 conch/153 m^2.

6.3. Trophic Relations

Dahl (1973 reported only light grazing pressure by herbivorous fish on the algal plain. Sponges are consumed to a small extent by certain fishes (Randall, 1983). The major herbivores of algal plains are snails, which graze on macroalgae and epiphytes (Berg, 1975). Food habits of *Strombus* and other herbivorous gastropods are given in Robertson (1961). Growth and mortality of juvenile queen conch (20 - 50 mm length) on the algal plain were investigated by Appeldoorn and Ballantine (1983). Conch grew an average of 0.21 mm/day (s. d. = 0.072, n = 36) at Media Tuna, Puerto Rico, a statistically faster rate than in seagrass beds or control tanks. Mortality at Media Luna averaged 0.9%/day, although in one experiment mortality was much higher (4 - 5%/day). The variable and often high mortality rates led Appeldoorn and Ballantine (1983) to conclude that algal plains were not necessarily a preferred or optimal habitat for juvenile conch. Growth and mortality estimates from earlier studies are reviewed by Wood and Olsen (1982). Small conch have numerous predators, including octopus and other gastropods, hermit crabs (Randall, 1964; Appeldoorn and Ballantine, 1983), box crabs (Shoup, 1968), and lobsters (Randall, 1964; Barr *et al.,* 1971). In one study by

Randall (1964), the only major predators on large conch were the spotted eagle ray (*Aetobatus narinari*), the southern stingray, and the loggerhead turtle (*Caretta caretta*).

6.4. Areal Extent

Studies of specific algal plains provide the greatest source of information on areal extent. For example, Boulon (1985a) examined a 'bank algae' site in Pillsbury Sound between St. Thomas and St. John and reported 'low rolling sand mounds ... densely colonized with algae, sponges, and a few species of coral.' Another well-studied site is Media Luna, south of La Parguera, Puerto Rico (Dahl, 1973; Ballantine, 1977). Other algal plains have been described in Great Lameshur Bay, St. John (Earle, 1972), and off the north coast of Puerto Rico and surrounding islands (Almodovar and Ballantine, 1989). Dahl (1973) considered the algal plains in Great Lameshur Bay, St. John, similar to those in Media Luna.

7. SAND/MUD

The sand/mud subsystem includes all non-'live bottom' habitats (sensu Struhsaker, 1969), or those with low percent cover (<10%), and associated demersal fishes of the open shelf, shelf-edge, and lower shelf to 100 fm (183 m). Sandy and mud bottom habitats are wide-ranging, found in coastal and shelf areas, and include inshore, sandy areas separating living reefs from turtle grass beds and shorelines; rocky bottoms near rocky shorelines; and mud substrates along mangrove shorelines (VIERS, 1969) and near river mouths (Erdman, 1956).

7.1. Species Occurrence

Molluscs, and particularly gastropods, are a characteristic fauna of sand/mud habitats in the Caribbean. Maes (1983) listed eight species of turrid gastropods - *Drillia cydia, Strictispira paxillus*, *Pyrgospira candace*, *Buchema interstriata*, *Crassipira apicata*, *C. pellisphocae*, *Pilsbryspira albomaculata* and *P. leucocyma* - occurring in 2 - 4 m depth on fine calcareous sand near Tortola, BVI. Queen conch and milk conch (*Strombus costatus*) occur in soft-bottom euphotic habitats and on sandy bottoms with coral rubble and macroalgae (Appeldoorn, 1985). The growth, food habits, life histories, and mariculture of gastropods in Puerto Rico have been reported by Robertson (1961), Randall (1964), Appeldoorn and Ballantine (1983), Ballantine and Appeldoorn (1983), and Appeldoorn (1984).

Deposit-feeding echinoderms, including the asteroid *Oreaster reticulatus* and the spatangoid *Meoma ventricosa*, co-occur on subtidal sand-bottom habitats in the Caribbean (Scheibling, 1982). Few studies of crustaceans have been conducted in the PRVI area. 'Bank pavement' areas north and south of St. John, where undercut edges provide shelter, are important reproductive habitats for both spiny lobsters (*Panulirus argus*) and demersal fishes (Boulon, 1985b). The Spanish, or sand, lobster (*Scyllaridea aequinoctialia*) occurs in sandy habitats and is occasionally caught in lobster traps (Idyll, 1971). Olsen *et al.* (1978) reported that *Portunus spinimanus*, a potentially exploitable species, was most abundant on 'flat sand bottom areas offshore from shoals' in depths of 14 - 32 fm. The Cassidoloid urchin, *Cassidulus caribbearum*, occurs in localized populations of high densities (up to 100/m^2) on the PRVI shelf, principally in shallow water areas with coarse sand bottoms (W. Gladfelter, 1978).

Both demersal and pelagic fishes occur in sand/mud areas. In one study, 60% of fish species observed in sand flat areas near reefs were demersal, while the remaining 40% were 'pelagic mid-water' types (Parrish, 1982). Randall (1983) listed 36 fish species occurring in sand/mud habitats (Table 40). Most species in the family Gerreidae, including *Diapterus* and most species of *Eucinostomus*, occur in these habitats, as do red goatfish (*Mullus auratus*), dwarf goatfish (*Upeneus parvus*), and lizardfishes (Synodontidae). The garden eel (*Nystactichthys halus*) and several species of snake eels (Opichthidaeae) live in burrows in sandy areas. Silversides (Atherinidae) occur over sandy bottoms as well as in seagrass and reef areas. Small schools of adult white mullet (*Mugil curema*) and young mullet of several species are found along clear-water sandy shores. Barracuda are common along 'turbid, silty shores'. Threadfins (Polynemidae) are 'adapted' for life on mud and sand bottoms, and occur in sandy areas near reefs (Randall, 1983).

A variety of sand/mud communities, each with a similar bottom type but varying in topography, depth, and location, have been described around St. John, and the fish fauna varies accordingly. Habitats such as 'shallow bay pavement', 'fore-reef pavement' (with and without ledges), and 'bank pavement', were censused by Boulon (1985a) for fish species of commercial importance, and 35 species were recorded (Table 41). In protected bays of St. John with a bottom cover of 'subtidal bedrock', Boulon (1985a) found 29 fish species of commercial importance (Table 42). Four species, including yellowtail snapper (*Ocyurus chrysurus*), coney, doctorfish (*Acantharus chirurgus*), and parrotfish (Scaridae), occurred frequently and in large numbers. Species that were moderately abundant included porgies (Sparidae), yellow goatfish (*Mulloidychthus martinicus*) and squirrelfish (Holocentridae). Dwarf herring (*Jenkinsia lamprotaenia*) were common and occurred with schools of blue runner (*Caranx crysos*), mackerel (Scombridae), and bar jack. Average fish size was smaller in the subtidal bedrock habitat than in the more seaward habitats. Sixteen fish species, including adults of several major fishery species (Boulon, 1985b), were observed in 'bank pavement' habitats in other areas near St. John (Table 43). The proximity of reefs was reflected by the occurrence of typical reef species in these areas.

Sylvester and Dammann (1973) captured large silk snapper (*Lutjanus vivanus*) in deep water over mud bottoms; this may be the only deep-water snapper using muddy substrates (Rivas, 1970). In Puerto Rico, mud bottoms are used by snake eels (Opichthidae; *Opichthus* spp.), conger eels (Congridae; *Conger* spp. and *Kaupichthus* sp.), croaker and drum (Sciaenidae; star drum (*Stellifer lanceolatus*), *Ophioscion*, and banded drum (*Larimus fasciatus*)), and by anchovies (Engraulidae; anchoveta (*Cetengraulis mysticetus*) (Erdman, 1956). Snook and tarpon were abundant in, but not restricted to, muddy habitats (Erdman, 1956).

Open sand beaches and adjacent shallows of Puerto Rico support small pompano (Trachinotus sp.), threadfin (Polynemidae), and sardines (*Harengula* sp.), while in adjacent deeper waters, scads (*Trachurus* spp., *Decapterus* spp.), frigate mackerel (*Auxia thazard*), and other Scombridae occur (Erdman, 1958b). Sheepshead porgy (*Calamus penna*) was the most numerous species observed in areas of low overall fish density on sand flats near reefs off Puerto Rico (Parrish, 1982). Ocean triggerfish (*Canthidermis sufflamen*) reproduce and guard young in sandy areas (20 m depth) and rocky areas (15 m depth) off St. Croix (Nellis, 1980).

Extensive sand/mud flats, often located behind reefs, provide habitat for bonefish (*Albula vulves*) (Erdman, 1960); Randall, 1983). Bonefish are limited by the sparseness of this habitat in the PRVI area, and have been observed most frequently (Erdman, 1960) at the following locations: the east coast of Culebra; the south and northeast coasts of Vieques; La Parguera, Puerto Rico; Los Morrillos, Cabo Rojo lighthouse; Boqueron, Cayo Fanduco; Bramadero Bay south of Mayaguez; east side of Cabros Island; Mameyes River to Luquilo Beach; south coast of St. Croix; Leinster Reef, and Fish Bays, St. John; Water isle and Benner Bay, St. Thomas; and, the south coast of Anegada, BVI. Bonefish larvae (45 - 64 mm) occur in 'shallow protected areas' (Erdman, 1960).

Nine species of rays (Dasyatididae), including most commonly the southern stingray (*Dasyatis americana*) and yellow stingray (*Urolophus jamaicensis*), occur in sandy areas, where they excavate depressions (Randall, 1983). One shark species, the Atlantic sharpnose shark (*Rhizopriodon terraenovae*) was captured on a sand flat near a reef off Puerto Rico (Parrish, 1982).

7.2. Biomass and Primary Productivity

Aside from benthic diatoms that may characterize sand/mud areas, it is likely that little or no primary productivity occurs in these habitats. No measures of diatom biomass or productivity have been located for this habitat. Detrital inputs from pelagic production, from inshore areas, or from the reef tract may enrich sand flat areas (Parrish and Zimmermann, 1977).

Abundance, spatial distribution and size structure of a large-bodied echinoderm, (*Oreaster reticulatus*), have been described for a population off St. Croix (Scheibling, 1980a). No other invertebrate densities for sand-bottom areas have been located.

Fish biomass in sand/mud habitats was estimated by Boulon (1985a) (Table 41). No other estimates of fish biomass were located. In general, higher catches (biomass) of fishes in traps have been reported from sandy areas near reefs than from traps placed directly on reefs, despite a higher overall fish density on reefs (Parrish, 1982). This suggests that limited shelter in open sandy areas may account for the lower species diversity and abundance there relative to reefs.

7.3. Trophic Relations

Little information on trophic relationships is available for the sand/mud habitat in the PRVI area. A demersal-based food web, however, is likely, since these areas offer little or no shelter for mid-water or planktivorous species during non-feeding hours. Diets of fishes in sand/mud habitats have been quantified generally. Gerreids feed on small benthic invertebrates such as polychaetes, sipunculide, mollusks, crabs, shrimps, amphipods, and other crustaceans (Randall, 1983). Goatfishes (Mullidae) consume primarily infaunal benthic organisms; lizardfishes (Synodontidae) take primarily small fishes; snake eels (Ophichthidae) consume octopuses, fish, and crabs; silversides (Atherinidae) are planktivorous; mullet (Mullidae) consume detritus and algae; rays (Dasyatidae) take primarily benthic invertebrates and occasionally take fishes (Randall, 1983). Bonefishes consume primarily small clams (44% of total diet) also taking crabs (33%), shrimp (11%), snails (5.6%), and worms, fish, etc. (5.6%); four larger bonefishes were found to take parrotfish, grunts, gobies, filefish, and eels (Erdman, 1960). On flats near leeward reefs, bonefish consumed more snails and fewer clams, but on average the diet was similar at Culebra and La Parguera, suggesting the general nature of the bonefishes' food habits (Erdman, 1960).

Filter-feeding and deposit-feeding organisms are likely to be common in sand/mud habitats, although just two site-specific studies of these trophic groups have been located. In one study, Scheibling (1982) described the spatial and temporal patterns of distribution and abundance and rates of bioturbation of *Oreaster reticulatus* and *Meoma ventricosa*, two large-bodied deposit feeders co-occurring on subtidal sand-bottom habitats of St. Croix. Food habitats of *Oreaster* were also described (Scheibling , 1980b, 1981). In a second study, the predators of *Cassiculus caribbearum*, a deposit-feeding urchin abundant along the north shore of Anegada, were described (W. Gladfelter, 1978). The major source of mortality for this species was predation by the gastropod *Cassia tuberosa*. Other predators included *Calappa* sp. (crab), *Phallium*

granulatum, palometa (*Trachinotus goodei*), and yellowhead wrasse (*Halichoeres garnoti*) (W. Gladfelter, 1978).

7.4. Areal Extent

The sand/mud habitat occurs in close association with nearly all other demersal habitats. A few references describe specific areas as having sand/mud bottoms. Along the southern sides of Anegada, Buck island, and St. Croix, for example, white, unconsolidated sandy bottoms extend for 'many square miles'. With scattered coral heads making up 10 - 30% of the substrate (VIERS, 1969). Areas of subtidal bedrock, ranging in depth from 0 - 3 m, fringe a large part of the coastline of St. John and are often covered with algal turf and various invertebrates, including live corals, which may cover 5 - 10% of the surface (Boulon, 1985a). Shallow bays of St. John have 'pavement' areas; not associated with adjacent reefs, that are 'flat, featureless bottoms of hard carbonate substrate' with a thin sand layer (Boulon, 1985a). Also extensive around St. John are 'fore-reef pavement' areas which are 'similar in appearance to shallow bay pavement areas but are located near reefs and may have extensive ledges' (Boulon, 1985a). Seaward of the inshore reefs are 'bank pavement' areas included in the sand/mud subsystem. Areas of 'raised hard-bottom' or 'bank pavement' occur around St. John, and have undercut edges that provide shelter for fish and crustaceans (Boulon, 1985a). Other sandy areas occur in shallow areas where currents are strong (Boulon, 1985a) and in the deepest water areas. Boulon (1985b) included 'The Narrows' between St. John and Tortola in the sand/mud habitat. Shallow bay pavement occurs in Reef Bay, Grootpan Bay, Hawksnest Bay, Honeymoon Bay, and Maho Bay (Boulon, 1985a). W. Gladfelter (1978) described a sandy lagoon, Loblolly Bay, on the north shore of Anegada Island, BVI.

Overall, approximately 50% of the PRVI shelf platform has a smooth bottom of intermixed sand and coral rubble, while the other half consists of isolated live coral heads interspersed with dead coral rubble (VIERS, 1969). Dead coral rubble dominates the edge of the 100-fm (183 m) contour (VIERS, 1969), and extensive barren rocky or mud substrates may occur just before the shelf break at 100 fm (Nelson and Appeldoorn, 1985). Boulon (1985b) interpreted contours off the southwest of St. John as hard-bottom, or 'bank pavement' areas, and stated: "it is unknown how much of the insular shelf south of St. John is comprised of this habitat," not finding any consistent correlates with sand/mud occurrence on nautical charts.

8. SHELF BREAK

A narrow but productive demersal zone, the 'shelf break', occurs below the depths of the coral reefs on the insular shelf. We have designated this area as the shelf break because of its steep vertical relief, and have included it as a subsystem because, although little information exists on this area, it appears to be potentially significant in both an ecological and fishery context.

Submersible studies provided a description of the bottom area of the shelf break, moving from the slope up to the shelf (Nelson and Appeldoorn, 1985). The slope of the sea bottom increased from 5 to 30 degrees from 250 to 150 fm (457 - 274 m), where the bottom type was primarily sand and silt. At 150 fm, rubble provided habitat for several species of snapper but few invertebrates. [Much of the rubble in this zone may be debris from inshore coral reefs displaced during hurricanes (Mitchell-Tapping, 1983).] From 150 to 100 fm, the slope of the sea bottom increased from 30 to 50 degrees, and sand and loose rubble was predominate. At 100 fm, a steep, smooth rock wall housed small fishes but still few invertebrates, although ambient light and fish densities increased markedly to 50 fm (91 m). The shelf break, from 100 - 150 fm, was extremely narrow but very steep, being nearly vertical in some areas, and provided a complex structural habitat for fishes. Above 50 fm, the slope dropped to 20 - 30 degrees, and above a narrow rubble zone, a typical tropical reef habitat was evident.

8.1. Species Occurrence

The deep-water fish species of the shelf break were described by two exploratory fishing studies around Puerto Rico and the US and British Virgin Islands, one conducted in 1965-69 (Kawaguchi, 197) and a second conducted in 1970-72 (Sylvester and Dammann, 1974). In the former study, eight sites at depths of 20 - 130 fm (37 - 238 m) were sampled around Puerto Rico, St. Thomas, Anegada, and Barracuda Banks, southeast of Anegada. Sixty-one percent of the catch (by weight) was snapper, 15% jack, and 22% grouper. Snapper species included silk, blackfin, yellowtail, vermilion (*Rhomboplites aurorubena*), schoolmaster (*L. apodus*), volaz, and dog (*L. jocu*). Serranids included misty grouper (*Epinephelus mystacinus*), Nassau grouper (*E. striatus*), yellowfin grouper (*Mycteroperca venenosa*), yellowmouth grouper (*M. interstitialis*), coney, and red hind (*E. guttatus*). Carangids included black jack (*Caranx lugubris*), horse-eye jack (*C. latus*), green jack (*C. caballus*), bar jack (*C. ruber*), almaco jack (*Seriola rivolina*), and amberjack (*Seriola* sp.).

In the second exploratory study, six geographic areas (north of St. Thomas and Jost Van Dyke; south of St. John; north of Anegada; southeast of Anegada and Virgin Gorda; St. Croix; and, southwest of St. Thomas) were not significantly different in yield or number of species, suggesting a uniformity of habitat use and habitat type across this area of the shelf. The dominant species caught was the silk snapper, followed by blackfin snapper (*L. buccanella*). A total of nine species of lutjanids, 10 species of serranids, two brachiostegids, one pomadasyid, and one holocentrid were caught.

Several studies have provided additional information on fish species found in the region of the shelf break. Olsen and LaPlace (1978) reported large spawning aggregations of Nassau grouper, red hind, and yellowfin grouper at the 100-fm contour 13 km south of St. Thomas. Boardman and Weiler (1980) reported that three species of snapper (silk, blackfin, and vermilion) were widely distributed and numerous in 70 -100 m depths around Puerto Rico, Vieques, Mona, and Desecheo. They found 62 fish species altogether. Silk and blackfin snapper were the most abundant snappers taken by fishing in deep water in the Virgin Islands; depth distribution of the silk snapper was 40 - 175 fm (73 - 320 m) and of the blackfin, 5 - 120 fm (9 - 219 m) (Sylvester *et al.*, 1980), indicating their occurrence within the shelf break subsystem, although juveniles of these species occur in shallower habitats (Sylvester *et al.*, 1980). In bottom fishing surveys off St. John, Idyll and Randall (1959) found seven species, including queen triggerfish (*Balistes vetula*), Nassau grouper, coney, red hind, squirrelfish (Holocentridae), porgies (Sparidae), and sand tilefish (*Malacanthus plumieri)* (Table 44).

Twelve fish species observed during submersible studies of the PRVI shelf slope included seven species below 100 fm (Table 45) (Nelson and Appeldoorn, 1985). Five snapper species and no groupers were observed below 150 fm. From 150 - 100 fm, two species of grouper (coney and misty grouper) and five species of snapper were observed, Several of these snapper species, referred to collectively as 'chillo', make up a major component of fishery landings - approximately 10% by weight - in Puerto Rico (Weiler and Suarez-Caabro, 1980). Prominent among these is the silk snapper.

8.2. Biomass and Primary Productivity

The shelf break occurs below the photic zone, and no primary productivity is expected to occur there. Rather, detrital input from surface and inshore production (for instance from phytoplankton, mangrove forests, and seagrass beds) may fuel its trophic webs, but no estimates of detrital input rates or detrital

standing stocks are available. If upwelling occurs at the shelf break, this may stimulate greater primary productivity and resultant phytoplankton 'rain' above the shelf break than elsewhere.

Using data from submersible studies (Nelson and Appeldoorn, 1985), overall fish density in the 150 - 100 fm zone was calculated to be 14.05 fish/ha. Within 100 - 50 fm - the area of the shelf break - fish density increased markedly to 32.81 fish/ha. We used an average of 1.6 kg wet wt/fish (Nelson and Appeldoorn, 1985) to derive estimates of 1.4, 3.3, 22.5, and 52.5 kg wet wt/ha, respectively, for depth categories of 250 - 200, 200 - 150, 150 - 100, and 100 - 50 fm. (It is possible that average weight changes with depth and this was not considered in these estimates.) By comparison, Randall (1963) found 1,590 kg/ha on a shallow coral reef off St. John. Thus, areas over 100 fm in depth are relatively low in secondary production, having 10 - 30 times less fish biomass than shallow coral reefs, although having much higher biomass than areas lower on the slope. These results contradict certain results from exploratory surveys of Sylvester and Dammann (1974), who reported that differences in fish abundance (yield) with depth were not significant statistically, but of interest; higher mean yields came from 75 - 99 fm (137 - 181 m) and 150 - 174 fm (274 - 318 m), whereas lower yields came from 50 - 74 fm (91 - 135 m). (Yield was defined as the number of fish caught per hour of fishing, and yield-with-depth data were apparently collected, but not published.) Without quantitative data from the latter study, however, the extent or sources of disparity between this and submersible studies remain unknown.

8.3. Trophic Relations

No information on food web relationships in the shelf break subsystem has been located.

8.4. Areal Extent

The zone of the shelf break is extremely narrow, comprising little more than a thin line on a two-dimensional map; the 40, 50, and 100 fm contour lines are virtually superimposed. Boardman and Weiler (1980) reported that the insular shelf of Puerto Rico included drop-offs of 200 - 300 fm (366 - 549 m) across a horizontal distance of 0.4 - 0.6 km. Kawaguchi (1974) reported total length of the drop-off around the PRVI arcs of 776 km. With a depth extent of 100 m, nearly vertical slope (0.5 km), and length of 776 km, the total surface area of the shelf break can be estimated at 78 km

9. PELAGIC ZONE

Shallow limestone platforms surrounding the islands of the West Indies underlie the pelagic zone, defined as 'open ocean beyond the coastal fringes to the depth of light penetration, at about 100 m' (Cushing, 1976). The pelagic subsystem explicitly includes the habitat of pelagic fishes, while the benthic component of these areas, including demersal fishes, is included in other subsystems (Fig. 1).

9.1. Species Occurrence

Documentation of species occurrence in the pelagic zone is sparse; six references to zooplankton, three lists of fish species, and four additional references to fishes were reviewed. Information on smaller, non-commercial species of the pelagic zone of the Caribbean is lacking. Stomach contents of larger pelagic fishes provide inferential data on smaller organisms (Table 46) (Erdman, 1958a); included as prey of 11 predator species were 49 fish species and various invertebrates. Floating objects influence the distribution of pelagic species and may be a means of transportation from other geographic areas (McKenney, 1965). Young flying fishes, for example, are often associated with *Sargassum* and *Thalassia* debris, where they shelter from predators (Breder, 1932; McKenney, 1965). Certain pelagic onidarians have characteristic faunal associates, and species such as *Physalia* consume juvenile fishes that are attracted to them for shelter (McKenney, 1965).

Zooplankton of the pelagic zone comprise three ecologically distinct groups; organisms that remain small, organisms that change their habitat with age, and organisms that grow but remain pelagic (McKenney, 1965). In the first group, Owre (1968) (from VIERS, 1969) reported that the eastern Caribbean serves as a 'nursery area' for zooplankton. Zooplankton species are listed along depth gradients in the PRVI area in Owre (1976). The greatest species diversity of zooplankton is found in deeper waters, and high numbers of few species occur in the upper 100 m of the pelagic zone (Owre, 1968), The second group of zooplankton include larvae of inshore species such as lobster (*Pagalirus arana*) (Idyll, 1971) and French grunts (McFarland, 1979), among many others. Larvae of the spaghetti eel (*Moringua edwardsi*) occur in the upper 35 m of the pelagic zone close to Puerto Rico and the Virgin Islands, and move to offshore, northern waters as they mature (Castle, 1979). In general, the Caribbean islands may be reproductive centers for larvae dispersed into the Atlantic by the Gulf Stream. In the third group, exocoetids, tuna, bilifishes, and numerous pelagic crustaceans, among others, spend their entire life cycles in the epipelagic zone (McKenney, 1965).

Off St. Croix, the pelagic zone is 'typical habitat' for the adults of 36 fish species (Table 47) in 13 families (Table 48) (Clavijo *et al.*, 1980). Eight 'common' species include flying fish (*Cypselurus heterurus*), ballyhoo (*Hemiramphus brasiliensis*), blue runner, wahoo (*Acanthocybium solanderi*), little tunny (*Euthynnus alletteratus*), king mackerel (*Scomberomorus cavalla*), sailfish (*Istiophorus platypterus*), and blue marlin (*Makaira nigricans*). Off the north and south coasts of St. John, the most common pelagic fish taken on line surveys by Idyll and Randall (1959) was little tunny; also common were cero, bar jack, blue runner, yellowtail, and king mackerel, as well as 13 less frequent species (Table 49). A third list of pelagic fish species included 28 'primarily offshore' species (Table 50) (Randall, 1983), including many bottom-associated species such as lutjanids. Many fish species apparently use both pelagic and benthic habitats. Pelagic fish species that often occur over reefs and are referred to as 'reef-indifferent' species, include Atlantic thread herring *Ophisthonema oglinum*), bar jack, and horse-eye jack (Parrish, 1982).

In other reports of fish species in the pelagic zone, two species of Istiophoridae, including the Atlantic sailfish (*Istiophorus albicans*) and the white marlin (*Tetrapturus* albidus), occur in the PRVI area (FAO, undated). (The blue marlin was not included as occurring in the shelf area on maps provided in the FAO report, although references to 'off St. Thomas' and 'off Puerto Rico' were made in discussions of its occurrence.) Fourteen world records for king mackerel, blue marlin, skipjack tuna (*Euthynnus pelamus*) and wahoo have been declared from the PRVI shelf (Walter, 1983a; FAO, undated).

9.2. Biomass and Primary Productivity

Primary production in the pelagic zone of the PRVI area is 'low overall', and varies 'apparently at random within relatively narrow limits' (Martinet and Saint Felix, 1982). The area is characterized by clear waters with low concentrations and rapid recycling of nutrients that control levels of production (Riley, 1972; Martinez and Saint Felix, 1982). Low phytoplankton production is characteristic of oligotrophic tropical waters (Margalef, 1968), where nitrogen may be limiting (Beers *et al.,* 1965; Thomas, 1970; Dugdale, 1967; Corredor, 1979). The passage of oceanic waters near island masses causes an upwelling of deeper, ammonia-rich waters; the resultant 'fertilization' of surface waters often produces local phytoplankton blooms (Corredor *et al.*, 1984). In central pelagic areas, net primary production has been reported to increase from 20 to 100 g C/m^2/yr to over 400 g C/m^2/yr where such 'fertilization' occurs (Margalef, 1971). Margalef (1971)

described temporary upwellings in the Caribbean pelagic zone, although Beers *et al.* (1965) considered upwellings unlikely, given temperature and salinity gradients.

Primary production measurements in bays of St. Thomas and St. John have ranged from 0.4 to 126 mg $C/m^3/hr$ (Table 51) (Burkholder and Damman, unpubl., in VIERS, 1969). Depth data showed that surface productivity levels extend at least to 25 m (Table 52, from VARS, 1969). Offshore blue waters of southern Puerto Rico had an average productivity of 5.0 mg $C/m^3/hr$ (Burkholder *et al.*, 1972). Productivity reached 45 mg $C/m^3/hr$ in shallow waters. Additional productivity data may be available in Gonzalez (1966) and Steven *et al.* (1970).

Estimates of phytoplankton biomass in the northeastern Caribbean give cell numbers between 2 and 200 per milliliter with carbon estimates of 0.7 to 5.0 g C/m^2 (Margalef, 1971). The greatest populations of phytoplankton occur in the thermocline and/or at the 1% light level (Wood, 1968; VIERS, 1969), which varies seasonally from 50 m in August to 100 m in January (Perlroth, 1968, in VIERS, 1969). These estimates of phytoplankton biomass may not accurately reflect productivity because the nannoplankton (less than 60 µm) that were not included in samples account for ten times the photosynthesis of net plankton in the Caribbean Sea (Malone, 1971, from Pomeroy, 1974).

Zooplankton may occur in the pelagic zone at levels equal to or greater than phytoplankton (Margalef, 1971). Biomasses for selected zooplankton species are given in ONR (1976). Farther reference to species numbers can be found in VIERS (1969).

No quantitative data on fish abundance in the pelagic zone of the PRVI area have been located. Qualitative abundances are presented in Tables 47 and 49.

9.3. Trophic Relations

Food habits of 11 species of pelagic fishes around Puerto Rino have been described by Erdman (1958a). Cursory analysis of Erdman's data indicated that pelagic 'young shore' fishes (probably juvenile reef and seagrass species) supported the majority of production of three major families of pelagic fishes. For Istiophoridae (three species), scombrids provided the main prey (32.5% of total diet), while 'young shore' fishes were next in importance (26.4%), followed by cephalopods (12.0%), carangids (10.8%), and other groups that were minor in the diet (total = 12.3%). Half of the diet of the Coryphaenidae (represented by one species) was 'young shore' fishes. Exocoetidan consumed 'young shore' fishes as 23% of the family's overall diet. (All of the above percentages were in terms of number of prey items rather than volume or weight, as these were not measured.)

FAO (undated) described food habits of three species of Istiophoridae that occur in the PRVI area. Atlantic sailfish (*Istiophorus albicans*) is the least oceanic of Atlantic billfishes migrating often to nearshore waters, where it feeds diurnally on small forage fish. Food of larval Atlantic sailfish consists primarily of copepods; but, after growth of a few millimeters, the diet shifts to predominantly fishes. Adult sailfishes feed mainly on pelagic fishes such as little tunny, *Hemiramphus* spp., *Trichiurus lepturus*, *Strongylura notatus*, *Caranx ruber*, *Lagodon rhomboides* and squids. They also take bottom-dwelling prey such as sea robins (Triglidae), cephalopods, and gastropods. The Atlantic blue marlin feeds on dolphin (Coryphaena) and tuna-like fishes, which were predominant in number and volume in marlin stomachs off Puerto Rico. The size range of prey taken by blue marlin was wide, including fishes of 20 - 120 cm total length, octopods from 35 - 81 cm; prey of the samesized blue marlin have included a 38-mm postlarval surgeonfish and an 11-kg squid. The Atlantic white marlin occurs in deep (>100 m) blue water, particularly over steep bottom topography, and, at least in the Gulf of Mexico, feeds (in order of preference) on squid, dolphin, blue runner (*Caranx crysos*), mackerel, flying fish, bonito, cutlassfishes, swellfishes, herrings, barracudas, moonfishes, triggerfishes, remoras, hammerhead sharks, and crabs.

Sharks are largely unstudied in the pelagic zone of the Caribbean, although recognized as top predators in the Gulf of Mexico (e.g., Baughmann and Springer, 1950). In studies of food habits of six oceanic shark species near St. Croix, Clavijo *et al.* (1981) found that the primary food of all six was fishes. The Atlantic manta (*Manta birostris*) was reported by Clavijo *et al.* (1980) to consume plankton, although Randall (1983) stated that it consumed molluscs while foraging over reefs.

The role of cetaceans in the pelagic environment has recently been noted by Hain *et al.* (1985), who argued that effective management of fisheries requires an understanding of the trophic role of larger marine mammals as predators. Ocean birds that consume fishes may also have a role in the pelagic! food web of the PRVI area.

9.4. Areal Extent

CFMC (1983) reported that the Puerto Rican - Virgin Islands shelf covers 10,000 km^2. The area over the shelf break is two estimated as 78 km^2.

10. DISCUSSION

Over 200 sources are cited in this report; hundreds more were reviewed. Only information specific to understanding and quantifying energy flow through the ecosystem was included. The major body of information came from 11 surveys of the area: Austin and Austin (1971) off western Puerto Rico; Boulon (1985a, 1985b) off St. John; Clavijo *et al.* (1980) off St. Croix; Idyll and Randall (1959) off St. John; Kimmel (1985) off La Parguera, Puerto Rico; Negron and Cintron in Puerto Rican estuaries; Nelson and Appeldoorn (1979) on the insular platform shelf; Ogden and Zieman (1977) off St. Croix; and Stoner (1988) in Laguna Joyuda, Puerto Rico. Nearly 50 species lists were taken directly from survey reports or compiled from them. In addition, lists were compiled from Randall's 1983 book, "Caribbean Reef Fishes".

In future analyses, the species lists will help us further define the subsystems and identify their interconnections, and will be combined with food habits data to develop trophic groups and estimate biomass. Comparisons among species lists are complicated by the use of different survey methods and even by the use of the same survey methods in different habitats. We found, for instance, that the compressive sampling methods used by Austin and Austin (1971) in mangrove estuaries revealed a larger number of cryptic and rare species than the visual methods employed by Kimmel (1585), Boulon (1985a, 1985b), and others. Presumably, the greater the physical structure in a habitat, the lower the efficiency of visual methods for revealing cryptic taxa, which may, in some cases, be extremely abundant. Furthermore, Kimmel (1985) tested three different visual methods and found that they gave different results. Boulon (1985a and 1985b) used a fourth visual method to provide quantitative density estimates for several habitats. In comparing species lists, therefore, we must assume, with caution, that differences in sampling techniques among studies are secondary to differences in fauna among the sites that were sampled. This allows us to proceed with a more extensive analysis of the data at hand. We can already see, for instance, that the same subsystem sampled at different sites may differ considerably in species composition. Preliminarily, we attribute this variation to the influence of neighboring subsystems. A larger-scale analysis of the sites that were sampled is apparently in order in future analyses. Finally, as a result of our experiences with these species lists, we make the general observation. To provide a good basis far ecosystem studies, it is important that future survey work use methods that will provide density estimates. Unfortunately for this approach, Kimmel (1985) presented fish density per unit time in his original work; we developed an index relating unit-time to unit-area, using the results of his comparison of the survey techniques to calculate appropriate densities. In addition, average fish weights or length-frequency distributions are very useful in estimating biomass from density.

The major work of Randall (1967), other Randall studies, and studies by Erdman (1958a) and others were used to determine the general food habits of the fishes of the PRVI area. Randall (1967) measured the relative volume of various dietary components in stomachs of 5,526 specimens representing 212 species. His information, compiled into a matrix, suggested that shrimp, crabs, gastropods, pelecypods, polychaetes, amphipods, copepods, and cephalopods were important dietary items. Fish in the families Clupeidae, Atherinidae, Engraulidae, Clinidae, Mullidae, Balistidae, and Haemulidae were important in the diets of some fish families. Plants and/or organic detritus figured prominently in the diets of scarids, gobies, and blennies. Randall's data were collected in terms of relative volume, which is roughly equivalent to relative weight and, therefore, roughly approximates the relative energy received from various sources. Stomach contents information quantified in terms of volume is potentially much more useful to ecosystem studies than stomach contents information recorded in terms of number of organisms or occurrence. Ideally, stomach contents information to be used in ecosystem analysis should be collected in terms of dry weight.

The Caribbean Fishery Management Council lists 10 species as being particularly important in the fisheries of Puerto Rico and the Virgin Islands: Nassau grouper, red hind, coney, lane snapper, mutton snapper, yellowtail snapper, white grunt, queen triggerfish, spotted goatfish, and yellow goatfish. Our calculations from recent biostatistical surveys indicate that these 10 species make up approximately 10% of Virgin Island landings, by weight: and 45% of Puerto Rican landings. By examination of species lists and the food habits matrix, we call place these species in various subsystems and trophic groups, and thereby determine which subsystems contribute directly or indirectly to their production. We may be able to estimate what proportion of total fish number and biomass in each subsystem is comprised of these species. Cursory examination of the data suggests that each of these species may be supported by more than one subsystem and that, with the possible exception of white grunt and queen triggerfish, none forms a very large component of biomass in any subsystem.

As noted by Stoner (1985), there are few truly estuarine species in the Caribbean. A number of species associated with reefs and seagrass beds also occur in estuaries - for instance, filefish, grunts, and several species of grouper and snapper. It is doubtful that any of these species are particularly euryhaline; they probably occur in outer estuarine areas or in estuaries which receive only small quantities of freshwater inflow.

The organization of available information in this review was a necessary prelude to development of a large-scale energy flow model of the region. Table 53 summarizes our qualitative evaluation of the adequacy of available data for modeling purposes. General categories of data for each subsystem are considered 'adequate' when sufficient data exist for modeling purposes, 'limited' when some data exist but more assumptions would be required, or simply 'not available' when no data were located. Overall, adequate data are available in 16 (25%) of the 64 categories. Limited data are available for 95 (55%) categories and no data for 13 (20%) categories. Gross estimates of the areal extent of each subsystem can be made, although better measurements are needed in some cases. The best-studied subsystems are seagrass beds and coral reefs, with at least limited data in all categories. Less data are available for mangrove estuaries, algal plains, and sand/mud subsystems, and relatively little data exist for the shelf break and pelagic subsystems. Fortunately, primary production is relatively well studied in all subsystems. Limited data are available for fishes overall, whereas invertebrates are the least-studied group. The lack of biomass and trophic data for invertebrates is unfortunate because macrocrustaceans are prominent in the diets of fish, including major fishery species.

The review has indicated that sufficient information is available to support an ecosystem analysis and modeling effort. Additional site-specific information not located during our review may exist in local institutions of the area and may help refine current estimates and fill deficiencies. Appropriate data from other geographic areas, especially South Florida and elsewhere in the Caribbean, can also be used to fill gaps, at least preliminarily. For future work, we recommend an iterative process in which a phase of analysis and modeling is followed by a phase of data collection, followed by more analysis and modeling with improved data. It is important in an ecosystem study to begin model development and analysis near the beginning of the study to gain a "whole-system perspective" by integrating existing data and to determine the relative sensitivity of model responses to various perceived data needs. The realism, reliability, and potential usefulness of the model in understanding fish stocks in relation to their environment should grow with each iteration of modeling and data collection.

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TABLES

Table 1. Fish species occurring in estuarine habitats of the Caribbean as noted by Randall (1983). List is not exhaustive, but includes species when common.

COMMON NAME	SCIENTIFIC NAME	PREY
ladyfish	*Elops saurus*	fishes, crust.
tarpon	*Megalopsatlanticus*	copepods, aquatic insects, fishes, crabs, shrimp
white mullet	*Mugil curema*	algae, detritus
crevalle jack*	*Caranx hippos*	
horse-eye jack*	*C. latus*	
leather jacket	*Oligoplites saurus*	
gray snapper	*Lutjanus griseus*	crustaceans
sea bream	*Archosargus rhomboidalis*	omnivorous
rainbow parrotfish*	*Scarus guacamaia*	
frillfin goby	*Bathygobius soporator*	
smooth puffer	*Lagocephalus laevigatus*	
checkered puffer	*Sphoeroides testudineus*	
balloonfish	*Diodon holocanthus*	molluscs, crabs, urchins
bridled burrfish	*Chilomycterus antennatus*	

* Occurrence in estuaries and bracksih water is explicitly stated.

Table 2. Fishes occurring as adults in mangroves of St. Croix (from Clavijo *et al.* 1980). Abundance is qualitative: VC = very common, C = common, O = occasional.

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE
timucu	*Strongylura timucu*	C
mosquitofish	*Gambusia* sp.*	C
silver jenny	*Eucinostomus gula*	C
yellowfin mojarra	*Gerres cinereus***	VC
sea bream	*Archosargus rhomboidalis*	O
reef croaker	*Odontoscion dentex*	C
white mullet	*Mugil curema*	C
liza	*M. liza**	O
fantail mullet	*M. trichodon*	O
fat sleeper	*Dormitator maculatus*	O
spinycheek sleeper	*Eleotris pisonis*	O
emerald sleeper	*Erotelis smaragdus*	O
notchtongue goby	*Bathygobius curacao*	O
frillfin goby	*B. soporator*	O
lyre goby	*Evorthodus lyricus*	O
unidentified goby	*Gobionellus* sp.	O
scrawled sole	*Trinectes inscriptus*	O
checkered puffer	*Sphoeroides testudineus*	C

* Introduced species.
** Also sand/rubble habitat.

Table 3. Fish species observed in 'mangrove shoreline' habitat of St. John (adapted from Boulon, unpubl.). Density estimates (total number of fish observed/area censused) calculated from seven visual censuses of area = 201.1 m^2 each (total area = 1407.43 m^2). Average fish size (cm) and sample size provided. Rank abundance lists relative abundance in this study. 'X' indicates the species observed by Boulon not observed by Kimmel (1985).

COMMON NAME	SCIENTIFIC NAME	DENSITY	SIZE	N	RANK	
bar jack	*Caranx ruber*	1.85E-02	27.9	26	11	X
bluestriped grunt	*Haemulon sciurus*	2.13E-03	2.7	3	17	
white grunt	*H. plumieri*	7.10E-04	10.1	1	20	
French grunt	*H. flavolineatum*	1.32E-01	7.6	186	6	
tomtate	*H. aurolineatum*	2.17E-01	6.3	305	4	X
juvenile grunts	*Haemulon* spp.	8.53E-01	3.8	1200	2	
dog snapper	*Lutjanus jocu*	3.62E-01	5.0	509	3	
gray snapper	*L. griseus*	7.10E-03	20.3	10	16	
schoolmaster	*L. apodus*	1.42E-02	12.7	20	12	
yellowtail snapper	*Ocyurus chrysurus*	4.12E-02	8.8	58	8	
mahogany snapper	*L. mahogoni*	1.77E-01	6.3	249	5	X
angelfish	*Pomacanthus* spp.	7.10E-04	10.1	1	20	
sea bream	*Archosargus rhomboidalis*	9.95E-03	7.6	14	14	
doctorfish	*Acanthnrus* sp.	9.95E-03	5.0	14	14	
yellow goatfish	*Mulloidichthys martinicus*	4.40E-02	10.1	62	7	
spotted goatfish	*Pseudupeneus maculatus*	2.138-03	8.8	3	17	X
parrotfish	Scaridae	2.63E-02	7.6	37	9	
great barracuda	*Sphyraena barracuda*	7.10E-04	7.6	1	20	
snook	*Centropomus undecimalis*	1.42E-03	30.4	2	18	X
squirrelfish	Holocentridae	7.10E-04	10.1	1	20	X
mojarra	Gerreidae	2.13E-02	5.0	36	10	
dwarf herring	*Jenkinsia lamprotaenia*	too numerous to count			1	
redear sardine	*Harengula humeralis*	1.07E-02	10.1	15	13	

Table 4. Fish species observed during visual surveys of mangroves of Hurricane Hole, St. John, and two sites in the British Virgin Islands, on Tortola and Norman Islands. Only species of commercial importance were recorded. 'A' indicates presence of species in adult form; 'J' indicates juveniles. 'X' indicates species not included in similar surveys of St. John within the Virgin Islands Biosphere Reserve (Boulon, 1985a). Adapted from Boulon (1985b).

COMMON NAME	SCIENTIFIC NAME	HURRICANE HOLE ST. JOHN	SOPER'S HOLE TORTOLA BVI	NORMAN ISLAND BVI	X
bar jack	*Caranx ruber*	A	-	J	-
bluestriped grunt	*Haemulon sciurus*	J,A	-	J,A	-
white grunt	*H. plumieri*	J	-	J,A	-
French grunt	*H. flavolineatum*	J,A	J	J,A	-
tomtate	*H. aurolineatum*	J,A	J	J	-
juvenile grunts	*Haemulon* spp.	J	J	J	-
dog snapper	*Lutjanus jocu*	J	-	-	-
gray snapper	*L. griseus*	J,A	A	-	-
schoolmaster	*L. apodus*	J,A	J,A	-	-
yellowtail	*Ocyurus chrysurus*	J,A	J	J	-
snapper mahogany	*L. mahogoni*	J,A	-	J,A	-
snapper French and queen angelfish	*Pomacanthus* spp.	J	-	-	-
coney	*Epinephelus fulvus*	-	-	A	X
Nassau grouper	*E. striatus*	-	A	-	X
porgies	Sparidae	J	-	-	X
doctorfish	*Acanthurus* sp.	J,A	-	J,A	-
yellow goatfish	*Mulloidichthys martinicus*	J,A	-	J,A	-
spotted goatfish	*Pseudupeneus maculatus*	J	-	-	-
parrotfish	Scaridae	J,A	J	J,A	
trunkfish	Ostraciontidae	-	-	J	X
great barracuda	*Sphyraena barracuda*	J	J,A	-	-
mullet	*Mugil curema*	-	A	-	-
squirrelfish	Holocentridae	J,A	-	J,A	-
mojarra	Serreidae	J	J	-	-
dwarf herring	*Jenkinsia lamprotaenia*	J	-	-	-
TOTAL SPECIES		21	11	14	4

Table 5. Fish species occurring in mangroves of La Parguera, Puerto Rico. The occurrence of a species also found by Boulon (unpubl.) in mangroves of St. John is noted by an 'X' in the column designated 'B' (Boulon). Fish species listed above the dotted line comprise a 'species group', which is a statistically-defined assemblage characteristic of the mangrove habitat of La Parguera. (An 'X' in column designated 'SG' indicates that species is a member of the species group.) Species listed below the line occurred in mangroves but were statistically better-associated with other species and habitats, as indicated by an 'X' in the column designated 'PO' (present only). Rank abundance is the overall relative abundance (based on relative abundance numbers) for all species listed as occurring in the mangroves. Adapted from Kimmel (1985).

COMMON NAME	SCIENTIFIC NAME	SG	PO	B	RANK ABUNDANCE
gray snapper	*Lutjanus griseus*	X	-	X	10
checkered puffer	*Sphoeroides testudineus*	X	-	-	22
dwarf herring	*Jenkinsia lamprotaenia*	X	-	X	3
sea bream	*Archosargus rhomboidalis*	X	-	X	13
mojarras	*Eucinostomus* sp.	X	-	-	11
yellowfin mojarra	*Gerres cinereus*	X	-	X	16
horse-eye jack	*Caranx latus*	X	-	-	19
sailors choice	*Haemulon parrai*	X	-	-	33
night sergeant	*Abudefduf taurus*	X	-	-	27
fry, anchovies	*Anchoa* spp.	X	-	-	4
redear sardine	*Harengula humeralis*	X	-	X	2
false pilchard	*H. clupeola*	X	-	-	1
postlarval fishes		X	-	-	57
hardhead silverside	*Antherinomorus stipes*	X	-	-	5
white mullet	*Mugil curema*	X	-	-	
juvenile jacks	*Caranx* spp.	X	-	-	
yellowtail snapper	*Ocyurus chrysurus*	-	X	X	23
French grunt	*Haemulon flavolineatum*	-	X	X	7
foureye butterflyfish	*Chaetodon capistratus*	-	X	-	17
white grunt	*H. plumieri*	-	X	X	34
striped parrotfish	*Scarus croicensis*	-	X	X	28
parrotfish stoplight	*Sparisoma viride*	-	X	-	26
bluestriped grunt	*H. sciurus*	-	X	X	9
schoolmaster	*Lutjanus apodus*	-	X	X	8
yellow goatfish	*Mulloidichthys martinicus*	-	X	X	36
sergeant major	*Abudefduf saxatilis*	-	X	-	14
gray angelfish	*Pomacanthus arcuatus*	-	X	X	32

Table 5. Fish species occurring in mangroves of La Parguera, Puerto Rico. The occurrence of a species also found by Boulon (unpubl.) in mangroves of St. John is noted by an 'X' in the column designated 'B' (Boulon). Fish species listed above the dotted line comprise a 'species group', which is a statistically-defined assemblage characteristic of the mangrove habitat of La Parguera. (An 'X' in column designated 'SG' indicates that species is a member of the species group.) Species listed below the line occurred in mangroves but were statistically better-associated with other species and habitats, as indicated by an 'X' in the column designated 'PO' (present only). Rank abundance is the overall relative abundance (based on relative abundance numbers) for all species listed as occurring in the mangroves. Adapted from Kimmel (1985). (cont.)

COMMON NAME	SCIENTIFIC NAME	SG	PO	B	RANK ABUNDANCE
porkfish	*Anisotremus virginicus*	-	X	-	20
redtail parrotfish	*S. chrysopterum*	-	X	-	15
doctorfish	*Acanthurus chirurgus*	-	X	X	12
juvenile grunts	*Haemulon* spp.	-	X	X	21
porcupinefish	*Diodon hystrix*	-	X	-	31
dusky damselfish	*Pomacentrus fuscus*	-	X	X	18
beaugregory	*P. leucostictus*	-	X	-	25
rainbow parrotfish	*Scarus guacamaia*	-	X	X	29
dog snapper	*Lutjanus jocu*	-	X	X	35
lizardfish	*Synodus* spp.	-	X	-	37
great barracuda	*Sphyraena barracuda*	-	X	X	24
lane snapper	*L. synagris*	-	X	-	30

Table 6. Ten most abundant fish species occurring in mangroves of La Parguera, Puerto Rico. Relative abundance decreases down the list. Adapted from Kimmel (1985).

FAMILY	COMMON NAME	SCIENTIFIC NAME
Clupeidae	false pilchard	*Harengula clupeola*
	dwarf herring	*Jenkinsia lamprotaenia*
Engraulidae	unidentified anchovy	*Anchoa* spp.
Atherinidae	hardhead silverside	*Atherinomorous stipes*
	post larval fishes	
Clupeidae	redear sardine	*H. humeralis*
Haemulidae	French grunt	*Haemulon flavolineatum*
Lutjanidae	schoolmaster	*Lutjanus apodus*
Haemulidae	bluestriped grunt	*H. sciurus*
Lutjanidae	gray snapper	*L. griseus*

Table 7. Fish species occurring in mangroves of western Puerto Rico. Mean fish size is from measured individuals. 'N' indicates sample size used in calculation of mean fish size (mm). Abundance is qualitative. Adapted from Austin and Austin (1971).

COMMON NAME	SCIENTIFIC NAME	MEAN SIZE	N	ABUNDANCE
lemon shark	*Negaprion brevirostris* [3]	1016	1	infrequent
eagle ray	*Aetobatus narinari* [4]	1000	1	
lady fish	*Elops saurus*	22	2	
		104-189	21	
tarpon	*Megalops atlanticus*	151-223	9	uncommon
bonefish	*Albula vulpes*	37	1	common[5]
redear sardine	*Harengula humeralis*	54-87	9	common
Atlantic thread herring	*Opisthonema oglinum*	124	1	common
sardine	*Sardinella* sp.	84-100	2	common
anchovy	*Cetengraulis edentulus*	48-63	4	
anchovy	*Anchoa* spp.	25-63	100	small #s
American eel	*Anguilla rostrata*	300	2	
manytooth conger	*Conger triporiceps* [1]	1	260-295	
speckled worm eel	*Myrophis punctatus*	113-316	2	
needlefish	*Strongylura* spp.	88-298	100	abundant
halfbeak	*Hyporhamphus unifasciatus*	200	150	
pugnose pipefish	*Syngnathus dunckeri*	51-165	14	common
snook	*Centropomus undecimalis*	87-223	47 [6]	
swordspine snook	*C. ensiferus*	24-102	19	common
schoolmaster	*Lutjanus apodus*	18-98	33	
dog snapper	*L. jocu* [1]	61-111		
gray snapper	*L. griseus* [2]	60	1	
Atlantic bumper	*Chloroscombrus crysurus*	15-23	8 [8]	
permit	*Trachinotus falcatus*	32-58	7	
lookdown	*Selene vomer*	45-58	2 [9]	
yellowfin mojarra	*Gerres cinereus*	18-88	100	common
spotfin mojarra	*Eucinostomus argenteus*	15-87	300	abundant
flagfin mojarra	*E. melanopterus*	18-52	13	
mottled mojarra	*E. lefroyi*	23-50	8	
silver jenny	*E. gula*	24-27	316	occasional
rhomboid mojarra	*Diapterus rhombeus*	33-68	300	abundant
Irish pompano	*D. auratus*	65-94	39	abundant
striped mojarra	*D. plumieri*	94-117		ubiquitous
burro grunt	*Pomadasys crocro*	71	1	very rare
white grunt	*Haemulon album*	95-98	3	
bluestriped grunt	*H. sciurus*	78	1 [12]	
French grunt	*H. flavolineatum*[1]			
black grunt	*H. bonariense*[1]	86-190	2	
Atlantic croaker	*Micropogonias undulatus*	22-117	3	
sea bream	*Archosargus rhomboidalis*	19-123	3	
foureye butterflyfish	*Chaetodon capistratus* [1,14]			very rare
dusky damselfish	*Pomacentrus fuscus*[14]	105	1	very rare

Table 7. Fish species occurring in mangroves of western Puerto Rico. Mean fish size is from measured individuals. 'N' indicates sample size used in calculation of mean fish size (mm). Abundance is qualitative. Adapted from Austin and Austin (1971). (cont.)

COMMON NAME	SCIENTIFIC NAME	MEAN SIZE	N	ABUNDANCE
parrotfish	Scaridae[1]			
spinycheek sleeper	*Electris pisonis*	32-245	2	rare
fat sleeper	*Dormitator maculatus*	45-81	8	rare
river goby	*Awaous tajasica*			
frillfin goby	*Bathygobius soporator*	36-70	8	common
highfin goby	*Gobionellus oceanicus*	19-178	10	uncommon
plumed scorpionfish	*Scorpaena grandicornis*	28-93	3	uncommon
key brotula	*Ogilbia cayorum*[1]			
great barracuda	*Sphyraena barracuda*	23-609	6	
mountain mullet	*Agonostomus monticola*			very rare
white mullet	*Mujil curema*	27-200	200	abundant
liza	*Mugil liza*	124	1	rare
hardhead silverside	*Antherinomorus stipes* [1,15]			
barbu	*Polydactylus virginicus*[16]	32-146	10	
bay wiff	*Citharichthys spilopterus*[16]	72	1	
occasional lined sole	*Achirus lineatus*	11-60	60	occasional
blackcheeked tonguefish	*Symphurus plagiusa*[16]	30-104	18	rare
scrawled filefish	*Aluterus scriptus*	37	1	very rare
checkered puffer	*Sphoeroides testudineus*	18-77	70	frequent

1 Almodovar and Pagan (unpubl.) reported these from La Parguera
2 Almodovar and Pagan reported *L. griseus* fairly common at La Parguera; specimens were 118 - 227 mm; 20 were 55 - 85 mm.
3 Collected by Erdman at La Parguera
4 Seen swimming, not collected.
5 Reported common at La Parguera
6 Larger specimens (380 - 1000 mm) recorded during fish kills.
7 One large specimen (150 mm) taken during fish kill.
8 Adult-sized specimens (75 - 100 mm) observed at La Parguera; large population reported in Mayaguez Bay, but not near mangroves.
9 Mayaguez Bay supports large population of adults.
10 Large numbers of 80 - 100 mm individuals taken by trawl in Mayaguez Bay
11 Very small (15 - 55 mm) individuals taken locally during July, but appears to require muddy-bottom habitats.
12 Also reported from La Parguera at 37 - 190 mm (n = 74), where proximity to reefs may be influential.
13 Large population is open Puerto Rican muddy bays but primarily high salinity.
14 Primarily reef fish ('stray' in mangroves).
15 Not inshore mangroves, but large schools on mangrove-covered keys, where they may replace *Jenkinsia* which occurs closer to shore.
16 Requires muddy bottoms.

Table 8. Fish species occurring in estuaries of Puerto Rico. From Bejarano (1979) in Negron and Cintron (1979).

LOCAL NAME	COMMON NAME	SCIENTIFIC NAME
anguila	American eel	*Anguilla rostrata*
saga	river goby	*Awaous tajasica*
congrio	violet goby	*Gobiodes broussoneti*
olivo, chupa piedra	sirajo goby	*Sicydium plumieri* *
moron	frillfin goby	*Bathygobius soporator*
esmerelda	highfin goby	*Gobionellus oceanicus*
guavina	bigmouth sleeper	*Gobiomorus dormitor*
mapiro	fat sleeper	*Dormitator maculatus*
moroncillo	spinycheek sleeper	*Eleotris pisonis*
burro, corvino	whitemouth croaker	*Micropogon furnieri**
ronco	ground drummer	*Bairdiella ronchus**
viejo	burro grunt	P*omadasys crocro*
barbu	barbu	*Polydactylus virginicus*
pargo prieto	gray snapper	*Lutjanus griseus*
sabalo	tarpon	*Megalops atlantica*
dajao	mountain mullet	*Agonostomus monticola*
jarea	white mullet	*Mugil curema*
lisa	liza	*M. liza*
mojarra	Irish mojarra	*Diapterus auratus*
mojarra	striped mojarra	*D. plumieri*
arreves	bay whiff	*Citharichthy spilopterus*
rabo amarillo	whalebone anchovy	*Cetengraulis edentulus**
cardina	false pilchard	*Harengula clupeola*
machuelo	redear sardine	*H. humeralis*
robalote, robalo machuelo	swordspine snook	*Centropomus ensiferus*
robalo	snook	*C. undecimalis*
jurel ojon	horse-eye jack	*Caranx latus*
jurel	crevalle jack	*C. hippos*
tilapia	Mozambique tilapia	*Tilapia mossambica*
machete	Atlantic cutlassfish	*Trichiurus lepturus*

Species not listed in "List of Common and Scientific Names of Fishes", AFS Spec. Publ. No. 12, 4th Ed., 1980.

Table 9. Total numbers of fished captured in Laguna Joyuda, 1984 -1985, summarized by family (from Stoner 1986). (Cv = cyclical or seasonal visitors, Sed = resident species (typical estuarine form), Occ = occasional visitor.

Family/Species	Rank by Number Indiv.	Life Number Collected	% of Total	History Type
Gerridae		2,229	54.3	
Diapterus olisthostomus **,*	8	79	1.9	Cv
H. plumieri *	7	94	2.3	Cv
H. rhombeus **,*	3	565	13.8	Cv
Diapterus juveniles	21	6	0.1	Cv
Eucinostomus argenteus *	4	319	7.8	Cv
E. gula *	2	816	19.9	Sed
Eucinostomus juveniles	19	10	0.2	Cv
Gerres cinereus *	5	296	7.2	Cv
Gerreidae juveniles	12	44	1.1	Cv
Soleidae				
Achirus lineatus *	1	1,348	32.9	Sed
Engraulidae		210	5.1	
Anchoa cubana *	6	124	3.0	Cv
A. hepsetus	12	44	1.1	Cv
A. lyolepis	25	1	<0.1	Cv
A. parva **	16	24	0.6	Cv
Anchoa juvenile	23	4	<0.1	Cv
Anchovia products **	17	13	0.3	Cv
Gobiidae		72	1.7	
Bathygobius soporator	20	7	0.2	Sed
Gobionellus boleosoma	9	58	1.4	Sed
G. oceanicus	22	5	0.1	Occ
Nes longus	24	2	<0.1	Occ
Lutjanidae		52	1.3	
Lutjanus analis	24	2	<0.1	Cv
L. apodus	24	2	<0.1	Cv
L. griseus	11	45	1.1	Cv
L. mahogoni	24	2	<0.1	Occ
Ocyurus chrysurus	25	1	<0.1	Occ
Sciaenidae				
Bairdiella ronchus **,*	10	52	1.3	Cv
Sparidae				
Archosargus rhomboidalis	13	28	0.7	Cv

Table 9. Total numbers of fished captured in Laguna Joyuda, 1984 -1985, summarized by family (from Stoner 1986). (Cv = cyclical or seasonal visitors, Sed = resident species (typical estuarine form), Occ = occasional visitor. (cont.)

Family/Species	Rank by Number Indiv.	Life Number Collected	% of Total	History Type
Eleotridae				
Erotelis smaragdus	14	26	0.6	Sed
Centropomidae				
Centropomus undecimalis	15	25	0.6	Cv
Tetraodontidae				
Sphoeroides testudineus	16	24	0.6	Occ
Carangidae		20	0.4	
Caranx hippos	21	6	0.1	Cv
C. latus	18	13	0.3	Cv
Decapterus macarellus	25	1	<0.1	Occ
Sphyraenidae				
Sphyraena barracuda	23	4	0.1	Occ
Haemulidae		3	0.1	
Haemulon parrai	25	1	<0.1	Occ
Pomadasys crocro	24	2	<0.1	Occ
Labridae				
Lachnolaimus maximus	24	2	<0.1	Occ
Scorpaenidae				
Scorpaena grandicornis	24	2	<0.1	Occ
Ephippidae				
Chaetodipterus faber	25	1	<0.1	Occ
Mugilidae				
Mugil curema	25	1	<0.1	Cv
Serranidae				
Mycteroperca juvenile	25	1	<0.1	Occ

* One of ten most abundant species.
** Species not listed in AFS Spec. Publ. No. 12, 4th Ed., 1980.

Table 10. Density of live mangroves (number of trees/acre) in eight mangrove swamps in Puerto Rico. Adapted from Heatwole (1985).

STUDY SITE	MANGROVE DENSITY
Boqueron	190
Punta Tocon	5,976
Keys near La Parguera	1,124
Humacao	4,629
Rio Herrara - North	21,326
Rio Herrara - South	94,716
Vega Baja	542
Puerto Jobos	7,371

Table 11. Values of parameters used in simulation models of mangrove ecosystems by Lugo *et al.* (1976). Rates are in units of g $C/m^2/day$.

PARAMETER	RATE
Gross Photosynthesis	10.72 (high) 5.54 (mean)
Respiration	5.07 (high) 3.79 (mean)
Litterfall	2.41
Tidal Export	1.1
Decomposition	0.12 - 0.16 (dry; 3 mos. of year) 0.30 (wet; 6 mos. of year)
Grazing	0.786

Table 12. Diel primary production (g C/m^2/day and kg C/lagoon/day) and respiration of estuarine waters within Joyuda Lagoon, Puerto Rico. From Owen and Tilly (1985).

DATE	March 19-20, 1983		April 7-8, 1983	
	g/m^2	kg/lagoon	g/m^2	kg/lagoon
gross production	2.4	3.2E3	4.5	6.1E3
respiration	1.5	2.1E3	2.8	3.8E3
net production	0.9	1.1E3	1.7	2.3E3
P/R ratio	1.6		2.6	

Table 13. Summary of major prey groups comprising the diet of 26 species (15 families) of juvenile fishes taken in mangroves of Puerto Rico. Frequency of prey in fish diet is expressed as percent of occurrence of individual prey items. Percent of species eating a specific prey group is also given. Adapted from Austin and Austin (1971).

PREY GROUP	PERCENT FISH DIET	PERCENT SPECIES CONSUMING
Crustaceans	49.80	76.9
Benthic algae	15.89	26.9
Molluscs	5.25	19.2
Polychaetes	4.34	19.2
Spermatophytes	4.21	30.8
Insects	3.29	7.6
Fishes	2.62	23.1
Plankton	1.65	7.6
Protozoans	0.154	3.8
Nemerteans	0.135	3.8

Table 14. Fish species commonly observed in seagrass beds, with their general food habits (taken from Randall 1983). List is not exhaustive, but includes only species explicitly referred to as common in seagrass beds.

FAMILY	COMMON NAME	SCIENTIFIC NAME	PREY
Fistulariidae	bluespotted cornetfish	*Fistularia tabacaria*	fishes
Atherinidae	hardhead silverside	*Atherinomorus stipes*	zooplankton
	reef silverside	*Hypoatherina harringtonensis*	
Serranidae	Nassau grouper (juv.)	*Epinephelus striatus*	
	mutton hamlet	*E. afer*	fishes
	lantern bass	*Serranus baldwini*	
	twospot sea bass	*Centropristis fuscula*	
Haemulidae	margate	*Haemulon album*	urchins, sipunculids
Sparidae	sea bream	*Archosargus rhomboidalis*	seagrasses; algae, benthic invert.
Scorpaenidae	plumed scorpionfish	*Scorpaena grandicornis*	
Labridae	dwarf wrasse	*Doratonotus megalepis*	
Scaridae	emerald parrotfish	*Nicholsina usta*	
Clinidae	blue-throat pikeblenny	*Chaenopsis ocellata*	
Balistidae	fringed tilefish	*Monacanthus ciliatus*	
	orange filefish	*Aluterus schoepfi*	algae, seagrass
Ostraciidae	trunkfish	*Lactophrys trigonus*	benthic inv., plants
	scrawled cowfish	*L. quadricornis*	sponges, anemones, gorgonians, plants, crustaceans
Tetradontidae	bandtail puffer	*Sphoeroides spengleri*	benthic org.
	sharpnose puffer	*Canthigaster rostrata*	seagrasses, benthic org.

Table 15. Ten most abundant fish species in the seagrass habitat of the La Parguera, Puerto Rico, area. Cumulative abundance of these ten species is 87.3% of all species observed. Relative abundance (number of individuals per unit time), as determined by visual census, decreases down the list. Adapted from Kimmel (1985).

FAMILY	COMMON NAME	SCIENTIFIC NAME
Clupeidae	dwarf herring	*Jenkinsia lamprotaenia*
Haemulidae	juvenile grunts	*Haemulon* sp.
Scaridae	striped parrotfish	*Scarus croicensis*
	bucktooth parrotfish	*Sparisoma radians*
Gobiidae	bridled goby	*Coryphopterus glaucofraenum*
	orangespotted goby	*Nes longus*
		Microgobius signatus
Scaridae	redtail parrotfish	*Sparisoma chrysopterum*
Haemulidae	white grunt	*Haemulon plumieri*
Lutjanidae	yellowtail snapper	*Ocyurus chrysurus*

Table 16. Density and size estimates of fishes censused in seagrass beds of St. John. Densities (number of fish/m^2) are calculated from five visual censuses of 201.1 m^2 each (density = total fish count/1005.5 m^2). Mean size is based on estimated sizes of each fish observed. 'N' is the number of individual fishes used to estimate area size. Maximum size for species is taken from Clavijo *et al.* (1989). Adapted from Boulon (1985a).

COMMON NAME	SCIENTIFIC NAME	DENSITY	MEAN SIZE (cm)	N	MAXIMUM SIZE (cm)
bar jack	*Caranx ruber*	4.8E-3	20.3	5	60
mahogany snapper	*Lutjanus mahogani*	9.9E-4	7.6	1	38
bucktooth parrotfish	*Sparisoma radians*	2.0E-3	5.0	2	19
trunkfish	Ostraciontidae	5.0E-3	20.3	5	45-48
great barracuda	*Sphyraena barracuda*	9.8E-4	91.4	1	300

Table 17. Fish species occurring as adults in seagrass beds of St. Croix as 'typical habitat'. Abundance: VC = very common, C = common, O = occasional, R = rare. Depth: S = shallow, W = wide depth range from shallow to deep, V = very shallow. Adapted from Clavijo *et al.* (1980).

FAMILY	COMMON NAME	SCIENTIFIC NAME	ABUNDANCE	DEPTH
Albulidae	bonefish	*Albula vulpes**	O	S
Muraenidae	purplemouth moray	*Gymnothorax vicinus*	C	S
Ophichthidae	goldspotted eel	*Myrichthys oculatus*	C	S
Fistularidae	bluespotted cornetfish	*Fistularia tabacaria*	O	S
Sygnathidae	crested pipefish	*Cosmocampus brachycephalus*	O	S
	insular pipefish	*Micrognathus tectus*	O	S
	pugnose pipefish	*Syngnathus dunckeri*	O	S
Serranidae	mutton hamlet	*Epinephelus afer*	O	S
Lutjanidae	mutton snapper	*Lutjanus analis*	C	W
Labridae	dwarf wrasse	*Doranotus megalepis*	O	S
	blackear wrasse	*Halichoeres poeyi*	VC	S
	green razorfish	*Hemipteronotus splendens*	C	S
Scaridae	bluelip parrotfish	*Cryptotomus roseus*	O	S
	emerald parrotfish	*Nicholsina usta*	O	S
	bucktooth parrotfish	*Sparisoma radians*	O	S
Polynemidae	littlescale threadfin	*Polydactylus oligodon*	O	S
Clinidae	rosy blenny	*Malacoctenus macropus*	O	S
Callionymidae	lancer dragonet	*Callionymus bairdi**	C	S
Gobiidae	scaleless goby	*Psilotropis alepis*	R	V
Scorpaenidae	plumed scorpionfish	*Scorpaena grandicornis*	O	S
	mushroom scorpionfish	*S. inermis*	O	W
Balistidae	fringed filefish	*Monacanthus ciliaris*	C	S
Ostraciidae	scrawled cowfish	*Lactophrys quadricornis*	C	S
	trunkfish	*L. trigonus*	O	S
Tetradontidae	bandtail puffer	*Sphoeroides spengleri*	C	S
Diodontidae	bridled burrfish	*Chilomycterus antennatus*	R	W
	ballonfish	*Diodon holocanthus**	VC	S

* Indicates that other habitats may also be characteristic of the species.

Table 18. Fish species of the seagrass community of Buck Island National Monument, St. Croix, USVI. Abundance is mean (± s.d.) number of individuals/m^2 in three 50-m quadrat samples. Adapted from Gladfelter *et al.* (1977).

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE
bucktooth parrotfish	*Sparisoma radians*	0.13 (0.231)
queen parrotfish	*Scarus vetula*	0.01 (0.012)
rainbow parrotfish	*S. guacamaia*	0.01 (0.012)
rosy parrotfish*		0.02 (0.035)
slippery dick	*Halichoeres bivittatus*	0.05 (0.050)
bluehead	*Thalassoma bifasciatum*	0.09 (0.101)
cleaning goby*		0.10 (0.173)
red hind	*Epinephelus guttatus*	0.01 (0.012)
harlequin bass	*Serranus tigrinus*	0.01 (0.012)
green razorfish	*Hemipteronotus splendens*	0.15 (0.254)
pearly razorfish	*H. novacula*	0.08 (0.106)
spotted goatfish	*Pseudupeneus maculatus*	0.21 (0.370)
trunkfish	*Lactophrys trigonis*	0.01 (0.012)
lizardfish	Synodontidae	0.01 (0.012)
squirrelfish	Holocentridae	0.03 (0.046)
bicolor damselfish	*Pomacentrus partitus*	0.67 (0.577)
queen angelfish	*Holacanthus ciliaris*	0.01 (0.012)
bar jack	*Caranx ruber*	0.06 (0.087)
soapfish	*Rypticus* sp.	0.01 (0.012)
flying gurnard	*Dactylopterus volitans*	0.01 (0 012)
sand tilefish	*Malacanthus plumieri*	0.02 (0.035)
ocean surgeon	*Acanthurus bahianus*	0.07 (0.127)
southern stingray	*Dasyatis americana*	0.01 (0.012)
garden eels	*Nystactichthys halis*	>0.67 (1.155)

* Species not listed in "List of Common and Scientific Names of Fishes", AFS Spec. Publ. No. 12, 4th Ed., 1980.

Table 19. Densities of fish species observed on nocturnal and diurnal surveys of seagrass beds of Tague Bay, St. Croix. Results are based on use of encircling net (30-m^2) on 56 night and 26 day sampling events. Densities are number of fish/m^2. Adapted from Robblee (1987).

FAMILY	COMMON NAME	SCIENTIFIC NAME	DENSITY NIGHT	DENSITY DAY
Clupeidae	redear sardine	*Harengula humeralis*	1.3E-3	-
	dwarf herring	*Jenkinsia lamprotaenia*	4.6E-2	-
	little-eye herring	*J. majua*	6.4E-4	-
Engraulidae	bigeye anchovy	*Anchoa lamprotaenia*	5.8E-3	-
Synodontidae	red lizardfish	*Synodus synodus*	-	1.3E-3
Atherinidae	reef silverside	*Hypoatherina harringtonensis*	6.4E-4	-
Holocentridae	squirrelfish	*Holocentrus ascensions*	1.9E-3	1.3E-3
	reef squirrelfish	*H. coruscus*	1.9E-3	-
	longspine squirrelfish	*H. rufus*	5.5E-2	-
	dusky squirrelfish	*H. vexillarius*	7.7E-3	-
	blackbar soldierfish	*Myripristis jacobus*	6.4E-4	-
Aulostomidae	trumpetfish	*Aulostomus maculatus*	1.3E-3	2.6E-3
Fistulariidae	bluespotted cornetfish	*Fistularia tabacaria*	6.4E-4	-
Syngnathidae	pipehorse	*Amphelikturus dendriticus*	-	1.3E-3
	pugnose pipefish	*Syngnathus dunckeri*	6.4E-4	-
	shortfin pipefish	*S. elucens*	7.7E-3	3.2E-2
Serranidae	harlequin bass	*Serranus tigrinus*	-	1.3E-3
Apogonidae	blackfin cardinalfish	*Astrapogon puncticulatus*	3.2E-3	-
	freckled cardinalfish	*Phaeoptyx conklini*	4.6E-2	
Lutjanidae	mahogany snapper	*Lutjanus mahogoni*	-	1.3E-3
	yellowtail snapper	*Ocyurus chrysurus*	5.1E-3	9.0E-3
Haemulidae	smallmouth grunt	*Haemulon chrysargyreum*	6.4E-4	-
	French grunt	*H. flavolineatum*	5.6E-2	-
	white grunt	*H. plumieri*	2.3E-1	-
	bluestriped grunt	*H. sciurus*	6.4E-4	-
Mullidae	spotted goatfish	*Pseudupeneus maculatus*	2.6E-3	5.1E-3
Chaetodontidae	foureye butterflyfish	*Chaetodon capistratus*	1.9E-3	5.1E-3

Table 19. Densities of fish species observed on nocturnal and diurnal surveys of seagrass beds of Tague Bay, St. Croix. Results are based on use of encircling net (30-m^2) on 56 night and 26 day sampling events. Densities are number of fish/m^2. Adapted from Robblee (1987). (cont.)

FAMILY	COMMON NAME	SCIENTIFIC NAME	DENSITY NIGHT	DENSITY DAY
Labridae	dwarf wrasse	*Doratonotus megalepis*	7.7E-3	4.6E-2
	slippery dick	*Halichoeres bivittatus*	1.9E-3	1.4E-1
	blackear wrasse	*H. poeyi*	1.3E-3	5.2E-2
	green razorfish	*Hemipternonotus splendens*	-	7.7E-3
Scaridae	bluelip parrotfish	*Cryptotomus roseus*	1.9E-3	2.9E-2
	striped parrotfish	*Scarus croicensis*	6.4E-4	1.3E-3
	princess parrotfish	*S. taeniopterus*	6.4E-4	-
	queen parrotfish	*S. vetula*	1.3E-3	-
	redtail parrotfish	*Sparisoma chrysopterum*	1.8E-2	3.6E-2
	bucktooth parrotfish	*S. radians*	2.5E-1	8.4E-1
	stoplight parrotfish	*S. viride*	6.4E-4	-
Opistognathidae	dusky jawfish	*Opistognathus whitehursti*	6.4E-4	1.3E-3
Clinidae	blenny	*Malacoctenus gilli*	6.4E-4	1.3E-3
	blenny	*M. versicolor*	-	1.3E-3
	banded blenny	*Paraclinus fasciatus*	4.5E-3	1.3E-3
Callionymidae	lancer dragonet	*Callionymus bairdi*	9.0E-3	3.2E-2
Gobiidae	goldspot goby	*Gnatholepis thompsoni*	6.4E-4	-
Acantharidae	ocean surgeon	*Acanthurus bahianus*	-	1.7E-2
	doctorfish	*A. chirurgus*	1.3E-3	2.6E-3
Scorpaenidae	goosehead scorpionfish	*Scorpaena bergi*	1.8E-2	1.5E-2
	mushroom scorpionfish	*S. inermis*	2.6E-3	9.0E-3
	spotted scorpionfish	*S. plumieri*	6.4E-4	-
Balistidae	fringed filefish	*Monacanthus ciliatus*	3.5E-2	9.1E-2
	slender filefish	*M. tuckeri*	1.3E-3	-
Ostraciidae	honeycomb cowfish	*Lactophrys polygonia*	-	2.6E-3
	trunkfish	*L. trigonus*	6.4E-4	-
	unidentified	*Lactophrys* spp.	-	1.3E-3
Tetraodontidae	bandtail puffer	*Sphoeroides spengleri*	1.3E-3	7.7E-3
Diodontidae	balloonfish	*Diodon holocanthus*	2.3E-2	5.6E-2
TOTAL			8.8E-1	1.48

Table 20. Results of night visual censuses (2100 - 2300 hours) of major species of fishes within seagrass beds, Tague Bay, St. Croix. Total number of fishes is mean (±S.D.) of six censuses along two (#1, #2) 1,000-m^2 transects (5 m on either side of 10 m). Mean density (# individuals/m^2) is average of total counts/1,000-m^2. Adapted from Ogden and Zieman (1977).

COMMON NAME	SCIENTIFIC NAME	DENSITY #1	DENSITY #2	MEAN DENSITY
balloonfish [1]	*Diodon holocanthus*	26 (±8)	25 (±2)	0.0255
longspine squirrelfish [1]	*Holocentrus rufus*	17 (±2)	13 (±5)	0.015
white grunt [2]	*Haemulon plumieri*	13 (±8)	8 (±2)	0.0105
French grunt [2]	*H. flavolineatum*	-	21 (±25)	0.0105
cardinalfish [3]	*Apogon* spp.	+	++	-
bluespotted cornetfish [3]	*Fistularia tabacaria*	1 (±0)	0.3 (±0.6)	6.5E-04
spotted goatfish	*Pseudupeneus maculatus*	1 (±0.6)	0.7 (±0.6)	8.5E-04
yellowtail snapper [1]	*Ocyurus chrysurus*	-	2 (±1)	0.001

[1] probably juvenile residents of seagrass beds

[2] observed in seagrass beds only at night

[3] not counted, '+' indicates relative abundance

Table 21. Standing crop (g dry wt/m^2), leaf production (g/m^2/day), turnover time (days), turnover (%), and growth rate (cm/day) of *Thalassia testudinum* blades at seven sites off La Parguera, Puerto Rico. Adapted from Gonzalez-Liboy (1979).

STUDY SITE	STANDING CROP	LEAF PRODUCTION	TURNOVER RATE	TURNOVER	GROWTH RATE
Cayo Enrique	136	4.38	31	3.2	0.56
Bird Island	129	5.71	23	4.4	0.55
Punta Guayacan	24.5	7.29	34	3.0	0.48
Magueyes Island (north)	61.2	2.13	29	3.4	0.79
Magueyes Island (west)	127.5	5.47	23	4.3	0.78
Magueyes Island (northeast)	173	3.84	45	2.2	0.51
South of Guayacan Island	122	6.05	20	4.9	0.61
Ceiba (Punta Medio Mundo)	281	10.70	26	3.8	0.29
MEAN (excluding Ceiba)	142	4.98	29.3	3.83	0.61

Table 22. Summary of total biomass (g dry wt/m^2), aboveground standing stocks (g dry wt/m^2), and literature references for *Thalassia testudinum* in Puerto Rico, Culebra, and Vieques. Adapted from Gonzalez-Liboy (1979).

STUDY SITE	TOTAL BIOMASS RANGE	TOTAL BIOMASS MEAN	ABOVEGROUND STANDING STOCK RANGE	ABOVEGROUND STANDING STOCK MEAN	REFERENCE
Puerto Rico					
West Las Palmas	3609-4909	2802		825	Burkholder *et al.* (1959)
East Las Palmas	2712-4102			498	"
East of La Parguera	538-694			138	"
Bahia Fosforescente	829-1098				
La Cueva, west	1300-5761				
La Cueva, north	3945-7375				
La Parguera	243-1334	773			Margalef and Rivero (1959)
La Parguera			150-220	186	Margalef (1962)
La Parguera	2400-46200	11326	351-2533	1292	Welch (1962)
Cayo Laurel		476	76-165	108	Delgado (1978)
Cayo Enrique		468	45-256	131	"
Guayacan		907	127-412	246	"
Guayacan	1605-2352	1986	245-816	512	Gonzalez-Liboy (1979)
Jobos Bay	10-5550	1655	10-690	250	Vicente (1975)
Guayanilla Bay	7-725	330			Vicente (1977)
Enrique Beef	467-1286	892	113-375	229	Gonzalez-Liboy (1979)
Magueyes (NE)	1145-2341	1660	350-862	586	"
Salinas			159-371	260	"
Bahia Sucia			300-904	551	"
Isla Cueva	378-722	532	133-303	240	"
Icacos Island	713-1676	1181	54-449	43	"
Culebra					
Puerto Manglar			49-289	174	"
Vieques					
Bahia Icacos			88-776	209	Vicente (1978)
Bahia Icacos			88-451	234	Gonzalez-Liboy (1979)
Mosquito Bay	832-1606	925	100-440	294	"
Esperanza	105-1191	632	70-614	230	"
Salinas del Sur			33-224	88	"
Salinas del Sur			50-144	78	Vicente (1978)
Ensenada Honda			37-2533	1292	Welch (1962)

Table 23. Invertebrate abundance (number of organisms/sampled area) in seagrass beds of Buck Island Reef National Monument. Three sampled groups are shown: (1) infaunal and epifaunal organisms collected with an airlift, sampled area = 1-m^2 (n = 7); (2) infaunal and epifaunal organisms collected within a 20 cm core (n = 8); and, (3) macroinvertebrates/100-m^2 recorded in a 10-m radius circle (n = 5). Abundances are means of three sampled seagrass beds dominated by *Thalassia*, *Syringodium* or *Halophila*. Adapted from Gladfelter *et al.* (1977).

FAUNAL GROUP	ABUNDANCE MEAN	S.E.
(1)		
polychaetes	6.0	11.30
hermit crabs	6.9	7.27
crabs	17.0	5.91
shrimp	11.2	5.96
lobster	0.6	0.36
other decapods	3.5	1.75
chitons	0.2	0.35
pycnogonids	0.1	0.17
Asteroidea	0.7	0.58
Ophiuroidea	5.5	8.73
Echinoidea	0.7	0.76
Holothuroidea	0.2	0.29
sea hares	0.8	0.68
bivalves	10.2	8.03
banded dove shell	3.0	4.36
emerald nerite	1.3	1.16
small false donax	1.2	2.02
bavays scallop	0.3	0.58
polka-dot pheasant	5.7	8.96
dwarf nassa	0.3	0.58
milk moon shell	0 8	0.76
paper bubbles	0.8	0.76
Buccinidae	0.3	0.58
beaded phos	0.7	1.16
Puerto Rican phos	0.5	0.87
Cerithium litteratum	1.3	2.31
lined phos	0.5	0.87
other gastropods	10.2	4.70
cephalochordates	0.4	0.53
Amphioxus	0.3	0.58
scorpionfish (juv.)	8.7	14.15
pikeblenny	0.3	0.58
dragonet	0.3	0.58
TOTAL	101.1	28.99

Table 23. Invertebrate abundance (number of organisms/sampled area) is seagrass beds of Buck Island Reef National Monument. Three sampled groups are shown: (1) infaunal and epifaunal organisms collected with an airlift, sampled area = 1-m^2 (n = 7); (2) infaunal and epifaunal organisms collected within a 20 cm core (n = 8); and, (3) macroinvertebrates/100-m^2 recorded in a 10-m radius circle (n = 5). Abundances are means of three sampled seagrass beds dominated by *Thalassia*, *Syringodium* or *Halophila*. Adapted from Gladfelter *et al.* (1977). (cont.)

FAUNAL GROUP	ABUNDANCE MEAN	S.E.
(2)		
poiychaetes	5.8	2.78
spider crabs	0.8	0.72
shrimp	0.1	0.23
amphipods	0.4	0.32
worm tubes	1.7	3.00
sipunculids	0.4	0.53
ophiuroids	0.4	0.32
echinoids	0.1	0.12
Cerithium algicola	1.1	1.85
C. litteratum	1.8	3.12
Murex sp.	0.1	0.12
Turbo sp.	0.5	0.81
green gastropods	1.2	0.25
other gastropods	3.4	0.71
bivalves	0.5	0.50
TOTAL	23.0	11.00
(3)		
Sabellastarte	2.0	2.18
Serpula	0.7	1.27
sponge	6.3	6.25
sea fans	0.7	0.66
other gorgonians	7.2	7.51
zoanthids	0.1	0.17
Condylactis	0.4	0.46
ophiuroids	0.5	0.92
Strombus gigas	2.6	1.70
bivalves	0.1	0.16
TOTAL	20.7	16.78

Table 24. Fish species of reefs in the Buck Island Reef National Monument. Densities {number of fish/1600 m^2) calculated using mean number of individuals (± S.E.) per census (1,600 m^2) at each of five study sites (January through September) (total of 147 censuses).

COMMON NAME	SCIENTIFIC NAME	DENSITY MEAN	S.E.
tarpon	*Megalops atlanticus*	0.1	0.13
redear sardine	*Harengula humeralis*	>800.0	447.21
sand diver	*Synodus intermedius*	0.7	0.54
Ophichthidae	*Myrichthys* sp.	0.1	0.13
green moray	*Gymnothorax funebris*	0.02	0.045
spotted moray	*G. moringa*	0.1	0.07
purplemouth moray	*G. vicinus*	0.1	0.14
	G. miliaris	0.1	0.16
Muraenidae	*Gymnothorax* sp.	0.1	0.08
houndfish	*Tylosaurus crocosylus*	4.8	9.62
trumpetfish	*Aulostomus maculatus*	3.0	1.70
squirrelfish	*Holocentrus adscensionis*	2.1	1.49
longspine squirrelfish	*H. rufus*	6.6	4.74
	Flammeo marianus	0.2	0.25
	Adioryx coruscus	1.0	1.81
	A. vexillarius	0.1	0.13
blackbar soldierfish	*Myripristis jacobus*	0.8	0.67
great barracuda	*Sphyraena barracuda*	1.3	1.05
	Atherinids	>1,000.0	0.00
coney	*Epinephelus fulvus*	0.2	0.40
red hind	*E. guttatus*	1.3	1.59
Nassau grouper	*E. striatus*	0.1	0.12
graysby	*E. cruentatus*	0.9	1.42
shy hamlet	*Hypolectrus guttavarius*	0.8	1.34
	H. chlorurus	0.02	0.045
	H. nigricans	0.5	0.75
	H. puella	0.8	1.21
butter hamlet	*H. unicolor*	0.6	0.78
yellowfin grouper	*Mycteroperca venenosa*	0.1	0.055
tiger grouper	*M. tigris*	0.3	0.37
tobaccofish	*Serranus tabacarius*	0.1	0.13
harlequin bass	*S. tigrinus*	1.1	2.20
	Gramma loreto	8.3	8.40
greater soapfish	*Rypticus saponaceus*	0.1	0.10
barred cardinalfish	*Apogon binotatus*	9.5	11.89
flamefish	*A. maculatus*	0.1	0.18
freckled cardinalfish	*Phaeoptyx conklini*	0.02	0.045
bar jack	*Caranx ruber*	17.9	16.31
	C. fusus	0.04	0.055
permit	*Trachinotus falcatus*	0.04	0.089
African pompano	*Alectis ciliaris*	0.04	0.055
cero	*Scomberomorus regalis*	0.2	0.25
boga	*Inermia vittata*	33.3	47.61

Table 24. Fish species of reefs in the Buck Island Reef National Monument. Densities {number of fish/1600 m^2) calculated using mean number of individuals (± S.E.) per census (1,600 m^2) at each of five study sites (January through September) (total of 147 censuses). (cont.)

COMMON NAME	SCIENTIFIC NAME	DENSITY MEAN	DENSITY S.E.
schoolmaster	*Lutjanus apodus*	4.4	3.24
mutton snapper	*L. analis*	0.02	0.045
gray snapper	*L. griseus*	0.1	0.084
mahogany snapper	*L. mahogoni*	5.3	5.67
yellowtail snapper	*Ocyurus chrysurus*	2.7	1.73
black margate	*Anisotremus surinamensis*	0.1	0.089
porkfish	*A. virginicus*	0.1	0.17
margate	*Haemulon album*	0.1	0.089
Spanish grunt	*H. macrostomum*	0.04	0.089
caesar grunt	*H. carbonarium*	0.1	0.10
smallmouth grunt	*H. chrysargyreum*	0.9	1.97
French grunt	*H. flavolineatum*	39.8	50.16
white grunt	*H. plumieri*	3.4	2.96
bluestriped grunt	*H. sciurus*	4.4	4.69
Sparidae	*Calamus* sp.	0.3	0.19
sand tilefish	*Malacanthus plumieri*	0.3	0.62
redspotted hawkfish	*Amblycirrhitus pinos*	0.02	0.045
high-hat	*Equetus acuminatus*	0.02	0.045
spotted drum	*E. punctatus*	0.2	0.39
yellow goatfish	*Mulloidichthys martinicus*	8.4	7.50
spotted goatfish	*Pseudupeneus maculatus*	2.1	1.46
glassy sweeper	*Pempheris schomburgki*	3.8	8.45
yellowfin mojarra	*Gerres cinereus*	3.4	3.84
glasseye snapper	*Priacanthus cruentatus*	1.0	1.18
Bermuda chub	*Kyphosus sectatrix*	11.1	13.91
	Bothus lunatus	0.4	0.34
spotted scorpionfish	*Scorpaena plumieri*	0.1	0.045
queen angelfish	*Holacanthus ciliaris*	0.2	0.29
rock beauty	*H. tricolor*	0.6	0.87
gray angelfish	*Pomacanthus arcuatus*	0.1	0.09
French angelfish	*P. paru*	0.9	0.93
foureye butterflyfish	*Chaetodon capistratus*	3.5	1.43
banded butterflyfish	*S. striatus*	0.1	0.084
spotfin butterflyfish	*S. ocellatus*	0.1	0.10
sergeant major	*Abudefduf saxatilis*	14.5	18.19
blue chromis	*Chromis cyaneus*	95.0	121.52
brown chromis	*C. multilineatus*	70.7	75.84
yellowtail damselfish	*Microspathodon chrysurus*	26.1	27.56
honey gregory	*Eupomacentrus mellis*	1.2	1.23
dusky damselfish	*Pomacentrus fuscus*	6.4	4.05
beaugregory	*P. leucostictus*	38.8	36.50
bicolor damselfish	*P. partitus*	24.5	51.42
threespot damselfish	*P. planifrons*	65.4	73.30
cocoa damselfish	*P. variabilis*	2.0	2.39

Table 24. Fish species of reefs in the Buck Island Reef National Monument. Densities {number of fish/1600-m^2) calculated using mean number of individuals (± s.e.) per census (1,600 m^2) at each of five study sites (January through September) (total of 147 censuses). (cont.)

COMMON NAME	SCIENTIFIC NAME	DENSITY MEAN	S.E.
Spanish hogfish	*Bodianus rufus*	0.4	0.45
creole wrasse	*Clepticus parrai*	34.3	44.91
slippery dick	*Halichoeres bivittatus*	12.3	10.63
yellowhead wrasse	*H. garnoti*	4.2	6.21
clown wrasse	*H. maculipinna*	3.0	4.55
blackear wrasse	*H. poeyi*	1.3	1.70
puddingwife	*H. radiatus*	1.1	0.55
bluehead	*Thalassoma bifasciatum*	133.5	67.84
midnight parrotfish	*Scarus coelestinus*	0.2	0.27
striped parrotfish	*S.. croicensis*	12.8	15.38
rainbow parrotfish	*S. guacamaia*	0.2	0.38
queen parrotfish	*S. vetula*	6.0	6.01
redband parrotfish	*Sparisoma aurofrenatum*	3.7	4.18
redtail parrotfish	*S. chrysopterum*	2.6	2.97
bucktooth parrotfish	*S. radians*	0.7	0.90
redfin parrotfish	*S. rubripinne*	2.0	2.24
stoplight parrotfish	*S. viride*	14.7	11.25
saddled blenny	*Malacoctenus triangulatus*	1.1	0.83
redlip blenny	*Ophioblennius atlanticus*	6.8	12.28
bridled goby	*Coryphopterus glaucofraenum*	64.1	72.89
masked goby	*C. personatus*	20.0	44.72
goldspot goby	*Gnatholepis thompsoni*	28.4	33.72
Gobiidae	*Gobiosoma* sp.	5.6	4.04
	Gobiid sp.	0.2	0.36
ocean surgeon	*Acanthurus bahianus*	27.3	30.84
doctorfish	*A. chirurgus*	0.9	0.82
blue tang	*A. coeruleus*	71.4	43.66
queen triggerfish	*Balistes vetula*	0.2	0.28
gray triggerfish	*B. capriscus*	0.02	0.045
black durgon	*Melichthys niger*	0.5	1.03
ocean triggerfish	*Canthidermis sufflamen*	0.1	0.22
scrawled filefish	*Aluterus scriptus*	0.04	0.089
orangespotted filefish	*Cantherhines pullus*	0.5	0.46
slender filefish	*Monacanthus tucker*	0.1	0.084
spotted trunkfish	*Lactophrys bicaudalis*	0.6	0.27
smooth trunkfish	*L. triqueter*	1.7	0.64
	Acanthostracion polygonius	0.02	0.045
bandtail puffer	*Sphoeroides spengleri*	0.1	0.13
sharpnose puffer	*Canthigaster rostrata*	1.3	1.29
balloonfish	*Diodon holocanthus*	0.1	0.084
porcupinefish	*D. hystrix*	0.2	0.11

Table 25. Fish species found on reefs of Buck Island National Monument, St. Croix. Diurnal survey results are given first; nocturnal survey results are given below the dotted line. Densities (number of fish/500 m^2) are mean abundances (± S.D.) calculated from counts of fishes at four reef sites on diurnal surveys and two reef sites on nocturnal surveys, along transects of 500 m. Abundance categories given in the original reference were converted to densities by using the mean of the range covered by each category, i.e. category II, 2 - 10 individuals, was assigned a value of 6 individuals. Adapted from Gladfelter *et al.* (1977).

			DENSITY	
FAMILY	COMMON NAME	SCIENTIFIC NAME	MEAN	S.D.
Carcharinidae	reef shark	*Carcharhinus springeri*	0.3	0.50
	lemon shark	*Negaprion brevirostris*	0.3	0.50
Myliobatidae	spotted eagle ray	*Aetobatis narinari*	0.5	0.58
Dasyatidae	southern stingray	*Dasyatis americana*	0.3	0.50
Ophichthidae	goldspotted eel	*Myrichthys oculatus*	0.3	0.50
Synodontidae	sand diver	*Synodus intermedius*	3.0	3.46
Hemiramphidae	ballyhoo	*Hemiramphus brasiliensis*	1.5	3.00
Belonidae	houndfish	*Tylosurus crocodilus*	12.5*	25.00
Aulostomidae	trumpetfish	*Aulostomus maculatus*	4.8	2.50
Fistulariidae	cornetfish	*Fistularia tabacaria*	0.3	0.50
Serranidae	coney	*Epinephelus fulvus*	2.0	2.71
	rock hind	*E. adscensionis*	0.3	0.50
	graysby	*E. cruentatus*	0.5	0.58
	red hind	*E. guttatus*	2.3	2.50
	Nassau grouper	*E. striatus*	0.8	0.50
	yellowtail hamlet	*Hypolectrus chlorurus*	0.5	0.58
	shy hamlet	*H. guttavarius*	2.0	2.71
	black hassle	*H. nigricans*	0.5	0.58
	barred hassle	*H. puella*	1.8	2.87
	butter hassle	*H. unicolor*	0.3	0.50
	tiger grouper	*Mycteroperca tigris*	0.8	0.50
	tobaccofish	*Serranus tabacarius*	0.3	0.50
	harlequin bass	*S. tigrinus*	2.0	2.71
Grammidae	fairy basslet	*Gramma loreto*	4.6	7.25
Grammistidae	greater soapfish	*Rypticus saponaceus*	0.3	0.50
Branchiotegidae	sand tilefish	*Malacanthus plumieri*	0.8	0.50
Echeneidae	sharksucker	*Echeneis* sp.	0.3	0.50
Carangidae	African pompano	*Alectis crinitis*	0.3	0.50
	blue runner	*Caranx crysos*	0.8	0.50
	bar jack	*C. ruber*	6.0	0.00
Emmlichthyidae	boga	*Inermia vittata*	3.9	7.75
Lutjanidae	mutton snapper	*Lutjanus analis*	0.5	0.58
	schoolmaster	*L. apodus*	15.8	13.91
	gray snapper	L. griseus	1.8	2.87
	dog snapper	*L. jocu*	1.0	0.00
	mahogany snapper	*L. mahogoni*	6.0	0.00
	lane snapper	*L. synagris*	0.3	8.50
	yellowtail snapper	*Ocyurus chrysurus*	8.4	4.75

Table 25. Fish species found on reefs of Buck Island National Monument, St. Croix. Diurnal survey results are given first; nocturnal survey results are given below the dotted line. Densities (number of fish/500 m^2) are mean abundances (± S.D.) calculated from counts of fishes at four reef sites on diurnal surveys and two reef sites on nocturnal surveys, along transects of 500 m. Abundance categories given in the original reference were converted to densities by using the mean of the range covered by each category, i.e. category II, 2 - 10 individuals, was assigned a value of 6 individuals. Adapted from Gladfelter *et al.* (1977). (cont.)

FAMILY	COMMON NAME	SCIENTIFIC NAME	DENSITY MEAN	DENSITY S.D.
Pomadasyidae	black margate	*Anistremus surinamensis*	0.5	0.58
	porkfish	*A. virginicus*	0.3	0.50
	Spanish grunt	*Haemulon macrostomus*	0.3	0.50
	tomtate	*H. aurolineatum*	0.3	0.50
	caesar grunt	*H. carbonarium*	0.5	0.58
	smallmouth grunt	*H. chrysargyraeum*	0.3	0.50
	French grunt	*H. flavolineatum*	13.4	14.75
	white grunt	*H. plumieri*	3.5	2.89
	bluestriped grunt	*H. sciurus*	3.5	2.89
Sparidae	porgy	*Calamus* sp.	0.3	0.50
Scianidae	spotted drum	*Equetus punctatus*	0.3	0.50
Mullidae	yellow goatfish	*Mulloidichthys martinicus*	6.0	0.00
	spotted goatfish	*Pseudupeneus maculatus*	0.5	0.58
Kyphosidae	Bermuda chub	*Kyphosus sectatrix*	3.5	2.89
Ephippidae	Atlantic spadefish	*Chaetodipterus faber*	0.5	0.58
Pomacanthidae	queen angelfish	*Holacanthus ciliaris*	0.3	0.50
	rock beauty	*H. tricolor*	0.5	0.58
	gray angelfish	*Pomacanthus arcuatus*	0.5	0.58
	French angelfish	*P. paru*	0.8	0.50
Chaetodontidae	foureye butterflyfish	*Chaetodon capistratus*	3.5	2.89
Pomacentridae	sergeant major	*Abudefduf saxatilis*	(A) 9.5	7.22
			(J) 1.5	3.00
	blue chromis	*Chromis cyanea* *	30.5	20.82
	brown chromis	*C. multilineata*	9.2	7.62
	yellowtail damsel	*Microspathodon chrysurus*	(A) 23.1	14.81
			(J) 1.8	2.87
	honey damselfish	*Eupomacentrus mellis*	4.8	2.50
	dusky damselfish	*E. fuscus*	(A) 25.5	11.55
			(J) 0.5	0.59
	beaugregory	*E. leucostictus*	10.6	16.79
	bicolor damselfish	*E. partitus*	10.9	16.58
	three-spot damselfish	*E. planifrons*	(A) 25.5	11.55
			(J) 18.1	12.42
	cocoa damselfish	*E. variabilis*	(A) 7.1	6.06
			(J) 1.8	2.87

Table 25. Fish species found on reefs of Buck Island National Monument, St. Croix. Diurnal survey results are given first; nocturnal survey results are given below the dotted line. Densities (number of fish/500 m^2) are mean abundances (± S.D.) calculated from counts of fishes at four reef sites on diurnal surveys and two reef sites on nocturnal surveys, along transects of 500 m. Abundance categories given in the original reference were converted to densities by using the mean of the range covered by each category, i.e. category II, 2 - 10 individuals, was assigned a value of 6 individuals. Adapted from Gladfelter *et al.* (1977). (cont.)

FAMILY	COMMON NAME	SCIENTIFIC NAME	DENSITY MEAN	S.D.
Labridae	Spanish hogfish	*Bodianus rufus*	(A) 0.8	0.50
			(J) 0.3	0.50
	creole wrasse	*Clepticus parrai*	(A) 3.9	7.75
	slippery dick	*Halichoeres bivittatus*	(A) 8.4	4.75
			(J) 12.1	15.76
	yellowhead wrasse	*H. garnoti*	(A) 3.0	3.46
			(J) 5.6	7.09
	clown wrasse	*H. maculipinna*	(A) 0.5	0.58
			(J) 0.3	0.50
	blackear wrasse	*H. poeyi*	(A) 2.0	2.71
			(J) 0.3	0.50
	puddingwife	*H. radiatus*	(A) 1.0	0.00
			(J) 6.0	0.00
	bluehead	*Thalassoma*	(A) 3.0	3.46
		bifasciatum *	(J) 50.0	50.00
Scaridae	midnight parrotfish	*Scarus coelestinus*	0.8	0.50
	blue parrotfish	*S. coeruleus*	(J) 0.5	0.58
	striped parrotfish	*S. croicensis*	(A) 0.5	0.58
			(J) 35.5	0.00
	rainbow parrotfish	*S. guacamaia*	0.8	0.50
	princess parrotfish	*S. taeniopterus*	(A) 1.2	1.26
			(J) 35.5	0.00
	redband parrotfish	*Sparisoma aurofrenatum*	(A) 3.2	3.20
			(J) 5.9	6.84
	redtail parrotfish	*S. chrysopterum*	(A) 2.0	2.71
			(J) 3.0	3.46
	bucktooth	*S. radians*	(A) 0.5	0.58
	parrotfish		(J) 0.3	0.50
	yellowtail	*S. rubripinne*	(A) 3.2	3.20
	parrotfish		(J) 4.1	7.60
	stoplight parrotfish	*S. viride*	(A) 13.1	4.75
Sphyraenidae	great barracuda	*Sphyraena barracuda*	1.0	0.00
Clinidae	hairy blenny	*Labrisomus nuchipinnis*	0.3	0.50
	saddled blenny	*Malacoctenus triangulatus*	0.5	0.58
Blenniidae	redlip blenny	*Ophioblennius atlantlcus*	2.0	2.71

Table 25. Fish species found on reefs of Buck Island National Monument, St. Croix. Diurnal survey results are given first; nocturnal survey results are given below the dotted line. Densities (number of fish/500 m^2) are mean abundances (± S.D.) calculated from counts of fishes at four reef sites on diurnal surveys and two reef sites on nocturnal surveys, along transects of 500 m. Abundance categories given in the original reference were converted to densities by using the mean of the range covered by each category, i.e. category II, 2 - 10 individuals, was assigned a value of 6 individuals. Adapted from Gladfelter *et al.* (1977). (cont.)

FAMILY	COMMON NAME	SCIENTIFIC NAME	DENSITY MEAN	DENSITY S.D.
Gobiidae	bridled goby	*Coryphopterus glucofrenum*	14.2	15.54
	goldspot goby	*Gnatholepis thompsoni*	0.5	0.58
	cleaning goby	*Gobiosoma* sp.	3.2	3.20
Acanthuridae	ocean surgeon	*Acanthurus bahianus* *	(A) 32.8	19.92
			(J) 18.1	12.42
	doctorfish	*A. chirurgus*	0.3	0.50
	blue tang	*A. coeruleus*	(A) 35.5	0.00
			(J) 6.0	0.00
Scorpaenidae	spotted scorpionfish	*Scorpaena plumieri*	0.3	0.58
Bothidae	peacock flounder	*Bothus lunatus*	1.0	0.00
Balistidae	scrawled filefish	*Aluterus scriptus*	0.3	0.50
	queen triggerfish	*Balistes vetula*	1.0	0.00
	orangespotted filefish	*Cantherhines pullus*	0.5	0.58
	ocean triggerfish	*Canthidermis sufflamen*	0.3	0.50
	black durgon	*Melichthys niger*	0.3	0.50
	slender filefish	*Monacanthus tuckeri*	0.3	0.50
Ostraciidae	spotted trunkfish	*Lactophrys bicaudalis*	0.8	0.50
	smooth trunkfish	*L. triqueter*	2.2	2.50
	honeycmb cowfish	*Acanthostracion polygonius*	0.3	0.50
Canthigasteridae	sharpnose puffer	*Canthigaster rostrata*	1.8	2.87
Tetraodontidae	bandtail puffer	*Sphoeroides spengleri*	0.3	0.50
NOCTURNAL				
Holocentridae	reef squirrelfish	*Adioryx coruscus*	7.8	10.96
	dusky squirrelfish	*A. vexillarius*	25.0	35.36
	saddle squirrelfish	*A. poco*	0.5	0.71
	longjaw squirrelfish	*Holocentrus ascensionis*	0.5	0.71
	squirrelfish	*H. rufus*	35.5	0.00
	longspine squirrelfish	*Flammeo marianus*	6.0	0.00
	blackbar soldierfish	*Myripristis jacobus*	35.5	0.00
Priacanthidae	glasseye	*Priacanthus cruentatus*	0.5	0.71

Table 25. Fish species found on reefs of Buck Island National Monument, St. Croix. Diurnal survey results are given first; nocturnal survey results are given below the dotted line. Densities (number of fish/500 m^2) are mean abundances (± S.D.) calculated from counts of fishes at four reef sites on diurnal surveys and two reef sites on nocturnal surveys, along transects of 500 m. Abundance categories given in the original reference were converted to densities by using the mean of the range covered by each category, i.e. category II, 2 - 10 individuals, was assigned a value of 6 individuals. Adapted from Gladfelter *et al.* (1977). (cont.)

FAMILY	COMMON NAME	SCIENTIFIC NAME	DENSITY MEAN	DENSITY S.D.
Apogonidae	barred cardinalfish	*Apogon binotatus*	15.5	0.00
	flamefish	*A. maculatus*	3.0	4.24
	belted cardinalfish	*A. townsendi*	35.5	0.00
	unidentified	*Apogon* sp.	3.0	4.24
		Phaeotyx sp. *	50.0	0.00
Pempheridae	copper sweeper	*Pempheris schomburgki* *	32.7	24.20
Haemulidae	French grunt	*Haemulon flavolineatum*	7.8	10.96
	white grunt	*H. plumieri*	3.0	4.24
Sciaenidae	reef croaker	*Odontoscion dentex*	7.8	10.96
	spotted drum	*Equetus punctatus*	0.5	0.71
Mullidae	yellow goatfish	*Mulloidichthys martinicus*	3.0	4.24

Table 26. Thirteen fish species considered abundant on reefs of Buck Island Reef National Monument, St. Croix, by Adey *et al.* (1977).

FAMILY	COMMON NAME	SCIENTIFIC NAME
Scaridae	stoplight parrotfish	*Sparisoma viride*
	queen parrotfish	*Scarus vetula*
	striped parrotfish	*S. croicensis*
	midnight parrotfish	*S. coelestinus*
Acanthuridae	blue tang	*Acanthurus coeruleus*
	ocean surgeon	*A. bahianus*
Pomacentridae	dusky damselfish	*Eupomacentrus fuscus*
	three-spot damselfish	*E. planifrons*
	cocoa damselfish	*E. variabilis*
	beaugregory	*E. leucostictus*
	yellowtail damselfish	*Microspathodon chrysurus*
	sergeant major	*Abudefduf saxatilis*
	blue chromis	*Chromis cyane*a

Table 27. Adult fishes using reefs as 'typical habitat' on St. Croix, USVI. Abundance is qualitative: V = very common, C = common, O = occasional, R = rare. Water depth: W = wide range from shallow to deep; V = very shallow, surface to 2 m; S = shallow, 1-15 m; and D = deep, below 15 m. Adapted from Clavijo *et al.* (1980).

FAMILY	COMMON NAME	SCIENTIFIC NAME	ABUNDANCE	DEPTH
Orectolobidae	nurse shark	*Ginglymostoma cirratum*	C	W
Carcharinidae	reef shark	*Carcharhinus perezi*	C	W
	tiger shark	*Galeocerdo cuvier*	C	W
	smooth dogfish	*Mustelus canis*	R	W
	lemon shark	*Negaprion brevirostris*	O	W
Myliobatidae	spotted eagle ray	*Aetobatis narinari*	O	S
Muraenidae	chestnut moray	*Enchelycore carychroa*	O	S
	viper ray	*E. nigricans*	O	S
	green moray	*Gymnothorax funebris*	C	S
	spotted moray	*G. moringa*	C	S
	goldentail moray	*Muraena miliaris*	O	S
	marbled moray	*Uropterygius diopus*	O	S
Congridae	bandtooth conger	*Ariosoma balearicum*	C	S
Ophichthidae	key moray eel	*Ahlia egmontis*	C	S
	stripe eel	*Aprognathodon platyventris*	O	S
	sharptail eel	*Myrichthys acuminatus*	C	S
	broadnose moray eel	*Myrophis platyrhynchus*	O	S
Antennariidae	longlure frogfish	*Antennarius multiocellatus*	O	S
	ocellated frogfish	*A. ocellatus*	O	S
Bythitidae	key brotula	*Ogilbia cayorum*	O	S
	black brotula	*Stygnobrotula latebricola*	O	S
Myctophidae	Caribbean flashlightfish	*Kryptophanaron alfredi*	O	D
Holocentridae	reef squirrelfish	*Holocentrus coruscus*	C	S
	saddle squirrelfish	*H. poco*	C	S
	dusky squirrelfish	*H. vexillarius*	C	S
	longjaw squirrelfish	*H. marianus*	C	W
	squirrelfish	*H. ascensions*	C	S
	longspine squirrelfish	*H. rufus*	V	W
	blackbar squirrelfish	*Myripristis jacobus*	C	S
	cardinal squirrelfish	*Plectrypops retrospinis*	O	W
Aulostomidae	trumpetfish	*Aulostomus maculatus*	C	W
Syngnathidae	longsnout seahorse	*Hippocampus reidi*	O	S
	harlequin pipefish	*Micrognathus ensenadae*	O	S
Serranidae	coney	*Epinephelus fulvus*	C	W
	rock hind	*E. adscensionis*	C	S
	graysby	*E. cruentatus*	C	W
	red hind	*E. guttatus*	C	W
	jewfish	*E. itajara*	O	W
	Nassau grouper	*E. striatus*	C	S
	yellowbelly hamlet	*Hypolectrus aberrans*	C	S
	yellowtail hamlet	*H. chlorurus*	C	S
	shy hamlet	*H. guttavarius*	O	S
	black hamlet	*H. nigricans*	C	S

Table 27. Adult fishes using reefs as 'typical habitat' on St. Croix, USVI. Abundance is qualitative: V = very common, C = common, O = occasional, R = rare. Water depth: W = wide range from shallow to deep; V = very shallow, surface to 2 m; S = shallow, 1-15 m; and D = deep, below 15 m. Adapted from Clavijo *et al.* (1980). (cont.)

FAMILY	COMMON NAME	SCIENTIFIC NAME	ABUNDANCE	DEPTH
	barred hamlet	*H. puella*	V	S
	butter hamlet	*H. unicolor*	C	S
	candy basslet	*Liopropoma carmabi*	O	D
	cave basslet	*L. mowbrayi*	O	D
	peppermint basslet	*L. rubre*	C	W
	yellowmouth grouper	*Mycteroperca interstitialis*	O	W
	tiger grouper	*M. tigris*	C	W
	yellowfin grouper	*M. venenosa*	O	W
	creole-fish	*Paranthias furcifer*	O	D
	school bass	*Schultzea beta*	C	D
	(new species)	*Serranus incisus*	R	D
	harlequin bass	*S. tigrinus*	O	W
Grammidae	(new species)	*Gramma linki*	O	D
	fairy basslet	*G. loreto*	C	W
Grammistidae	reef bass	*Pseudogramma gregoryi*	O	S
	greater soapfish	*Rypticus saponaceus*	C	S
	spotted soapfish	*R. subbifrenatum*	R	S
Priacanthidae	bigeye	*Priacanthus arenatus*	C	S
	glasseye snapper	*P. cruentatus*	O	S
	short bigeye	*Pristigenys alta*	R	D
Apogonidae	barred cardinalfish	*Apogon binotatus*	A	W
	whitestar cardinalfish	*A. lachneri*	C	W
	flamefish	*A. maculatus*	A	W
	pale cardinalfish	*A. planifrons*	O	S
	sawcheek cardinalfish	*A. quadrisquamatus*	C	W
	belted cardinalfish	*A. townsendi*	C	W
	bronze cardinalfish	*Astrapogon alutus*	R	S
	blackfin cardinalfish	*A. puncticulatus*	O	S
	bigtooth cardinalfish	*A. affinis*	O	W
	freckled cardinalfish	*Phaeoptyx conklini*	A	S
	dusky cardinalfish	*P. pigmentaria*	O	W
	sponge cardinalfish	*P. xenus*	O	W
Rachycentridae	cobia	*Rachycentron canadum*	R	W
Echeneidae	sharksucker	*Echeneis naucrates*	O	W
	remora	*Remora remora*	O	W
Carangidae	yellow jack	*Caranx bartholomaei*	C	W
	horse-eye jack	*C. latus*	C	W
	bar jack	*C. ruber*	A	S
	bigeye scad	*Selar crumenophthalmus*	C	S
	greater amberjack	*Seriola dumerili*	O	W
	almaco jack	*S. rivoliana*	O	W
	permit	*Trachinotus flacatus*	C	V
Inermiidae	boga	*Inermia vittata*	C	D

Table 27. Adult fishes using reefs as 'typical habitat' on St. Croix, USVI. Abundance is qualitative: V = very common, C = common, O = occasional, R = rare. Water depth: W = wide range from shallow to deep; V = very shallow, surface to 2 m; S = shallow, 1-15 m; and D = deep, below 15 m. Adapted from Clavijo *et al.* (1980). (cont.)

FAMILY	COMMON NAME	SCIENTIFIC NAME	ABUNDANCE	DEPTH
Lutjanidae	schoolmaster	*Lutjanus apodus*	A	S
	cubera snapper	*L. cyanopterus*	O	W
	gray snapper	*L. griseus*	O	W
	dog snapper	*L. jocu*	C	W
	mahogany snapper	*L. mahogani*	C	S
	Caribbean red snapper	*L. purpureus*	R	D
	lane snapper	*L. synagris*	C	W
Haemulidae	yellowtail snapper	*Ocyurus chrysurus*		
	black margate	*Anisotremus surinamensis*	O	S
	porkfish	*A. virginicus*	O	S
	tomtate	*Haemulon aurolineatum*	C	W
	caesar grunt	*H. carbonarium*	O	W
	smallmouth grunt	*H. chrysargyreum*	C	W
	French grunt	*H. flavolineatum*	A	W
	Spanish grunt	*H. macrostomus*	O	W
	cottonwick	*H. melanurum*	O	W
	sailors choice	*H. parrai*	O	W
	white grunt	*H. plumieri*	C	W
	bluestriped grunt	*H. sciurus*	C	W
Sparidae	jolthead porgy	*Calamus bajonado*	O	W
	sheepshead porgy	*C. penna*	O	W
	pluma	*C. pennatula*	O	W
Sciaenidae	jacknife-fish	*Equetus lanceolatus*	C	S
	high-hat	*E. acuminatus*	C	S
	potted drum	*E. punctatus*	O	S
	eel croaker	*Odontoscion dentex*	C	S
Mullidae	yellow goatfish	*Mulloidichthys martinicus*	C	S
	spotted goatfish	*Pseudupeneus maculatus*	C	S
Pempheridae	glassy sweeper	*Pempheris schomburgki*	C	S
Kyphosidae	Bermuda chub	*Kyphosus sectatrix*	C	S
Ephippidae	Atlantic spadefish	*Chaetodipterus faber*	O	W
Pomacanthidae	queen angelfish	*Holacanthus ciliaris*	C	S
	red beauty	*H. tricolor*	C	S
	gray angelfish	*Pomacanthus arcuatus*	C	S
	French angelfish	*P. paru*	G	S
	cherubfish	*Centropyge argi*	O	D
Chaetodontidae	foureye butterflyfish	*Chaetodon capistratus*	A	S
	spotfin butterflyfish	*C. ocellatus*	O	W
	reef butterflyfish	*C. sedentarius*	O	W
	banded butterflyfish	*C. striatus*	C	S
	longsnout butterflyfish	*C. aceleatus*	O	D

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FAMILY	COMMON NAME	SCIENTIFIC NAME	ABUNDANCE	DEPTH
Pomacentridae	sergeant major	*Abudefduf saxatilis*	C	S
	blue chromis	*Chromis cyanea*	C	W
	sunshinefish	*C. insolatus*	C	D
	brown chromis	*C. multilineatus*	C	W
	purple reeffish	*C. scotti*	O	D
	dusky damselfish	*Pomacentrus fuscus*	A	S
	beaugregory	*P. leucostictus*	A	S
	bicolor damselfish	*P. partitus*	C	W
	threespot damselfish	*P. planifrons*	C	S
	cocoa damselfish	*P. variabilis*	O	S
	honey gregory	*Stegastes mellis*	O	S
	yellowtail damselfish	*Microspathodon chrysurus*	C	S
Cirrhithidae	redspotted hawkfish	*Amblycirrhitus pinos*	O	W
Labridae	spotfin hogfish	*Bodianus pulchellus*	O	D
	Spanish hogfish	*B. rufus*	C	W
	Creole wrasse	*Clepticus parrai*	C	W
	slippery dick	*Halichoeres bivittatus*	C	S
	yellowhead wrasse	*H. garnoti*	O	W
	clown wrasse	*H. maculipinna*	C	S
	rainbow wrasse	*H. pictus*	O	W
	puddingwife	*H. radiatus*	C	S
	hogfish	*Lachnolaimus maximus*	R	S
	bluehead	*Thalassoma bifasciatum*	A	S
Scaridae	midnight parrotfish	*Scarus coelestinus*	O	S
	blue parrotfish	*S. coeruleus*	O	S
	rainbow parrotfish	*S. guacamaia*	O	W
	striped parrotfish	*S. croicensis*	C	S
	princess parrotfish	*S. taeniopterus*	C	W
	queen parrotfish	*S. vetula*	A	S
	greenblotch parrotfish	*Sparisoma atomarium*	O	W
	redband parrotfish	*S. aurofrenatum*	C	W
	redtail parrotfish	*S. chrysopterum*	C	S
	redfin parrotfish	*S. rubripinne*	C	S
	stoplight parrotfish	*S. viride*	A	S
Sphyraenidae	great barracuda	*Sphyraena barracuda*	C	W
	southern sennet	*S. picudilla*	O	W
Clinidae	spinyhead blenny	*Acanthemblemaria spinosa*	C	S
	blackhead blenny	*Emblemariopsis bahamensis*	O	S
	roughhead triplefin	*Enneanectes boehlkei*	O	S
	arrow blenny	*Lucayablennius zingaro*	C	W
	saddled blenny	*Malacoctenus triangulatus*	C	S
	banded blenny	*Paraclinus fasciatus*	O	V
	smootheye blenny	*Starksia atlantica*	O	S
	blackbar blenny	*S. fasciata*	O	S

Table 27. Adult fishes using reefs as 'typical habitat' on St. Croix, USVI. Abundance is qualitative: V = very common, C = common, O = occasional, R = rare. Water depth: W = wide range from shallow to deep; V = very shallow, surface to 2 m; S = shallow, 1-15 m; and D = deep, below 15 m. Adapted from Clavijo *et al.* (1980). (cont.)

FAMILY	COMMON NAME	SCIENTIFIC NAME	ABUNDANCE	DEPTH
	dwarf blenny	*S. nanodes*	O	W
	naked blenny	*Stathmonotus gymnodermis*	O	S
	eelgrass blenny	*S. stahli*	O	S
Blennidae	orangespotted blenny	*Hypleurochilus springeri*	C	S
	redlip blenny	*Ophioblennius atlanticus*	A	S
Gobiidae	barfin goby	*Coryphopterus alloides*	O	W
	glass goby	*C. hyalinus*	O	W
	peppermint goby	*C. lipernes*	O	W
	masked goby	*C. personatus*	C	W
	shortstripe goby	*Gobiosoma chancei*	C	W
	orangeside goby	*G. dilepis*	O	S
	sharknose goby	*G. evelynae*	C	S
	cleaning goby	*G. prochilos*	C	S
	figure-eight goby	*G saucrum*	O	S
	slaty goby	*G. tenob*	O	W
	rusty goby	*Quisquilius hipoliti*	C	W
	smallmouth goby	*Risor ruber*	O	S
Acanthuridae	ocean surgeon	*Acanthurus bahianus*	G	S
	doctorfish	*A. chirurgus*	C	W
	blue tang	*A. coeruleus*	A	S
Scombridae	cero	*Scomberomorus regalis*	C	W
Scorpaenidae	spotted scorpionfish	*Scorpaena plumieri*	C	S
	reef scorpionfish	*Scorpaenodes caribbeaus*	C	S
Bothidae	maculated flounder	*Bothus maculiferus*	O	S
	eyed flounder	*B. ocellatus*	C	S
Balistidae	scrawled filefish	*Aluterus scriptus*	O	S
	gray triggerfish	*Balistes capriscus*	O	W
	queen triggerfish	*B. vetula*	C	S
	whitespotted filefish	*Cantherhines macrocerus*	O	S
	orangespotted filefish	*C. pullus*	C	S
	ocean triggerfish	*C. sufflamen*	O	W
	black durgon	*Melichthys niger*	C	W
	slender filefish	*Monacanthus tuckeri*	C	S
	sargassum triggerfish	*Xanthichthys ringens*	C	D
Ostraciidae	spotted trunkfish	*Lactophrys bicaudalis*	O	S
	honeycomb cowfish	*L. polygonia*	O	W
	smooth trunkfish	*L. triqueter*	C	S
Tetraodontidae	sharpnose puffer	*Canthigaster rostrata*	A	W
Diodontidae	web burrfish	*Chilomycterus antillarum*	R	W
	porcupinefish	*Diodon hystrix*	C	S
	balloonfish	*D. holocanthus*	A	S

Table 28. Fish species occurring on reefs off La Parguera, Puerto Rico; Presence of species on two reef types - shallow (SR) and offshore (OR) - is indicated by 'X'. Shallow reef here includes three reef habitats ('HRS', 'LRA', 'LRS') and offshore reef here includes three deep-reef habitats ('HRE', 'HRO', 'LRO'). Fish species are grouped into species groups using cluster analysis of abundance measures (number of fish per unit time). Adapted from Kimmel (1985).

SPECIES GROUP	SCIENTIFIC NAME	SR	OR
A	*Holocentrus rufus*	X	X
	Acanthurus bahianus	X	X
	Thalassoma bifasciatum	X	X
	Stegastes partitus	X	X
	Ocyurus chrysurus	X	X
	Coryphoperus glaucofraenum	X	X
	Caranx ruber	X	X
	Acanthurus coeruleus	X	X
	Haemulon flavolineatum	X	X
	Chaetodon capistratus	X	X
	Haemulon plumieri	X	X
	Scarus iserti	X	X
	Sparisoma viride	X	X
	Gobiosoma evelynae	X	X
	Sparisoma aurofrenatum	X	X
B	*Myripristis jacobus*	X	X
	Epinephelus cruentatus	X	X
	Haemulon sciurus	X	X
	Aulostomus maculatus	X	X
	Lutjanus mahogoni	X	X
	L. apodus	X	X
	Mulloidichthys martinicus	X	X
	Abudefduf saxatilis	X	X
	Microspathodon chrysurus	X	X
	Hypoplectrus chlorosus	X	X
	Stegastes planifrons	X	X
	S. variabilis	X	X
	Hypoplectrus puella	X	X
	H. unicolor	X	X
	Gramma loreto	X	X
	Coryphopterus personatus	X	X
C	*Epinephelus guttatus*	X	X
	Canthigaster rostrata	X	X
	Pomacanthus arcuatus	X	X
	Holacanthus ciliaris	X	X
	Anisotremus virginicus	X	X
	Chaetodon striatus	X	X
	Halichoeres maculipinna	X	X
	Scomberomorus regalis	X	X
	Lachnolaimus maximus	X	X

Table 28. Fish species occurring on reefs off La Parguera, Puerto Rico; Presence of species on two reef types - shallow (SR) and offshore (OR) - is indicated by 'X'. Shallow reef here includes three reef habitats ('HRS', 'LRA', 'LRS') and offshore reef here includes three deep-reef habitats ('HRE', 'HRO', 'LRO'). Fish species are grouped into species groups using cluster analysis of abundance measures (number of fish per unit time). Adapted from Kimmel (1985). (cont.)

SPECIES GROUP	SCIENTIFIC NAME	SR	OR
	Acanthemblemaria spinosa	X	X
	Gobiosoma chancei	X	X
	Pseudupeneus maculatus	X	X
	Calamus pennatula	X	X
	Gnatholepis thompsoni	X	X
	Halichoeres garnoti	X	X
	Serranus tigrinus	X	X
D	*Scarus vetula*	X	X
	S. taeniopterus	X	X
	Epinephelus fulvus	X	X
	Holacanthus tricolor	X	X
	Melichthys niger	X	X
	Bodianus rufus	X	X
	Chromis cyaneus	X	X
E	*Xanthichthys ringens*	-	X
	Liopropoma rubre	-	X
	Chromis insolatus	-	X
	Apogon lachneri	-	X
F	*Halichoeres bivittatus*	X	X
	Holocentrus ascensionis	X	X
	Sparisoma chrysopterum	X	X
	Acanthurus chirurgus	X	X
	Halichoeres poeyi	X	X
	Haemulon juveniles	X	-
	Diodon holacanthus	X	X
	Halichoeres radiatus	X	X
	Ophioblennius atlanticus	X	X
	Haemulon carbonarium	X	X
	Stegastes diencias	X	X
	Diodon hystrix	X	X
	Malacoctenus triangulatus	X	X
	Stegastes fuscus	X	-
	Haemulon chrysargyreum	X	X
	Stegastes leucostictus	X	X

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SPECIES GROUP	SCIENTIFIC NAME	SR	OR
G	*Sparisoma radians*	X	-
	Malacoctenus macrops	X	-
	Holocentrus coruscus	X	X
	Tylosurus acus	X	-
	Atherinidae	X	-
	Sparisoma juveniles	X	-
	Holocentrus vexillarius	X	X
	Apogon maculatus	X	-
H	*Gobiosoma saucrum*	X	-
	Scarus guacamaia	X	X
	Oligoplites saurus	X	-
	Apogon xenus	X	X
	Pomacanthus paru	X	X
	Scarus coelestinus	X	X
	Odontoscion dentex	X	X
	Sparisoma rubripinne	X	-
	Malacoctenus sp.	X	X
	Sphoeroides greelyi	X	-
	Lactophrys bicaudalis	X	-
	Echeneis naucrates	X	X
	Haemulon album	X	-
	Hypoplectrus guttavarius	X	-
	Haemulon macrostomum	X	X
	Anisotremus surinamensis	X	X
	Lutjanus jocu	X	X
	Priacanthus cruentatus	X	X
	Equetus punctatus	X	X
	Coryphopterus dicrus	X	X
	Chaetodipterus faber	X	X
	Mycteroperca rubra	X	-
I	*Hypoplectrus abberans*	X	X
	Lactophrys triqueter	X	X
	Epinephelus striatus	X	X
	E. adscensionis	X	X
	Synodus sp.	X	X
	Haemulon aurolineatum	X	X
	Sphyraena barracuda	X	X
	Balistes vetula	X	X
	Equetus acuminatus	X	X

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SPECIES GROUP	SCIENTIFIC NAME	SR	OR
	Hypoplectrus indigo	X	X
	H. nigricans	X	X
	Lutjanus analis	X	X
	Opisthonema oglinum	X	-
	Sparisoma atomarium	X	X
	Dasyatis americana	X	X
J	*Chaenopsis limbaughi*	X	-
	Acanthemblemaria sp.	X	-
	Bothus lunatus	X	X
	Lactophrys polygonia	X	X
	Sphoeroides spengleri	X	X
	Lythrypnus nesiotes	X	X
K	*Chaetodon ocellatus*	X	X
	Gymnothorax moringa	X	X
	Mycteroperca tigris	-	X
	Gymnothorax funebris	-	X
	Caranx bartholomaei	X	X
	Ginglymostoma cirratum	X	X
	Canthidermis sufflamen	-	X
	Aluterus schoepfi	-	X
	Scomberomorus cavalla	-	X
	Centropyge argi	-	X
	Halichoeres cyanocephalus	-	X
	Apogon binotatus	X	X
L	*Cantherhines pullus*	X	X
	Amblycirrhitus pinos	-	X
	Holocentrus marianus	X	X
	Clepticus parrai	X	X
	Chaetodon aculeatus	X	X
	Coryphopterus lipernes	-	X
	Paranthias furcifer	-	X
	Chaetodon sedentarius	X	X
	Quisquilius hipoliti	-	X
	Inermia vittata	-	X
	Aluterus scriptus	X	X
	Apogon maculatus	-	X
	Gymnothorax vicinus	-	X

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SPECIES GROUP	SCIENTIFIC NAME	SR	OR
M	*Nes longus*	X	-
	Eucinostomus argenteus	X	-
	Lutjanus synagris	X	-
	Entomacrodus nigricans	X	-
	Caranx crysos	-	X
	C. hippos	X	X
N	*Lutjanus griseus*	X	X
	Jenkinsia lamprotaenia	X	-
	Archosargus rhomboidalis	X	-
	Eucinostomus sp.	X	-
	Gerres cinereus	X	-
	Caranx latus	X	X
	Haemulon parrai	X	-
	Abudefduf taurus	-	X
O	*Malacanthus plumieri*	X	X
	Apogon quadrisquamatus	X	X
	Cryptotomus roseus	X	X
	Opistognathus aurifrons	X	X
	Serranus tabacarius	-	X

Table 29. The 18 most abundant fish species in a line transect survey of a reef off La Parguera, Puerto Rico. Relative abundance is abundance of each species over total abundance of all species, expressed as a percentage. Density is number of fish/hectare. Adapted from Kimmel (1985).

Family	Common Name	Scientific Name	Relative Abundance	Density
Pomacentridae	bicolor damselfish	*Pomacentrus partitus*	22.28	9,458
Labridae	bluehead	*Thalassoma bifasciatum*	13.60	5,773
Pomacentridae	blue chromis	*Chromis cyaneus*	9.27	3,935
Scaridae	striped parrotfish	*Scarus croicensis*	4.26	1,808
Scaridae	redband parrotfish	*Sparisoma aurofrenatum*	4.22	1,791
	yellowhead wrasse	*Halichoeres garnoti*	4.00	1,698
Acanthuridae	ocean surgeon	*Acanthurus bahianus*	3.53	1,498
Holocentridae	longspine squirrelfish	*Holocentrus rufus*	3.00	1,274
Holocentridae	blackbar soldierfish	*Myripristis jacobus*	2.91	1,235
Labridae	Creole wrasse	*Clepticus parrai*	2.73	1,159
Chaetodontidae	longsnout butterflyfish	*Chaetodon aculeatus*	2.39	1,015
Serranidae	coney	*Epinephelus fulvus*	2.14	908
Gobiidae	peppermint goby	*Coryphopterus lipernes*	1.71	726
Scaridae	princess parrotfish	*Scarus taeniopterus*	1.61	683
Scaridae	stoplight parrotfish	*Sparisoma viride*	1.61	683
Pomacentridae	brown chromis	*Chromis multilineatus*	1.57	666
Balistidae	black durgon	*Melichthys niger*	1.51	641
Gobiidae	bridled goby	*Coryphopterus glaucofraenum*	1.82	433
Clinidae	spinyhead blenny	*Acanthemblemaria spinosa*	6.96	408

Table 30. Fishes observed in visual censuses of six reef environments of St. John: UFR = upper fore-reef; LFR = lower fore-reef; GF = gorgonian flats; PR = patch reef (natural and artificial). Only fishes of commercial importance were recorded. Densities (number of fish/m^2) are calculated mean number of fish in each 201.1-m^2 census, weighted by number of censuses. Density is written in exponential notation. Fish sizes (cm) are weighted by number of fishes observed. Adapted from Boulon (1985a).

	UFR		LFR		GF	
SPECIES	DENSITY	SIZE	DENSITY	SIZE	DENSITY	SIZE
mackerel	-	-	6.7E-4	36.5	5.3E-4	40.6
kingfish	-	-	-	-	-	-
carang	5.0E-3	23.8	7.2E-3	23.9	-	-
blackjack	-	-	8.2E-5	25.4	-	-
amberjack	-	-	1.6E-4	53.3	-	-
queen triggerfish	1.1E-4	25.4	4.2E-4	34.6	-	-
bluestriped grunt	2.5E-3	19.5	3.9E-3	17.4	-	-
white grunt	6.3E-3	14.2	2.2E-3	13.3	-	-
French grant	9.5E-2	9.4	4.8E-2	12.7	4.6E-3	12.7
tomtate	6.8E-3	8.6	1.6E-2	13.9	8.2E-5	15.2
small-mouth grunt	7.0E-3	10.5	2.1E-3	12.7	-	-
Spanish grunt	3.6E-4	16.0	-	-	-	-
caesar grunt	1.7E-3	12.7	1.1E-4	NA	-	-
sailors choice	-	-	5.8E-4	15.2	-	-
juvenile grunts	-	-	-	-	-	-
margate	-	-	1.6E-4	25.4	8.2E-5	25.4
mutton snapper	2.8E-5	76.2	4.1E-4	36.8	-	-
dog snapper	2.8E-4	17.7	3.3E-4	38.1	-	-
gray snapper	8.7E-4	38.1	1.2E-3	25.4	-	-
schoolmaster	1.2E-2	15.4	1.0E-2	19.8	-	-
yellowtail snapper	3.9E-3	17.4	1.3E-2	17.7	8.2E-3	16.5
mahogany snapper	6.6E-3	15.6	9.9E-4	16.5	-	-
French and queen angelfish	1.1E-4	5.0	9.9E-4	25.4	-	-
gray angelfish	2.5E-4	27.1	2.9E-3	23.8	1.2E-3	23.1
red hind	1.1E-4	12.7	2.0E-3	17.8	3.7E-3	13.2
graysby	-	-	2.5E-4	21.5	-	-
coney	3.6E-4	16.5	1.1E-3	20.3	-	-
mutton hamlet	-	-	-	-	-	-
Nassau grouper	-	-	4.1E-4	35.5	-	-
black grouper	-	-	8.9E-5	37.2	8.2E-5	30.4
tiger grouper	-	-	4.2E-4	23.2	4.1E-5	30.4
porgies	-	-	7.4E-4	22.8	3.7E-4	15.2
doctorfish	5.9E-2	11.4	5.8E-2	12.7	3.0E-2	10.1
yellow goatfish	1.2E-2	16.8	5.4E-3	17.6	5.3E-4	17.3
spotted goatfish	1.4E-4	12.6	1.8E-3	17.4	7.4E-4	13.9
Spanish hogfish	1.9E-5	25.4	7.4E-4	22.8	-	-
parrotfish	1.8E-2	16.3	4.9E-2	14.8	5.9E-2	14.5
trunkfish	4.0E-4	17.1	5.8E-4	19.0	-	-
porkfish	5.6E-5	16.5	1.6E-4	17.7	-	-
sea chubs	4.0E-4	24.1	5.0E-4	29.2	-	-
spadefish	-	-	1.6E-3	27.9	-	-
barracuda	2.5E-4	96.5	4.1E-4	100.3	-	-
mullet	3.4E-4	25.4	-	-	-	-
squirrelfish	3.2E-3	14.5	1.5E-2	15.2	4.1E-4	14.0
mojarra	8.7E-4	25.3	6.7E-4	21.6	-	-

Table 30. Fishes observed in visual censuses of six reef environments of St. John: UFR = upper fore-reef; LFR = lower fore-reef; GF = gorgonian flats; PR = patch reef (natural and artificial). Only fishes of commercial importance were recorded. Densities (number of fish/m^2) are calculated mean number of fish in each 201.1-m^2 census, weighted by number of censuses. Density is written in exponential notation. Fish sizes (cm) are weighted by number of fishes observed. Adapted from Boulon (1985a). (cont.)

	PR			
	NATURAL		ARTIFICIAL	
SPECIES	DENSITY	SIZE	DENSITY	SIZE
mackerel	4.4E-4	40.6	-	-
kingfish	2.2E-4	106.6	-	-
carang	1.6E-2	19.0	-	-
blackjack	-	-	-	-
amberjack	-	-	-	-
queen triggerfish	3.3E-3	31.7	5.0E-3	20.3
bluestriped grunt	3.9E-3	16.5	-	-
white grunt	3.5E-3	18.0	2.5	7.6
French grant	1.2E-1	6.5		
tomtate	1.9E-2	11.7	9.9	3.8
small-mouth grunt	-	-	-	-
Spanish grunt	-	-	-	-
caesar grunt	-	-	-	-
sailors choice	6.6E-3	22.8	-	-
juvenile grunts	2.2E-2	3.8	-	-
margate	-	-	-	-
mutton snapper	1.1E-4	NA	-	-
dog snapper	-	-	-	-
gray snapper	0.12	17.7	-	-
schoolmaster	5.0E-3	20.3	-	-
yellowtail snapper	2.4E-1	20.2	3.5E-2	12.7
French and queen angelfish	-	-	5.0E-3	20.3
gray angelfish	3.5E-3	27.9	-	-
red hind	1.5E-3	19.0	5.0E-3	25.4
graysby	-	-	-	-
coney	2.3E-3	19.0	5.0E-3	20.3
mutton hamlet	-	-	1.2E-1	17.7
Nassau grouper	2.2E-4	35.5	-	-
black grouper	4.4E-4	22.8	-	-
tiger grouper	-	-	-	-
porgies	1.4E-3	20.3	-	-
doctorfish	1.2E-2	13.4	7.4E-2	11.4
yellow goatfish	1.5E-2	16.0	-	-
spotted goatfish	4.4E-4	14.E	-	-
Spanish hogfish	6.6E-4	16.5	-	-
parrotfish	3.8E-2	13.8	5.0E-3	10.1
trunkfish	4.4E-4	12.7	-	-
porkfish	-	-	-	-
sea chubs	1.1E-4	NA	-	-
spadefish	-	-	-	-
barracuda	5.5E-4	83.3	5.0E-3	76.2
mullet	-	-	-	-
squirrelfish	3.5E-3	15.2	5.0E-1	15.2
mojarra	2.2E-4	10.1	-	-

Table 31. Fish species observed during visual censuses of shallow reef habitats of St. John and the British Virgin Islands. Only species of commercial importance were recorded, 'A' indicates adults, 'J' indicates juveniles. Adapted from Boulon (1985b).

	REEF BAY ST. JOHN Patch Reef (15-25 m)	NORMAN ISLAND BVI Lower Fore-reef (6-16 m)	GREAT THATCH ISLAND .....BVI..... Upper Fore-reef (to 13 m)	Lower Fore-reef (to 25 m)
bar jack	A	A	-	J
queen triggerfish	A	A	-	-
bluestriped grunt	A	-	A	-
white grunt	A	A	-	-
French grunt	A	A	J,A	A
tomtate	-	A	J,A	-
schoolmaster	A	-	A	-
yellowtail snapper	A	-	-	J,A
mahogany snapper	-	-	J,A	-
gray angelfish	J,A	-	-	-
rock beauty	-	A	-	-
red hind	A	A	-	-
graysby	-	A	-	-
coney	A	-	-	-
Nassau grouper	A	-	-	-
tiger grouper	-	J	-	-
doctorfish	A	J,A	J,A	A
yellow goatfish	-	A	A	-
spotted goatfish	-	A	-	-
Spanish hogfish	J,A	-	-	-
parrotfish	J,A	J,A	J,A	J,A
trunkfish	A	-	-	-
squirrelfish	A	A	A	A
mojarra	J,A	-	A	-
dwarf herring	-	-	J,A	-
TOTAL # SPECIES	17	14	11	6

Table 32. Common fish species occurring on shallow reefs of the Caribbean. Adapted from Randall (1983).

FAMILY	COMMON NAME	SCIENTIFIC NAME
Orectolobidae	nurse shark	*Ginglymostoma cirratum*
Carcharhinidae	tiger shark	*Galeocerdo cuvier*
	lemon shark	*Negaprion brevirostris*
	sharpnose shark	*Rhizoprionodon porosus*
	Caribbean reef shark	*Carcharhinus perezi*
	blacktip shark	*C. limbatus*
	bull shark	*C. leucas*
Sphyrnidae	great hammerhead	*Sphyrna mokarran*
	scalloped hammerhead	*S. lewini*
Dasyatididae	southern stingray	*Dasyatis americana*
	yellowspotted stingray	*Urolophus jamaicensis*
Myliobatidae	spotted eagle ray	*Aetobatis narinari*
Torpedinidae	lesser electric ray	*Narcine brasiliensis*
Elopidae	ladyfish	*Elops* sp.
	tarpon	*Megalops atlanticus*
Albulidae	bonefish	*Albula vulpes*
Clupeidae	redear sardine	*Harengula humeralis*
	false pilchard	*H. clupeola*
	thread herring	*Opisthonema oglinum*
	dwarf herring	*Jenkinsia lamprotaenia*
Engraulididae	dusky anchovy	*Anchoa lyolepis*
Synodontidae	sand diver	*Synodus intermedius*
	galliwasp	*S. foetens*
	rockspear	*S. synodus*
	snakefish	*Trachinocephalus myops*
Congridae	manytooth conger	*Conger triporiceps*
	garden eel	*Heteroconger halis*
Ophichthidae	potted snake eel	*Ophichthus ophis*
	shrimp eel	*O. gomesii*
	goldspotted snake eel	*Myrichthys oculatus*
	sharptail eel	*M. acuminatus*
Muraenidae	spotted moray	*Gymnothorax moringa*
	green moray	*G. funebris*
	purplemouth moray	*G. vicinus*
	goldentail moray	*G. miliaris*
	viper moray	*Enchelycore nigricans*
	chain moray	*Echidna catenata*
Belonidae	timucu	*Strongylura timucu*
	redfin needlefish	*S. notata*
	houndfish	*Tylosurus crocodilus*
	keeled needlefish	*Platybelone argalus*
Hemiramphidae	ballyhoo	*Hemiramphus brasiliensis*
	balao	*H. balao*
Fistulariidae	cornetfish	*Fistularia tabacaria*
Aulostomidae	trumpetfish	*Aulostomus maculatus*
Syngnathidae	Caribbean pipefish	*Syngnathus caribbaeus*
	slender sea horse	*Hippocampus reidi*

Table 32. Common fish species occurring on shallow reefs of the Caribbean. Adapted from Randall (1983). (cont.)

FAMILY	COMMON NAME	SCIENTIFIC NAME
Holocentridae	longjaw squirrelfish	*Holocentrus ascensionis*
	squirrelfish	*H. rufus*
	longspine squirrelfish	*Neoniphon marianus*
	reef squirrelfish	*Sargocentron coruscum*
	dusky squirrelfish	*S. vexillarium*
	blackbar soldierfish	*Myripristis jacobus*
	cardinal soldierfish	*Plectrypops retrospinis*
Atherinidae	hardhead silversides	*Atherinomorus stipes*
	reef silversides	*Allanetta harringtonensis*
Mugilidae	white mullet	*Mugil curema*
Sphyraenidae	great barracuda	*Sphyraena barracuda*
	southern sennet	*S. picudilla*
Polynemidae	barbu	*Polydactylus virginicus*
	smallscale threadfin	*P. oligodon*
Serranidae	red hind	*Epinephelus guttatus*
	rock hind	*E. adscensionis*
	Nassau grouper	*E. striatus*
	red grouper	*E. morio*
	jewfish	*E. itajara*
	coney	*E. fulvus*
	graysby	*E. cruentatus*
	mutton hamlet	*Epinephelus afer*
	yellowfin grouper	*Mycteroperca venenosa*
	black grouper	*Mycteroperca bonaci*
	tiger grouper	*M. tigris*
	yellowmouth grouper	*M. interstitialis*
	scamp	*M. phenax*
	comb grouper	*M. rubra*
	white grouper	*M. cidi*
	marbled grouper	*Dermatolepis inermis*
	barred hamlet	*Hypoplectrus puella*
	butter hamlet	*H. unicolor*
	indigo hamlet	*H. indigo*
	black hamlet	*H. nigricans*
	yellowtail hamlet	*H. chlorurus*
	yellowbellied hamlet	*H. aberrans*
	shy hamlet	*H. guttavarius*
	golden hamlet	*H. gummigutta*
	aguavina	*Diplectrum bivittatum*
	sand perch	*D. formosum*
	vieja	*Serranus dewegeri*
	harlequin bass	*S. tigrinus*
	tobacco fish	*S. tabacarius*
	lantern bass	*S. baldwini*
	orangeback bass	*S. annularis*
	chalk bass	*S. tortugarum*

Table 32. Common fish species occurring on shallow reefs of the Caribbean. Adapted from Randall (1983). (cont.)

FAMILY	COMMON NAME	SCIENTIFIC NAME
	two-spot bass	*S. flaviventris*
	slide-mouth bass	*Schultzea beta*
	swissguard basslet	*Liopropoma rubre*
	candy basslet	*L. carmabi*
	ridgeback basslet	*L. mowbrayi*
	creole fish	*Paranthias furcifer*
Grammatidae	fairy basslet	*Gramma loreto*
	blackcap basslet	*G. melacara*
Grammistidae	soapfish	*Rypticus saponaceus*
Centropomidae	snook	*Centropomus undecimalis*
Priacanthidae	glasseye	*Priacanthus cruentatus*
	bigeye	*P. arenatus*
Inermiidae	boga	*Inermia vittata*
	bogita	*Emmelichthyops atlanticus*
Apogonidae	flamefish	*Apogon maculatus*
	freckled cardinalfish	*Phaeoptyx conklini*
	barred cardinalfish	*A. binotatus*
	conchfish	*Astrapogon stellatus*
Malacanthidae	sand tilefish	*Malacanthus plumieri*
Cirrhitidae	redspotted hawkfish	*Amblycirrhitus pinos*
Rachycentridae	cobia	*Rachycentron canadum*
Echeneididae	sharksucker	*Echeneis naucrates*
	remora	*Remora remora*
Carangidae	greater amber jack	*Seriola dumerili*
	almaco jack	*S. rivoliana*
	rainbow runner	*Elagatis bipinnulatus*
	mackerel scad	*Decapterus macarellus*
	round scad	*D. punctatus*
	bigeye scad	*Selar crumenophthalmus*
	bar jack	*Caranx ruber*
	yellow jack	*C. bartholomaei*
	blue runner	*C. crysos*
	crevalle jack	*C. hippos*
	horse-eye jack	*C. latus*
	black jack	*C. lugubria*
	African pompano	*Alectis ciliaris*
	palometa	*Trachinotus goodei*
	permit	*T. falcatus*
	leather jacket	*Oligoplites saurus*
Scombridae	cero	*Scomberomorus regalis*
	serra Spanish mackerel	*S. brasiliensis*
	king mackerel	*S. cavalla*
	little tunny	*Euthynnus alletteratus*

Table 32. Common fish species occurring on shallow reefs of the Caribbean. Adapted from Randall (1983). (cont.)

FAMILY	COMMON NAME	SCIENTIFIC NAME
Lutjanidae	cubera snapper	*Lutjanus cyanopterus*
	gray snapper	*L. griseus*
	schoolmaster	*L. apodus*
	dog snapper	*L. jocu*
	mutton snapper	*L. analis*
	lane snapper	*L. synagris*
	mahogany snapper	*L. mahogoni*
	yellowtail snapper	*Ocyurus chrysurus*
Haemulidae	striped grunt	*Haemulon striatum*
	tomtate	*H. aurolineatum*
	smallmouth grunt	*H. chrysargyreum*
	bronzestriped grunt	*H. boschmae*
	Latin grunt	*H. steindachneri*
	black grunt	*H. bonariense*
	sailors choice	*H. parra*
	cottonwick	*H. melanurum*
	Spanish grunt	*H. macrostomum*
	margate	*H. album*
	white grunt	*H. plumieri*
	bluestriped grunt	*H. sciurus*
	French grunt	*H. flavolineatum*
	corocoro	*Orthopristis rubra*
	black margate	*Anisotremus surinamensis*
	porkfish	*A. virginicus*
Sparidae	saucereye porgy	*Calamus calamus*
	pluma	*C. pennatula*
	jolthead porgy	*C. bajonado*
	sheepshead porgy	*C. penna*
	sea bream	*Archosargus rhomboidalis*
	red porgy	*Pagrus sedecim*
	round spot porgy	*Diplodus caudimacula*
Sciaenidae	reef croaker	*Odontoscion dentex*
	cubbyu	*Pareques acuminatus*
	spotted drum	*Equetus punctatus*
	jackknife fish	*E. lanceolatus*
Mullidae	yellow goatfish	*Mulloidychthys martinicus*
	spotted goatfish	*Pseudupeneus maculatus*
Pempheridídae	copper sweeper	*Pempheris schomburgki*
	shortfin sweeper	*P. poeyi*
Gerreidae	yellowfin mojarra	*Gerres cinereus*
	spotfin mojarra	*Eucinostomus argenteus*
	mottled mojarra	*E. lefroyi*
Kyphosidae	Bermuda chub	*Kyphosus sectatrix*
	yellow chub	*K. incisor*
Ephippidae	spade fish	*Chaetodipterus faber*

Table 32. Common fish species occurring on shallow reefs of the Caribbean. Adapted from Randall (1983). (cont.)

FAMILY	COMMON NAME	SCIENTIFIC NAME
Bothidae	peacock flounder	*Bothus lunatus*
	eyed flounder	*B. ocellatus*
	tropical flounder	*Paralichthys tropicus*
Cynoglossidae	Caribbean tonguefish	*Symphurus arawak*
Opistognathidae	yellowhead jawfish	*Opistognathus aurifrons*
	longjaw jawfish	*O. macrognathus*
	mottled jawfish	*O. maxillosus*
	dusky jawfish	*O. whitehurstii*
Scorpaenidae	spotted scorpionfish	*Scorpaena plumieri*
	grass scorpionfish	*S. grandicornis*
	barbfish	*S. brasiliensis*
	reef scorpionfish	*Scorpaenodes caribbaeus*
Dactylopteridae	flying gurnard	*Dactylopterus volitans*
Callionymidae	lancer dragonet	*Callionymus bairdi*
Chaetodontidae	foureye butterflyfish	*Chaetodon capistratus*
	banded butterflyfish	*C. striatus*
	spotfin butterflyfish	*C. ocellatus*
	reef butterflyfish	*C. sedentarius*
	longsnout butterflyfish	*C. aculeatus*
Pomacanthidae	gray angelfish	*Pomacanthus arcuatus*
	French angelfish	*P. paru*
	rock beauty	*Holacanthus tricolor*
	queen angelfish	*H. ciliaris*
	blue angelfish	*H. bermudensis*
	cherubfish	*Centropyge argi*
Pomacentridae	dusky damselfish	*Stegastes dorsopunicans*
	yellow damselfish	*S. planifrons*
	cocoa damselfish	*S. variabilis*
	beaugregory	*S. leucostictus*
	bicolor damselfish	*S. partitus*
	yellowtail damselfish	*Microspathodon chrysurus*
	sergeant major	*Abudefduf saxatilis*
	night sergeant	*Chromis multilineata*
	blue chromis	*Chromis cyanea*
Labridae	Spanish hogfish	*Bodianus rufus*
	spotfin hogfish	*B. pulchellus*
	hogfish	*Lachnolaimus maximus*
	slippery dick	*Halichoeres bivittatus*
	pudding wife	*H. radiatus*
	yellowhead wrasse	*H. garnoti*
	clown wrasse	*H. maculipinna*
	painted wrasse	*H. pictus*
	black-ear wrasse	*H. poeyi*
	bluehead	*Thalassoma bifasciatum*
	dwarf wrasse	*Doratonotus megalepis*
	creole wrasse	*Clepticus parra*

Table 32. Common fish species occurring on shallow reefs of the Caribbean. Adapted from Randall (1983). (cont.)

FAMILY	COMMON NAME	SCIENTIFIC NAME
	pearly razorfish	*Xyrichtys novacula*
	green razorfish	*X. splendens*
	straight-tail razorfish	*X. martinicensis*
Scaridae	slender parrotfish	*Cryptotomus roseus*
	emerald parrotfish	*Nicholsina usta*
	yellowtail parrotfish	*Sparisoma rubripinne*
	redtail parrotfish	*S. chrysopterum*
	stoplight parrotfish	*S. viride*
	redband parrotfish	*S. aurofrenatum*
	bucktooth parrotfish	*S. radians*
	queen parrotfish	*Scarus vetula*
	striped parrotfish	*S. iserti*
	princess parrotfish	*S. taeniopterus*
	blue parrotfish	*S. coeruleus*
	rainbow parrotfish	*S. guacamaia*
	midnight parrotfish	*S. coesestinus*
Blenniidae	molly miller	*Scartella cristata*
	seaweed blenny	*Parablennius marmoreus*
	pearl blenny	*Entomacrodus nigricans*
	redlip blenny	*Ophioblennius atlanticus*
Labrisomidae	hairy blenny	*Labrisomus nuchipinnis*
	saddled blenny	*Malacoctenus triangulatus*
	checkered blenny	*Starksia ocellata*
	banded blenny	*Paraclinus fasciatus*
	seagrass blenny	*Stathmonotus stahli*
Tripterygiidae	redeye triplefin	*Enneanectes pectoralis*
Chaenopsidae	sailfin blenny	*Emblemaria pandionis*
	yellowface pikeblenny	*Chaenopsis limbaughi*
Carapodidae	pearlfish	*Carapus bermudensis*
Gobiidae	frillfin goby	*Bathygobius separator*
	goldspot goby	*Gnatholepis thompsoni*
	bridled goby	*Coryphopterus glaucofraenum*
	rusty goby	*Quisquilius hipoliti*
	sharknose goby	*Gobiosoma evelynae*
	hovering goby	*loglossus helenae*
Acanthuridae	blue tang	*Acanthurus coeruleus*
	ocean surgeon	*A. bahianus*
	doctorfish	*A. chirurgus*
Balistidae	queen triggerfish	*Balistes vetula*
	gray triggerfish	*B. capriscus*
	black durgon	*Melichthys niger*
	sargassum triggerfish	*Xanthichthys ringens*
	ocean triggerfish	*Canthidermis sufflamen*

Table 32. Common fish species occurring on shallow reefs of the Caribbean. Adapted from Randall (1983). (cont.)

FAMILY	COMMON NAME	SCIENTIFIC NAME
Monacanthidae	fringed filefish	*Monacanthus ciliatus*
	slender filefish	*M. tuckeri*
	speckled filefish	*Stephanolepis setifer*
	tail-light filefish	*Cantherhines pullus*
	whitespotted filefish	*C. macrocerus*
	scrawled, filefish	*Aluterus scriptus*
	orange filefish	*A. schoepfii*
	unicorn filefish	*A. monoceros*
Ostraciidae	smooth trunkfish	*Lactophrys triqueter*
	spotted trunkfish	*L. bicaudalis*
	buffalo trunkfish	*L. trigonus*
	scrawled cowfish	*Acanthostracion quadricornis*
	honeycomb cowfish	*A. polygonius*
Tetraodontidae	bandtail puffer	*Sphoeroides spengleri*
	Caribbean puffer	*S. greeleyi*
	sharpnose puffer	*Canthigaster rostrata*
Diodontidae	spiny puffer	*Diodon holocanthus*
	porcupinefish	*Diodon hystrix*
	web burrfish	*Chilomycterus antillarum*
	bridled burrfish	*C. antennatus*
Batrachoididae	sapo bocon	*Amphichthys cryptocentrus*
	sapo cano	*Thalassophryne maculosa*
Gobiesocidae	hourglass clingfish	*Tomicodon fasciatus*
	tadpole clingfish	*Arcos macrophthalmus*
Antennariidae	longlure frogfish	*Antennarius multiocellatus*
	spitlure frogfish	*A. striatus*
Ogcocephalidae	redbellied batfish	*Ogcocephalus nasutus*

Table 33. Productivity (g carbon/m^2/day) and growth rates (cm/yr) of Caribbean corals in the Puerto Rico-Virgin Island area.

Coral Species	Productivity Net	Productivity Gross	Productivity Resp.	Growth Rate	Site	Reference
Acropora palmata	0.54 -1.94	- -1.91	0.79	-	Tague Bay, St. Croix	Rogers and Salesky (1981)
	1.51 -1.84	2.41	8.97 -1.19	-	Buck Isl. Beef Nat. Mon., St. Croix	Gladfelter *et al.* (1977)
A. cervicornis	-	-	-	0-22.8 (mean=8.35)	San Cristobal Reef, PR	Rogers (1979)
	-	-	-	7.1	St. Croix	Gladfelter *et al.* (1978)
Monastrea annularis	-	-	-	0.4-1.2	Salt Rr. Canyon, St. Croix	Hubbard and Scaturo (1985)
				0.79-1.16	St. Croix	Dodge and Brass (1984)
				0.76	Buck Isl., St. Croix	Gladfelter *et al.* (1978)
M. cavernosa	- -	-	-	0.29-0.45	Salt Rr, Canyon, St. Croix	Hubbard and Scaturo (1985)
Siderastes siderea	-	-	-	0.14-0.31	"	"
Porites asteroides	-	-	-	0.19-0.31	"	"
D. labyrinth	-	-	-	0.29-0.36	"	"
A. agaricites	-	-	-	0.16	"	"
C. natens	-	-	-	0.41	"	"
Stephanocoenia	-	-	-	0.18	"	"

* g carbon/m^2/day = g O_2/m^2/hr * 0.3 (Connor and Adey, 1977).

Table 34. Productivity (net and gross) (g $O_2/m^2/hr$), respiration (g $C/m^2/day$), and standing stocks (g dry wt/m^2) of algal communities associated with coral reefs in the Puerto Rico-Virgin Island area.

Coral Species	Productivity Net	Productivity Gross	Productivity Resp.	Standing Stock	Reference
Algal	14.4 -21.2	22.7 -37.8	8.3-16.8	-	Connor and Adey (1977)
Macroscopic algae	4.3 -32.4	-	0.7-2.2	-	Rogers and Salesky (1881)
Algal turf	0.7 -3.2	-	0.4-1.4	-	Rogers and Salesky (1881)
Benthic algae	8.5 - -1.5	-	4.3-11.7		Stanhope (1880)
Reef turf	2-3	-	-	-	Carpenter (1985)
"Thin" algal turfs	-	-	-	19.0	Adey *et al.* (1977)
Algal back reef	-	6.3	-	-	-
Algal fore reef	-	3.6	-	-	-
Coralline algae	-	12.1	-	-	Connor and Adey (1977)

Table 35. Composition of foraging guilds of fish communities at five reef sites in Buck Island Reef National Monument, St. Croix. Values are percent of total individuals counted on 147 censuses; the number of censuses per reef site is given below the site name. Species were placed in trophic groups according to Randall (1967). Adapted from W. Gladfelter (1980).

	REEF SITE				
	NORTH LAGOON	SW LAGOON	NW LEEWARD	SOUTH FOREREEF	EAST FOREREEF
TROPHIC GROUP	(30)	(30)	(30)	(32)	(25)
Herbivores	73.0	49.9	34.3	38.8	24.3
Planktivores	1.9	4.9	10.3	39.0	54.2
Invertebrate Feeders	22.9	33.9	51.3	17.3	24.1
Piscivores	2.2	1.4	4.2	4.9	6.8

Table 36. Species and qualitative abundance of algae on algal plain off Puerto Rico (from Dahl, 1973), (R = rare, O = occasional, U = uncommon, C = common, VC = very common).

Phylum	Scientific Name	Abundance
Chlorophyta	*Anadyomene stellata*	O, large clumps
	Bryopsis plumosa	scattered, (40 mm height)
	Caulerpa ashmeadii	U
	C. cupressoides v. *flabellata*	O, to 150 mm ht.
	C. mexicana	C
	C. microphysa	VC
	C. racemosa v. *microphysa*	O
	Halimeda incrassata	VC
	H. simulans	O
	Udotea conglutinata	VG
	U. flabellum	C
Phaeophyceae	*Dictyopteris deliculata*	R
	D. jamaicensis	
	D. justii	
	Dictyota bartayresii	C
	D. cervicornis	
Rhodophyceae	*Acanthophora spicifera*	C
	Agardhiella tenera	VC
	Anthithamnion antillarum	
	Botryocladia sp.	
	Callithamnion cordatum	
	Champia parvula	C
	Chondria floridana	C
	Chrysymenia enteromorpha	O
	Chondria attenuata	
	Dasya mollis	
	D. ramosissima	
	Dichyurus occidentalis	C
	Galaxaura oblongata	
	Gracilaria foliifera	
	G. folifera v. *angustissima*	
	G. mammillaris	C
	Halymenia pseudofloresia	R
	Hypoglossum tenuifolium	
	Laurencia intricata	C
	Lophocladian trichocladis	
	Seirospora occidentalis	
	Spermothamnion sp.	
Spematophyta	*Halophila decipiens*	R

Table 37. Ten most abundant fish species occurring on the algal plain (= 'rubble/sand biotope'). Abundance decreases down the list. Cumulative abundance of this list is 51.2% of total species observed on the plain. Adapted from Kimmel (1985).

FAMILY	COMMON NAME	SCIENTIFIC NAME
Pomacentridae	bicolor damselfish	*Pomacentrus partitus*
Gobiidae	goldspot goby	*Gnatholepis thompsoni*
	bridled goby	*Coryphopterus glaucofraenum*
Haemulidae	misc. juveniles	*Haemulon* spp.
Serranidae	chalk bass	*Serranus tortugarum*
Inermiidae	boga	*Inermia vittata*
Opistognathidae	yellowhead jawfish	*Opistognathus aurifrons*
Labridae	bluehead	*Thalassoma bifasciatum*
Haemulidae	white grunt	*Haemulon plumieri*
Acanthuridae	ocean surgeon	*Acanthurus bahianus*

Table 38. Fish species group 'O' (defined using clustering techniques) found to characterize algal plains of Puerto Rico by Kimmel (1985).

FAMILY	COMMON NAME	SCIENTIFIC NAME
Malacanthidae	sand tilefish	*Malacanthus partitus*
Apogonidae	sawcheek cardinalfish	*Apogon quadrisquamatus*
Scaridae	bluelip parrotfish	*Cryptotomus roseus*
Opistognathidae	yellowhead jewfish	*Opistognathus aurifrons*
Serranidae	tobaccofish	*Serranus tabacarius*
	chalk bass	*S. tortugarum*
	lantern bass	*S. baldwini*
Gobiidae	hovering goby	*loglossus helenae*
Clinidae	sailfin blenny	*Emblemaria pandionis*

Table 39. Wet weights of major floral and faunal constituents of the algal plains of Puerto Rico. Wet weight in grams found in one 6.25-m^2 quadrat. Adapted from Dahl (1973).

GROUP	SPECIES	WET WEIGHT
Plants	*Halimeda* spp.	37.8
	Udotea spp.	11.6
	Anadyomene stellata	8.5
	Laurencia spp.	4.5
	Gracilaria spp.	2.3
	Caulerpa mexicana	2.0
	Agardhiella tenera	1.6
	Dictyota sp.	0.5
	Valonia ventricosa	0.5
	Caulerpa microphysa	0.4
	Dictyurus occidentalis	0.3
	TOTAL	70.3
Animals*	Sponges	988.0
	Tunicates	8.8
	Bryozoans	2.3
	Molluscs/polychaetes	2.2
	Gorgonians	2.2
	TOTAL	1,003.5

* Mobile fauna (eg. crabs, brittle stars) not included.

Table 40. Fish species occurring on sand/mud bottoms. List is not exhaustive, but includes species that sere explicitly specified as common in sand/mud bottom habits. Adapted from Randall (1983).

FAMILY	COMMON NAME	SCIENTIFIC NAME	PREY
Polynemidae	barbu	*Polydactylus virginicus*	
	littlescale threadfin	*P. oligodon*	
Serranidae	rock hind [1]	*Epinephelus adscensionis*	fishes, crust.
	chalk bass	*Serranus tortugarum*	
Malacanthidae	sand tilefish [2]	*Malacanthus plumieri*	invert., fishes
Cirrhitidae	redspotted hawkfish [3]	*Amblycirrhitus pinos*	
Carangidae	palometa	*Trachinotus goodei*	sm. fish, molluscs, invert.
	permit	*T. falcatus*	molluscs, sea urchin, crust., conch
Lutjanidae	mutton snapper	*Lutjanus analis*	
	lane snapper	*L. synagris*	
Haemulidae	margate	*Haemulon album*	urchins, sipunculids
	pigfish	*Orthopristis chrysoptera*	
	black margate	*Anisotremus surinamensis*	
Sparidae	saucereye porgy	*Calamus calamus*	invert., urchins, crabs
	pluma [4]	*C. pennatula*	
	sheepshead porgy	*C. penna*	
	red porgy	*Pagrus pagrus*	
	roundspot porgy	*Diplodus caudimacula*	
Pomacentridae	night sergeant	*Abudefduf taurus*	algae
Labridae	straight-tail razorfish	*Xyrichtys martinicensis*	
Blennidae	molly miller	*Scartella cristata*	herbivorous
	seaweed blenny	*Parablennius marmoreus*	algae
	pearl blenny	*Entomacrodus nigricans*	
Clinidae	yellowface pikeblenny	*Chaenopsis limbaughi*	crust.
Gobiidae	frillfin goby	*Bathygobius soporator*	
	orangespotted goby	*Nes longus*	
Tetradontidae	bandtail puffer	*Sphoeroides spengleri*	
	Caribbean puffer	*S. greeleyi*	
Batrachoididae	sapo	*Batrachoides surinamensis*	crust., moll.
	sapo bocon	*Amphichthus cryptocentrus*	
Gobiesocidae	hourglass clingfish	*Tomicodon fasciatus*	
	tadpole clingfish	*Arcos macrophthalmus*	
Antennaridae	spitlure frogfish	*Antennarius scaber*	
Ogcocephalidae	pancake batfish	*Halieutichthys aculeatus*	
	shortnose batfish	*Ogcocephalus nasutus*	molluscs, crabs, polychaetes, algae

[1] Most common in shallow water on rocky bottoms.

[2] Constructs burrow; depths greater than 30 feet, often near reefs.

[3] Bottom-dwelling on hard substratum.

[4] Most common *Calamus* in the West Indies.

Table 41. Fishes observed in four sand/mud habitats of St. John shallow bay pavement, fore-reef pavement, fore-reef pavement with ledges, and bank pavement. Densities (number of fish/m^2) determined using counts of fishes over 201.1-m^2 transects; the number of transects per habitat is shown in parentheses below habitat name. Mean fish size (cm) per transect is also given. Adapted from Boulon (1985a).

	SHALLOW BANK PAVEMENT (7)		REEF PAVEMENT (25)		PAVEMENT W/ LEDGE (2)		BANK PAVEMENT (7)	
SPECIES	DENSITY	SIZE	DENSITY	SIZE	DENSITY	SIZE	DENSITY	SIZE
mackerel	-	-	1.2E-3	39.7	2.5E-3	30.4	7.1E-4	25.5
kingfish	7.1E-4	76.2	-	-	-	-	1.4E-3	60.9
blue runner	-	-	-	-	2.51-3	25.4	-	-
bar jack	5.7E-3	21.9	1.3E-2	22.8	-	-	1.1E-2	24.1
queen triggerfish	-	-	4.1E-4	31.7	-	-	5.7E-3	31.7
bluestriped grunt	2.1E-3	16.5	1.8E-3	17.7	5.8E-3	17.7	9.2E-3	21.5
white grunt	-	-	-	-	-	-	7.1E-3	25.4
French grunt	7.1E-4	12.7	2.0E-1	5.0	1.7E-2	15.2	1.8E-1	17.7
tomtate	-	-	-	-	-	-	7.1E-4	12.7
margate	-	-	2.0E-4	40.6	-	-	-	-
gray snapper	-	-	-	-	-	-	9.2E-3	29.5
schoolmaster	-	-	2.0E-4	20.3	8.7E-2	20.3	1.4E-3	20.3
yellowtail snapper	5.0E-3	15.2	5.0E-3	20.3	1.7E-2	21.5	4.9E-2	27.9
mahogany snapper	-	-	-	-	2.0E-2	25.4	7.1E-4	20.3
French and queen angelfish	-	-	4.0E-4	25.4	2.5E-3	27.9	-	-
gray angelfish	-	-	2.6E-3	24.1	5.0E-3	27.9	5.7E-3	26.6
rock beauty	-	-	4.0E-4	17.7	2.5E-3	12.7	-	-
red hind	2.1E-3	17.1	2.0E-3	16.5	-	-	1.4E-3	17.7
coney	2.8E-3	21.5	8.0E-4	16.5	2.5E-3	20.3	5.7E-8	19.9
Nassau grouper	1.4E-3	25.4	2.0E-4	30.4	-	-	-	-
black grouper	-	-	2.0E-4	30.4	-	-	7.1E-4	25.4
porgies	1.4E-3	12.7	1.0E-3	19.0	-	-	-	-
doctorfish	9.5E-2	10.1	9.2E-2	11.4	4.7E-2	15.2	8.0E-2	17.7
yellow goatfish	3.6E-3	15.2	2.0E-3	17.7	5.0E-3	25.4	4.3E-3	17.7
spotted goatfish	4.3E-3	16.5	8.0E-4	13.9	-	-	1.4E-3	11.4
Spanish hogfish	-	-	-	-	5.0E-3	22.8	1.4E-3	20.3
parrotfish	5.6E-2	8.8	6.2E-2	13.9	5.0E-2	12.7	1.78-2	17.7
trunkfish	1.4E-3	16.1	4.0E-4	16.1	-	-	7.1E-4	20.3
porkfish	-	-	-	-	-	-	1.4E-3	20.3
sea chubs	-	-	2.4E-3	19.0	5.0E-3	27.9	5.7E-3	27.9
spadefish	-	-	-	-	-	-	3.6E-3	17.7
barracuda	-	-	4.0E-4	68.5	-	-	-	
squirrelfish	2.8E-3	13.9	1.4E-3	15.2	1.7E-2	15.2	5.7E-3	15.2
mojarra	2.8E-3	21.5	4.0E-4	20.3	-	-	-	-
dwarf herring	xxx	NA	xxx	NA	-	-	-	-

xxx - Too numerous to count.
NA - Not available.

Table 42. Fish species censused in the 'subtidal bedrock' habitat of St. John (Boulon, 1985a). Mean fish size in cm; only species of commercial importance were surveyed.

COMMON NAME	SCIENTIFIC NAME	MEAN SIZE
mackerel	Scombridae	45.7
blue runner	*Caranx crysos*	30.4
bar jack	*C. ruber*	34.1
bluestriped grunt	*Haemulon sciurus*	20.3
white grunt	*H. plumieri*	15.2
French grunt	*H. flavolineatum*	12.7
margate	*H. album*	12.7
schoolmaster	*Lutjanus apodus*	15.2
yellowtail snapper	*Ocyurus chrysurus*	10.1
mahogany snapper	*L. mahogoni*	8.8
French and queen angelfish	Pomacanthidae	25.4
gray angelfish	*Pomacanthus arcuatus*	30.4
red hind	*Epinephelus guttatus*	17.7
graysby	*E. cruentatus*	17.7
coney	*E. fulvus*	16.5
Nassau grouper	*E. striatus*	29.2
black grouper	*Mycteroperca bonaci*	20.3
tiger grouper	*M. tigris*	45.7
porgies	Sparidae	17.7
doctorfish	*Acanthurus chirurgus*	10.1
yellow goatfish	*Mulloidichthys martinicus*	15.2
spotted goatfish	*Pseudupeneus maculatus*	8.8
Spanish hogfish	*Bodianus rufus*	15.2
parrotfish	Scaridae	12.7
trunkfish	Ostraciontidae	12.7
barracuda	*Sphyraena* sp.	53.5
squirrelfish	Holocentridae	13.9
mojarra	Gerreidae	21.5
dwarf herring	*Jenkinsia lamprotaenia*	-

Table 43. Fish species observed on visual censuses of two 'bank pavement habitat' sites near St. John. 'X' indicates presence at survey site. Only fishes of commercial importance were surveyed. All individuals were adults except as noted. Adapted from Boulon (1985b).

	SURVEY SITE	
COMMON NAME	SOUTH	NORTHEAST
kingfish	X	-
bar jack	X	-
queen triggerfish	X	X
bluestriped grunt	X	X
French grunt	X	-
tomtate	-	X
grey snapper	-	X
schoolmaster	-	X
yellowtail snapper	X	X
grey angel fish	X	X *
red hind	-	X
coney	X	X
doctorfish	X	X
Spanish hogfish	X	-
parrotfish	X	X *
squirrelfish	X	X

* Juveniles also noted.

Table 44. Fish species taken during bottom fishing surveys off St. John (from Idyll and Randall, 1959).

COMMON NAME	SCIENTIFIC NAME
queen triggerfish	*Balistes vetula*
Nassau grouper	*Epinephelus striatus*
coney	*E. fulvus*
red hind	*E. guttatus*
squirrelfish	*Holocentrus ascensionis*
porgies	*Calamus* sp.
sand tilefish	*Malacanthus plumieri*

Table 45. Fishes occuring in the shelf break habitat of the Puerto Rico-Virgin Island insular shelf. Number of commercial groupers and snappers seen per hectare by depth category, from submersible surveys around Puerto Rico and the US Virgin Islands, Oct. 1 - 23, 1985 (from Nelson and Appeldoorn, 1985), and estimated biomass, assuming an average wet weight of 1.6 kg/fish. Number of transects in each depth category is given below depth range in parentheses.

		DEPTH RANGE (fathoms)**			
	COMMON	SCIENTIFIC	250-220	200-150	150-100	100-50
FAMILY	NAME	NAME	(45)	(66)	(40)	(25)
Serranidae						
	coney	*Epinephelus fulvus*	-	-	-	1.35
	red hind	*E. guttatus*	-	-	0.08	7.38
	misty grouper	*E. mystacinus*	-	-	-	0.93
	Nassau grouper	*E. striatus*	-	-	-	0.14
Lutjanidae						
	black snapper	*Apsilus dentatus*	-	-	-	0.77
	queen snapper	*Etelis oculatus*	0.37	0.36	0.41	-
	unidentified snapper	*Lutjanus* sp.	0.43	0.39	8.40	7.56
	blackfin snapper	*L. buccanella*	-	0.05	0.39	11.09
	dog snapper	*L. jocu*	-	-	-	0.14
	Caribbean red snapper	*L. purpureus*	-	-	-	0.25
	silk snapper	*L. vivanus*	-	0.45	4.19	2.89
	wenchman	*Pristipomoides aquilonaris*	0.05	0.83	0.50	-
	vermillion snapper	*Rhomboplites aurorubens*	-	-	-	0.14
TOTAL NUMBER PER HECTARE			0.85	2.08	14.05	32.81
ESTIMATED BIOMASS (kg/ha)			1.4	3.3	22.5	52.5

Table 46. Species occurring in pelagic habitat of Puerto Rico as reported in study of food habits of 11 pelagic fishes. The first eleven species listed were predators examined in the study; the remaining species were prey items. Adapted from Erdman (1958).

COMMON NAME	SCIENTIFIC NAME
blue marlin	*Makaira nigricans*
white marlin	*Tetrapturus albidus*
sailfish	*Istiophorus platypterus*
yellowfin tuna	*Thunnus albacares*
blackfin tuna	*T. atlanticus*
skipjack tuna	*Euthynnus pelamis*
little tunny	*E. alletteratus*
wahoo	*Acanthocybium solanderi*
cero	*Scomberomorus regalis*
dolphin	*Coryphaena hippurus*
great barracuda	*Sphyraena barracuda*
orangespotted filefish	*Cantherines pullus*
slender filefish	*Monacanthus tuckeri*
scrawled filefish	*Aluterus scriptus*
orange filefish	*A. schoepfi*
sargassum triggerfish	*Xanthichthys ringens*
Balistidae	*Melichthys piceus*
smooth puffer	*Lagocephalus laevigatus*
porcupinefish	*Diodon hystrix*
trunkfish	*Lactophrys trigonus*
bigeye	*Priacanthus arenatus*
yellow goatfish	*Mulloidichthys martinicus*
squirrelfish	*Holocentrus ascensionis*
blackbar soldierfish	*Myripristis jacobus*
bigeye soldierfish	*Ostichthys trachypoma*
trumpetfish	*Aulostomus maculatus*
houndfish	*Tylosurus crocodilus*
flat needlefish	*Ablennes hians*
ballyhoo	*Hemiramphus brasiliensis*
flying half beak	*Euleptorhamphus velox*
flyingfish	*Cypselurus* sp.
flying gurnard	*Dactylopterus volitans*
blue runner	*Caranx crysos*
Atlantic bumper	*Chloroscombrus chrysurus*
leatherjacket	*Oligoplites saurus*
round scad	*Decapterus punctatus*
bigeye scad	*Selar crumenophthalmus*
Carangidae	*Urapsis heidi*
dolphin	*Coryphaena hippurus*
pompano dolphin	*C. equisetis*
swordfish	*Xiphias gladius*
frigate mackerel	*Auxis thazard*
freckled driftfish	*Psenes cyanophrys*

Table 46. Species occurring in pelagic habitat of Puerto Rico as reported in study of food habits of 11 pelagic fishes. The first eleven species listed were predators examined in the study; the remaining species were prey items. Adapted from Erdman (1958). (cont.)

COMMON NAME	SCIENTIFIC NAME
man-of-war fish	*Nomeus gronovii*
Serranidae	*Epinephelus* sp.
Bramidae	*Brama raii*
Bramidae	*Teractes* sp.
snake mackerel	*Gempylus serpens*
sackfish	*Epinnula orientalis*
black swallower	*Pseudoscopelus* sp.
Myctophidae	
mullet	*Mujil curema*
dwarf herring	*Jenkinsia lamprotaenia*
Clupeidae	*Harengula* sp.
anchovy	*Anchoa choerostoma*
Gerreidae	
sergeant major	*Abudefduf saxatilis*
Xenocongridae	
goldspotted eel	*Myrichthys oculatus*
sand diver	*Synodus intermedius*
striped parrotfish	*Scarus croicensis*
bucktooth parrotfish	*Sparisoma radians*
misc. grunts	*Haemulon* sp.
tomtate	*Haemulon aurolineatum*
barbu	*Polynemus virginicus*
Ceratoidea	
Lutjanidae	
creole wrasse	*Clepticus parrai*
.....	
squid	
octopus	
crustaceans	*Argonauta*
crabs	*Portunus* sp.
megalops stage, crabs	
stomatopods	
mantis shrimp	*Squilla*
euphausid shrimp	

Table 47. Pelagic fish species, qualitative abundance, and depth ranges as reported for St. Croix by Clavijo *et al.* (1980). Included are species reported as oceanic in habitat (or occurring away from shoreline).

Common Name	Scientific Name	Abundance	Depth [1]
sixgill shark	*Hexanchus griseus*	occas.	W
silky shark	*Carcharhinus falciformis*	occas.	W
bull shark	*C. leucas*	occas.	W
blacktip shark	*C. limbatus*	occas.	W
oceanic whitetip shark	*C. longimanus*	occas.	W
great hammerhead	*Sphyrna mokarran*	occas.	W
Atlantic manta	*Manta birostris*	occas.	W
sargassum fish	*Histrio histrio*	occas.	V
flyingfish	*Cypselurus heterurus*	common	V
ballyhoo	*Hemiramphus brasiliensis*	common	V
flat needlefish	*Ablennes hians*	occas.	V
African pompano	*Alectis ciliaris*	common	W
blue runner	*Caranx crysos*	common	W
crevalle jack	*C. hippos*	occas.	W
black jack	*C. lugubris*	occas.	D
mackerel scad	*Decapterus macarellus*	occas. [2]	W
rainbow runner	*Elagatis bipinnulata*	occas.	W
pompano dolphin	*Coryphaena equisetis*	occas.	W
dolphin	*C. hippurus*	occas.	W .
tripletail	*Lobotes surinamensis*	occas.	W
rabbitfish	*Promethichthys prometheus*	rare	D
tyrant fish	*Evoxymetopon taeniatus*	rare	D
wahoo	*Acanthocybium solanderi*	common	W
little tunny	*Euthynnus alletteratus*	common	W
skipjack tuna	*E. pelamis*	occas.	W
king mackerel	*Scomberomorus cavalla*	common	W
Spanish mackerel	*S. maculatus*	rare	W
albacore	*Thunnus alalunga*	occas.	W
yellowfin tuna	*T. albacares*	occas.	W
blackfin tuna	*T. atlanticus*	occas.	W
swordfish	*Xiphias gladius*	occas.	W
sailfish	*Istiophorus platypterus*	common	W
blue marlin	*Makaira nigricans*	common	W
white marlin	*Tetrapterus albidus*	occas.	W
longbill spearfish	*T. pfluegeri*	rare	W
man-of-war fish	*Nomeus gronovii*	occas.	V

[1] Depth codes: W = wide, D = deep (>15 m), V = very shallow.

[2] Species also occurs on reefs.

Table 48. Families of adult fishes exclusively or primarily pelagic around St. Croix. Adapted from Clavijo *et al.* (1980).

Family	Total Number of Species in Area	Number of Pelagic Species	Exceptions
Hexanchidae (cow sharks)	1	1	
Carcharhinidae (requiem sharks)	8	4	reef shark, tiger shark , dogfish amor - all reef dwellers
Sphrynidae (hammerhead sharks)	1	1	
Mobulidae (mantas)	1	1	
Exocoetidae (flyingfishes and half beaks)	2	2	
Coryphaenidae (dolphins)	2	2	
Lobotidae (tripletails)	1	1	
Gempylidae (snake mackerels)	1	1	
Trichiuridae (cutlassfishes)	1	1 .	
Scombridae (mackerels and tunas)	9	1	cero - reef
Xiphiidae (swordfish)	1	1	
Istiophoridae (billfishes)	4	4	
Stromateidae (butter fishes)	1	1	

Table 49. Fish species taken off St. John during line-fishing surveys (from Idyll and Randall 1959).

A. Species most frequently encountered.

Common Name	Scientific Name
cero	*Scomberomorus regalis*
bar jack	*Caranx ruber*
blue runner	*C. crysos*
yellowtail snapper [1]	*Ocyurus chrysurus*
king mackerel	*Scomberomorus cavalla*
little tunny	*Euthynnus alletteratus*

B. Species taken less frequently.

Common Name	Scientific Name
great barracuda [1]	*Sphyraena barracuda*
horse-eye jack	*Caranx latus*
houndfish	*Tylosaurus crocodilus*
yellowfin grouper [1]	*Mycteroperca venenosa*
Nassau grouper [1]	*Epinephelus striatus*
dolphin	*Coryphaena hippurus*
greater amber jack	*Seriola dumerili*
African pompano	*Alectis ciliaris*
blackfin tuna	*Thunnus atlanticus*
coney [1]	*Epinephelus fulvus*
smalltail shark	*Carcharhinus porosus*
sand diver	*Synodus intermedius*
sharksucker	*Echeneis naucrates*

[1] A bottom-associated species.

Table 50. Species listed as occurring primarily 'offshore' (or is 'open water') by Randall (1983).

Family	Common Name	Scientific Name
Belonidae	agujon	*Tylosurus acus*
Exocoetidae	balao	*Hemiramphus balao*
Syngnathidae	sargassum pipefish	*Syngnathus pelagicus* [1]
Inermiidae	boga	*Inermia vittata* [2]
Echeneidae	sharksucker	*Echeneis naucrates* [3]
	remora	*Remora remora* [4]
	marlinsucker	*R. osteochir* [5]
	whalesucker	*R. australis* [6]
	white suckerfish	*Remorina albescens* [7]
Carangidae	almaco jack	*Seriola rivoliana*
	rainbow runner	*Elagatis bipinnulata*
	mackerel scad	*Decapterus macarellus*
	round scad	*D. punctatus*
	blue runner	*Caranx crysos*
	horse-eye jack	*C. latus*
	African pompano	*Alectis ciliaris*
Scombridae	cero [8]	*Scomberomorus regalis*
	Atlantic sierra	*S. brasiliensis*
	king mackerel	*S. cavalla*
	little tunny	*Euthynnus alletteratus*
Lutjanidae [9]	blackfin snapper	*Lutjanus buccanella*
	silk snapper	*L. vivanus*
	Caribbean red snapper	*L. purpureus*
	black snapper	*Apsilus dentatus*
	vermilion snapper	*Rhomboplites aurorubens*
	queen snapper	*Etelis oculatus*
	wenchman	*Pristipomoides aquilonaris*
Antennariidae	sargassumfish	*Histrio Histrio*

[1] Found on floating sargassum.

[2] 20-m depth; zooplanktivorous.

[3] Hosts are sharks, rays, sea turtles, large reef fishes.

[4] Usual hosts are offshore sharks.

[5] Usual hosts are billfishes.

[6] Usual hosts are whales and porpoises.

[7] Found in the gill chambers or mouths of manta rays.

[8] Most common *Scomberomorus* in the West lndies.

[9] All the snappers are deepwater species associated with the bottom.

Table 51. Net primary productivity (NPP) of surface pelagic waters, taken in March, 1966, at various sites in the Virgin Islands. Both units and specific habitat of measurement differed among studies. Reproduced from VIERS (1969) using Burkholder and Dammann (unpubl.).

LOCATION	NPP	UNITS	HABITAT
St. John			
Pillsbury Sound	8.9	mg C/m^3/day	blue water
Chocolate Hole	10.3	"	shallow water
Great Cruz Bay	26 2	"	shallow water
Fish Bay	0.4	mg C/m^3/hr	
Coral Bay	2.3	"	
Cruz Bay	24.6	"	
St. Thomas			
Mangrove Lagoon	80.6	mg C/m^3/day	shallow water
	6.1	mg C/m^3/hr	
Pineapple Bay	126.4	mg C/m^3/day	green flagellate bloom
Magens Bay	0.7	mg C/m^3/hr	
Botany Bay	0.07	"	
Hull Bay	0.8	"	

Table 52. Net primary productivity (NPP) (mg C/m^3/day) and chlorophyll "*a*" concentration (mg/m^2) of pelagic waters along a depth gradient (m) in Great Cruz Bay, St. John. Reproduced from VIERS (1969) using Burkholder and Dammann (unpubl.).

Depth	NPP	Chlorophyll "*a*"
0	8.9	0.28
5	6.1	0.37
10	11.1	0.39
15	9.7	0.37
20	9.3	0.34
25	6.8	0.45

Table 53. Summary of data available for the PRVI area and its adequacy for modeling purposed; A = adequate information, L = limited information, N = no information. Information was renewed for areal extent, primary producers (species lists, biomass, rates), invertebrates (species lists, biomass, trophic relations) and fishes (species lists, biomass, trophic relations) in seven subsystems - mangrove/estuaries, seagrass, coral reefs, algal plains, sand/mud, shelf break, and pelagic.

	MANGROVE /ESTUARIES	SEAGRASS	CORAL REEFS	ALGAL PLAINS	SAND /MUD	SHELF BREAK	PELAGIC
Primary Production							
Species Lists	A	A	A	A	-	-	N
Biomass	A	A	L	L	-	-	L
Rates	L	A	A	N	-	-	L
Invertebrates							
Species Lists	L	L	A	L	L	N	L
Biomass	N	L	L	L	N	N	N
Trophic	N	L	L	L	L	N	N
Fishes							
Species Lists	A	A	A	L	A	L	A
Biomass	L	L	L	N	L	L	N
Trophic	L	L	A	L	L	N	L
Areal Extent	A	L	A	L	L	L	L

PLATES

Plate 1. Coastal view from St. John, US Virgin Islands. (Credit: Michael B. Robblee, Center for Water and Restoration Studies, US Geological Survey, Ft. Lauderdale, FL.)

Plate 2. Elkhorn coral (*Acropora palmata*) on patch reef, Teague Bay, St. Croix, US Virgin Islands (Credit: Michael B. Robblee, Center for Water and Restoration Studies, US Geological Survey, Ft. Lauderdale, FL.).

Plate 3. Red mangrove (*Rhizophora mangle*) prop roots with gray snapper (*Lutjanus griseus*) and attached fire sponge (*Tedania ignis*) (Luo). (Credit: Jiangang Luo, Cooperative Institute for Marine and Atmospheric Science, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Coral Gables, FL.)

Plate 4. Red mangrove (*Rhizophora mangle*) prop roots with gray snapper (*Lutjanus griseus*), seagrass, and attached fire sponge (*Tedania ignis*). (Credit: Jiangang Luo, Cooperative Institute for Marine and Atmospheric Science, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Coral Gables, FL.)

Plate 5. Red mangrove (*Rhizophora mangle*) prop roots with pork fish (*Anisotremus virginicus*) (foreground) gray snapper (*Lutjanus griseus*) (background), and attached fire sponge (*Tedania ignis*). (Credit: Jiangang Luo, Cooperative Institute for Marine and Atmospheric Science, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Coral Gables, FL.)

Plate 6. Red mangrove (*Rhizophora mangle*) leaves, trunk, and prop roots. (Credit: Jiangang Luo, Cooperative Institute for Marine and Atmospheric Science, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Coral Gables, FL.)

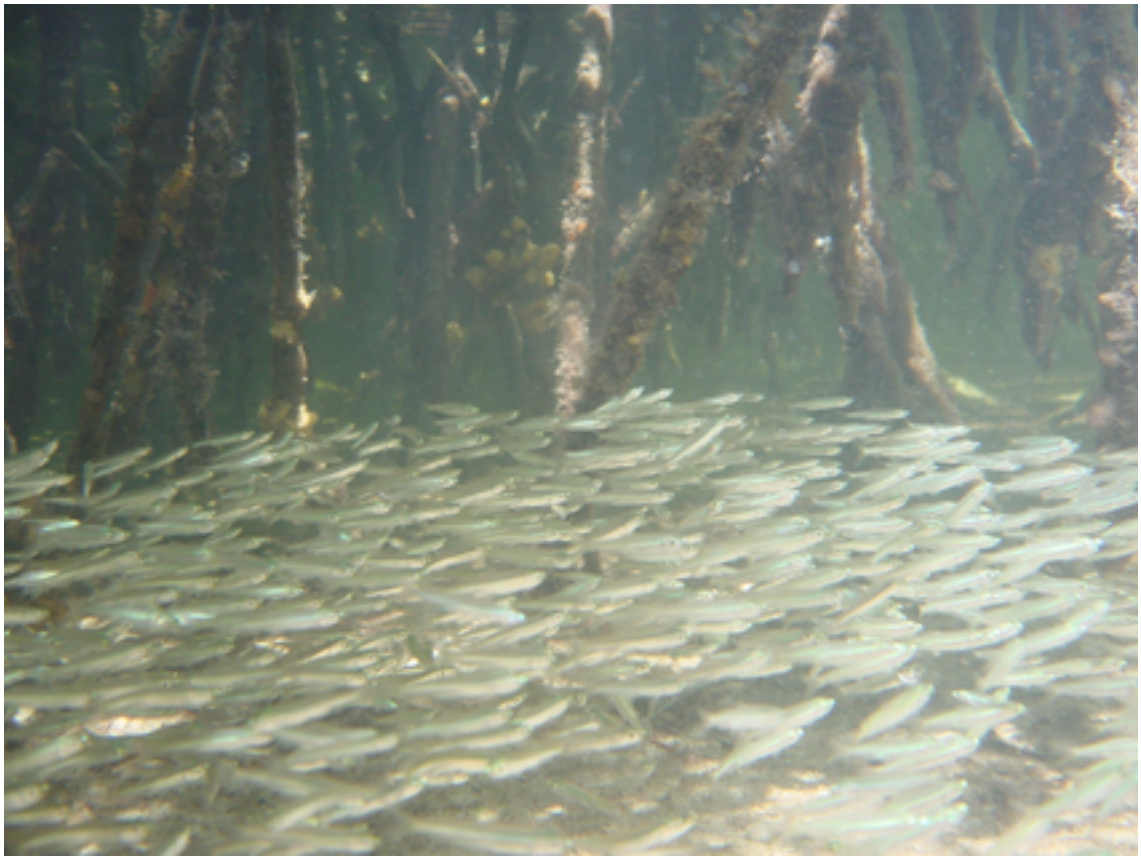

Plate 7. Schooling forage fish among mangrove (*Rhizophora mangle*) prop roots. (Credit: Brian Teare, Cooperative Institute for Marine and Atmospheric Science, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Coral Gables, FL.)

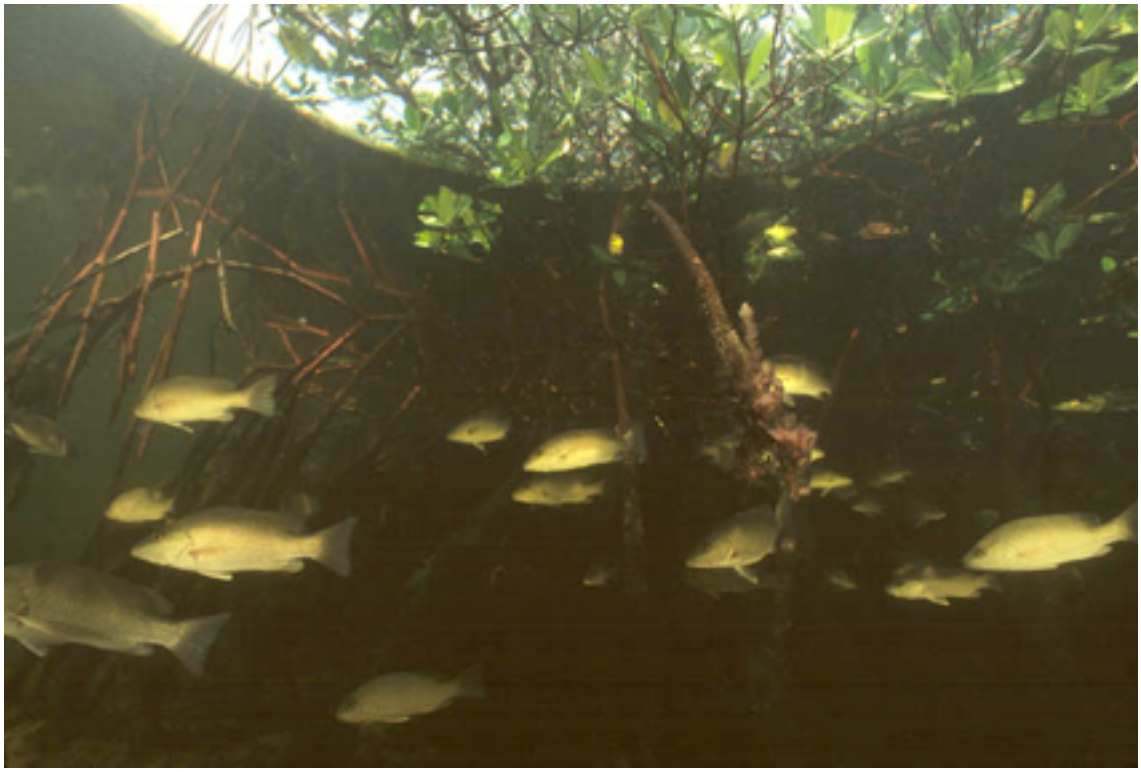

Plate 8. Gray snapper (*Lutjanus griseus*) among red mangrove (*Rhizophora mangle*) prop roots along Biscayne Bay, Florida, shoreline. (Credit: David Forcucci, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Coral Gables, FL.)

Plate 9. Blue-striped grunt (*Haemulon sciurus*) and gray snapper (*Lutjanus griseus*) among plexarid gorgonian and corals, South Florida patch reef. (Credit: Joseph Serafy, NOAA/National Marine Fisheries Service/Southeast Fisheries Science Center, Miami, FL.)

Plate 10. Gray snappers (*Lutjanus griseus*), blue-striped grunts (*Haemulon sciurus*), corals, and gorgonians on South Florida patch reef. (Credit: Joseph Serafy, NOAA/National Marine Fisheries Service/Southeast Fisheries Science Center, Miami, FL.)

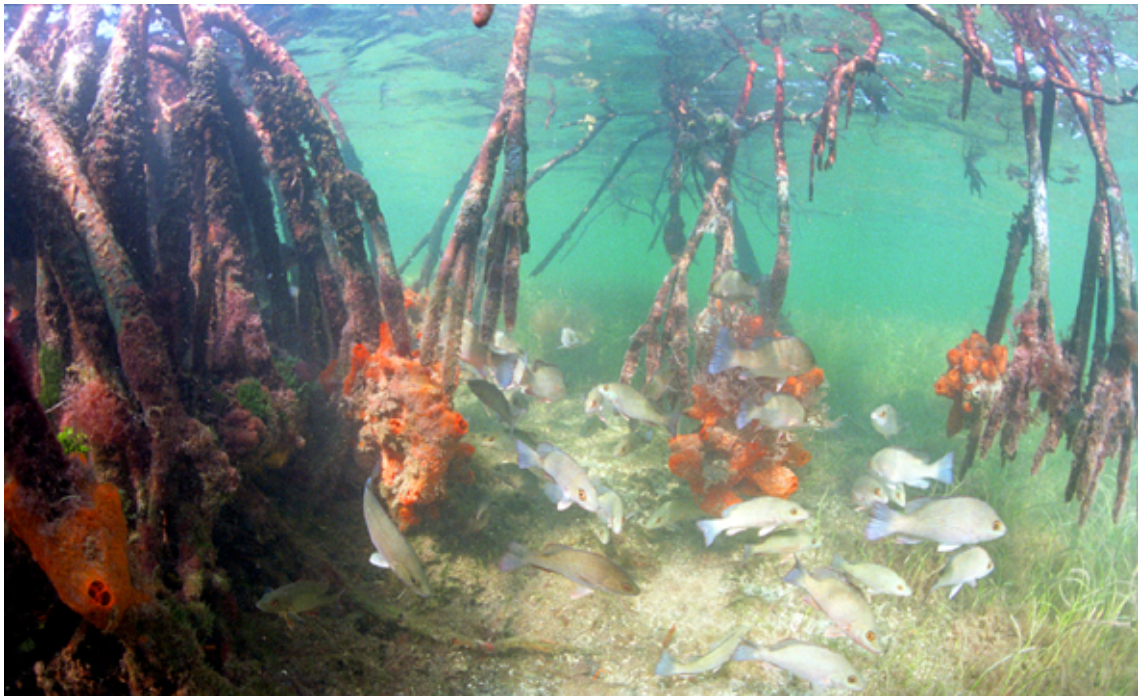

Plate 11. Gray snapper (*Lutjanus griseus*) among red mangrove (*Rhizophora mangle*) prop roots and seagrass. (Credit: Jiangang Luo, Cooperative Institute for Marine and Atmospheric Science, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Coral Gables, FL.)

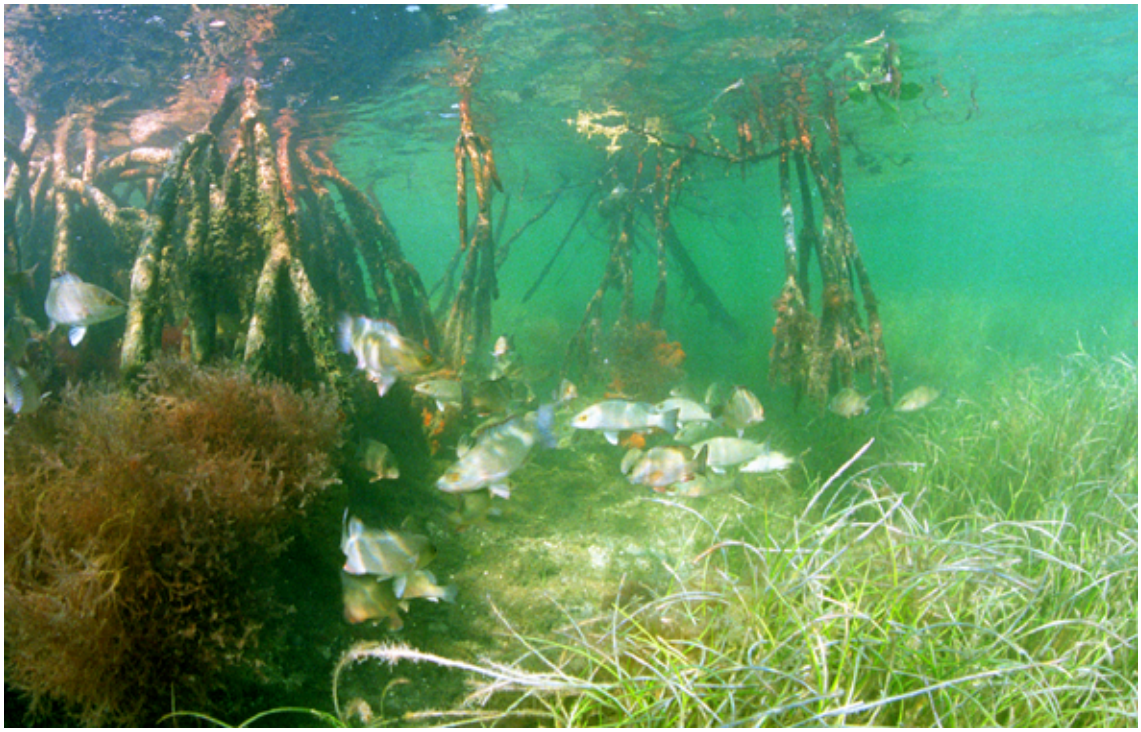

Plate 12. Gray snapper (*Lutjanus griseus*) among red mangrove (*Rhizophora mangle*) prop roots, seagrass, and brown algae. (Credit: Jiangang Luo, Cooperative Institute for Marine and Atmospheric Science, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Coral Gables, FL.)

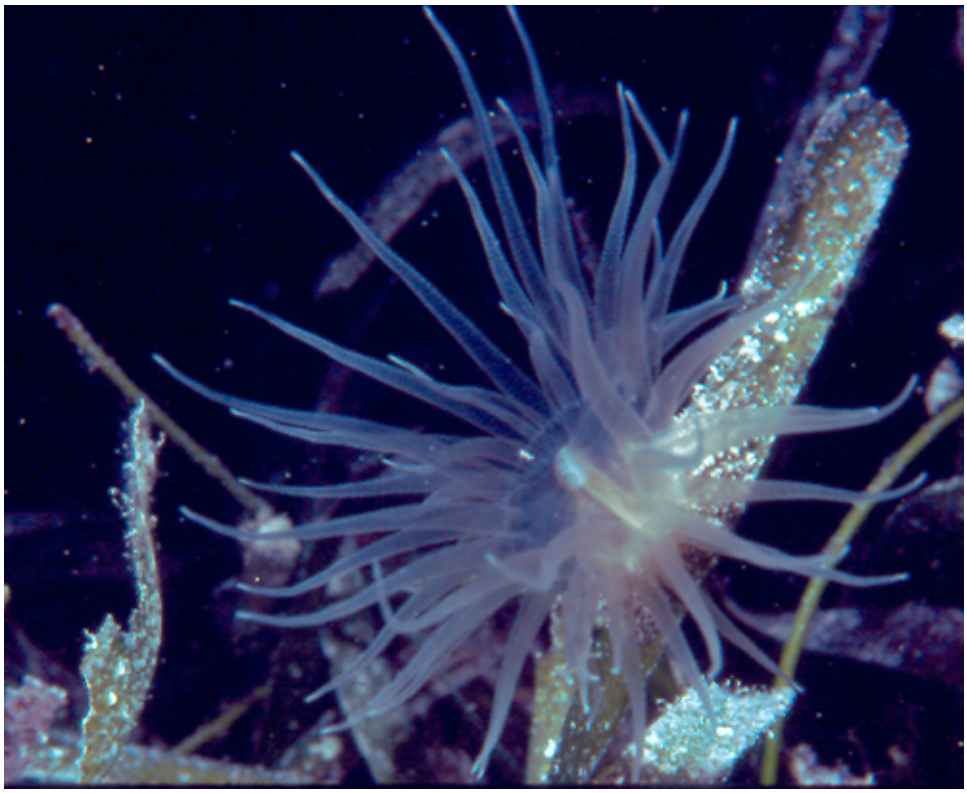

Plate 13. Sea anemone on turtle grass blade foraging for invertebrates in the water column at night, Teague Bay, St. Croix, US Virgin Islands. (Credit: Michael B. Robblee, Center for Water and Restoration Studies, US Geological Survey, Ft. Lauderdale, FL.)

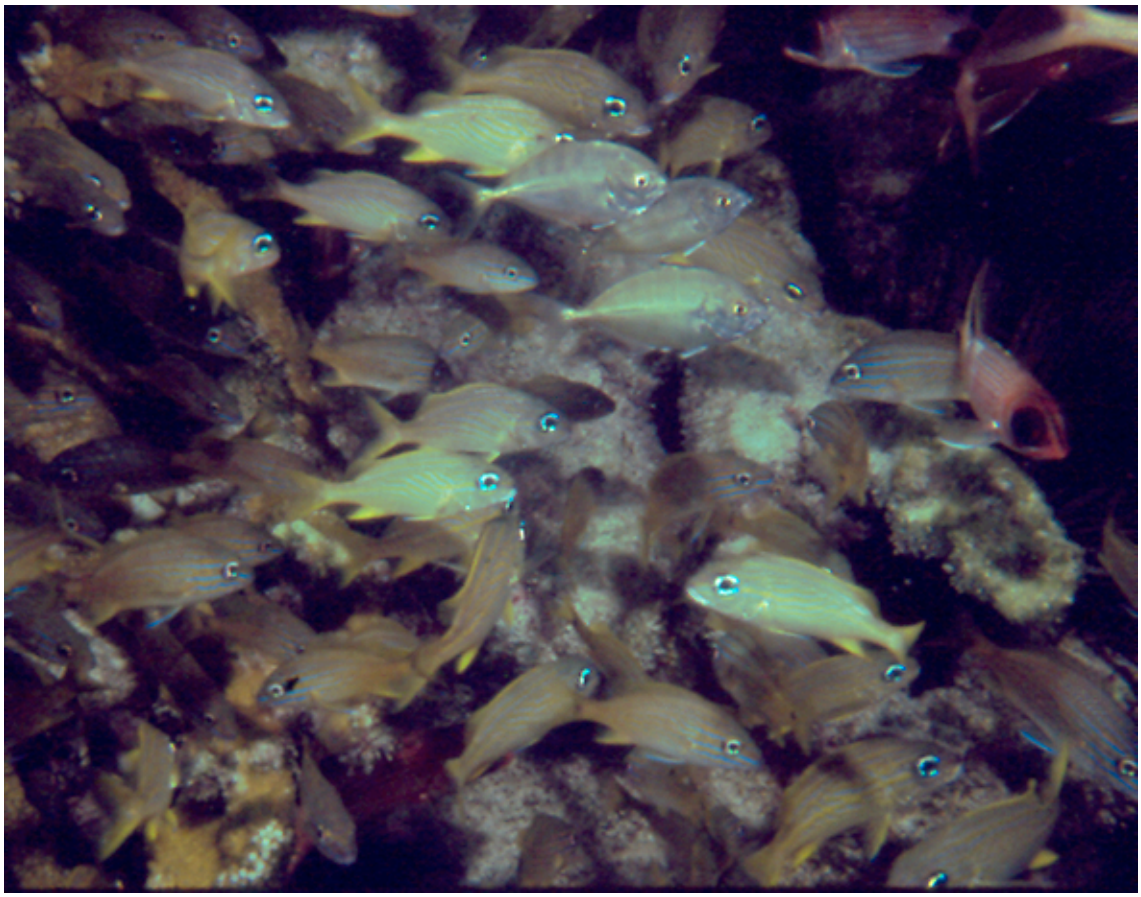

Plate 14. Grunts with juvenile jacks and longspine squirrelfish (*Holocentrus rufus*), Teague Bay, St. Croix, US Virgin Islands. (Credit: Michael B. Robblee, Center for Water and Restoration Studies, US Geological Survey, Ft. Lauderdale, FL.)

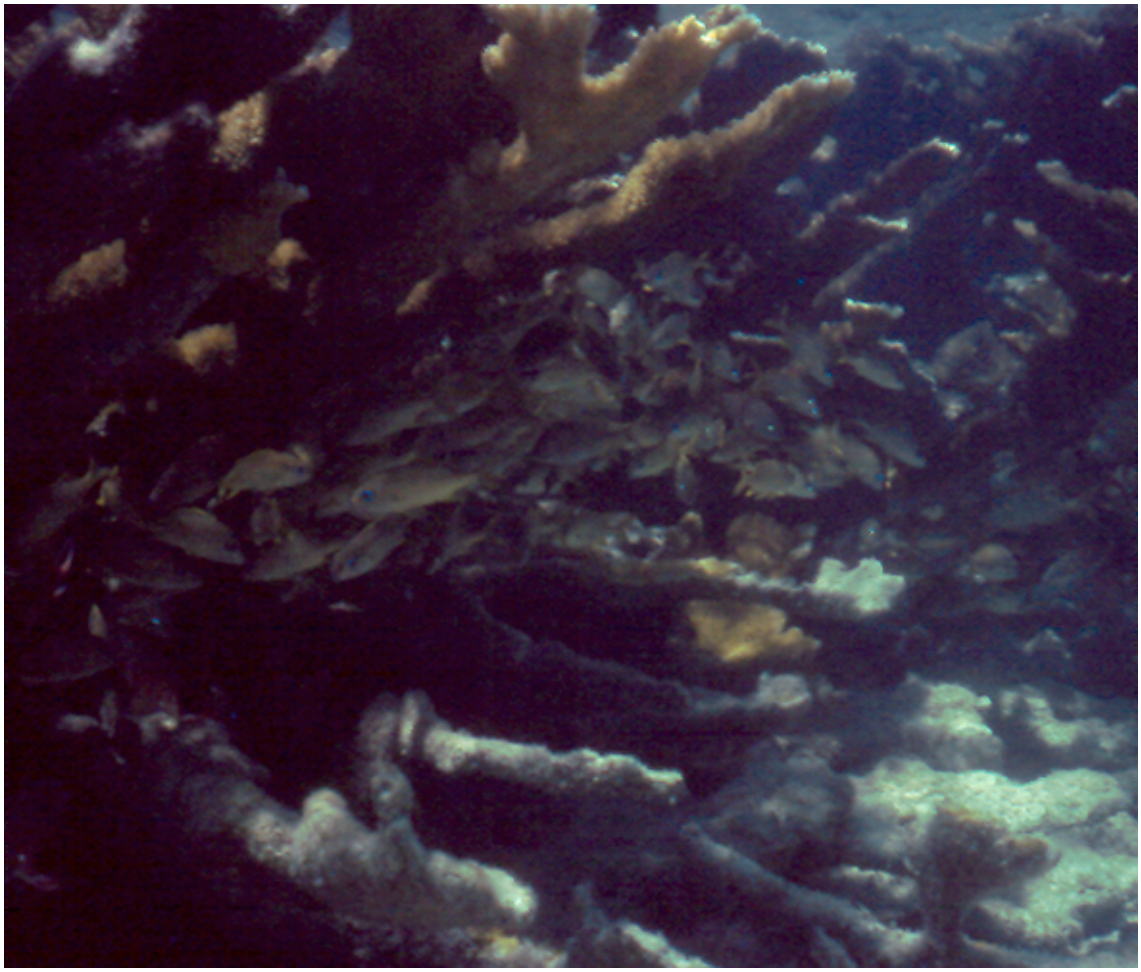

Plate 15. Resting school of juvenile grunts on patch reef, Teague Bay, St. Croix, US Virgin Islands. (Credit: Michael B. Robblee, Center for Water and Restoration Studies, US Geological Survey, Ft. Lauderdale, FL.)

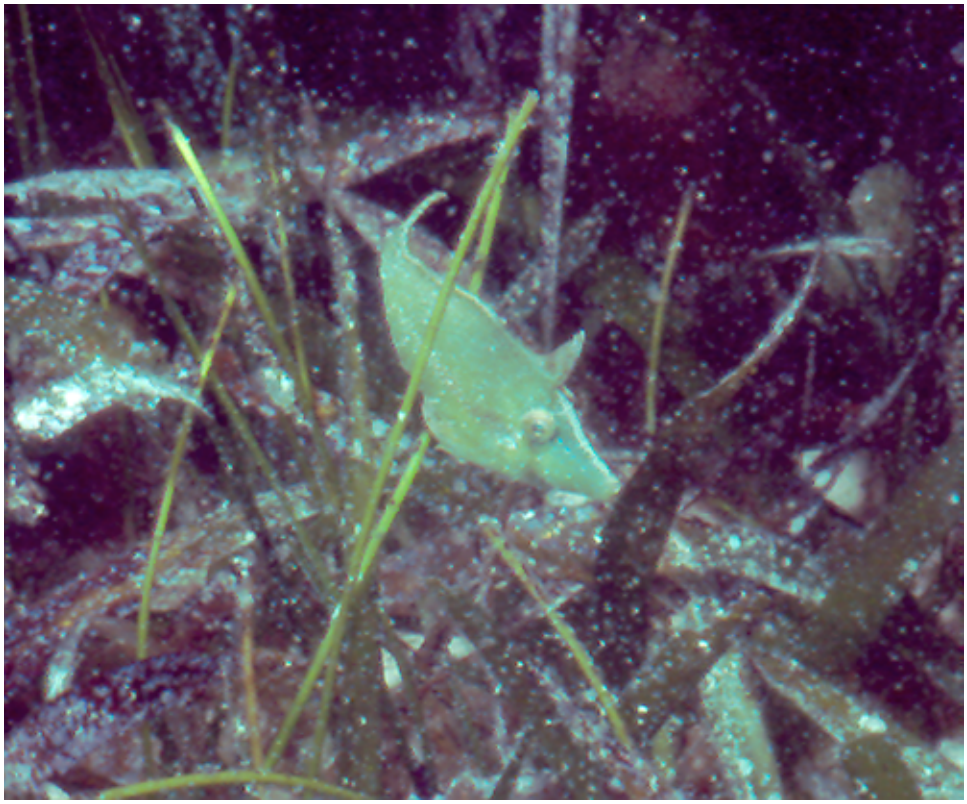

Plate 16. Fringed filefish (*Monocanthus ciliatus*) in turtle grass (*Thalassia testudinum*), Teague Bay, St. Croix, US Virgin Islands. (Credit: Michael B. Robblee, Center for Water and Restoration Studies, US Geological Survey, Ft. Lauderdale, FL.)

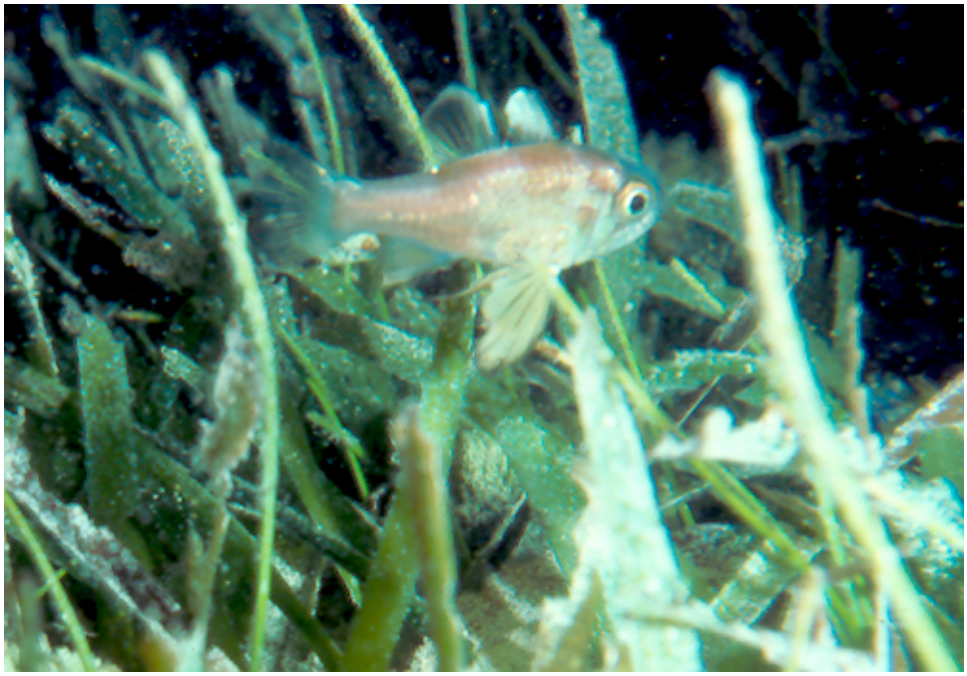

Plate 17. Blackfin cardinalfish (*Astrapogon puncticulatus*) in turtle grass (*Thalassia testudinum*) at night, Teague Bay, St. Croix, US Virgin Islands. (Credit: Michael B. Robblee, Center for Water and Restoration Studies, US Geological Survey, Ft. Lauderdale, FL.)

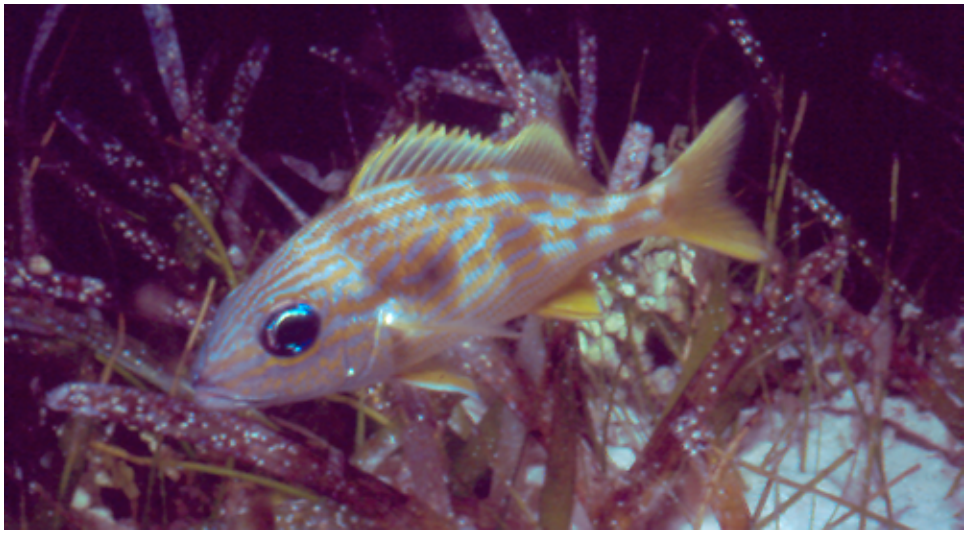

Plate 18. French grunt (*Haemulon flavolineatum*) in turtle grass (*Thalassia testudinum*) at night, with nocturnal coloration, Teague Bay, St. Croix, US Virgin Islands. (Credit: Michael B. Robblee, Center for Water and Restoration Studies, US Geological Survey, Ft. Lauderdale, FL.)

Plate 19. Reef squirrelfish (*Sargocentron coruscum*) over turtle grass (*Thalassia testudinum*) and manatee grass (*Syringodium filiforme*), at night, Teague Bay, St. Croix, U.S Virgin Islands. (Credit: Michael B. Robblee, Center for Water and Restoration Studies, US Geological Survey, Ft. Lauderdale, FL.)

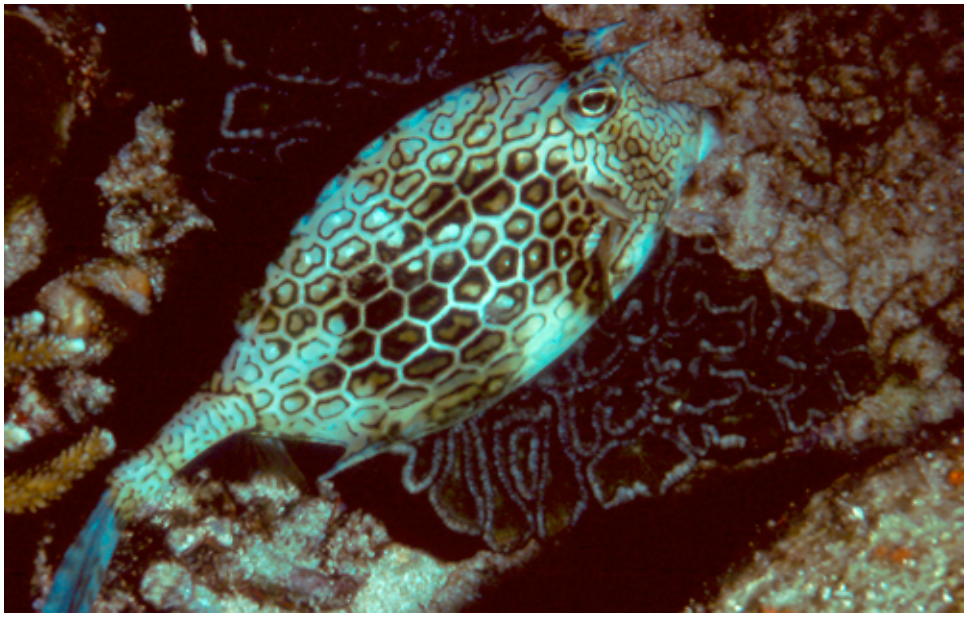

Plate 20. Honeycomb cowfish (*Lactophrys polygonia*) on reef, Teague Bay, St. Croix, US Virgin Islands. (Credit:William B. Gladfelter, West Indies Laboratory, Fairleigh Dickinson University, St. Croix, US Virgin Islands.)

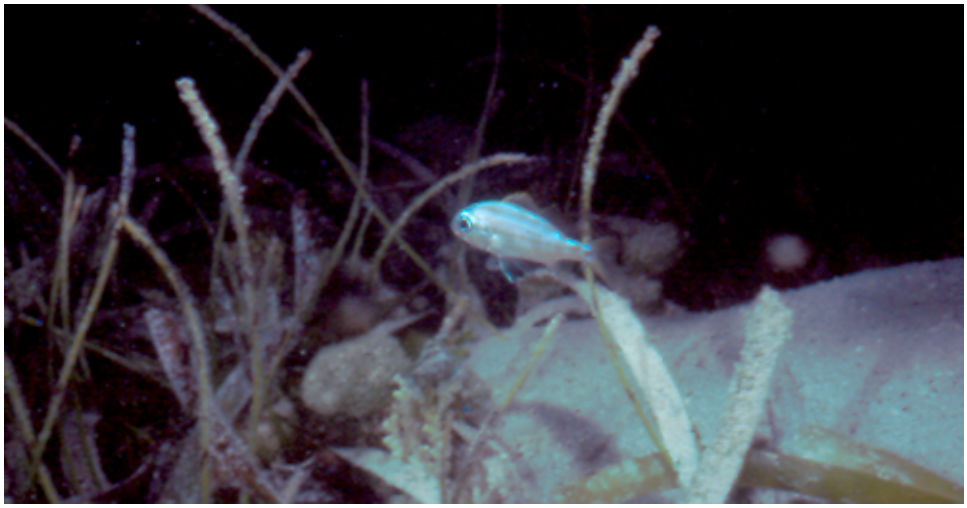

Plate 21. Juvenile grunt (*Haemulon* sp.) at night over burrowing *Callianassa* shrimp sand mound in turtle grass (*Thalassia testudinum*), Teague Bay, St. Croix, US Virgin Islands. (Credit: Michael B. Robblee, Center for Water and Restoration Studies, US Geological Survey, Ft. Lauderdale, FL.)

Plate 22. Longspine squirrelfish (*Holocentrus rufus*) staging for nightly migration from reef to nearby grass beds. Long-spined urchin (*Diadema antillarum*) in right foreground), Teague Bay, St. Croix, US Virgin Islands. (Credit: Michael B. Robblee, Center for Water and Restoration Studies, US Geological Survey, Ft. Lauderdale, FL.)

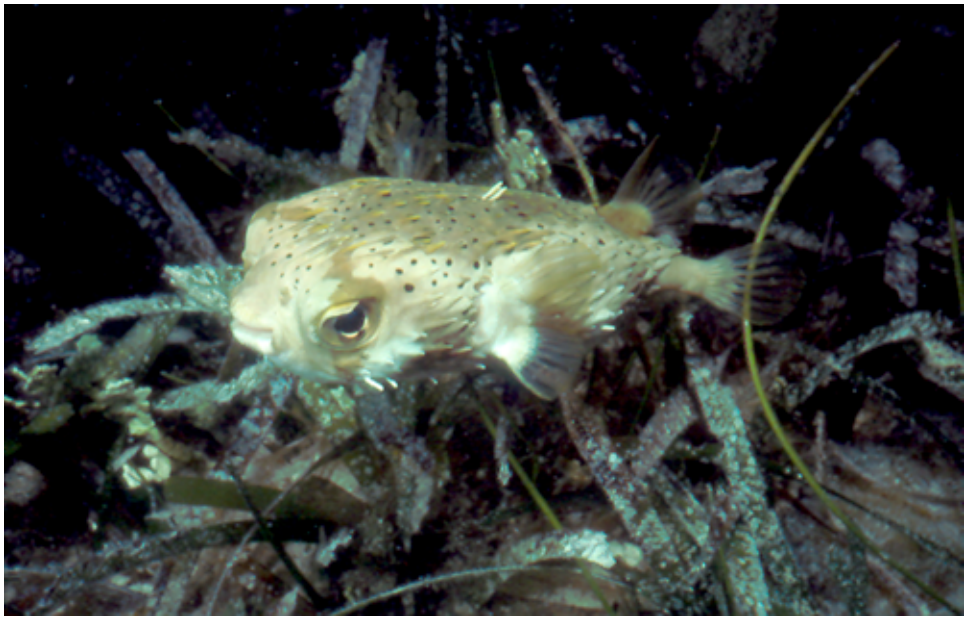

Plate 23. Balloonfish (*Diodon holocanthus*) in turtle grass (*Thalassia testudinum*) at night, Teague Bay, St. Croix, US Virgin Islands. (Credit: Michael B. Robblee, Center for Water and Restoration Studies, US Geological Survey, Ft. Lauderdale, FL.)

Plate 24. Christmas tree worms (*Spirobranchus* sp.) on Teague Bay reef, St. Croix, US Virgin Islands. (Credit: Michael B. Robblee, Center for Water and Restoration Studies, US Geological Survey, Ft. Lauderdale, FL.)

PREDATORS	Carcharinidae	Dasyatidae	Myliobatidae	Elopidae	Dussumieridae	Synodontidae	Ophichthidae	Congridae	Belonidae	Hemiramphidae
Benthic algae										40.50
Spring algae										
Zooxanthellae										
Planktonic algae										
Drifting plants (*Sargassum*)										
Spermatophytes (*Thalassia*)										
Protozoa										
Sponges										
Coral										
Zoantharians										
Gorgonians										
Hydrozoans										
Schyphozoans										
Ctenophores										
Bryozoans										
Sipunculids			20.60							
Polychaetes			17.30					0.40		4.45
Chitons										
Gastropods				53.40						
Pteropods									4.50	15.70
Scaphopods										
Pelecypods			10.80	46.60						
Cephalopods							1.66	16.66		
Copepods						74.00			66.30	0.60
Ostracods									3.80	
Barnacles										
Physids										
Tanaids										
Isopods										
Amphipods						1.70				
Stomatopods			2.00					6.49		
Shrimp			7.60				0.17	1.06	2.27	
Crabs			17.60					49.06		
Spiny lobster										
Scyllarid lobster										
Hermit crabs										
Echinoids								2.33		
Ophiurids										
Asteroids										
Holothurians										
Hemichordates			2.30							
Tunicates									18.60	
Carcharinidae										
Dasyatidae										
Myliobatidae										
Elopidae										
Clupeidae							5.25		40.79	29.05
Dissumieridae										
Synodontidae										

	PREDATORS	Carcharinidae	Dasyatidae	Myliobatidae	Elopidae	Dussumieridae	Synodontidae	Ophichthidae	Congridae	Belonidae	Hemiramphidae
Benthic algae											40.50
Ophichthidae											
Congridae											
Belonidae										12.03	
Hemiranphidae											
Fistularidae											
Aulostomidae											
Holocentridae											
Mugilidae										4.54	
Sphyraenidae											
Atherinidae					100.00		5.25				
Serranidae											
Grammistidae											
Grammidae											
Cirrhitidae											
Apogonidae											
Priocanthidae		25.00									
Pempheridae											
Lutjanidae											
Emmelichthyidae											
Pomadasyidae											
Sparidae											
Kyphosidae											
Gerreidae											
Scianidae											
Mullidae											
Banchiostegidae											
Rachycentridae											
Echeneidae											
Carangidae							5.25			12.03	
Scombridae											
Pomacentridae											
Labridae		25.00									
Scaridae											
Bothidae											
Gobidae											
Blennidae											
Clinidae											
Opisthognathidae			5.45								
Dactylopteridae											
Ephippidae											
Chaetodontidae											
Acanthuridae			5.45							4.54	
Balistidae											
Monacanthidae		6.25									
Ostraciontidae											
Tetradontidae											
Diodontidae		6.25									
Antennaridae											

	PREDATORS	Carcharinidae	Dasyatidae	Myliobatidae	Elopidae	Dussumieridae	Synodontidae	Ophichthidae	Congridae	Belonidae	Hemiramphidae
Benthic algae											40.50
Ogcocephalidae											
Sea turtles		12.50									
Engrulidae			5.45				33.33			21.09	
Scorpaenidae			5.45								
Haemulidae							5.25				
Muraenidae											
Fish larvae											
Fishes		25.00					43.84	17.77			
Un ID animal mat.						4.20				1.04	5.90
Un ID plant mat.											
Un ID crustaceans						3.80		6.23			
Fish eggs						1.10					
Shrimp larvae						11.40			2.50		1.45
Crab larvae						3.80				0.35	2.35
Un ID eggs									2.40		
Gastropod larvae									1.90		
Insects										1.10	
Stomatopod larvae										0.22	
Cephalopod larvae											
Hermit crab larvae											
Scylland larvae											
Barnacle larvae											
Polychaete larva											
Echiuroids											
Inermidae											
Ostraciidae											
Euphausids											
Malaconthidae											
Pomacanthidae											
Syngnathidae											
Ocyurus chrysurus											
Lutjanus synagris											
Lutjanus mahagoni											
Lutjanus jocu											
Lutjanus griseus											
Lutjanus cyanopterus											
Lutjanus apodus											
Lutjanus analis											
Lutjanus species											
Lutjanus apher											
Cephalopholis fulva											
Epinephelus adscensionis											
Epinephelus guttatus											
Epinephelus itajara											
Epinephelus morio											
Epinephelus striatus											
Hypoplectrus aberrans											
Hypoplectrus chlosurus											

	PREDATORS	Carcharinidae	Dasyatidae	Myliobatidae	Elopidae	Dussumieridae	Synodontidae	Ophichthidae	Congridae	Belonidae	Hemiramphidae
Benthic algae											40.50
Hypoplectrus negronis											
Hypoplectrus puella											
Mycteroperca bonaci											
Mycteroperca interstitialis											
Mycteroperca tigris											
Mycteroperca venenosa											
Paranthias furcifer											
Cephalopholis cruentata											
Diplectrum radiale											
Exocoetidae											
Organic detritus											
Alcyonarian											
Hydroids											
Anthozoa											
Isopod larvae											
Pelecypod larvae											
Priopuloids											
Nebaliacea											
Anemones											
Mollusk eggs											
Opistobranchs											
Coelenterate											
Pycnogonids											
Mollusk											
Spiny lobster larvae											
Serranus sp.											
Total		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	Fistularidae	Aulostomidae	Holocentridae	Mugilidae	Sphyraenidae	Atherinidae	Serranidae	Grammistidae	Grammidae	Cirrhitidae	Apogonidae
Benthic algae				75.00					N		
Spring algae									O		
Zooxanthellae											
Planktonic algae						1.10			R		
Drifting plants (*Sargassum*)									E		
Spermatophytes (*Thalassia*)				25.00					P		
Protozoa									O		
Sponges									R		
Coral									T		
Zoantharians											
Gorgonians											
Hydrozoans											
Schyphozoans											
Ctenophores											
Bryozoans											
Sipunculids											
Polychaetes			10.30							12.10	4.80
Chitons			1.56				0.08				
Gastropods			4.84				0.43				
Pteropods											
Scaphopods											
Pelecypods							0.03				
Cephalopods					10.95		0.92				
Copepods			0.56			59.60	7.68				7.50
Ostracods			0.21							45.80	
Barnacles						5.00					
Physids			1.80				0.88				
Tanaids										1.40	1.35
Isopods			1.37				0.19			2.50	3.20
Amphipods			0.46				0.15			2.10	9.75
Stomatopods			0.06				3.34	8.30			
Shrimp	26.50		24.96				16.29	34.20		10.55	12.25
Crabs			37.00				17.73	8.60		7.10	11.85
Spiny lobster							2.45				
Scyllarid lobster					0.95		1.16				
Hermit crabs							0.06				
Echinoids											
Ophiurids			1.01								
Asteroids											
Holothurians											
Hemichordates											
Tunicates							0.61				3.65
Carcharinidae											
Dasyatidae							0.33				
Myliobatidae											
Elopidae											
Clupeidae					7.95		0.50				
Dissumieridae							0.38				
Synodontidae					2.65						

	Fistularidae	Aulostomidae	Holocentridae	Mugilidae	Sphyraenidae	Atherinidae	Serranidae	Grammistidae	Grammidae	Cirrhitidae	Apogonidae
Benthic algae				75.00					N		
Ophichthidae							0.06				
Congridae							0.06				
Belonidae											
Hemiranphidae					2.65		2.50				
Fistularidae											
Aulostomidae							0.74				
Holocentridae		11.03					1.17				
Mugilidae											
Sphyraenidae					2.65						
Atherinidae					5.30		2.40				
Serranidae							0.38				
Grammistidae											
Grammidae											
Cirrhitidae											
Apogonidae		3.68					0.47				
Priocanthidae							0.07				
Pempheridae											
Lutjanidae							0.14				
Emmelichthyidae					2.65						
Pomadasyidae											
Sparidae											
Kyphosidae											
Gerreidae											
Scianidae							0.35				
Mullidae	5.00	3.68					0.25				
Banchiostegidae											
Rachycentridae											
Echeneidae											
Carangidae					7.95		0.24				
Scombridae											
Pomacentridae		11.03					1.45				
Labridae		3.68					0.46	31.93			
Scaridae							4.39				
Bothidae					2.65						
Gobidae		3.68					0.94				
Blennidae		7.35					1.60	15.96			
Clinidae		11.03					0.33				
Opisthognathidae											
Dactylopteridae											
Ephippidae											
Chaetodontidae							0.47				
Acanthuridae		7.35			2.65		1.88				
Balistidae	50.00						1.76				
Monacanthidae							0.24				
Ostraciontidae											
Tetradontidae					2.65		0.33				
Diodontidae					2.65		0.33				
Antennaridae											

	Fistularidae	Aulostomidae	Holocentridae	Mugilidae	Sphyraenidae	Atherinidae	Serranidae	Grammistidae	Grammidae	Cirrhitidae	Apogonidae
Benthic algae				75.00					N		
Ogcocephalidae							0.28				
Sea turtles											
Engrulidae		3.68					0.14				
Scorpaenidae											
Haemulidae		7.36			2.65		4.07				
Muraenidae					2.65		0.52				
Fish larvae			1.14			4.05	0.03				
Fishes			0.54		41.45	10.00	11.83				
Un ID animal mat.			0.01				0.38			0.80	
Un ID plant mat.											
Un ID crustaceans							4.77				15.45
Fish eggs			4.37			1.10	0.40				0.90
Shrimp larvae			3.65			17.80	0.29			10.55	24.30
Crab larvae			2.98							7.10	5.06
Un ID eggs							0.01				
Gastropod larvae							0.01				
Insects											
Stomatopod larvae			2.96								
Cephalopod larvae			0.21								
Hermit crab larvae			0.13								
Scylland larvae			0.13								
Barnacle larvae						5.00					
Polychaete larva						1.35					
Echiuroids							0.10				
Inermidae							0.17				
Ostraciidae							0.07				
Euphausids											
Malaconthidae											
Pomacanthidae											
Syngnathidae											
Ocyurus chrysurus					2.65		0.07				
Lutjanus synagris											
Lutjanus mahagoni											
Lutjanus jocu											
Lutjanus griseus											
Lutjanus cyanopterus											
Lutjanus apodus											
Lutjanus analis											
Lutjanus species							0.07				
Lutjanus apher											
Cephalopholis fulva							0.07				
Epinephelus adscensionis											
Epinephelus guttatus											
Epinephelus itajara											
Epinephelus morio											
Epinephelus striatus											
Hypoplectrus aberrans											
Hypoplectrus chlosurus											

	Fistularidae	Aulostomidae	Holocentridae	Mugilidae	Sphyraenidae	Atherinidae	Serranidae	Grammistidae	Grammidae	Cirrhitidae	Apogonidae
Benthic algae				75.00					N		
Hypoplectrus negronis											
Hypoplectrus puella							0.07				
Mycteroperca bonaci											
Mycteroperca interstitialis											
Mycteroperca tigris											
Mycteroperca venenosa											
Paranthias furcifer											
Cephalopholis cruentata											
Diplectrum radiale											
Exocoetidae											
Organic detritus											
Alcyonarian											
Hydroids											
Anthozoa											
Isopod larvae											
Pelecypod larvae											
Priopuloids											
Nebaliacea											
Anemones											
Mollusk eggs											
Opistobranchs											
Coelenterate											
Pycnogonids											
Mollusk											
Spiny lobster larvae											
Serranus sp.											
Total	81.50	73.52	100.25	100.00	103.70	105.00	99.57	98.99		100.00	100.06

	Priacanthidae	Pempheridae	Lutjanidae	Emmelichthyidae	Pomadasyidae	Sparidae	Kyphosidae	Gerreidae	Sciaenidae	Mullidae	Branchiostomidae / Malacanthidae
Benthic algae						6.47	68.91				
Spring algae											
Zooxanthellae											
Planktonic algae					0.04						
Drifting plants (*Sargassum*)							30.84				
Spermatophytes (*Thalassia*)						7.43					
Protozoa							0.25				
Sponges					0.02						
Coral											
Zoantharians											
Gorgonians											
Hydrozoans			0.89								
Schyphozoans				16.70							
Ctenophores			0.34								
Bryozoans					0.04						
Sipunculids					4.83	0.93		4.30		5.60	7.20
Polychaetes	13.95	27.30		1.30	13.51	6.72		16.10	9.17	15.95	7.20
Chitons					1.62	0.60		3.95			7.20
Gastropods	0.60		3.44		5.33	12.27		8.05	0.80	0.75	
Pteropods	0.76										
Scaphopods					0.18						
Pelecypods	0.15				4.60	7.35		13.20	0.15	9.90	
Cephalopods	3.32		3.38		0.45						
Copepods			0.64	76.70	0.39			1.00	0.40		
Ostracods					0.16				0.07	1.00	
Barnacles					0.17						
Physids	3.90		0.36								
Tanaids					0.21			2.95		0.55	
Isopods	3.25				1.71				5.47	3.80	
Amphipods	0.35	1.10	0.06		2.08	0.03		21.10	0.07	3.05	1.60
Stomatopods			7.11		1.80	0.50		1.40	0.07	2.00	15.00
Shrimp	19.85		4.74		9.68	0.97		5.95	32.10	13.87	1.40
Crabs	6.05		24.36		17.56	19.93		18.95	12.77	19.07	
Spiny lobster			1.05								18.50
Scyllarid lobster			0.57		0.04						
Hermit crabs			0.38		0.89	3.75			2.02		
Echinoids					17.60	9.68					2.70
Ophiurids					4.50	4.95		0.90	0.50	4.85	21.90
Asteroids					0.16						
Holothurians					1.00	0.66					
Hemichordates					0.62			0.95			
Tunicates			0.34		0.04						
Carcharinidae											
Dasyatidae											
Myliobatidae											
Elopidae											
Clupeidae			9.14								
Dissumieridae											
Synodontidae			3.12								

	Priacanthidae	Pempheridae	Lutjanidae	Emmelichthyidae	Pomadasyidae	Sparidae	Kyphosidae	Gerreidae	Sciaenidae	Mullidae	Branchiostomidae / Malacanthidae
Benthic algae						6.47	68.91				
Ophichthidae			0.72								2.06
Congridae											2.06
Belonidae											
Hemiranphidae											
Fistularidae			0.25								
Aulostomidae			0.87								
Holocentridae			4.10								
Mugilidae											
Sphyraenidae											
Atherinidae	9.37		3.99								
Serranidae			0.87								
Grammistidae											
Grammidae											
Cirrhitidae											
Apogonidae											
Priocanthidae											
Pempheridae											
Lutjanidae											
Emmelichthyidae											
Pomadasyidae											
Sparidae											
Kyphosidae											
Gerreidae											
Scianidae											
Mullidae			0.61								
Banchiostegidae											
Rachycentridae											
Echeneidae											
Carangidae											
Scombridae											
Pomacentridae			1.01								
Labridae			1.11								6.20
Scaridae			7.38								
Bothidae											
Gobidae			0.25							1.07	
Blennidae					0.06						
Clinidae											
Opisthognathidae											
Dactylopteridae											
Ephippidae											
Chaetodontidae											
Acanthuridae			0.25								
Balistidae			1.11								
Monacanthidae											
Ostraciontidae											
Tetradontidae			0.25								
Diodontidae			2.33								
Antennaridae											

	Priacanthidae	Pempheridae	Lutjanidae	Emmelichthyidae	Pomadasyidae	Sparidae	Kyphosidae	Gerreidae	Sciaenidae	Mullidae	Branchiostomidae / Malacanthidae
Benthic algae						6.47	68.91				
Ogcocephalidae											
Sea turtles											
Engrulidae											
Scorpaenidae			1.26								
Haemulidae			5.89								
Muraenidae			1.23								2.06
Fish larvae	16.54		0.94						5.19		
Fishes				3.30	0.92			1.60	5.29		
Un ID animal mat.	0.60		0.55		0.95	0.02	0.16			2.10	6.40
Un ID plant mat.											
Un ID crustaceans		2.80	0.86		3.60	0.06	3.50	3.50		3.90	
Fish eggs			0.34						8.25		
Shrimp larvae	2.50	18.90	1.21		2.25				16.47	2.87	
Crab larvae	6.05	24.50	0.44	2.00	1.05					3.97	
Un ID eggs					0.88	0.58				0.10	
Gastropod larvae			0.09								
Insects			0.06								
Stomatopod larvae	3.55	16.70							0.87		
Cephalopod larvae	2.22	3.30	0.24								
Hermit crab larvae		5.40			0.20						
Scylland larvae	0.70				0.11						
Barnacle larvae											
Polychaete larva											
Echiuroids					0.09						
Inermidae											
Ostraciidae											
Euphausids			0.10								
Malaconthidae			0.25								
Pomacanthidae			0.36								
Syngnathidae											1.07
Ocyurus chrysurus											
Lutjanus synagris											
Lutjanus mahagoni											
Lutjanus jocu											
Lutjanus griseus											
Lutjanus cyanopterus											
Lutjanus apodus											
Lutjanus analis											
Lutjanus species											
Lutjanus apher											
Cephalopholis fulva			*0.36*								
Epinephelus adscensionis											
Epinephelus guttatus											
Epinephelus itajara											
Epinephelus morio											
Epinephelus striatus											
Hypoplectrus aberrans											
Hypoplectrus chlosurus											

	Priacanthidae	Pempheridae	Lutjanidae	Emmelichthyidae	Pomadasyidae	Sparidae	Kyphosidae	Gerreidae	Sciaenidae	Mullidae	Branchiostomidae / Malacanthidae
Benthic algae						6.47	68.91				
Hypoplectrus negronis											
Hypoplectrus puella											
Mycteroperca bonaci											
Mycteroperca interstitialis											
Mycteroperca tigris											
Mycteroperca venenosa											
Paranthias furcifer											
Cephalopholis cruentata											
Diplectrum radiale											
Exocoetidae											
Organic detritus											
Alcyonarian											
Hydroids											
Anthozoa					0.07						
Isopod larvae											
Pelecypod larvae											
Priopuloids					0.07						
Nebaliacea					0.04						
Anemones					0.31						
Mollusk eggs											
Opistobranchs											
Coelenterate											
Pycnogonids											
Mollusk											
Spiny lobster larvae											
Serranus sp.											
Total	93.71	100.00	99.20	100.00	99.83	82.90	103.66	103.90	99.66	94.40	102.55

	Rachycentridae	Echeneidae	Carangidae	Scombridae	Pomacentridae	Labridae	Scaridae	Bothidae	Gobidae	Blennidae	Clinidae
Benthic algae					21.00		84.28		20.66	46.79	
Spring algae											
Zooxanthellae											
Planktonic algae					1.29	0.01	0.48				
Drifting plants (*Sargassum*)											
Spermatophytes (*Thalassia*)					0.64		14.54				
Protozoa											
Sponges					0.21		0.31				
Coral					0.42		0.04				
Zoantharians											
Gorgonians							0.26				
Hydrozoans			0.06		0.61	1.82					
Schyphozoans					0.12						
Ctenophores											
Bryozoans											
Sipunculids						0.60					
Polychaetes					4.50	7.29				3.20	3.33
Chitons				2.23	0.01	1.10					6.67
Gastropods			4.71		0.55	15.74				0.20	7.17
Pteropods			9.34		0.18	1.74					
Scaphopods						0.58					
Pelecypods			1.76		0.12	10.97			3.33		
Cephalopods			0.12	15.54		0.39		1.45			
Copepods		11.00	5.32		18.10	12.13			8.67		
Ostracods			0.71		0.08	0.67			4.67		
Barnacles					0.33	0.04					
Physids			0.22		0.12						
Tanaids					0.07	0.31					
Isopods		20.00	0.20		1.29	1.14			33.33		0.83
Amphipods		4.00			0.40	1.74		7.50	1.33		1.77
Stomatopods			0.34			0.73		7.10			
Shrimp			0.60	0.13	0.33	2.78		7.50			2.56
Crabs			0.85		0.59	12.20		12.50			33.23
Spiny lobster											
Scyllarid lobster											
Hermit crabs			0.58		0.49	2.01					
Echinoids			2.08			6.19	0.01				3.50
Ophiurids					0.21	6.04			3.30	2.30	37.43
Asteroids					0.37						
Holothurians						0.14					
Hemichordates											
Tunicates					5.52	0.43					
Carcharinidae											
Dasyatidae											
Myliobatidae											
Elopidae											
Clupeidae			16.85	20.48	0.50			14.28			
Dissumieridae											
Synodontidae											

	Rachycentridae	Echeneidae	Carangidae	Scombridae	Pomacentridae	Labridae	Scaridae	Bothidae	Gobidae	Blennidae	Clinidae
Benthic algae					21.00		84.28		20.66	46.79	
Ophichthidae											
Congridae											
Belonidae				2.13							
Hemiranphidae				2.13							
Fistularidae											
Aulostomidae											
Holocentridae			2.42								
Mugilidae											
Sphyraenidae											
Atherinidae				10.57							
Serranidae											
Grammistidae											
Grammidae											
Cirrhitidae											
Apogonidae											
Priocanthidae			1.66								
Pempheridae				4.39							
Lutjanidae			1.66								
Emmelichthyidae											
Pomadasyidae											
Sparidae			1.66								
Kyphosidae											
Gerreidae											
Scianidae											
Mullidae			2.66	3.15							
Banchiostegidae											
Rachycentridae											
Echeneidae											
Carangidae			1.66					14.28			
Scombridae											
Pomacentridae			0.42	6.27							
Labridae			1.66	4.27							
Scaridae			3.35								
Bothidae											
Gobidae								14.50			
Blennidae			0.85								
Clinidae			1.66								
Opisthognathidae											
Dactylopteridae											
Ephippidae											
Chaetodontidae											
Acanthuridae			0.63								
Balistidae		10.00	1.66								
Monacanthidae			0.42								
Ostraciontidae											
Tetradontidae											
Diodontidae											
Antennaridae											

	Rachycentridae	Echeneidae	Carangidae	Scombridae	Pomacentridae	Labridae	Scaridae	Bothidae	Gobidae	Blennidae	Clinidae
Benthic algae					21.00		84.28		20.66	46.79	
Ogcocephalidae											
Sea turtles											
Engrulidae			6.61	9.67				14.28			
Scorpaenidae											
Haemulidae			1.66	13.06							
Muraenidae											
Fish larvae		10.00	0.61	3.15							
Fishes			12.50		1.34	1.81					3.50
Un ID animal mat.			0.59		6.82						
Un ID plant mat.		32.50				2.98					
Un ID crustaceans		7.50	0.07	0.40	1.97	3.90	0.04	5.55	0.67		
Fish eggs					1.93	0.13				0.12	
Shrimp larvae			2.32		2.55	1.77					
Crab larvae			1.08		0.09	0.80					
Un ID eggs					0.40	0.30			3.33	3.20	
Gastropod larvae			1.61			0.64					
Insects					0.13						
Stomatopod larvae						0.03					
Cephalopod larvae											
Hermit crab larvae											
Scylland larvae											
Barnacle larvae											
Polychaete larva											
Echiuroids											
Inermidae											
Ostraciidae	100.00										
Euphausids											
Malaconthidae											
Pomacanthidae											
Syngnathidae			2.08								
Ocyurus chrysurus			1.66	4.39							
Lutjanus synagris											
Lutjanus mahagoni											
Lutjanus jocu											
Lutjanus griseus											
Lutjanus cyanopterus											
Lutjanus apodus											
Lutjanus analis											
Lutjanus species											
Lutjanus apher											
Cephalopholis fulva											
Epinephelus adscensionis											
Epinephelus guttatus											
Epinephelus itajara											
Epinephelus morio											
Epinephelus striatus											
Hypoplectrus aberrans											
Hypoplectrus chlosurus											

	Rachycentridae	Echeneidae	Carangidae	Scombridae	Pomacentridae	Labridae	Scaridae	Bothidae	Gobidae	Blennidae	Clinidae
Benthic algae					21.00		84.28		20.66	46.79	
Hypoplectrus negronis											
Hypoplectrus puella											
Mycteroperca bonaci											
Mycteroperca interstitialis											
Mycteroperca tigris											
Mycteroperca venenosa											
Paranthias furcifer											
Cephalopholis cruentata											
Diplectrum radiale											
Exocoetidae											
Organic detritus				4.39	13.53				20.67	46.79	
Alcyonarian											
Hydroids					0.54					0.60	
Anthozoa					7.88						
Isopod larvae											
Pelecypod larvae											
Priopuloids											
Nebaliacea											
Anemones											
Mollusk eggs					1.18						
Opistobranchs					0.59						
Coelenterate					0.56						
Pycnogonids											
Mollusk							0.04				
Spiny lobster larvae											
Serranus sp.											
Total	100.00	95.00	96.90	106.35	97.56	99.15	100.00	98.94	99.96	103.20	99.99

	Opisthognathidae	Dactylopteridae	Ephippidae	Chaetodontidae	Acanthuridae	Balistidae	Monacanthidae	Ostraciontidae	Tetradontidae	Diodontidae	Antennaridae
Benthic algae			3.75	8.11	44.53	20.69	16.21	4.00	1.75		
Spring algae											
Zooxanthellae											
Planktonic algae			1.25		1.89	0.85	0.20				
Drifting plants (*Sargassum*)				0.10		3.27					
Spermatophytes (*Thalassia*)			2.30	0.02	6.90	1.46	16.00	3.04	5.30		
Protozoa											
Sponges			32.70	37.65			19.63	9.68			
Coral			2.30			0.27	0.12				
Zoantharians			18.50	5.55	0.03		0.68	2.16			
Gorgonians			6.30	0.85			3.18	0.84			
Hydrozoans	0.32					0.76	3.70				
Schyphozoans								0.50			
Ctenophores											
Bryozoans				0.09			0.38				
Sipunculids						0.30		3.14			
Polychaetes	3.65		13.70	16.14		0.70	0.70	9.12	7.60		
Chitons						0.03		0.30	1.40		
Gastropods					0.01	0.53	0.45	1.54	9.60	51.86	
Pteropods						8.90					
Scaphopods											
Pelecypods		7.20				1.53	0.03	2.42	16.00	8.60	
Cephalopods											
Copepods	21.35			0.54		0.07	8.30		0.90		
Ostracods									0.04		
Barnacles											
Physids	1.35			0.52							
Tanaids				0.11			1.43				
Isopods	9.90						1.10		1.10		
Amphipods		1.40	0.10	1.48		2.01	0.97	0.68	5.70		
Stomatopods		19.30				0.02	0.60				6.25
Shrimp	45.65	5.40		2.47		0.28	1.16	3.54	5.50	0.13	
Crabs	1.25	61.70				2.62		11.58	20.40	0.53	6.25
Spiny lobster											
Scyllarid lobster						0.03					
Hermit crabs						1.03	0.10	0.22	0.90	14.50	
Echinoids				1.27		32.60	0.02		6.90	11.53	
Ophiurids	2.00					1.10	0.32	2.82	6.00		
Asteroids						0.46		1.68			
Holothurians			2.30				0.13	4.32			
Hemichordates								0.66	3.40		
Tunicates			12.60	1.99		0.80	1.18	15.46	0.90		
Carcharinidae											
Dasyatidae											
Myliobatidae											
Elopidae											
Clupeidae											
Dissumieridae											
Synodontidae											

	Opisthognathidae	Dactylopteridae	Ephippidae	Chaetodontidae	Acanthuridae	Balistidae	Monacanthidae	Ostraciontidae	Tetradontidae	Diodontidae	Antennaridae
Benthic algae			3.75	8.11	44.53	20.69	16.21	4.00	1.75		
Ophichthidae											
Congridae											
Belonidae											
Hemiranphidae											
Fistularidae											
Aulostomidae											
Holocentridae											
Mugilidae											
Sphyraenidae											
Atherinidae											
Serranidae											25.00
Grammistidae											
Grammidae											
Cirrhitidae											
Apogonidae											
Priocanthidae											
Pempheridae											
Lutjanidae											
Emmelichthyidae											
Pomadasyidae											
Sparidae											
Kyphosidae											
Gerreidae											
Scianidae											
Mullidae											
Banchiostegidae											
Rachycentridae											
Echeneidae											
Carangidae											
Scombridae											
Pomacentridae											
Labridae											
Scaridae											
Bothidae											
Gobidae											
Blennidae											
Clinidae											
Opisthognathidae											
Dactylopteridae											
Ephippidae											
Chaetodontidae											
Acanthuridae											
Balistidae											
Monacanthidae											
Ostraciontidae											
Tetradontidae											
Diodontidae											
Antennaridae											

	Opisthognathidae	Dactylopteridae	Ephippidae	Chaetodontidae	Acanthuridae	Balistidae	Monacanthidae	Ostraciontidae	Tetradontidae	Diodontidae	Antennariidae
Benthic algae			3.75	8.11	44.53	20.69	16.21	4.00	1.75		
Ogcocephalidae											
Sea turtles											
Engrulidae											
Scorpaenidae											25.00
Haemulidae											37.50
Muraenidae											
Fish larvae											
Fishes	11.17	5.00				1.10			0.70		
Un ID animal mat.	0.47				0.02		0.80	11.32	2.10	0.01	
Un ID plant mat.				10.00		5.83					
Un ID crustaceans				1.33	0.10	1.03	2.70				
Fish eggs	0.37										
Shrimp larvae	2.35	0.10				0.05	1.09				
Crab larvae		0.20				2.05					
Un ID eggs				0.89	0.01		0.02	0.42	2.10		
Gastropod larvae						0.83	3.12				
Insects											
Stomatopod larvae											
Cephalopod larvae											
Hermit crab larvae											
Scylland larvae											
Barnacle larvae	0.15					0.47					
Polychaete larva											
Echiuroids											
Inermidae											
Ostraciidae											
Euphausids											
Malaconthidae											
Pomacanthidae											
Syngnathidae											
Ocyurus chrysurus											
Lutjanus synagris											
Lutjanus mahagoni											
Lutjanus jocu											
Lutjanus griseus											
Lutjanus cyanopterus											
Lutjanus apodus											
Lutjanus analis											
Lutjanus species											
Lutjanus apher											
Cephalopholis fulva											
Epinephelus adscensionis											
Epinephelus guttatus											
Epinephelus itajara											
Epinephelus morio											
Epinephelus striatus											
Hypoplectrus aberrans											
Hypoplectrus chlosurus											

	Opisthognathidae	Dactylopteridae	Ephippidae	Chaetodontidae	Acanthuridae	Balistidae	Monacanthidae	Ostraciontidae	Tetradontidae	Diodontidae	Antennariidae
Benthic algae			3.75	8.11	44.53	20.69	16.21	4.00	1.75		
Hypoplectrus negronis											
Hypoplectrus puella											
Mycteroperca bonaci											
Mycteroperca interstitialis											
Mycteroperca tigris											
Mycteroperca venenosa											
Paranthias furcifer											
Cephalopholis cruentata											
Diplectrum radiale											
Exocoetidae											
Organic detritus				5.55	46.42		12.22		1.75		
Alcyonarian											
Hydroids				1.43			4.26		4.66		
Anthozoa				3.61	0.01						
Isopod larvae					3.83						
Pelecypod larvae					0.03						
Priopuloids											
Nebaliacea											
Anemones											
Mollusk eggs											
Opistobranchs											
Coelenterate											
Pycnogonids											
Mollusk		0.02									
Spiny lobster larvae											
Serranus sp.											
Total	99.98	100.32	95.80	99.70	103.78	91.67	100.80	89.44	104.70	87.16	100.00

	Ogcocephalidae	Cetaceans	Oreclolobidae	Canthigasteridae?	Scorpaenidae	*Lutjanus analis*	*Lutjanus apodus*	*Lutjanus cyanopter*	*Lutjanus griseus*	*Lutjanus jocu*	*Lutjanus mahogoni*	*Lutjanus synagris*
Benthic algae	11.10			1.10								
Spring algae												
Zooxanthellae												
Planktonic algae												
Drifting plants (*Sargassum*)												
Spermatophytes (*Thalassia*)				16.10								
Protozoa												
Sponges												
Coral				15.00								
Zoantharians												
Gorgonians												
Hydrozoans				2.70								
Schyphozoans												
Ctenophores												
Bryozoans												
Sipunculids												
Polychaetes	4.40			7.20								
Chitons												
Gastropods	25.90			7.80			0.50		6.80	3.60		
Pteropods						13.00						
Scaphopods												
Pelecypods	1.70			5.20								
Cephalopods			11.00		1.24	3.10	3.45			9.20	9.40	
Copepods												
Ostracods												
Barnacles	0.60											
Physids												
Tanaids												
Isopods												
Amphipods				3.10								
Stomatopods					4.36	0.80	3.70					50.00
Shrimp				2.90	58.12	2.30	3.45		13.2		12.50	
Crabs	47.50			9.80	11.26	44.40	22.20		40	15.40	3.10	50.00
Spiny lobster						1.90				6.60		
Scyllarid lobster									0.9	1.80		
Hermit crabs				2.30	0.32	2.80						
Echinoids				3.80								
Ophiurids												
Asteroids				3.80								
Holothurians												
Hemichordates												
Tunicates												
Carcharinidae												
Dasyatidae												
Myliobatidae												
Elopidae												
Clupeidae			35.60		2.81		3.03	12.50	39.10	5.78		
Dissumieridae												
Synodontidae											25.00	

	Ogcocephalidae	Cetaceans	Oreclolobidae	Canthigasteridae?	Scorpaenidae	*Lutjanus analis*	*Lutjanus apodus*	*Lutjanus cyanopter*	*Lutjanus griseus*	*Lutjanus jocu*	*Lutjanus mahogoni*	*Lutjanus synagris*
Benthic algae	11.10			1.10								
Ophichthidae					2.81					5.78		
Congridae												
Belonidae												
Hemiranphidae												
Fistularidae						1.99						
Aulostomidae							6.06			2.99		
Holocentridae						1.99				5.78	25.00	
Mugilidae												
Sphyraenidae												
Atherinidae							6.16			2.89	25.00	
Serranidae							6.06					
Grammistidae												
Grammidae												
Cirrhitidae												
Apogonidae												
Priocanthidae												
Pempheridae												
Lutjanidae												
Emmelichthyidae												
Pomadasyidae												
Sparidae							6.06					
Kyphosidae												
Gerreidae												
Scianidae												
Mullidae						1.99				2.89		
Banchiostegidae												
Rachycentridae												
Echeneidae												
Carangidae												
Scombridae												
Pomacentridae							6.06					
Labridae						1.99	3.03			2.89		
Scaridae			17.80			1.99	9.09	37.50		11.56		
Bothidae												
Gobidae						1.99						
Blennidae												
Clinidae												
Opisthognathidae												
Dactylopteridae												
Ephippidae												
Chaetodontidae												
Acanthuridae			17.80		1.41	1.99						
Balistidae			17.80			3.97	3.03			2.89		
Monacanthidae												
Ostraciontidae												
Tetradontidae	8.80					1.99						
Diodontidae						1.99		25.00				
Antennaridae												

	Ogcocephalidae	Cetaceans	Oreclolobidae	Canthigasteridae?	Scorpaenidae	*Lutjanus analis*	*Lutjanus apodus*	*Lutjanus cyanopter*	*Lutjanus griseus*	*Lutjanus jocu*	*Lutjanus mahogoni*	*Lutjanus synagris*
Benthic algae	11.10			1.10								
Ogcocephalidae												
Sea turtles												
Engrulidae												
Scorpaenidae						1.99	6.06					
Haemulidae						3.97	3.03	25.00		5.78		
Muraenidae							3.03			5.78		
Fish larvae				2.18								
Fishes					2.56							
Un ID animal mat.				12.80	1.26	1.90						
Un ID plant mat.												
Un ID crustaceans				2.30	10.00		6.00			0.90		
Fish eggs										1.80		
Shrimp larvae												
Crab larvae												
Un ID eggs												
Gastropod larvae												
Insects												
Stomatopod larvae												
Cephalopod larvae												
Hermit crab larvae												
Scylland larvae												
Barnacle larvae												
Polychaete larva												
Echiuroids												
Inermidae												
Ostraciidae												
Euphausids												
Malaconthidae												
Pomacanthidae					0.77					2.89		
Syngnathidae					2.89							
Ocyurus chrysurus												
Lutjanus synagris												
Lutjanus mahagoni												
Lutjanus jocu												
Lutjanus griseus												
Lutjanus cyanopterus												
Lutjanus apodus												
Lutjanus analis												
Lutjanus species												
Lutjanus apher												
Cephalopholis fulva										*2.89*		
Epinephelus adscensionis												
Epinephelus guttatus												
Epinephelus itajara												
Epinephelus morio												
Epinephelus striatus												
Hypoplectrus aberrans												
Hypoplectrus chlosurus												

	Ogcocephalidae	Cetaceans	Oreclolobidae	Canthigasteridae?	Scorpaenidae	*Lutjanus analis*	*Lutjanus apodus*	*Lutjanus cyanopter*	*Lutjanus griseus*	*Lutjanus jocu*	*Lutjanus mahogoni*	*Lutjanus synagris*
Benthic algae	11.10			1.10								
Hypoplectrus negronis												
Hypoplectrus puella												
Mycteroperca bonaci												
Mycteroperca interstitialis												
Mycteroperca tigris												
Mycteroperca venenosa												
Paranthias furcifer												
Cephalopholis cruentata												
Diplectrum radiale												
Exocoetidae												
Organic detritus				1.10								
Alcyonarian												
Hydroids												
Anthozoa												
Isopod larvae												
Pelecypod larvae												
Priopuloids												
Nebaliacea												
Anemones												
Mollusk eggs												
Opistobranchs												
Coelenterate												
Pycnogonids												
Mollusk												
Spiny lobster larvae												
Serranus sp.												
Total	100.00	0.00	100.00	99.18	99.81	98.04	100.00	100.00	100.00	100.09	100.00	100.00

	Ocyurus chrysurus	*Alphestes afer*	*Cephalopholis fulva*	*Epinephelus adscen*	*Epinephelus guttatu*	*Epinephelus itajara*	*Epinephelus morio*	*Epinephelus striatus*	*Mycteroperca bonac*	*Hypoplectrum aberr*	*Hypoplectrum chloc*	*Hypoplectrum nigric*
Benthic algae												
Spring algae												
Zooxanthellae												
Planktonic algae												
Drifting plants (*Sargassum*)												
Spermatophytes (*Thalassia*)												
Protozoa												
Sponges												
Coral												
Zoantharians												
Gorgonians												
Hydrozoans	7.10											
Schyphozoans												
Ctenophores	2.70											
Bryozoans												
Sipunculids												
Polychaetes												
Chitons				1.60								
Gastropods	3.60			3.20				1.60				
Pteropods	6.10											
Scaphopods												
Pelecypods	1.20							0.70				
Cephalopods	1.90	2.50			7.00			5.20				
Copepods	5.10											
Ostracods												
Barnacles												
Physids	2.90									0.60		5.90
Tanaids												
Isopods												
Amphipods	0.50											
Stomatopods	2.40		12.40		16.50			5.50		6.30		2.90
Shrimp	6.48	6.80	20.70	4.40	10.50			5.00		43.80	51.20	29.40
Crabs	19.80	77.00	17.20	66.70	39.50	12.20	33.30	22.50		18.70	17.10	17.60
Spiny lobster						45.60		3.50				
Scyllarid lobster						23.30						
Hermit crabs								1.20				
Echinoids												
Ophiurids												
Asteroids												
Holothurians												
Hemichordates												
Tunicates	2.70											
Carcharinidae												
Dasyatidae						6.65						
Myliobatidae												
Elopidae												
Clupeidae	7.55							2.92				
Dissumieridae												
Synodontidae								2.92				

	Ocyurus chrysurus	*Alphestes afer*	*Cephalopholis fulva*	*Epinephelus adscen*	*Epinephelus guttatu*	*Epinephelus itajara*	*Epinephelus morio*	*Epinephelus striatus*	*Mycteroperca bonac*	*Hypoplectrum aberr*	*Hypoplectrum chloc*	*Hypoplectrum nigric*
Benthic algae												
Ophichthidae		1.67										
Congridae		1.67										
Belonidae												
Hemiranphidae												
Fistularidae									50.00			
Aulostomidae			6.57		3.52							
Holocentridae								4.39				
Mugilidae												
Sphyraenidae												
Atherinidae								2.92				
Serranidae												
Grammistidae												
Grammidae												
Cirrhitidae												
Apogonidae												
Priocanthidae								1.46				
Pempheridae												
Lutjanidae								1.46				
Emmelichthyidae												
Pomadasyidae												
Sparidae												
Kyphosidae												
Gerreidae												
Scianidae												
Mullidae					3.52			1.46				
Banchiostegidae												
Rachycentridae												
Echeneidae												
Carangidae												
Scombridae												
Pomacentridae								7.30				
Labridae								4.39				
Scaridae			6.57	10.05	3.52			5.84				
Bothidae												
Gobidae												
Blennidae											25.00	
Clinidae			6.57									
Opisthognathidae												
Dactylopteridae												
Ephippidae												
Chaetodontidae												
Acanthuridae		3.50	6.57					1.46				
Balistidae			13.14	10.05	3.52			1.46				
Monacanthidae												
Ostraciontidae												
Tetradontidae			6.57									
Diodontidae						6.65						
Antennaridae												

	Ocyurus chrysurus	*Alphestes afer*	*Cephalopholis fulva*	*Epinephelus adscen*	*Epinephelus guttatu*	*Epinephelus itajara*	*Epinephelus morio*	*Epinephelus striatus*	*Mycteroperca bonac*	*Hypoplectrum aberr*	*Hypoplectrum chloc*	*Hypoplectrum nigric*
Benthic algae												
Ogcocephalidae												
Sea turtles						5.60						
Engrulidae								2.92				
Scorpaenidae												
Haemulidae								2.92	50.00			
Muraenidae		1.67			3.52			5.84				
Fish larvae	7.55											
Fishes							16.70			11.90		44.20
Un ID animal mat.	2.50											
Un ID plant mat.												
Un ID crustaceans		6.70	3.70	4.00	3.30		50.00			18.70	6.70	
Fish eggs	0.90											
Shrimp larvae	0.72											
Crab larvae	3.49											
Un ID eggs												
Gastropod larvae	0.70											
Insects	0.50											
Stomatopod larvae												
Cephalopod larvae	1.90											
Hermit crab larvae												
Scylland larvae	1.90											
Barnacle larvae												
Polychaete larva												
Echiuroids					2.00							
Inermidae					3.52							
Ostraciidae								1.46				
Euphausids	0.50											
Malaconthidae												
Pomacanthidae												
Syngnathidae												
Ocyurus chrysurus								1.46				
Lutjanus synagris												
Lutjanus mahagoni												
Lutjanus jocu												
Lutjanus griseus												
Lutjanus cyanopterus												
Lutjanus apodus												
Lutjanus analis												
Lutjanus species												
Lutjanus apher												
Cephalopholis fulva									*1.46*			
Epinephelus adscensionis												
Epinephelus guttatus												
Epinephelus itajara												
Epinephelus morio												
Epinephelus striatus												
Hypoplectrus aberrans												
Hypoplectrus chlosurus												

	Ocyurus chrysurus	*Alphestes afer*	*Cephalopholis fulva*	*Epinephelus adscen*	*Epinephelus guttatu*	*Epinephelus itajara*	*Epinephelus morio*	*Epinephelus striatus*	*Mycteroperca bonac*	*Hypoplectrum aberr*	*Hypoplectrum chloc*	*Hypoplectrum nigric*
Benthic algae												
Hypoplectrus negronis												
Hypoplectrus puella												
Mycteroperca bonaci												
Mycteroperca interstitialis												
Mycteroperca tigris												
Mycteroperca venenosa												
Paranthias furcifer												
Cephalopholis cruentata												
Diplectrum radiale												
Exocoetidae												
Organic detritus												
Alcyonarian												
Hydroids												
Anthozoa												
Isopod larvae												
Pelecypod larvae												
Priopuloids												
Nebaliacea												
Anemones												
Mollusk eggs												
Opistobranchs												
Coelenterate												
Pycnogonids												
Mollusk												
Spiny lobster larvae												
Serranus sp.												
Total	90.69	101.51	99.99	100.00	99.92	100.00	100.00	97.78	101.46	100.00	100.00	100.00

	Hypoplectrum puell	*Mycteroperca inters*	*Mycteroperca tigris*	*Mycteroperca venos*	*Paranthias furcifer*	*Cephalopholis cruen*	*Serranus tabacarius*	*Serranus tigrinis*
Benthic algae								
Spring algae								
Zooxanthellae								
Planktonic algae								
Drifting plants (*Sargassum*)								
Spermatophytes (*Thalassia*)								
Protozoa								
Sponges								
Coral								
Zoantharians								
Gorgonians								
Hydrozoans								
Schyphozoans								
Ctenophores								
Bryozoans								
Sipunculids								
Polychaetes								
Chitons								
Gastropods						3.80		
Pteropods								
Scaphopods								
Pelecypods								
Cephalopods				3.90				
Copepods					61.70			
Ostracods								
Barnacles								
Physids	8.90				2.30			
Tanaids								
Isopods	3.70							
Amphipods					3.10			
Stomatopods	5.30					8.90		8.90
Shrimp	51.00			0.90	5.95	17.30		71.90
Crabs	21.10					3.80		7.80
Spiny lobster								
Scyllarid lobster								
Hermit crabs								
Echinoids								
Ophiurids								
Asteroids								
Holothurians								
Hemichordates								
Tunicates					12.20			
Carcharinidae								
Dasyatidae								
Myliobatidae								
Elopidae								
Clupeidae			7.14					
Dissumieridae								
Synodontidae								

	Hypoplectrum puell	*Mycteroperca inters*	*Mycteroperca tigris*	*Mycteroperca venos*	*Paranthias furcifer*	*Cephalopholis cruen*	*Serranus tabacarius*	*Serranus tigrinis*
Benthic algae								
Ophichthidae								
Congridae								
Belonidae								
Hemiranphidae								
Fistularidae								
Aulostomidae				4.76				
Holocentridae				9.53				
Mugilidae						3.31		
Sphyraenidae								
Atherinidae			7.14	4.76				
Serranidae				4.76				
Grammistidae								
Grammidae								
Cirrhitidae								
Apogonidae						3.31		
Priocanthidae								
Pempheridae								
Lutjanidae								
Emmelichthyidae								
Pomadasyidae								
Sparidae								
Kyphosidae								
Gerreidae								
Scianidae			7.14					
Mullidae								
Banchiostegidae								
Rachycentridae								
Echeneidae								
Carangidae			6.76					
Scombridae								
Pomacentridae			14.29	29.59		3.31		
Labridae								
Scaridae			14.29	14.29				
Bothidae								
Gobidae						6.62		
Blennidae			7.14					
Clinidae								
Opisthognathidae								
Dactylopteridae								
Ephippidae								
Chaetodontidae						3.31		
Acanthuridae			21.43	4.76				
Balistidae			7.14					
Monacanthidae				4.76				
Ostraciontidae								
Tetradontidae								
Diodontidae								
Antennaridae								

	Hypoplectrum puell	*Mycteroperca inters*	*Mycteroperca tigris*	*Mycteroperca venos*	*Paranthias furcifer*	*Cephalopholis cruen*	*Serranus tabacarius*	*Serranus tigrinis*
Benthic algae								
Ogcocephalidae								
Sea turtles								
Engrulidae								
Scorpaenidae								
Haemulidae			14.29	4.76		3.31		
Muraenidae								
Fish larvae					0.60			
Fishes	10.00						100.00	9.70
Un ID animal mat.					7.70			
Un ID plant mat.								
Un ID crustaceans					0.20			1.70
Fish eggs								
Shrimp larvae					5.95			
Crab larvae								
Un ID eggs					0.10			
Gastropod larvae					0.20			
Insects								
Stomatopod larvae								
Cephalopod larvae								
Hermit crab larvae								
Scylland larvae								
Barnacle larvae								
Polychaete larva								
Echiuroids								
Inermidae								
Ostraciidae								
Euphausids								
Malaconthidae								
Pomacanthidae								
Syngnathidae								
Ocyurus chrysurus								
Lutjanus synagris								
Lutjanus mahagoni								
Lutjanus jocu								
Lutjanus griseus								
Lutjanus cyanopterus								
Lutjanus apodus								
Lutjanus analis								
Lutjanus species								
Lutjanus apher								
Cephalopholis fulva								
Epinephelus adscensionis								
Epinephelus guttatus								
Epinephelus itajara								
Epinephelus morio								
Epinephelus striatus								
Hypoplectrus aberrans								
Hypoplectrus chlosurus								

	Hypoplectrum puell	*Mycteroperca inters*	*Mycteroperca tigris*	*Mycteroperca venos*	*Paranthias furcifer*	*Cephalopholis cruen*	*Serranus tabacarius*	*Serranus tigrinis*
Benthic algae								
Hypoplectrus negronis								
Hypoplectrus puella								
Mycteroperca bonaci								
Mycteroperca interstitialis								
Mycteroperca tigris								
Mycteroperca venenosa								
Paranthias furcifer								
Cephalopholis cruentata								
Diplectrum radiale								
Exocoetidae								
Organic detritus								
Alcyonarian								
Hydroids								
Anthozoa								
Isopod larvae								
Pelecypod larvae								
Priopuloids								
Nebaliacea								
Anemones								
Mollusk eggs								
Opistobranchs								
Coelenterate								
Pycnogonids								
Mollusk								
Spiny lobster larvae								
Serranus sp.								
Total	100.00	0.00	106.76	86.77	100.00	56.97	100.00	100.00

	Serranus tortugarum
Benthic algae	
Spring algae	
Zooxanthellae	
Planktonic algae	
Drifting plants (*Sargassum*)	
Spermatophytes (*Thalassia*)	
Protozoa	
Sponges	
Coral	
Zoantharians	
Gorgonians	
Hydrozoans	
Schyphozoans	
Ctenophores	
Bryozoans	
Sipunculids	
Polychaetes	
Chitons	
Gastropods	
Pteropods	
Scaphopods	
Pelecypods	
Cephalopods	
Copepods	92.00
Ostracods	
Barnacles	
Physids	
Tanaids	
Isopods	
Amphipods	
Stomatopods	
Shrimp	
Crabs	
Spiny lobster	
Scyllarid lobster	
Hermit crabs	
Echinoids	
Ophiurids	
Asteroids	
Holothurians	
Hemichordates	
Tunicates	
Carcharinidae	
Dasyatidae	
Myliobatidae	
Elopidae	
Clupeidae	
Dissumieridae	
Synodontidae	

	Serranus tortugarum
Benthic algae	
Ophichthidae	
Congridae	
Belonidae	
Hemiranphidae	
Fistularidae	
Aulostomidae	
Holocentridae	
Mugilidae	
Sphyraenidae	
Atherinidae	
Serranidae	
Grammistidae	
Grammidae	
Cirrhitidae	
Apogonidae	
Priocanthidae	
Pempheridae	
Lutjanidae	
Emmelichthyidae	
Pomadasyidae	
Sparidae	
Kyphosidae	
Gerreidae	
Scianidae	
Mullidae	
Banchiostegidae	
Rachycentridae	
Echeneidae	
Carangidae	
Scombridae	
Pomacentridae	
Labridae	
Scaridae	
Bothidae	
Gobidae	
Blennidae	
Clinidae	
Opisthognathidae	
Dactylopteridae	
Ephippidae	
Chaetodontidae	
Acanthuridae	
Balistidae	
Monacanthidae	
Ostraciontidae	
Tetradontidae	
Diodontidae	
Antennaridae	

	Serranus tortugarum
Benthic algae	
Ogcocephalidae	
Sea turtles	
Engrulidae	
Scorpaenidae	
Haemulidae	
Muraenidae	
Fish larvae	
Fishes	
Un ID animal mat.	
Un ID plant mat.	
Un ID crustaceans	
Fish eggs	8.00
Shrimp larvae	
Crab larvae	
Un ID eggs	
Gastropod larvae	
Insects	
Stomatopod larvae	
Cephalopod larvae	
Hermit crab larvae	
Scylland larvae	
Barnacle larvae	
Polychaete larva	
Echiuroids	
Inermidae	
Ostraciidae	
Euphausids	
Malaconthidae	
Pomacanthidae	
Syngnathidae	
Ocyurus chrysurus	
Lutjanus synagris	
Lutjanus mahagoni	
Lutjanus jocu	
Lutjanus griseus	
Lutjanus cyanopterus	
Lutjanus apodus	
Lutjanus analis	
Lutjanus species	
Lutjanus apher	
Cephalopholis fulva	
Epinephelus adscensionis	
Epinephelus guttatus	
Epinephelus itajara	
Epinephelus morio	
Epinephelus striatus	
Hypoplectrus aberrans	
Hypoplectrus chlosurus	

	Serranus tortugarum
Benthic algae	
Hypoplectrus negronis	
Hypoplectrus puella	
Mycteroperca bonaci	
Mycteroperca interstitialis	
Mycteroperca tigris	
Mycteroperca venenosa	
Paranthias furcifer	
Cephalopholis cruentata	
Diplectrum radiale	
Exocoetidae	
Organic detritus	
Alcyonarian	
Hydroids	
Anthozoa	
Isopod larvae	
Pelecypod larvae	
Priopuloids	
Nebaliacea	
Anemones	
Mollusk eggs	
Opistobranchs	
Coelenterate	
Pycnogonids	
Mollusk	
Spiny lobster larvae	
Serranus sp.	
Total	100.00