5 Description of the fishery/affected environment

5.1 Physical environment

The U.S. Caribbean is located in the eastern extreme of the Caribbean archipelago, about 1,100 mi east-southeast of Miami, Florida (Figure 1) (Olcott 1999). It comprises the Commonwealth of Puerto Rico in the Greater Antilles and the Territory of the USVI in the Lesser Antilles island chain, both of which separate the Caribbean Sea from the western central Atlantic Ocean.

The rectangular-shaped island of Puerto Rico is the smallest and the most eastern island of the Greater Antilles (CFMC 2002c), and is located between the North Atlantic Ocean and the Caribbean Sea. The island measures about 110 mi from east to west; 40 mi from north to south. The overall area of Puerto Rico, including its principal offshore islands of Vieques, Culebra, and Mona, is estimated at 3,471 mi^2 (Olcott 1999); the combined length of its coasts, 700 mi (CFMC 2002c).

The USVI are part of the Virgin Islands chain, which lies about 50 mi east of Puerto Rico and consist of about 80 islands and cays (Olcott 1999). The USVI include the largest and most important islands of the Virgin Islands chain: St. Croix, St. Thomas, and St. John. Together, their coastlines extend about 175 mi. St. Croix is located about 40 nm (74 km) south of St. Thomas and St. John (CFMC 2002c). Covering about 84 mi^2, that island is entirely surrounded by the Caribbean Sea. The islands of St. Thomas and St. John are bordered by the Atlantic Ocean to the north and the Caribbean Sea to the south. Their respective areas are about 32 and 19 mi^2 (Olcott 1999).

More detailed information on the physical environment can be found in Section 3.1 of the EFH FSEIS (CFMC 2004).

5.1.1 Geology

The nearshore waters of Puerto Rico range from 0-20 m in depth and outer shelf waters range from 20-30 m in depth at the depth of the shelf break. The north coast of Puerto Rico is marked by a narrow insular shelf that is only 2-3 km wide. Depths extend to over 1,200 ft (400 m) beyond the shelf break (CFMC 2002c); the deepest point in the Atlantic Ocean, the Milwaukee Depth, lies at a depth of 27,493 feet (8,380 m) in the western end of the Puerto Rico Trench, about 100 miles (160 km) northwest of the island. Mona Passage, measuring about 75 mi (120 km) wide and more than 3,300 ft (1,000 m) deep, separates Puerto Rico from Hispaniola to the west. The southeast coast has a narrow shelf approximately 8 km wide (CFMC 2002c), after which the sea bottom descends to the 16,400 ft (5,000 m) deep Venezuelan Basin of the Caribbean Sea. The east coast lies on the same geological platform as the USVI of St. Thomas and St. John. Waters in that area extend to depths of less than 240 ft (73 m) throughout (CFMC 2002c).

The shelf shared by the islands of St. Thomas and St. John is about 12.9 km wide on the south and 32.2 km wide on the north (Goenaga and Boulon 1992). St. Croix, which lies on a different geological platform, is separated from the other islands by a 4,000 m-deep trench (CFMC 2002c). The St. Croix shelf is much narrower and shallower than that of the northern islands (Goenaga and Boulon 1992), extending only 4 km wide in the south, less than 0.2 km wide on the northwest, though up to several km wide in the northeast and out on Lang Bank (CFMC 2002c).

5.1.2 Oceanography and climate

The North Equatorial Current is the predominant hydrological driving force in the Caribbean region. It flows from east to west along the northern boundary of the Caribbean plateau and splits at the Lesser Antilles. To the north, the current flows westward along the north coasts of the U.S. Caribbean islands, splitting north of the Mona Channel. The north branch flows north of Silver and Navidad Banks, past the Turks and Caicos, to form the Bahama Current. The south branch parallels the north coast of Hispaniola about 30 km offshore. A small gyre has been documented off the northwest corner of Puerto Rico resulting in an easterly flow nearshore in this area (CFMC 2002c). To the south, the current enters the Caribbean Sea through the passages between the Lesser Antilles (Chakalall *et al.* 1998). The water then continues northwestward as the Caribbean Current, the main surface circulation in the Caribbean Sea.

The Caribbean Current flows about 100 km south of the U.S. Caribbean islands at an average speed of 0.5 to 1 knots (CFMC 2002c). The current is characterized by large cyclonic and anticyclonic gyres. Its flow exits the Caribbean through the Yucatan Strait into the Gulf of Mexico and, to the northwest, into the North Atlantic (Kjerfve 1998). Its strength is influenced by changes in the position of the inter-tropical convergence zone (ITCZ). It increases in strength during the winter when the thermal equator is farthest south. It decreases in strength during the summer when the thermal equator shifts north, and surface waters in the Caribbean are influenced by increasing precipitation. This is the time of year when the North Equatorial Counter Current is established and surface waters of the equatorial Atlantic are displaced to the east (Kjerfve 1998).

Fluctuations in the water mass transport of the Gulf Stream are influenced by seasonal changes in Caribbean surface salinity transport and to wind speed changes in the tropical-subtropical trade wind zone (Kjerfve 1998). Westerly trade wind circulations to the north are responsible for the major wind and wave patterns. High winds occur in the winter; hurricanes in the autumn (CFMC 2002c).

The zonal shift of the ITCZ is also responsible for the seasonal change in precipitation in the Caribbean. The dry season occurs when the ITCZ is near the equator (Kjerfve 1998), generally in the late winter to spring (Kjerfve 1998; Olcott 1999). The wet season occurs when the ITCZ is at its most northerly position in the Caribbean, generally in the late summer into late fall (Kjerfve 1998; Olcott 1999); about 50 % of the annual rainfall occurs during this wet season. Average

annual precipitation in Puerto Rico ranges from less than 40 in (101.6 cm) on the southern coastal plain, to greater than 200 in (512 cm) in the mountains. Along the coasts, average annual precipitation ranges from about 30 in (76.2 cm) on the lee side of the island along the southwestern coast to about 75 in (190.5 cm) on the windward north coast. Average annual precipitation ranges from less than 30 in (76.2 cm) to greater than 55 in (139.7 cm) in the USVI. Most of the precipitation in this region is returned to the atmosphere by evapotranspiration – evaporation from the land and water surfaces and transpiration by plants (Olcott 1999).

Surface water salinity changes along with the seasonal change in precipitation. But precipitation affects salinity only indirectly. The discharge from the Amazon, Orinoco, and Magdalena rivers is the main contribution to buoyancy in the Caribbean, increasing silica concentrations, decreasing salinity and chlorophyll pigments, and increasing the input of terrestrial materials (Kjerfve 1998). The plume of the Orinoco River, as tracked by satellite imagery, seasonally penetrates across the Caribbean Basin, potentially exerting a region-wide influence (Kjerfve 1998). It could be responsible for events of high turbidity and algal blooms that often occur in the Caribbean Basin in October (CFMC 2002c).

Locally, Puerto Rico's rivers influence the nearshore environment by discharging silt, nutrients, various chemicals and, of course, freshwater. The USVI has no permanent streams, and outflows only occur during periods of heavy rainfall. But these are sometimes sufficient to muddy coastal surface waters up to one half mile (0.8 km) from shore (CFMC 1985).

Sea surface temperature ranges from a minimum of 25 degrees Celsius in February-March to a maximum of about 28.5 degrees Celsius in August-September. Inshore temperatures may be higher (e.g., 30 degrees Celsius) due to shallower depths or, in some cases, to thermal plumes from generator plants (CFMC 2002c).

Tidal regimes differ between the north and south coasts. The fluctuations range from a diurnal tide of about 10 cm in the south coast to a semi-diurnal regime of between 60-100 cm along the north coast, where waves are larger (CFMC 2002c). But the astronomical tidal range is slight (20-30 cm) (Kjerfve 1998).

5.1.3 Major habitat types

The coastal-marine environment of Puerto Rico and the USVI is characterized by a wide variety of habitat types. NOAA's National Ocean Service has mapped 21 distinct benthic nearshore habitat types using aerial photographs acquired in 1999. Those maps display 49 km^2 of unconsolidated sediment, 721 km^2 of submerged vegetation, 73 km^2 of mangroves, and 756 km^2 of coral reef and colonized hard bottom over an area of 1600 km^2 in Puerto Rico. They document 24 km^2 of unconsolidated sediment, 161 km^2 of submerged vegetation, 2 km^2 of mangroves, and 300 km^2 of coral reef and hard bottom over an area of 490 km^2 in the USVI. Coral reefs, seagrass beds, and mangrove wetlands are the most productive marine habitat areas (CFMC 2002c). CFMC (2002c) provides an in-depth description of the distribution of these

habitats, along with information on their ecological functions and condition. A summary of the habitat-life history associations of Caribbean Council-managed species is provided in Section 5.2 (Biological Environment).

Generally, the north coast of Puerto Rico is characterized by a mixture of coral and rock reefs. The east coast is characterized by a sandy bottom, which commonly contains algal and sponge communities. The southern shelf is characterized by hard or sand-algal bottoms with emergent coral reefs, seagrass beds, and shelf edge. A small seamount known as Grappler Bank lies 70 m below the surface waters about 25 mi (40.3 km) off the southeast coast of the island. An extensive seagrass bed extends 9 km off the central south coast to Caja de Muertos Island. Habitats along the southern portion of the west coast are similar to those of the south coast (CFMC 2002c).

A general description of the marine environments of the USVI is given in Island Resources Foundation (1977). The fringing reefs on St. John are said to be poorly developed (Randall 1963). Outside this area, in Coral Bay, a more-mature reef profile is found at Lagoon Point. St. Croix has the most extensive reefs, with many miles of bank-barrier reefs, often with algal ridges, extending in an almost unbroken line from Coakley Bay on the north coast, around the eastern tip to Great Pond Bay on the south coast. There are also numerous fringing and patch reefs. On the north coast, the eastern shelf is up to several kilometers wide and is rimmed by emergent Holocene reefs, considered to be the best developed on the island. The western portion is less than 0.2 km wide and is traversed by two small submarine canyons; in the Salt River and Cane Bay areas, the edge of the shelf drops precipitously into great depths and the reefs form a vertical wall supporting abundant growths of black coral. The south shore has a shelf up to 4 km wide (Hubbard *et al.* 1981). The reef zonation of the entire island has been mapped from aerial photographs for the Bureau of Land Management.

These environments are threatened by human activities, such as coastal development and fishing activities, but also by natural factors, such as El Niño Southern Oscillation events and hurricanes, which leave habitats more vulnerable to human disturbance. Climate changes resulting from global warming are also a threat. Bryant *et al.* (1998) reports that almost two-thirds of the mapped coral reefs in the Caribbean are at risk, and one-third are at high risk of impact resulting from increasing water temperatures.

Once the amendment is submitted for review by the Secretary, NMFS' Office of Sustainable Fisheries will request initiation of an EFH consultation from the Office of Habitat Conservation to determine whether the actions proposed in this amendment would adversely affect essential fish habitat.

Additional information on regional habitat types can be found in Section 3.2 of the EFH FSEIS (CFMC 2004).

5.2 Biological environment

5.2.1 Caribbean Council-managed species

This section summarizes the available information on the biology, life history, and status of Caribbean Council-managed species. NMFS' 2001 report to Congress on the status of U.S. fisheries classifies most stocks in the U.S. Caribbean as "unknown" (NMFS 2002). Because information on the status of stocks is required to calculate the biological parameters and stock status determination criteria proposed in this amendment, the SFA Working Group established by the Caribbean Council was required to make determinations on the status of those stocks for which no formal determination has been made. As stated in Restrepo *et al.* (1998), "in cases of severe data limitations, qualitative approaches may be necessary, including expert opinion and consensus-building methods."

The status determinations of the Working Group reported in the following sub-sections are based on best professional judgement, informed by available scientific and anecdotal information on a variety of factors, including the anecdotal observations of fishermen as reported by fishery managers, life history information, and the status of individual species as evaluated in other regions. The discussion resulting in these determinations took place at the 23-24 October 2002 meeting of the SFA Working Group in Carolina, Puerto Rico. Notice of the meeting location, date, and agenda was provided in the *Federal Register* (67 FR 63622). The minutes of that meeting are available by request from the Caribbean Council.

Detailed identification and description of EFH for managed species can be found in the EFH FSEIS (CFMC 2004).

5.2.1.1 Caribbean spiny lobster, *Panulirus argus*

The Caribbean spiny lobster belongs to the Palinuridae family, which contains about 50 different species of spiny lobsters in 8 genera. The Caribbean spiny lobster, *P. argus* (hereafter referred to as spiny lobster), occurs in the Western Central and South Atlantic Ocean, including the Caribbean Sea and the Gulf of Mexico. North Carolina marks its northernmost limit; Brazil, its southernmost limit (Bliss 1982). This species is taken in commercial, subsistence, and recreational fisheries.

The spiny lobster occurs from the extreme shallows of the littoral fringe to depths of at least 100 m (Kanciruk 1980; Munro 1974a). CFMC (1981) reports that its distribution off Puerto Rico extends to the edge of the shelf, which is described as the 100-fathom contour (183 m). Sexes are separate and anatomically distinct. Males have larger and heavier carapaces, but lighter and shorter tails than females. But relationships between total length and total weight are very nearly identical for males and females in Caribbean waters (Munro 1974a). Molting appears to be tied to reproduction for females (Munro 1974a; Phillips *et al.* 1980), but males appear to be able to reproduce successfully year round (Phillips *et al.* 1980).

Maturity occurs at a single molt (the "maturity molt") and is generally related to length, rather than age. According to CFMC (1981), most females reach sexual maturity between 3.1-3.5 in (7.9-8.9 cm) carapace length (CL) and are at peak egg production between 4.3-5 in CL. Conservation Management Institute reports that intense fishing may have caused a decline in the minimum size of spawning females in Florida waters (CMI 1996). Fecundity varies greatly among size classes, but is generally high. In the early years of a spiny lobster, the larger a female, the more eggs produced. But fecundity begins to decrease at a certain age; possibly around the time when molting decreases in frequency (Munro 1974a). Munro (1974) reports that egg production per unit body weight ranges from about 670 to 1,210 eggs/g of total body weight, with an average of 830 eggs/g. CFMC (1981) reports that the number of eggs ranges from 0.5-1.7 million per spawning. Kanciruk (1980) estimates maximum age as 20 years.

Spiny lobsters spawn at least once a year (Cobb and Wang 1985). Females in Bermuda have been reported to spawn at least twice (Morgan 1980; Munro 1974a) between May and August. But the numbers of broods produced in Caribbean waters, where the spawning period appears to be more extended are not known. For most territories within the Caribbean Sea, egg-bearing (berried) females have been observed in all months of the year, but with greatest frequency in the months from February to August (Munro 1974a). CFMC (1981) reports that reproduction occurs year-round, but declines in the fall.

Fertilization is external (Bliss 1982). Females carry fertilized eggs until they are fully developed (Cobb and Wang 1985), a period of about four weeks, and tend to move towards deeper water when the eggs are ready to hatch (Munro 1974a). Embryos hatch as planktonic larvae (Bliss 1982), which spend up to eleven months (Phillips *et al.* 1980) or more (Munro 1974a; Phillips and Sastry 1980) at sea before metamorphosing into the puerulus stage (Cobb and Wang 1985) and settling on the ocean bottom. This extended planktonic stage could permit extremely wide dispersal of the larvae. And it appears most likely that larvae spawned in the Caribbean could, for example, settle at Bermuda (Munro 1974a).

Shallow areas with mangroves and seagrass (*Thalassia testudinum*) beds serve as nursery areas for pre-adult populations wherever such habitats are available (Munro 1974a). Generally, spiny lobsters move offshore when they reach reproductive size (Phillips *et al.* 1980). Adults are found on most shelf areas which offer adequate shelter in the form of reefs, wrecks or other forms of cover (Munro 1974a). This species shelters communally by day in groups of two to over one hundred (Cobb and Wang 1985) in holes and crevices in reefs or other refuges. The largest dominant male usually occupies the most favored and safest position deep within the refuge. At night, they emerge to feed (Munro 1974a).

These animals are primarily carnivores, and serve as the major benthic carnivores in some ecosystems (Kanciruk 1980). They generally feed on smaller crustaceans, mollusks and annelids (Cobb and Wang 1985). One study reported that specimens taken from a lagoon area appeared to feed only on mollusks, but that individuals taken in reef habitat consumed algae, foraminifera, sponge spicules, polychaetes and sand, in addition to bivalve and gastropod mollusk and

crustacean remains (Munro 1974a). The reported consumption of seaweed, algae, and inorganic material has been attributed both to incidental ingestion (Cobb and Wang 1985) and to a shortage of other food sources (Kanciruk 1980), as opposed to preference. A 1971 study reported that juveniles at the USVI sheltered in daytime aggregations of the sea urchin (*Diadema antillarum*) and thus gained access to extensive feeding areas which were otherwise devoid of shelter (Munro 1974a).

Tagging experiments indicate that, with few exceptions, adult spiny lobsters do not usually undertake extensive movements. But some studies show evidence of seasonal inshore-offshore movements, and of extensive mass migrations. Mass migrations have been reported most often from Florida and the Bahamas, where movement is usually southwards (Munro 1974a) and occurs in mid-autumn or mid-winter, usually after a period of stormy weather (Cobb and Wang 1985). This migratory behavior is especially striking in the Bahamas, where large numbers of lobsters are observed to migrate day and night in queues of 2-60 animals. As many as 100,000 individuals have been observed moving in queue formation in a southerly direction on the shelf area west of Bimini (Cobb and Wang 1985).

The significance of migratory behavior is not yet understood. While local spiny lobster populations travel the same direction each year; populations in other areas may travel in different directions. And return migrations have not been described (Cobb and Wang 1985). Some hypothesize that migrations may serve to redistribute young mature adults in areas appropriate for adult habitation and larval release (Phillips *et al.* 1980); others, that the lobsters may be trying to escape the stress of severe winters in shallow waters (Cobb and Wang 1985).

Pelagic fishes, including the tunas *Katsuwonus pelamis* and *Thunnus atlanticus*, feed on spiny lobster in their planktonic phase. Natural predators of sub-adult and adult spiny lobster include large benthic feeding fishes, sharks, octopuses (Cobb and Wang 1985), rays, skates, crabs, dolphins (Munro 1974a) and turtles (CMI 1996). A small whelk (*Murex pomum*) is reported to eat lobsters in traps, and presumably in nature, by boring through the carapace. Barnacles (*Balanus ebureus*) settle on the carapace of large specimens and could serve as indicators of habitat and of the intermolt period (Munro 1974a).

5.2.1.2 Caribbean conch resource

The term "conch" usually refers to gastropods of the family Strombidae (Genus *Strombus*), but is often applied to large, usually edible, gastropods in other families as well. As defined by the Caribbean Council's Queen Conch FMP, the Caribbean conch resource comprises 13 species of gastropods within the families Strombidae, Cymatiidae, Cassidae, Turbinellidae, Fasciolariidae, and Trochidae. But only one species, the queen conch (*Strombus gigas*), has been the focus of fishery management measures defined in that FMP.

5.2.1.2.1 Queen conch, *Strombus gigas*

A member of the Strombidae family, the queen conch occurs in semi-tropical and tropical waters of the Atlantic Ocean, ranging from south Florida (USA) and Bermuda to northern South America, including the Caribbean Sea (Rhines 2000). This species is taken in both commercial and recreational fisheries.

The Queen Conch FMP (CFMC 1996a) provides a detailed description of the biology and life history of the queen conch. This species generally occurs on expanses of shelf to about 76 m (250 ft) depth. It is commonly found on sandy bottoms that support the growth of seagrasses, primarily turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*), shoal grass (*Halodule wrightii*), and epiphytic algae upon which it feeds. This species also occurs on gravel, coral rubble, smooth hard coral or beach rock bottoms, and sandy algal beds (CFMC 1996a).

The adult queen conch grows to 15-30.5 cm (6-12 in) in length (CFMC 1996a), weighs about 2 kg (4.4 lb), on average, and generally lives 6 to 7 years; although it may survive as many as 26 (Rhines 2000), or even 40 (CFMC 1996a) years in deep water habitats. Growth in shell length generally ceases at the time of sexual maturity, after which growth occurs primarily through the thickening of the shell, especially at the lip (CFMC, CFRAMP 1999). Rhines (2000) reports age at maturation as 3.5 - 4 years. The average age of maturation of queen conch off Puerto Rico is 3.2 years (about 4 years for 100% maturation); off St. John, USVI, 3 years. This species reaches an acceptable market size at 17.8 cm (7 in), which translates to about 2.5 years of age (CFMC 1996a). Estimated natural mortality rate is 0.30 annually (Appeldoorn, pers. comm.).

Sexes are separate and fertilization is internal. Copulation can precede spawning events by several weeks (CFMC 1996a). Rhine (2000) reports the peak reproductive season extends from April to August. Peak spawning activity in the U.S. Caribbean appears to occur from May through September. Spawning occurs in aggregations (CFMC 1996a).

Egg masses are composed of a number of gelatinous egg strings, usually deposited in clean coral sand with low organic content; but sometimes also in seagrass habitat (CFMC 1996a). Fecundity is highly variable: individual strings may contain as many as 185,000 - 460,000 eggs (Rhines 2000); egg masses, from 310,000 - 750,000 eggs. Females commonly spawn 6-8 times per season, and produce 1-25 egg masses per season (CFMC 1996a).

Embryos hatch into planktonic larvae (Colin 1978; Rhines 2000) after a period of about 5 days. Larvae spend between 18 and 40 days in the water column before settling and metamorphosing into adults. Little is known about recruitment patterns. Some studies have concluded that the majority of larvae are retained locally (e.g., within the area where they are spawned); others, that larvae could be transported 43 km (26 mi) per day, or 900 km (540 mi) during the 3-week larval period. Eggs hatched off Puerto Rico and the USVI may supply conch to areas located downstream, such as Haiti, Dominican Republic, and Cuba. Conversely, islands situated upstream in the Caribbean arc may provide conch that settle in Puerto Rico and the USVI

(CFMC 1996a). However, the evidence of local retainment of larvae would suggest that it is important to focus primarily on management of the local conch stock.

Juveniles settle in shallow, subtidal habitats where they spend much of their first year buried in sediment (CFMC 1996a; CFMC, CFRAMP 1999; Rhines 2000). At shell lengths ranging from 5-10 cm (2-3.9 in), young juveniles begin to emerge and take up an epibenthic existence. Some studies have documented a habitat shift at the time of emergence, from the area of settlement into nearby seagrass beds. Conch exhibit two migrational patterns. The first is an ontogenetic migration into deeper water, which generally becomes more pronounced in large juveniles, who leave nursery areas and move into deeper water (CFMC, CFRAMP 1999). Aggregations of over 100,000 juveniles have been reported in the Bahamas (CFMC 1996a). The second migration is related to spawning. Conch generally move inshore to spawn as temperatures start to increase in March, and return to deeper water in October. This migration is manifest as a general shift in the distribution of conch, with conch in deep water migrating, but still remaining deep relative to conch in shallow water areas (CFMC, CFRAMP 1999).

Queen conch larvae feed on plankton (Rhine 2000). Juvenile and adults graze on algae and seagrasses (Rhines 2000; Sefton and Webster 1986). Foraminiferans, bryozoans, and small bivalves and gastropods have also been found in conch stomachs but were probably ingested accidentally while grazing (Rhines 2000). Feeding has been observed in sand flats and shallow, sandy lagoons (Sefton and Webster 1986), particularly in turtle grass beds (Colin 1978; Sefton and Webster 1986), and on hard bottomed habitats and in rubble (Rhines 2000).

Juveniles are preyed on by a variety of gastropod mollusks, cephalopods, crustaceans, and fish (Colin 1978). Adults are preyed upon by crabs, turtles, sharks, and rays (Rhines 2000). The hermit crab (*Petrochirus dogenes*) expropriates the shell of the queen conch after consuming the animal. The conchfish (*Astrapogon stellatus*), and possibly a *procellanid* crab, has a commensal relationship with the queen conch; the former spends the day within the conch's mantle cavity, emerging at night to feed (Colin 1978).

5.2.1.2.2 Other Caribbean conch resources

Less is known about the biology and status of the 12 other Caribbean conch species. The Council included these species in the management unit because they are occasionally marketed, but they are not generally of economic importance to U.S. Caribbean fisheries. Some, such as the milk conch (*Strombus costatus*) and West Indian fighting conch (*Strombus pugilis*), are used for food, but to a lesser extent than queen conch. Others, such as the Atlantic triton's trumpet (*Charonia variegata*) and the flame helmet (*Cassis flammea*) are collected for the ornamental trade (CFMC 1996a).

This section summarizes the available information on the biology and life history of these species. The status of the other Caribbean conch resources is unknown. No definition of overfished or overfishing has been developed for these species (NMFS 2002). The SFA

Working Group did not make a determination on their status, as the preferred alternative in Section 4 is to move them to a monitoring-only category.

5.2.1.2.2.1 Atlantic triton's trumpet, *Charonia variegata*

A member of the Cymatiidae family, the Atlantic triton's trumpet occurs in the Western Atlantic, from North Carolina (USA) to the northern coast of South America, including the Gulf of Mexico and Caribbean Sea (The Academy of Natural Sciences of Philadelphia 2002). This species has also been recorded in the eastern Mediterranean Sea, off the Cape Verde Islands, and off St. Helena (Colin 1978). In the U.S. Caribbean, it has been reported off Mona Island, Puerto Rico, and off St. Thomas and St. Croix, USVI (The Academy of Natural Sciences of Philadelphia 2002).

One of the largest and highly prized Caribbean snails (Colin 1978; Sefton and Webster 1986), this species is generally found on sandy bottoms near reef habitat. It most commonly occurs to depths of about 10 m (Colin 1978) but, apparently, can be found to depths of 45 m (The Academy of Natural Sciences of Philadelphia 2002). Maximum reported length is 45 cm (Sefton and Webster 1986). This species is most active at night (Colin 1978), when it has been observed to feed on sea cucumbers (Colin 1978; Sefton and Webster 1986). It seeks shelter in holes and caves during the day (Sefton and Webster 1986).

5.2.1.2.2.2 Cameo helmet, *Cassis madagascarensis*

A member of the Cassidae family, the cameo helmet has been reported to depths of 27 m, from North Carolina (USA) to the northern coast of South America, including the Gulf of Mexico and Caribbean Sea. In the U.S. Caribbean, it has been reported off St. Thomas and St. Croix, USVI. Maximum reported length is 35 cm (The Academy of Natural Sciences of Philadelphia 2002).

5.2.1.2.2.3 Caribbean helmet, *Cassis tuberosa*

The Caribbean helmet is a member of the Cassidae family. Also known as the "king helmet," this species occurs to depths of about 20 m (Colin 1978), from North Carolina (USA) to the northern coast of South America, including the Gulf of Mexico and Caribbean. In the U.S. Caribbean, it has been reported off all three islands in the USVI (The Academy of Natural Sciences of Philadelphia 2002). This species most commonly occurs in seagrass beds, but can also be encountered on the sandy margins of reefs (Colin 1978). Maximum reported length is about 30 cm (The Academy of Natural Sciences of Philadelphia 2002). It has been observed to feed on sea urchins (Colin 1978).

5.2.1.2.2.4 Caribbean vase, *Vasum muricatum*

A member of the Turbinellidae family, the Caribbean vase has been reported to depths of 15 m, from Florida (USA) to the northern coast of South America, including the Gulf of Mexico and

Caribbean Sea. In the U.S. Caribbean, it has been reported off Puerto Rico and all three of the USVI. Maximum reported length is 12.5 cm (The Academy of Natural Sciences of Philadelphia 2002).

5.2.1.2.2.5 Flame helmet, *Cassis flammea*

A member of the Cassidae family, the flame helmet has been reported in depths to about 20 m (Colin 1978), from Florida (USA) to the northern coast of South America, including the Gulf of Mexico and Caribbean Sea. In the U.S. Caribbean, it has been reported off Puerto Rico and all three of the USVI. Maximum reported length is 15.4 cm (The Academy of Natural Sciences of Philadelphia 2002).

5.2.1.2.2.6 Green star shell, *Astrea tuber*

The green star shell is a small mollusc that ranges from South Florida throughout the West Indies. This species is typically found in shallow water. Average length is approximately 5.1 cm (Morris 1975).

5.2.1.2.2.7 Hawkwing conch, *Strombus raninus*

A member of the Strombidae family, the hawkwing conch has been reported in depths to 6 m from North Carolina (USA) to the northern coast of South America, including the Gulf of Mexico and Caribbean Sea. In the U.S. Caribbean, it has been reported off St. Thomas and St. Croix, USVI (The Academy of Natural Sciences of Philadelphia 2002). Usually found in seagrass meadows and sand flats, this species generally reaches 6.4-8.9 cm in length (CFMC 1996a). Maximum reported length is 12.1 cm (The Academy of Natural Sciences of Philadelphia 2002).

5.2.1.2.2.8 Milk conch, *Strombus costatus*

The milk conch is a member of the Strombidae family. Also known as the harbor conch (CFMC 1996a), this species has been reported in depths to 27 m, from North Carolina (USA) to the northern coast of South America, including the Gulf of Mexico and Caribbean Sea. In the U.S. Caribbean, it has been reported off St. Croix, USVI (The Academy of Natural Sciences of Philadelphia 2002). Usually found in seagrass meadows and sand flats, this species generally reaches 10-15 cm in length (CFMC 1996a). Maximum reported length is 23.1 cm (The Academy of Natural Sciences of Philadelphia 2002).

5.2.1.2.2.9 Roostertail conch, *Strombus gallus*

A member of the Strombidae family, the roostertail conch has been reported in depths to 48 m, from Florida (USA) to the northern coast of South America, including the Caribbean Sea. In the U.S. Caribbean, it has been reported off St. John, USVI (The Academy of Natural Sciences of

Philadelphia 2002). Usually found in seagrass meadows and sand flats, this species generally reaches 8.9-12.7 cm in length (CFMC 1996a). Maximum reported length is 19.7 cm (The Academy of Natural Sciences of Philadelphia 2002).

5.2.1.2.2.10 True tulip, *Fasciolaria tulipa*

A member of the Fasciolariidae family, the true tulip has been reported in depths to 37 m, from North Carolina (USA) to the northern coast of South America, including the Gulf of Mexico and Caribbean Sea. In the U.S. Caribbean, it has been reported off St. Croix, USVI. Maximum reported length is 25 cm (The Academy of Natural Sciences of Philadelphia 2002). The true tulip is a carnivorous snail, commonly found in shallow grassy areas and often stranded by the receding tide (Zeiller 1974).

5.2.1.2.2.11 West Indian fighting conch, *Strombus Pugilis*

A member of the Strombidae family, the West Indian fighting conch has been reported in depths to 55 m, from Florida (USA) to the northern coast of South America, including the Caribbean Sea. In the U.S. Caribbean, it has been reported off St. Croix, USVI (The Academy of Natural Sciences of Philadelphia 2002). Usually found in seagrass meadows and sand flats, this species generally reaches 5-7.6 cm in length (CFMC 1996a). Maximum reported length is 11 cm (The Academy of Natural Sciences of Philadelphia 2002).

5.2.1.2.2.12 Whelk (West Indian top shell), *Cittarium pica*

A member of the Trochidae family, the whelk has been reported in depths to 2 m, from the Florida Keys (USA) to the northern coast of South America, including the Caribbean Sea. In the U.S. Caribbean, it has been reported off St. Croix, USVI. Maximum reported length is 13.6 cm (The Academy of Natural Sciences of Philadelphia 2002).

5.2.1.3 Caribbean reef fish

The Caribbean reef fish fishery management unit comprises 140 species. Of these, 80 are taken primarily in commercial, subsistence, and/or recreational fisheries; the remainder are utilized primarily in the commercial aquarium trade and for private (recreational harvest) aquariums. This section summarizes the available information on the biology, life history, and status of these species. The status of these stocks has not been evaluated in a formal stock assessment. But Appeldoorn *et al.* (1992) reported on the reef fish fishery in 1992 based on an examination of available fishery landings and biostatistical data. At that time, the authors noted that, although insufficient data were available to measure overfishing, there was reasonable direct and anecdotal evidence to suggest that many species had been, and continued to be overexploited.

They reported that total landings in Puerto Rico had declined about 25% from 1931 to 1989, despite an estimated 30% and 55% increase in the respective number of fishermen and fishing

vessels employed in the fishery during that same period of time. They also noted that several families comprised a smaller proportion of the total demersal catch, and that the composition of snapper catches had shifted from mostly shallow water to deeper water species. They concluded that total finfish landings for the USVI appeared reasonably stable between 1975 and 1989, the longest time period for which data were available, but that catch per unit effort based on fish traps had declined in both the USVI and Puerto Rico. And landings of larger individuals of common grouper species, such as coney and red hind, had decreased. They indicated that growth overfishing appeared to be a major problem, but that it could not be quantified because of the lack of essential biological data specifically tuned to Puerto Rico and the USVI (Appeldoorn *et al.* 1992).

The authors identified a number of means to improve the status of knowledge about this group. They recommended continuing efforts to standardize and improve data collection, entry, and storage, and to gather data on reef fish growth and fecundity necessary to produce yield-per-recruit models and calculate spawning potential ratios. The authors also identified the need to improve compliance and to secure compatible regulations between the Caribbean Council and the state governments, noting that, "without compatible regulations and cooperation to increase compliance, particularly by the Commonwealth of Puerto Rico, no improvements for the fishery can be anticipated because so little reef habitat is under direct Council control" (Appeldoorn *et al.* 1992).

5.2.1.3.1 Surgeonfishes, Acanthuridae

The Acanthuridae family contains about 75 species of surgeonfishes in 6 genera, distributed in most tropical waters across the globe. These species are commonly found in small groups, or larger aggregations, usually in association with coral reef habitat. Only three species are included in the Caribbean reef fish fishery management unit, and all belong to the genus *Acanthurus*. These fishes occur in both the Western and Eastern Atlantic, and have been observed to associate with larger mixed-species aggregations of other reef fishes, including parrotfishes, grunts, goatfishes, and wrasses. Almost entirely herbivorous, they compete with parrotfishes, various damselfishes, filefishes, and others for algae and plants. Sharks, rays, barracuda, the mutton hamlet, coney, groupers, snappers, and jacks have all been identified as predators of both juvenile and adult surgeonfishes. Surgeonfish larvae have been observed in the stomachs of skipjack, yellowfin, and blackfin tuna (Reeson 1975a). The spines on the caudal peduncle of these fishes are capable of inflicting painful wounds (Robins and Ray 1986 in Froese and Pauly 2002). The biology, life history, and status information specific to each species is described below.

5.2.1.3.1.1 Ocean surgeonfish, *Acanthurus bahianus*

In the Western Atlantic, the ocean surgeonfish ranges from Massachusetts (USA), southward to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is fished for food and for bait, but is believed to be of minor importance to commercial fisheries. It also is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

The ocean surgeonfish inhabits shallow bottom habitats with coral or rocky formations, in depths from 2-40 m (Robins and Ray 1986 in Froese and Pauly 2002). It also may be encountered over algal plains and seagrass beds that lie adjacent to reef habitats. Characterized as a benthic resident (Reeson 1975a), this species usually occurs in groups of five or more individuals (Robins and Ray 1986 in Froese and Pauly 2002), and commonly schools with the doctorfish, *Acanthurus chirurgus* (Reeson 1975a).

Maximum reported size is 38.1 cm SL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at first maturity is estimated in Froese and Pauly (2002) as 22.8 cm SL. But Reeson (1975b) provides a smaller estimate of 11 cm FL based on a study conducted in Jamaican waters. Breeding is believed to occur year round off Jamaica, with peak spawning activity occurring from January to February and from August to September (Reeson 1975a). In the northeastern Caribbean, individuals in spawning condition have been observed in February, April, and November (Erdman 1976). One spawning aggregation composed of about 20,000 individuals has been documented south of Salinas de Ensenada and Guanica, Puerto Rico, at 15-18 m depth, from November through April (Rielinger 1999).

No estimate of approximate life span or natural mortality is available. This fish feeds primarily on algae and seagrasses, but also consumes a great deal of inorganic material (e.g., sand, small shells, etc.), which is believed to aid in the digestive process. It also has been observed to feed on dead fish both in traps and in fish pens (Reeson 1975a).

5.2.1.3.1.1.1 Doctorfish, *Acanthurus chirurgus*

In the Western Atlantic, the doctorfish ranges from Massachusetts (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is considered to be of minor importance to commercial fisheries (Robins and Ray 1986 in Froese and Pauly 2002).

The doctorfish is generally found in loose aggregations from depths of 2-24 m in shallow reefs or rocky areas (Robins and Ray 1986 in Froese and Pauly 2002), but may also be encountered over adjacent algal plains and seagrass beds (Reeson 1975a). It is characterized as a suprabenthic nomad, and commonly schools with the ocean surgeonfish, *Acanthurus bahianus* (Reeson 1975a).

This fish is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.25-0.50). Maximum reported size is 35 cm TL (male); maximum weight, 5,100 g (Robins and Ray 1986 in Froese and Pauly 2002). Length and age at first maturity is estimated as 19.4 cm TL and 2.7 years, respectively (Froese and Pauly 2002). A study conducted in Jamaican waters observed the occurrence of ripe individuals in catches taken from September to November, and the highest proportions of active fish from January to May (Reeson 1975a). In the northeastern Caribbean, individuals in spawning condition have been observed in January, February, and June (Erdman 1976). The approximate life span of the doctorfish is 10.9 years. Estimated natural mortality rate is 0.64 (Froese and Pauly 2002). It feeds primarily on algae but,

like the ocean surgeonfish, ingests inorganic material in the process (Reeson 1975a; Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.1.2 Blue tang, *Acanthurus coeruleus*

In the Western Atlantic, the blue tang ranges from New York (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is marketed fresh, and is occasionally used as bait. But it is considered to be of minor importance to commercial fisheries. It also is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

The blue tang is generally encountered in coral reef, or inshore grassy or rocky habitat, from 2-40 m depth (Robins and Ray 1986 in Froese and Pauly 2002). Characterized as a suprabenthic nomad, this species is generally solitary in the evening hours (Reeson 1975a), but also has been observed in small and large groups. This fish is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.11-0.50). Maximum reported size is 39 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Length and age at first maturity is estimated as 23.3 cm TL and 6.3 years, respectively. Approximate life span is 25.8 years; natural mortality rate, 0.32 (Froese and Pauly 2002).

A study conducted in Jamaican waters reported the occurrence of high proportions of active and/or ripe fishes during most months of the year on the oceanic banks, and few fishes with active gonads in the nearshore environment (Reeson 1975a). Rielinger (1999) describes one aggregation site documented off Puerto Rico, which is located south of Salinas de Ensenada & Guanica. About 6000-7000 individuals reportedly spawn at that site in association with the full to new moon. These aggregations occur at 10-30 m depth (Rielinger 1999). Studies in the Bahamas also have observed what appeared to be pre-spawning aggregations late in the day (Reeson 1975a). The blue tang feeds almost entirely on algae (Robins and Ray 1986 in Froese and Pauly 2002), but also consumes organic detritus and seagrasses (Reeson 1975a).

5.2.1.3.2 Frogfishes, Antennariidae

The Frogfish family contains 41 species in 12 genera, distributed in most tropical waters around the globe (Pietsch and Grobecker 1987). Only the Genus *Antennarius* is represented in the Caribbean reef fish fishery management unit. Those species reported in Caribbean waters include the striated frogfish (*A. striatus*) (Pietsch and Grobecker 1987 in Froese and Pauly 2002), the island frogfish (*A. bermudensis*) (Böhlke and Chaplin 1993 in Froese and Pauly 2002), the ocellated frogfish (*A. ocellatus*), the dwarf frogfish (*A. pauciradiatus*), and the longlure frogfish (*A. multiocellatus*) (Robins and Ray 1986 in Froese and Pauly 2002). All are utilized primarily in the aquarium trade (Pietsch and Grobecker 1987 in Froese and Pauly 2002).

Both juvenile and adult frogfishes are benthic (Pietsch and Grobecker 1987 in Froese and Pauly 2002), often living in association with sponges on which they can be highly cryptic. Reported depth ranges are 4-30 m (island frogfish) (Böhlke and Chaplin 1993 in Froese and Pauly 2002),

0-66 m (longlure frogfish), 6-73 m (dwarf frogfish), up to 150 m (ocellated frogfish) (Robins and Ray 1986 in Froese and Pauly 2002), and 10-219 m (striated frogfish) (Pietsch and Grobecker 1987 in Froese and Pauly 2002). Maximum reported sizes range from 6.3 cm total length (TL) (dwarf frogfish) to 38 cm TL (ocellated frogfish) (Robins and Ray 1986 in Froese and Pauly 2002). These fishes feed voraciously on other fishes and crustaceans. Females produce thousands of eggs. Some, such as the striated frogfish, lay their eggs in a ribbon-like sheath or mass of gelatinous mass, called an "egg raft," or "veil;" others attach their eggs to their body (Pietsch and Grobecker 1987 in Froese and Pauly 2002).

5.2.1.3.3 Cardinalfishes, Apogonidae

The Cardinalfish family contains 207 species in 22 genera, distributed in the Atlantic, Indian, and Pacific Oceans (Nelson 1994 in Froese and Pauly 2002). The two species included in the Caribbean reef fish fishery management unit belong to the generas *Apogon* and *Astrapogen*. Both species are utilized primarily in the aquarium trade (Nelson 1994 in Froese and Pauly 2002).

5.2.1.3.3.1 Flamefish, *Apogon maculatus*

The flamefish occurs in the Western Atlantic, ranging from Massachusetts (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea (Robins and Ray 1986 in Froese and Pauly 2002).

The flamefish is found to 128 m depth, commonly along sea walls and pilings, in harbors, and in coral reef habitats. It is nocturnal, hiding in cracks and crevices during the day. Maximum reported size is 11.1 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at first maturity is estimated as 7.7 cm TL. Estimated natural mortality rate is 1.98 (Froese and Pauly 2002). Males brood eggs in their mouths, and have been observed with eggs in the Bahamas in the months of June and July. The diet of the flamefish is not described, but most known members of the cardinalfish family feed on zooplankton and benthic invertebrates (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.3.2 Conchfish, *Astrapogen stellatus*

The conchfish occurs in the Western Central Atlantic, ranging from Florida (USA) to northern South America, including the Caribbean Sea (Robins and Ray 1986 in Froese and Pauly 2002).

A demersal species, the conchfish is encountered to 40 m depth. It prefers the clear insular waters of oceanic islands. Maximum reported size is 8 cm SL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at first maturity is estimated as 5.8 cm standard length (SL) (Froese and Pauly 2002). No estimate of natural mortality rate is available. Males brood eggs in their mouths. This species has a commensal relationship with the queen conch, *Strombus gigas*, and with the stiff penshell , *Atrina rigida*, a bivalve. It occupies the mantle cavity of the former,

emerging at night to feed on small crustaceans (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.4 Trumpetfishes, Aulostomidae

The Trumpetfish family contains three species within the genus *Aulostomus* (Nelson 1984 in Froese and Pauly 2002). Only one species, the trumpetfish (*A. maculatus*), is included in the Caribbean reef fish fishery management unit.

5.2.1.3.4.1 Trumpetfish, *Aulostomus maculatus*

The trumpetfish occurs in both the Western and Eastern Atlantic. In the Western Atlantic, its range extends from southern Florida (USA) to northern South America, including the Caribbean Sea. This species is marketed locally, but is considered to be of minor importance to commercial fisheries. It also is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

The trumpetfish is commonly found from depths of 2-25 m, in weedy areas and particularly around reefs, where it often swims among sea whips (gorgonians). Maximum reported size is 100 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at first maturity is estimated as 53.5 cm TL. Estimated natural mortality rate is 0.29 (Froese and Pauly 2002). This fish feeds on small fishes and crustaceans, often ambushing its prey from behind the bodies of large herbivorous fishes. It is capable of opening its mouth to the full diameter of its body to suck in prey items (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.5 Leatherjackets or Triggerfish, *Balistidae*

The Balistidae family contains 40 species in 11 genera, distributed in the Atlantic, Indian, and Pacific Oceans (Nelson 1994 in Froese and Pauly 2002). Only 4 genera are represented in the Caribbean reef fish fishery management unit: *Balistes*, *Canthidermes*, *Melichthys*, and *Xanthicthys*. These fish are popular and hardy aquarium trade species, but are often aggressive (Nelson 1994 in Froese and Pauly 2002). They are also a popular target of subsistence fishing on many islands.

5.2.1.3.5.1 Queen triggerfish, *Balistes vetula*

The queen triggerfish occurs in both the Eastern and Western Atlantic. In the Western Atlantic, its range extends from Massachusetts (USA) to southeastern Brazil, including the Gulf of Mexico and Caribbean Sea (Robins and Ray 1986 in Froese and Pauly 2002). Erdman (1976) reported that this species is commonly caught in fish pots in the northeastern Caribbean. It is considered to be an excellent food fish, but its liver is poisonous (Robins and Ray 1986 in Froese and Pauly 2002). According to Robins and Ray (1986), in Froese and Pauly (2002), the queen triggerfish is of minor importance to commercial fisheries, but also is taken recreationally and utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002). It is often one of the most

popular fishes to be taken artisanally and used for subsistence or local commerce.

The queen triggerfish is generally found over rocky or coral areas, from depths of 2-275 m. It also has been observed over sand and grassy areas (Robins and Ray 1986 in Froese and Pauly 2002). There is some evidence that juveniles tend to inhabit shallower waters, then move into deeper water as they mature (Aiken 1975b). This fish may school, but also has been observed alone and in small groups (Aiken 1975b; Robins and Ray 1986 in Froese and Pauly 2002).

The queen triggerfish is reportedly moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.15-0.57). Maximum reported size is 60 cm TL (male); maximum weight is 5,440 g (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity, and age at first maturity, are estimated in Froese and Pauly (2002) as 40.8 cm TL and 2.8 years, respectively. Aiken (1975b) estimates mean size at maturity as 26.5 cm fork length (FL) and 23.5 cm for males and females, respectively, collected in a Jamaican study. Fecundity measured in 3 individuals averaged 73 eggs per gram body weight. And peak spawning occurred from January to February and from August to October (Aiken 1975b). In the northeastern Caribbean, individuals in spawning condition have been observed from February through June (Erdman 1976). Approximate life span is 12.5 years. Estimated natural mortality rate is 0.48 (Froese and Pauly 2002). This fish primarily feeds on benthic invertebrates, such as sea urchins (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.5.2 Ocean triggerfish, *Canthidermis sufflamen*

The ocean triggerfish occurs in both the Western and Eastern Atlantic. In the Western Atlantic, it ranges from Massachusetts (USA) to South America, including the Gulf of Mexico and Caribbean Sea. This species is taken in both commercial and recreational fisheries, and also is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

The ocean triggerfish occurs from 5-60 m depth (Robins and Ray 1986 in Froese and Pauly 2002), usually in mid-water or at the surface (Aiken 1975b), and is often associated with *Sargassum*. Adults are commonly encountered near dropoffs of seaward reefs, but occasionally occur in shallow waters as well (Robins and Ray 1986 in Froese and Pauly 2002). This fish is sometimes solitary, but also is known to form small groups in open water (Aiken 1975b; Robins and Ray 1986 in Froese and Pauly 2002). It has also been observed to form schools of well over 50 individuals. It is sometimes seen in association with the black durgon (Aiken 1975b).

Maximum reported size is 65 cm TL (male); maximum weight, 6,120 g (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 36.6 cm TL (Froese and Pauly 2002). The fecundity of 4 individuals taken from Jamaican waters averaged 217 eggs per gram body weight. Ripe fishes have been observed off Jamaica in January, May, August, September and December, with a maximum in September (Aiken 1975b). In the northeastern Caribbean, individuals in spawning condition have been observed in April (Erdman 1976). Estimated natural mortality rate is 0.57 (Froese and Pauly 2002). This species feeds primarily on large

zooplankton (Robins and Ray 1986 in Froese and Pauly 2002), but also has been observed to consume benthic invertebrates (Aiken 1975b).

5.2.1.3.5.3 Black durgon, *Melichthys niger*

The black durgon is widely distributed around the globe, occurring in the Western and Eastern Pacific, the Western and Eastern Atlantic, and the Western Indian Oceans. In the Western Atlantic, its range extends from Florida (USA) to Brazil, including the Caribbean Sea. It is apparently absent in the Gulf of Mexico. This species, known as the "black triggerfish" in some areas, is marketed fresh, but is considered to be of minor importance to commercial fisheries. It also is utilized in the aquarium trade (Matsuura 2001 in Froese and Pauly 2002).

Although present in many of the world's oceans, the black durgon commonly occurs only around isolated oceanic islands where it generally inhabits clear seaward reefs to 75 m depth (Matsuura 2001 in Froese and Pauly 2002). Individuals may be observed inshore, on occasion, in as little as 3-4 m of water. Like the ocean triggerfish, the black durgon usually occupies the mid-water column, and these two species are sometimes observed in association with one another (Aiken 1975b). Maximum reported size is 50 cm TL (male) (Matsuura 2001 in Froese and Pauly 2002). Size at maturity is estimated as 29 cm TL. Estimated natural mortality rate is 0.47 (Froese and Pauly 2002). Ripe fishes were observed in a Jamaican study during the month of March, and from August to November (Aiken 1975b). In the northeastern Caribbean, individuals in spawning condition have been observed in April (Erdman 1976). This species feeds primarily on calcareous algae and zooplankton, but also on phytoplankton (Matsuura 2001 in Froese and Pauly 2002). It may compete with the gray and French angelfishes, as these species feed mainly on sponges (Aiken 1975b).

5.2.1.3.5.4 Sargassum triggerfish, *Xanthichthys ringens*

The Sargassum triggerfish occurs in the Western Atlantic, ranging from North Carolina (USA), southward to Brazil, including the Caribbean Sea. This species is utilized primarily in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

The sargassum triggerfish occurs from 25-80 m depth, and is sometimes the most common fish on seaward reef slopes, usually well below 30 m depth (Robins and Ray 1986 in Froese and Pauly 2002). Juveniles often live among floating *Sargassum* (Aiken 1975b; Robins and Ray 1986 in Froese and Pauly 2002). Adults also may be found beneath *Sargassum* or other floating objects (Aiken 1975b). This fish is sometimes solitary; other times forms small groups. Maximum reported size is 25 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at first maturity is estimated as 15.7 cm TL. Estimated natural mortality rate is 1.11 (Froese and Pauly 2002). Spawning occurs in deep water (Robins and Ray 1986 in Froese and Pauly 2002). A Jamaican study, based on a small sample size, reported the occurrence of ripe fishes in March and November (Aiken 1975b). Prey items include crabs and sea urchins (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.6 Filefishes, *Monacanthidae*

The Monacanthidae family contains 95 species in 31 genera, distributed in the Atlantic, Indian, and Pacific Oceans (Nelson 1994 in Froese and Pauly 2002). Genera represented in the Caribbean reef fish fishery management unit include *Aluterus* and *Cantherhines*.

5.2.1.3.6.1 Scrawled filefish, *Aluterus scriptus*

The scrawled filefish occurs in the Western and Eastern Atlantic, and in the Eastern Pacific Oceans. Within the Western Atlantic, its range extends from Nova Scotia, Canada to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is taken in commercial and recreational fisheries, and is also utilized in the aquarium trade (Hutchins 1986 in Froese and Pauly 2002). Halstead *et al.* (1990), in Froese and Pauly (2002), report that it can be ciguatoxic.

The scrawled filefish can be found from 4-120 m depth, in lagoons, seaward reef habitats and, on occasion, under floating objects. Maximum reported size is 110 cm TL (male); maximum weight, 2,500 g (Hutchins 1986 in Froese and Pauly 2002). Size at first maturity is estimated as 58.3 cm TL. Estimated natural mortality rate is 0.27 (Froese and Pauly 2002). The diet of this fish is composed of algae, seagrass, hydrozoans, gorgonians, colonial anemones, and tunicates (Hutchins 1986 in Froese and Pauly 2002).

5.2.1.3.6.2 Whitespotted filefish, *Cantherhines macrocerus*

Also known as the "American whitespotted filefish," this species occurs in both the Western and Eastern Atlantic Oceans. In the Western Atlantic, it ranges from Florida (USA) to Brazil, including the Caribbean Sea (Robins and Ray 1986 in Froese and Pauly 2002). It is taken in commercial and recreational fisheries, and also is utilized in the aquarium trade.

The whitespotted filefish inhabits coral reef or rocky bottom habitats, occurring from 5-25 m depth. It is often found among gorgonians, and generally occurs in pairs. Maximum reported size is 46 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 27 cm TL; natural mortality rate, as 0.72 (Froese and Pauly 2002). Its diet is composed primarily of sponges, gorgonians, and algae. But it also consumes hydroids and stinging coral (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.7 Combtooth blennies, Blenniidae

The Blennidae family contains 345 species in 53 genera, distributed in the Atlantic, Pacific, and Indian Oceans. Only one of these species, the redlip blenny (*Ophioblennius atlanticus*), is included in the Caribbean reef fish fishery management unit (Nelson 1994 in Froese and Pauly 2002).

5.2.1.3.7.1 Redlip blenny, *Ophioblennius atlanticus*

The redlip blenny occurs in both the Eastern and Western Atlantic. In the Western Atlantic, it ranges from North Carolina (USA) to Brazil, including the Caribbean Sea. It is reportedly rare in the northern Gulf of Mexico (Bath 1990 in Froese and Pauly 2002). This species is utilized primarily in the aquarium trade. Its bite can cause severe injuries (Bath 1990, and Jenyns 1842, in Froese and Pauly 2002).

Adults are restricted to shallow waters, generally less than 8 m in depth, and dwell among rocks and coral reefs, where there is considerable wave action. Maximum reported size is 19 cm TL (male) (Bath 1990 in Froese and Pauly 2002). Size at maturity is estimated as 12.4 cm TL; natural mortality rate, as 1.35 (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in June and July (Erdman 1976). Females deposit eggs in small holes, crevices, or empty bivalve shells, and nests are guarded by males or by both parents (Nelson 1994 in Froese and Pauly 2002). Larvae are pelagic. Filamentous algae is the primary food item (Bath 1990 in Froese and Pauly 2002).

5.2.1.3.8 Lefteye flounders, Bothidae

The Bothidae family contains 116 species in 13 genera, distributed in tropical and temperate waters of the Atlantic, Indian, and Pacific Oceans. Only one species, the peacock flounder (*Bothus lunatus*), is included in the Caribbean reef fish fishery management unit (Nelson 1994 in Froese and Pauly 2002).

5.2.1.3.8.1 Peacock flounder, *Bothus lunatus*

The peacock flounder occurs in both the Western and Eastern Atlantic. In the Western Atlantic, it ranges from Florida (USA) to Brazil, including the Caribbean Sea. It is reportedly absent in the Gulf of Mexico. This species is marketed fresh, but is considered to be of minor importance to commercial fisheries. It also is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

A demersal species, the peacock flounder is found to depths of 100 m in clear sandy areas near mangroves, among seagrass, coral, and rubble. It is the most common flounder species found in association with coral reefs (Robins and Ray 1986 in Froese and Pauly 2002). Maximum size is estimated as 46 cm TL; size at maturity, 27 cm TL. Estimated natural mortality rate is 0.72 (Froese and Pauly 2002). This fish is a pelagic spawner (Nelson 1994 in Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in April (Erdman 1976). It feeds primarily on small fishes, but also on crustaceans and octopuses (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.9 Jacks, Carangidae

The Carangidae family contains 140 species in 33 genera, distributed in the Atlantic, Indian, and Pacific Oceans. Jacks are some of the most important tropical marine fishes for commercial, subsistence, and recreational fisheries (Nelson 1984 in Froese and Pauly 2002). Only two genera are represented in the Caribbean reef fish fishery management unit: *Caranx* and *Seriola.*

5.2.1.3.9.1 Yellow jack, *Caranx bartholomaei*

The yellow jack occurs in both the Western and Eastern Atlantic Oceans. In the Western Atlantic, its range extends from Massachusetts (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is taken in both commercial and recreational fisheries (Cervigón 1993 in Froese and Pauly 2002). Dammann (1969), in Froese and Pauly (2002), reports that it can be ciguatoxic.

The yellow jack is generally found in offshore reef and open marine water habitat to 50 m depth. This fish is generally solitary, but also has been observed to occur in small groups. Juveniles are often found near the shore on seagrass beds (Cervigón 1993 in Froese and Pauly 2002), but are thought to move to the outer margins of the shelf at or before maturity (Thompson and Munro 1974c). They often occur in association with jellyfish or floating *Sargassum* (Cervigón 1993 in Froese and Pauly 2002).

Maximum reported size is 100 cm TL (male); maximum weight, 14 kg (Cervigón 1993 in Froese and Pauly 2002). Size at maturity is estimated as 53.5 cm TL; natural mortality rate, as 0.29 (Froese and Pauly 2002). Fecundity, as measured in a Jamaican study, is estimated at over one million eggs per ovary for large individuals (Thompson and Munro 1974c). According to Cervigón (1993), in Froese and Pauly (2002), this species spawns offshore from February to October. Thompson and Munro (1974c) report that ripe fishes have been collected in November over the oceanic banks off Jamaica. This species feeds on small fishes (Cervigón 1993 in Froese and Pauly 2002).

5.2.1.3.9.2 Blue runner, *Caranx crysos*

The blue runner occurs in both the Eastern and Western Atlantic. In the Western Atlantic, it ranges as far north as Nova Scotia, Canada, south to Brazil, including the Gulf of Mexico and throughout the Caribbean Sea. In the tropical Eastern Pacific, it is replaced by the green jack, *Caranx caballus*, which may be conspecific. An excellent food fish, the blue runner is taken in both commercial and recreational fisheries. It also is used for bait, and in the aquarium trade (Smith-Vaniz *et al.* 1990 in Froese and Pauly 2002). Dammann (1969), in Froese and Pauly (2002), reports that it can be ciguatoxic.

A pelagic species, the blue runner is found to 100 m depth, but generally stays close to the coast. Juveniles often occur in association with floating *Sargassum*. This species is highly resilient,

with a minimum population doubling time of less than 15 months (K=0.32-0.38; tmax=11; Fec=41,000). Maximum reported size is 70 cm TL (male); maximum weight, 5,050 g (Smith-Vaniz *et al.* 1990 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 39.1 cm TL and 2.5 years, respectively (Froese and Pauly 2002). Maximum reported age is 11 years (Smith-Vaniz *et al.* 1990 in Froese and Pauly 2002). Estimated natural mortality rate is 0.49 (Froese and Pauly 2002). This fish is thought to form spawning aggregations (Thompson and Munro 1974c). Spawning period is protracted (Erdman 1976). Some studies suggest that spawning activity peaks from January through August. One estimated that the spawning season extends from February to September (Thompson and Munro 1974c). Erdman reported in 1976 that, historically, more adults captured off La Parguera were in spawning condition from March through May than at other times of the year. Prey items include fishes, shrimps, and other invertebrates (Smith-Vaniz *et al.* 1990 in Froese and Pauly 2002).

5.2.1.3.9.3 Horse-eye jack, *Caranx latus*

The horse-eye jack occurs in both the Western and Eastern Atlantic. In the Western Atlantic, it ranges from New Jersey (USA) to Brazil, including the Gulf of Mexico and throughout the Caribbean Sea. This species is considered to be of minor commercial importance, but also is targeted in recreational fisheries. It can be ciguatoxic (Robins and Ray 1986 in Froese and Pauly 2002).

The horse-eye jack is a pelagic schooling species, usually found in offshore reefs, where it often approaches divers. Its depth range is 60-140 m. Some individuals may penetrate into brackish water, and even ascend rivers. Juveniles are encountered along shores of sandy beaches; also over muddy bottoms. Maximum reported size is 101 cm FL (male); maximum weight is 13.4 kg (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated in Froese and Pauly (2002) as 54.1 cm FL. A study conducted in Jamaican waters reports that most fishes are probably mature by about 42.5 cm FL. Fecundity, as measured in that study, was estimated as over one million eggs per ovary for large individuals (Thompson and Munro 1974c). Erdman (1976) reports that the spawning period of this species is protracted. Thompson and Munro (1974c) report that spawning activity is believed to peak in or around February-April and September-October. Spawning is reported to occur June through August off Cuba (Garcia-Cagide *et al.* 1994). Natural mortality rate has not been estimated for this species. Prey items include fishes, shrimp, and other invertebrates (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.9.4 Black jack, *Caranx lugubris*

The black jack is widely distributed around the globe, occurring in the Western Indian, the Western and East Central Pacific, and the Western and Eastern Atlantic Oceans. In the Western Atlantic, it ranges from Bermuda to Brazil, including the Gulf of Mexico and Caribbean Sea. Commercial fisheries for this species are believed to be minor. But the black jack also is fished recreationally, and is cultured commercially (Paxton *et al.* 1989 in Froese and Pauly 2002). Lieske and Myers (1994), in Froese and Pauly (2002), report that it can be ciguatoxic.

A pelagic species, the black jack occurs in clear oceanic waters from 12-354 m depth. It is sometimes observed near drop-offs at the outer edge of reefs and, less commonly, over shallow banks. It occasionally forms schools. This species is of low resilience, with a minimum population doubling time of 4.5 - 14 years (K=0.12). Maximum reported size is 100 cm TL (male); maximum weight is 17.9 kg (Paxton *et al.* 1989 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 51.3 cm TL and 5.1 years, respectively. Approximate life span is 24 years. Estimated natural mortality rate is 0.27 (Froese and Pauly 2002). The spawning period of this species is protracted (Erdman 1976). This fish feeds at night, primarily on fishes (Paxton *et al.* 1989 in Froese and Pauly 2002).

5.2.1.3.9.5 Bar jack, *Caranx ruber*

The bar jack occurs in the Western Atlantic, ranging from New Jersey (USA) to southern Brazil, including the Gulf of Mexico and throughout the Caribbean Sea. This species is taken in both commercial and recreational fisheries. Large individuals can be ciguatoxic (Berry and Smith-Vaniz 1978 in Froese and Pauly 2002).

The bar jack is commonly found in clear insular areas or coral reef habitats off mainland coasts, from depths of 3-35 m. Juveniles frequent areas with *Sargassum* (Berry and Smith-Vaniz 1978 in Froese and Pauly 2002) and appear to be common in shallow water (0-15 m) reef habitats, but are thought to move to the outer margins of the shelf at or before maturity (Thompson and Munro 1974c). This fish is generally easily approached. It is sometimes solitary, but usually forms schools, possibly associated with spawning events (Berry and Smith-Vaniz 1978 in Froese and Pauly 2002). In the Bahamas, the bar jack has been observed to school near the surface in July and August. But the general movement and destination of these schools is unknown (Thompson and Munro 1974c).

This species is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.14-0.24; tm=3; Fec=800,000). Maximum reported size is 59 cm FL and 69 cm TL for males and females, respectively. Maximum reported weight is 8,200 g (Berry and Smith-Vaniz 1978 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 37.9 cm TL and 4.6 years, respectively. A study conducted in Jamaican waters reported minimum size of maturity for both males and females as 22-23.9 cm FL, mean length at maturity as about 24 cm TL for both sexes, and indicates that most fishes probably mature by 26-27 cm FL. The ovaries of three specimens measuring 25 cm, 28 cm, and 31 cm FL, were estimated to contain 131,917, 67,750, and 230,690 eggs, respectively. The authors of that study reported the occurrence of ripe fishes in all months of the year and suggested that, based on high proportions of ripe fishes seen in April and October, these might be the peak spawning months for this species (Thompson and Munro 1974c). Erdman (1976) agrees that the spawning period of this species is protracted. Garcia-Cagide *et al.* (1994) reported that peak spawning off Cuba occurrs during April and July. Estimated natural mortality rate is 0.33 (Froese and Pauly 2002). Prey items include fishes, shrimps and other invertebrates (Berry and Smith-Vaniz 1978 in Froese and Pauly 2002).

5.2.1.3.9.6 Greater amberjack, *Seriola dumerili*

The greater amberjack occurs in the Indo-West Pacific, and in the Western and Eastern Atlantic Oceans. In the Western Atlantic, it ranges as far north as Nova Scotia, Canada, southward to Brazil, including the Gulf of Mexico and the Caribbean Sea. This species is believed to be of minor importance to commercial fisheries. But it also is fished recreationally, and is utilized in the aquarium trade. It has been reported to be ciguatoxic in some areas (Paxton *et al.* 1989 in Froese and Pauly 2002).

The greater amberjack is found to depths of 360 m, inhabiting deep seaward reefs and, occasionally, coastal bays. Juveniles occur singly or in small schools in association with floating plants or debris in oceanic and offshore waters. This species is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.18; tm=4). Maximum reported size is 190 cm TL (male); maximum weight, 80.6 kg (Paxton *et al.* 1989 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 78.8 cm TL and 2.3 years, respectively (Froese and Pauly 2002). Fecundity, as measured in a Jamaican study, is estimated at over one million eggs per ovary for large individuals. That study observed ripe individuals offshore in the months of August and November (Thompson and Munro 1974c). Off the Florida Keys, greater amberjack spawn from January through June with a peak occurring during February through April (MARMAP unpublished data). Approximate life span is 11.6 years. Estimated natural mortality rate is 0.40 (Froese and Pauly 2002). The greater amberjack feeds primarily on fishes such as the bigeye scad, but also on invertebrates (Paxton *et al.* 1989 in Froese and Pauly 2002).

5.2.1.3.9.7 Almaco jack, *Seriola rivoliana*

The almaco jack is widely distributed in waters around the globe. It occurs in the Indo-West Pacific, the Eastern Pacific, and the Western Atlantic, where it ranges from Cape Cod (USA) to northern Argentina. This species is thought to occur in the Eastern Atlantic as well. But the extent of its distribution there is not well established. The almaco jack is taken in both commercial and recreational fisheries (Myers 1991 in Froese and Pauly 2002). It may cause ciguatera poisoning, particularly those individuals taken in coral reef areas (Cervigón *et al.* 1992 in Froese and Pauly 2002; Myers 1991 in Froese and Pauly 2002).

A benthopelagic species, the almaco jack inhabits outer reef slopes and offshore banks; generally from 15-160 m depth, but possibly to deeper depths. It has been observed to occur in small groups. Juveniles are often seen around floating objects. Maximum reported size is 160 cm FL (male); maximum weight, 59.9 kg (Myers 1991 in Froese and Pauly 2002). Size at maturity is estimated as 81.1 cm FL (Froese and Pauly 2002). No estimate of natural mortality rate is available for this species. Fishes serve as its primary prey. But invertebrates also make up a portion of its diet (Myers 1991 in Froese and Pauly 2002).

5.2.1.3.10 Butterflyfishes, Chaetodontidae

The Chaetodontidae family contains 114 species of butterflyfishes in 10 genera, distributed in the tropical Atlantic, Indian, and Pacific Oceans (Nelson 1994 in Froese and Pauly 2002). Burgess (1978) reports that these residential fishes occur as individuals, commonly as pairs strongly or loosely bound together, as small groups of three or more, and as relatively large aggregations for feeding and, possibly, for spawning. But a study conducted in Jamaican waters noted that no schooling behavior has been reported for the four *Chaetodon* species included in the Caribbean reef fish fishery management unit, rather they tend to occur in smaller groups (Aiken 1975a). The authors of that study report that butterflyfishes of this genus usually occur in pairs; generally male and female. This is supported by reports that butterflyfish enter fish traps in pairs in the Virgin Islands (Aiken 1975a). It is suspected that these pairs form early in life, but stay together for purposes of spawning (Burgess 1978). Butterflyfishes are highly fecund (one gonad count showed 3000-4000 eggs) (Burgess 1978), producing many more eggs/g body weight than the angelfishes (Aiken 1975a). Eggs (Nelson 1994 in Froese and Pauly 2002) and, possibly, early juveniles (Aiken 1975a), are pelagic.

These fishes are typically diurnal (Nelson 1994 in Froese and Pauly 2002), and have been observed to feed on small invertebrates, including coral polyps and planktonic copepods, and, to a lesser extent, algae (Burgess 1978). They also ingest inorganic material such as sand and coral fragments and thus play a direct role in the transport of calcareous fragments by reef fishes (Aiken 1975a). Juveniles of many species have been observed removing parasites from other fishes. But, it is believed that the bulk of their food is obtained from other sources, and that parasite-picking behavior is only exhibited on occasion (Burgess 1978). These fishes show no direct evidence of competition among themselves (Aiken 1975a). They are preyed on by the same predators as other reef fishes, including moray eels, snappers, scorpionfishes, and groupers. Their diurnal behavior makes them easy prey to night-hunting predators such as moray eels, since they are comatose during the evening hours. Butterflyfish larvae are frequently found among stomach contents of large pelagic fishes; major predators appear to be tunas and dolphins (Burgess 1978).

CFMC (1985) reports that butterflyfishes in the U.S. Caribbean are consumed in the USVI, but not in Puerto Rico. They are of primary importance to the aquarium trade (CFMC 1985).

5.2.1.3.10.1 Longsnout butterflyfish, *Chaetodon aculeatus*

The longsnout butterflyfish occurs in the Western Atlantic, from southern Florida to northern South America and in the Gulf of Mexico and Caribbean Sea (Allen 1985 in Froese and Pauly 2002).

The longsnout butterflyfish occurs from 1-91 m depth (Allen 1985 in Froese and Pauly 2002; Burgess 1978), but is most commonly found on reefs (Allen 1985 in Froese and Pauly 2002) from 5-55 m depth (Burgess 1978). Maximum reported size is about 9 cm TL (male) (Aiken

1975a; Allen 1985 in Froese and Pauly 2002). Size at maturity is estimated as 6.4 cm TL; natural mortality rate, 2.29 (Froese and Pauly 2002). This fish feeds on small invertebrates (Allen 1985 in Froese and Pauly 2002; Burgess 1978) and is often seen nibbling on the tubefeet of sea urchins or the tentacles of tubeworms (Allen 1985 in Froese and Pauly 2002). It appears to be one of the butterflyfishes that does not pick parasites from the bodies of other fishes (Allen 1985 in Froese and Pauly 2002; Burgess 1978).

5.2.1.3.10.2 Foureye butterflyfish, *Chaetodon capistratus*

The foureye butterflyfish occurs in the Western Atlantic, ranging from Massachusetts (USA) to northern South America, including the Gulf of Mexico and Caribbean Sea (Allen 1985 in Froese and Pauly 2002). This species is common in the Caribbean and, in 1902, was reported as the most abundant butterflyfish in Puerto Rican waters (Burgess 1978). Olsen *et al.* (1984), in Froese and Pauly (2002), report that it can be ciguatoxic.

The foureye butterflyfish can be found in rocky and reef areas, and in seagrass (e.g., *Thalassia*) beds. One study indicates that juveniles are more apt to be taken in grass flats, the adults being reef fishes (Burgess 1978). This species occurs from2-20 m depth, generally singly or in pairs (Allen 1985 in Froese and Pauly 2002). It is generally easily approached (Allen 1985 in Froese and Pauly 2002). Allen (1985), in Froese and Pauly (2002), report maximum size as 7.5 cm TL (male). But the largest male captured in a study off Jamaican measured 14 cm TL; the largest female, 13 cm TL (Aiken 1975a).

Size at maturity, as estimated by Froese and Pauly (2002) is 5.4 cm TL; natural mortality rate, 1.81. The smallest mature specimens captured off Jamaica measured 7 cm TL (female) and 9 cm TL (male). Eggs per gram body weight calculated ranged from 181 for a specimen of 8 cm TL weighing 16 g (2,900 eggs total), to 478 for a specimen of 10.4 cm TL, weighing 27 g (12,900 eggs total) (Aiken 1975a). Data collected in Jamaican waters between September 1969 and February 1973 indicate that ripe fishes occur in every month except April (no data were collected for the month of October). Spawning peaks occurred between December and March (Aiken 1975a). In the northeastern Caribbean, individuals in spawning condition have been observed in April (Erdman 1976). The foureye butterflyfish feeds primarily on zoantharians, polychaete worms, gorgonians, and tunicates (Allen 1985 in Froese and Pauly 2002).

5.2.1.3.10.3 Spotfin butterflyfish, *Chaetodon ocellatus*

The spotfin butterflyfish occurs in the Western Atlantic; generally along the coast from Florida (USA) to Brazil, but also in the Gulf of Mexico and Caribbean Sea. Larvae, sometimes swept northward, probably accounts for the sighting of juvenile specimens off Massachusetts (USA) during the summer months, and even as far north as Nova Scotia (Canada) (Randall 1996 in Froese and Pauly 2002). Burgess (1978) reports the occurrence of juveniles in seines operated in eel grass at Wood's Hole. He also notes that they are fairly common off the New Jersey coast in the late summer months; but absent the rest of the year (Randall 1996 in Froese and Pauly 2002).

According to Randall (1996), in Froese and Pauly (2002), the spotfin butterflyfish can be found to 30 m depth. But Burgess (1978) reports that this species has been encountered rather frequently at depths of 40-80 m. These fishes are frequently observed in pairs and, sometimes, in small groups of four or five. They are reportedly more apt to swim and feed over comparatively bare and sandy areas than other species of butterflyfishes (Burgess 1978). Maximum reported size is 20 cm TL (male) (Randall 1996 in Froese and Pauly 2002).

Size at maturity is estimated as 12.9 cm TL; natural mortality rate, 1.30 (Froese and Pauly 2002). The smallest mature specimen observed in a study conducted in Caribbean waters was 11 cm TL (female). Number of eggs per gram body weight ranged from 110 for a specimen of 13.4 cm TL weighing 110 g (total of 12,500 eggs), to 464 for a specimen of 15.5 cm TL weighing 138 g (total of 64,000 eggs). Data collected in Jamaican waters from September 1969 to February 1973 indicate that small numbers of ripe fishes can be found year-round, but no data were collected for the months of March, April, and June. The greatest proportions of ripe fishes were found in January and May (Aiken 1975a). In the northeastern Caribbean, individuals in spawning condition have been observed in May (Erdman 1976).

5.2.1.3.10.4 Banded butterflyfish, *Chaetodon striatus*

The banded butterflyfish occurs in both the Western and Eastern Central Atlantic Oceans. In the Western Atlantic, it ranges from Massachusetts (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea (Allen 1985 in Froese and Pauly 2002).

The banded butterflyfish is usually found in association with reef habitat (Allen 1985 in Froese and Pauly 2002), but can also be found in tidal pools and in eel grass beds, where its barred pattern affords it some protective coloration. Coral rubble bottom only sparsely covered with algae has been reported to be a preferred habitat (Burgess 1978). Its known depth range extends from 3-55 m. These fishes generally occurs singly or in pairs. But adults may form plankton-feeding aggregations of up to 20 individuals, and occasionally clean other reef fishes which join the group, such as grunts, parrotfishes, and surgeonfishes (Allen 1985 in Froese and Pauly 2002).

Maximum reported size is 17 cm TL (male) (Allen 1985 in Froese and Pauly 2002). Size at maturity is estimated as 10.6 cm TL; natural mortality rate, 1.53 (Froese and Pauly 2002). The smallest mature fish captured in a study conducted in Caribbean waters was 13 cm TL (male). Number of eggs per gram body weight ranged from 220 for a specimen of 13.9 cm TL weighing 52 g (total of 11,450 eggs), to 600 for a smaller specimen of 11.7 cm TL weighing 42 g (total of 25,200 eggs). A study collected in Jamaican waters from September 1969 to February 1973 reported that the greatest proportion of ripe fishes was collected in January-February, but more than 40% of the fishes were ripe in all months (Aiken 1975a). In the northeastern Caribbean, individuals in spawning condition have been observed in April (Erdman 1976). Prey items include polychaete worms, coral polyps, crustaceans, and mollusk eggs (Allen 1985 in Froese and Pauly 2002).

5.2.1.3.11 Hawkfishes, Cirrhitidae

The Cirrhitidae family contains 32 species in 9 genera, distributed in the tropical Western and Eastern Atlantic, Indian, and Pacific (mainly Indo-Pacific) Oceans. Only one species, the redspotted hawkfish (*Amblycirrhitus pinos*) is included in the Caribbean reef fish fishery management unit (Nelson 1994 in Froese and Pauly 2002). It is utilized primarily in the aquarium trade.

5.2.1.3.11.1 Redspotted hawkfish, *Amblycirrhitus pinos*

The redspotted hawkfish occurs in the Western Atlantic, ranging from southern Florida (USA) to northern South America, including the Gulf of Mexico and Caribbean Sea. One observation in the Eastern Atlantic has also been reported (Robins and Ray 1986 in Froese and Pauly 2002).

The redspotted hawkfish is moderately common in rocky areas and among rubble, often in crevices and shallow caves, from depths of 2-46 m. Maximum reported size is 9.5 cm SL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 6.7 cm SL (Froese and Pauly 2002). No estimate of natural mortality rate is available for this species. This fish is a protogynous hermaphrodite, with few dominant males. Spawning takes place in open water near the surface (Nelson 1994 in Froese and Pauly 2002). It feeds mainly on small crustaceans, particularly copepods, shrimps and shrimp larvae, crabs, and crab larvae as well as polychaetes (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.12 Flying gurnards, Dactylopteridae

The Dactylopteridae family contains 7 species in 2 genera, distributed in the tropical Indo-Pacific and Atlantic Oceans. Only one species, the flying gurnard (*Dactylopterus volitans*) is included in the Caribbean reef fish fishery management unit (Nelson 1994 in Froese and Pauly 2002). This fish is taken in commercial and recreational fisheries, and also is utilized in the aquarium trade (Eschmeyer and Dempster 1990 in Froese and Pauly 2002). In the U.S. Caribbean, it is utilized primarily in the aquarium trade.

5.2.1.3.12.1 Flying gurnard, *Dactylopterus volitans*

The flying gurnard occurs in both the Western and Eastern Atlantic Oceans. In the Western Atlantic, it ranges from Massachusetts (USA) to Argentina, including the Gulf of Mexico (Eschmeyer and Dempster 1990 in Froese and Pauly 2002) and Caribbean Sea.

A benthic species (Nelson 1994 in Froese and Pauly 2002), the flying gurnard is found over reefs, on sand, mud, or over rocks in sandy areas, to 100 m depth. It exhibits a “walking” movement on the sea floor, accomplished by an alternate movement of the pelvic fins. Maximum reported size is 90 cm TL (male); maximum weight, 1,810 g. Size at maturity is estimated as 48.8 cm TL; natural mortality rate, 0.31 (Froese and Pauly 2002). Primary prey

items include benthic crustaceans, especially crabs, as well as clams and small fishes (Eschmeyer and Dempster 1990 in Froese and Pauly 2002).

5.2.1.3.13 Spadefishes, Ephippidae

The Ephippidae family contains 20 species in 7 genera, distributed in the Atlantic, Indian, and Pacific Oceans (Nelson 1994 in Froese and Pauly 2002). Only one species, the Atlantic spadefish *(Chaetodipterus faber*) is included in the Caribbean reef fish fishery management unit. This fish is taken in commercial and recreational fisheries, is utilized in the aquarium trade, and has been reared in captivity (Robins and Ray 1986 in Froese and Pauly 2002). In the U.S. Caribbean, it is utilized primary in the aquarium trade. Olsen *et al.* (1984), in Froese and Pauly (2002), report that it can be ciguatoxic.

5.2.1.3.13.1 Atlantic spadefish, *Chaetodipterus faber*

The Atlantic spadefish occurs in the Western Atlantic, from Massachusetts (USA) to southeastern Brazil, including the Gulf of Mexico (Robins and Ray 1986 in Froese and Pauly 2002) and Caribbean Sea.

A demersal species, the Atlantic spadefish is found in depths of 3-35 m, and is abundant in shallow coastal waters, from mangroves and sandy beaches, to wrecks and harbors. It often circles divers. Juveniles (black phase) are common in estuaries and are often found in very shallow water swimming at an angle resembling dead leaves or as infertile red mangrove pods and other debris. Adults often occur in very large schools of up to 500 individuals. Maximum reported size is 91 cm TL (male); maximum weight, 9,000 g (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 49.3 cm TL; natural mortality rate, 0.31 (Froese and Pauly 2002). All members of the spadefish family are thought to be pelagic spawners (Nelson 1994 in Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in May and September (Erdman 1976). This fish feeds on benthic invertebrates like crustaceans, mollusks, annelids, cnidarians, as well as on plankton (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.14 Gobies, Gobiidae

The largest family of marine fishes, the Gobiidae family contains at least 1,800 species in 212 genera, mostly distributed in tropical and subtropical areas (Nelson 1994 in Froese and Pauly 2002). The two species included in the Caribbean reef fish fishery management unit fall under the genera *Gobiosoma* and *Priolepis*. Both are utilized primarily in the aquarium trade.

5.2.1.3.14.1 Neon goby, *Gobiosoma oceanops*

The neon goby occurs in the Western Atlantic, from southern Florida (USA) to Belize, including the Gulf of Mexico (Robins and Ray 1986 in Froese and Pauly 2002) and Caribbean Sea. It has

also been reared in captivity (Robins and Ray 1986 in Froese and Pauly 2002).

This fish is found in to 45 m depth, usually associated with coral heads. Maximum reported size is 5 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 3.8 cm TL; natural mortality rate, 3.39 (Froese and Pauly 2002). It removes ecto-parasites from other fishes (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.14.2 Rusty goby, *Priolepis hipoliti*

The rusty goby occurs in the Western Atlantic, ranging from southern Florida (USA) to northern South America, including the Caribbean Sea (Robins *et al.* 1991 in Froese and Pauly 2002).

This fish occurs to depths of 130 m. It is commonly found on shallow bottoms of coral reefs with clear water, usually on the undersides of ledges and roofs of caves. Maximum reported size is 4 cm TL (male) (Robins *et al.* 1991 in Froese and Pauly 2002). Size at maturity is estimated as 3.1 cm TL; natural mortality rate, 4.08 (Froese and Pauly 2002). It is generally sedentary and feeds on minute crustaceans (Robins *et al.* 1991 in Froese and Pauly 2002).

5.2.1.3.15 Basslets, Grammatidae

The Grammatidae family contains 9 species in 2 genera, distributed in the Western Atlantic and Western Pacific Oceans (Nelson 1984 in Froese and Pauly 2002). Only one species, the royal gramma (*Gramma loreto*) is included in the Caribbean reef fish fishery management unit. It is utilized primarily in the aquarium trade, and has been reared in captivity (Asoh and Yoshikawa 1996 in Froese and Pauly 2002).

5.2.1.3.15.1 Royal gramma, *Gramma loreto*

The royal gramma occurs in the Western Central Atlantic, from Bermuda, the Bahamas, and Central America, to northern South America (Asoh and Yoshikawa 1996 in Froese and Pauly 2002).

The royal gramma is found to 60 m depth, and is commonly observed in caves or under ledges, retreating into recesses when alarmed. Maximum reported size is 8 cm TL (male) (Asoh and Yoshikawa 1996 in Froese and Pauly 2002). Size at maturity is estimated as 5.8 cm TL; natural mortality rate, 2.43 (Froese and Pauly 2002). Males exhibit various types of nest care behavior. This fish feeds on the ecto-parasites of other fishes (Asoh and Yoshikawa 1996 in Froese and Pauly 2002).

5.2.1.3.16 Grunts, Haemulidae

The Haemulidae family contains 150 species in 17 genera, distributed in the Atlantic, Indian, and Pacific Oceans (Nelson 1994 in Froese and Pauly 2002). Genera represented in the Caribbean

reef fish fishery management unit include *Anisotremus* and *Haemulon*. These species are considered to be important food fishes (Nelson 1994 in Froese and Pauly 2002). But Olsen *et al.* (1984), in Froese and Pauly (2002), report that all can be ciguatoxic.

The grunts are pelagic spawners (Nelson 1994 in Froese and Pauly 2002). Some species are thought to spawn two or more times each year for some species; others may spawn more or less continuously throughout the year. Several species are believed to form spawning aggregations. Both eggs and larvae are thought to be pelagic. Settlement takes place in shallow water, and the young of many species school on nursery grounds, such as shallow back-reef areas or grass beds, until reaching maturity when they join the adult schools. Adults of most species typically form schools of a few to several hundred fishes on coral reefs by day, and feed in adjacent areas by night. This schooling behavior is an important factor in trap fishing, as one study has shown that, when a few white grunts entered a trap, conspecific attraction tended to draw in more individuals. Schools of mixed species of grunts are common (Gaut and Munro 1974).

All grunts are carnivores, feeding largely on invertebrates, although some supplement their diet with small fishes. Both the wide variety of food items taken and apparent differences in preferred foods probably reduces the amount of interspecific competition for food. But the grunts do compete for food with many other reef fishes, including porgies (*Sparidae*), goatfishes (*Mullidae*), wrasses and hogfishes (*Labridae*), and mojarras (*Gerreidae*). Predators include groupers (*Serranidae*), snappers (*Lutjanidae*), and jacks (*Carangidae*) (Gaut and Munro 1974).

5.2.1.3.16.1 Porkfish, *Anisotremus virginicus*

The porkfish occurs in the Western Atlantic, ranging from Florida (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. It is not indigenous to waters off Bermuda. This species is fished commercially and also is utilized in the aquarium trade. It has been reared in captivity (Robins and Ray 1986 in Froese and Pauly 2002).

The porkfish inhabits reef and rocky bottom habitats from 2-20 m depth. Maximum reported size is 40.6 cm TL (male); maximum weight, 930 g (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 24.2 cm TL; natural mortality rate, 0.428 (Ault *et al.* 1998). Peak breeding season appears to be between January and April in Jamaican waters, and spawning probably occurs offshore (Gaut and Munro 1974). In the northeastern Caribbean, individuals in spawning condition have been observed in April, July, October, and December (Erdman 1976). This species feeds at night on mollusks, echinoderms, annelids, and crustaceans. Juveniles pick parasites from the bodies of larger fishes (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.16.2 Margate, *Haemulon album*

Also known as the "white margate," this species occurs in the Western Atlantic, from the Florida Keys (USA) to Brazil, including the Caribbean Sea. It is taken in commercial and recreational

fisheries, and also is utilized in the aquarium trade (Cervigón 1993 in Froese and Pauly 2002).

The margate is found in pairs or larger schools, over seagrass beds, sand flats, coral reefs, and wrecks from 20-60 m depth. This fish is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.19-0.20; tm=3.5; Fec=800,000). Maximum reported size is 79 cm TL (male); maximum weight, 7,140 g (Cervigón 1993 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 40.2 cm TL and 3.2 years, respectively. A Jamaican study reports mean size at maturity as about 24 cm FL, and size of full mature as 26-27.98 cm FL (Gaut and Munro 1974). Approximate life span is 14.3 years. Estimated natural mortality rate is 0.374 (Ault *et al.* 1998). Peak breeding season appears to be between January and April in Jamaican waters, with a secondary, minor peak in September-November. But spawning is not necessarily synchronous in different localities (Gaut and Munro 1974). In the northeastern Caribbean, individuals in spawning condition have been observed in February, March, April, and September (Erdman 1976). Garcia-Cagide *et al.* (1994) have reported that margate off Cuba are in spawning condition throughout the year with a peak occurring during March and April. This fish feeds on benthic invertebrates, and has been observed to nose into the sand to eat such subsurface invertebrates as peanut worms and heart urchins (Cervigón 1993 in Froese and Pauly 2002).

5.2.1.3.16.3 Tomtate, *Haemulon aurolineatum*

The tomtate occurs in the Western Atlantic, ranging from Massachusetts (USA) to Brazil, including the Gulf of Mexico (Robins and Ray 1986 in Froese and Pauly 2002) and Caribbean Sea. This species is taken for food and for bait and is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

The tomtate inhabits seagrass beds, sand flats, patch reefs (Robins and Ray 1986 in Froese and Pauly 2002), and even muddy bottom habitat, to depths of 45 m. It has been observed to form schools or small groups near coral (Gaut and Munro 1974). This fish is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.18-0.35; tmax=9; Fec=29,000). Maximum reported size is 25 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 19 cm TL and 3.4 years, respectively. Approximate life span is 13.5 years; natural mortality rate, 0.333 (Ault *et al.* 1998). Based on a small sample size, a Jamaican study reported a mean length of 15.4 cm, mean weight of 69 g, and a mean fecundity of 30,000. Peak breeding season appeared to be between January and April (Gaut and Munro 1974). In the northeastern Caribbean, individuals in spawning condition have been observed from January through May, and in July and August (Erdman 1976). Prey items include small crustaceans, mollusks, other benthic invertebrates, plankton, and algae (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.16.4 French grunt, *Haemulon flavolineatum*

The French grunt occurs in the Western Atlantic, ranging from Bermuda, South Carolina (USA),

and the northern Gulf of Mexico, to Brazil, including the Caribbean Sea. This species is taken for food and for bait, and is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

The French grunt occurs in large schools on rocky and coral reefs to 60 m depth. It is often found under ledges or in association with elkhorn coral. Juveniles are abundant in nearshore seagrass beds. This fish is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.24). Maximum reported size is 30 cm TL (male). (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 16.9 cm TL and 2.1 years, respectively. But a Jamaican study reports that individuals might often mature at lengths of 12 cm FL or less. The mean length of a small number of individuals captured in that study was 16.9 cm; mean weight was 109 g; and mean fecundity was 31,000 (Gaut and Munro 1974). Approximate life spawn is 8.1 years; natural mortality rate, 0.333 (Ault *et al.* 1998). It appears that breeding of this species probably is continuous at a low level throughout the year (Gaut and Munro 1974). In the northeastern Caribbean, individuals in spawning condition have been observed in March and September (Erdman 1976). Small crustaceans serve as the primary prey (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.16.5 White grunt, *Haemulon plumieri*

Also known simply as, the "grunt," this species occurs in the Western Atlantic, ranging from Chesapeake Bay (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. This fish supports commercial and recreational fisheries, is utilized in the aquarium trade, and has been reared in captivity (Courtenay and Sahlman 1978 in Froese and Pauly 2002).

The white grunt is found from 3-40 m depth, in dense aggregations during the day on patch reefs, around coral formations, or on sandy bottoms. Juveniles commonly inhabit seagrass (*Thalassia testudinum*) beds. This fish is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.16-0.35; tm=2; tmax=13; Fec=64,000). Maximum reported size is 53 cm TL (male); maximum weight, 4,380 g (Courtenay and Sahlman 1978 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 27.2 cm TL and 2.6 years, respectively. A study in Jamaican waters reported mean size at maturity as about 20 cm FL and 22 cm FL for males and females, respectively. Males and females appeared to be fully mature at 24-24.9 cm FL and 26-27.9 cm FL, respectively (Gaut and Munro 1974). Approximate life span is 11 years; natural mortality rate, 0.375 (Ault *et al.* 1998). Peak breeding season appears to be between January and April in Jamaican waters, with a secondary, minor peak in September-November (Gaut and Munro 1974). In the northeastern Caribbean, individuals in spawning condition have been observed from February through April, and in September and November (Erdman 1976). The white grunt feeds on crustaceans, small mollusks, and small fishes, and frequently exhibits a territorial "kissing" display, in which two contenders push each other on the lips with their mouths wide open (Courtenay and Sahlman 1978 in Froese and Pauly 2002).

5.2.1.3.16.6 Bluestriped grunt, *Haemulon sciurus*

The bluestriped grunt occurs in the Western Atlantic, ranging from Florida (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is generally considered to be of minor importance to commercial fisheries. But it also is utilized in the aquarium trade (Courtenay and Sahlman 1978 in Froese and Pauly 2002).

The bluestriped grunt is found in small groups over coral and rocky reefs to 30 m depth. Juveniles are abundant in seagrass (*Thalassia*) beds. This species is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.22-0.30; tm=2; Fec=47,000). Maximum reported size is 46 cm TL (male); maximum reported weight, 750 g (Courtenay and Sahlman 1978 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 23.6 cm TL and 2.3 years, respectively. A Jamaican study reported, based on a small sample size, that few fishes mature before 18 cm FL and that full maturity is probably at about 22 cm FL. For a sample size of just 3, mean length was 24.2 cm, mean weight was 283 g, and mean fecundity was 32,000 (Gaut and Munro 1974). Approximate life span is 9.5 years; natural mortality rate, 0.50 (Ault *et al.* 1998). Peak breeding season in Jamaican waters appears to be between January and April, with a secondary, minor peak in September-November (Gaut and Munro 1974). In the northeastern Caribbean, individuals in spawning condition have been observed in January and March (Erdman 1976). Off Cuba, bluestriped grunt are reported to be in spawning condition during October through April with a peak during December and January (Garcia-Cagide *et al.* 1994). The blue-striped grunt feeds on crustaceans, bivalves and, occasionally, on small fishes (Courtenay and Sahlman 1978 in Froese and Pauly 2002).

5.2.1.3.17 Squirrelfishes and Soldierfishes, Holocentridae

The Holocentridae family contains 65 species in 8 genera, distributed in the tropical Atlantic, Indian, and Pacific Oceans. Most members of this family are nocturnal, and hide during the day in crevices or beneath reef ledges, along with cardinalfishes, bigeyes, and sweepers. These fish are hardy aquarium trade species, and also important subsistence food fishes in many areas (Nelson 1994 in Froese and Pauly 2002). Genera represented in the Caribbean reef fish fishery management unit include *Myripristis*, *Holocentrus*, and *Plectrypops*.

5.2.1.3.17.1 Squirrelfish, *Holocentrus adscensionis*

The squirrelfish occurs in both the Western and Eastern Atlantic Oceans. In the Western Atlantic, it ranges from North Carolina (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is considered to be of minor importance to commercial fisheries. But it is also utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002). Wyatt (1976) indicates that it appears to be a hardy fish, having been found to survive for several days in traps, and believed to be somewhat tolerant to pollution. Olsen *et al.* (1984), in Froese and Pauly (2002), report that it can be ciguatoxic.

The squirrelfish is found in shallow coral reefs and in deeper offshore waters, to 180 m depth (Robins and Ray 1986 in Froese and Pauly 2002). Wyatt (1976) reports that it is commonly found from 12-30 m depth in the Caribbean, whereas further north in American waters, it is more usually found at 8-12 m. Adults are demersal; juveniles, planktonic. Maximum reported size is 61 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 34.6 cm TL; natural mortality rate, 0.64 (Froese and Pauly 2002). The mean lengths of fishes captured in traps set in an inshore reef area off Jamaica were 19.5 cm FL and 16.5 cm FL for males and females, respectively. Most spawning in that area appears to occur from January to March, with a slightly smaller peak in October (Wyatt 1976). In the northeastern Caribbean, individuals in spawning condition have been observed in February, April, and September (Erdman 1976). The squirrelfish is a nocturnal species, hiding in deep crevices or under coral ledges during the day, and moving to sand and grass beds at night to feed (Robins and Ray 1986 in Froese and Pauly 2002) primarily on crabs and shrimp. Probable predators include sharks, snappers, and groupers (Wyatt 1976).

5.2.1.3.17.2 Longspine squirrelfish, *Holocentrus rufus*

The longspine squirrelfish occurs in the Western Atlantic Ocean, ranging from southern Florida (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is considered to be of minor importance to commercial fisheries, but also is utilized in the aquarium trade. It is marketed fresh, but is not popular as a food fish (Robins and Ray 1986 in Froese and Pauly 2002). Wyatt (1976) indicates it appears to be a hardy fish, having been found to survive for several days in traps, and believed to be somewhat tolerant to pollution. Olsen *et al.* (1984), in Froese and Pauly (2002), report that it can be ciguatoxic.

The longspine squirrelfish is generally found to 32 m depth, near the mouths of caves and holes (Robins and Ray 1986 in Froese and Pauly 2002). Young are planktonic (Wyatt 1976). Maximum reported size is 35 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 21.2 cm TL; natural mortality rate, 0.96 (Froese and Pauly 2002). Wyatt (1976) reports the mean length of males and females captured in offshore Jamaican waters was 17.5 cm. Spawning activity in Jamaican waters is believed to be similar to that of the squirrelfish, with the greatest proportion of ripe fishes observed in October and in February (Wyatt 1976). Wyatt (1983) reported that spawning of longspine squirrelfish occurred during August through June off Jamaica, In the northeastern Caribbean, individuals in spawning condition have been observed from February through March, in June, and from August through October (Erdman 1976). This species is nocturnal, and usually moves to sandy areas and grass beds at night to feed on crabs, shrimps, gastropods, and brittle stars (Robins and Ray 1986 in Froese and Pauly 2002). Probable predators include sharks, snappers, and groupers (Wyatt 1976).

5.2.1.3.17.3 Blackbar soldierfish, *Myripristis jacobus*

The blackbar soldierfish occurs in both the Western and Eastern Atlantic Oceans. In the Western

Atlantic, it ranges from North Carolina (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is considered to be of minor importance to commercial fisheries, but also is utilized in the aquarium trade. It is marketed fresh, but is not popular as a food fish (Robins and Ray 1986 in Froese and Pauly 2002).

The blackbar soldierfish is a demersal species, commonly found aggregating around coral and deeper rocky reefs (Robins and Ray 1986 in Froese and Pauly 2002). According to Wyatt (1976), its depth range rarely exceeds 25 m. But Robins and Ray (1986), in Froese and Pauly (2002) report that it can be found to 100 m depth. Maximum reported size is 25 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 15.7 cm TL; natural mortality rate, 0.77 (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in March (Erdman 1976). This fish is largely nocturnal. It feeds primarily on planktonic organisms (Robins and Ray 1986 in Froese and Pauly 2002), and has a more restricted foraging range than other squirrelfish (Wyatt 1976). *Myripristis* spp. have been observed spawning in open water, a few days after the full moon (Nelson 1994 in Froese and Pauly 2002).

5.2.1.3.17.4 Cardinal soldierfish, *Plectrypops retrospinis*

The Cardinal soldierfish occurs in the Western Atlantic, ranging from Bermuda and southern Florida (USA) to northern South America, and throughout the Caribbean. This species is considered to be of minor importance to commercial fisheries, but also is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

The Cardinal soldierfish occurs to 22 m depth, but is rarely observed, generally remaining in deep recesses of coral reefs during the day. Maximum reported size is 15 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 10 cm TL; natural mortality rate, 1.60 (Froese and Pauly 2002).

5.2.1.3.18 Wrasses and Hogfish, Labridae

The Labridae family contains 500 species in 60 genera, distributed in the Atlantic, Indian, and Pacific Oceans (Nelson 1994 in Froese and Pauly 2002). Six genera are represented in the Caribbean reef fish fishery management unit: *Bodianus*, *Clepticus*, *Halichoeres*, *Hemipteronotus*, *Lachnolaimus*, and *Thalassoma*. Some of these species are utilized primarily in commercial fisheries; others in the aquarium trade.

5.2.1.3.18.1 Spanish hogfish, *Bodianus rufus*

The Spanish hogfish occurs in the Western Atlantic, ranging from Bermuda and southern Florida (USA) to southern Brazil, including the Gulf of Mexico and Caribbean Sea. This species is considered to be of minor importance to commercial fisheries. But it also is utilized in the aquarium trade. It may hybridize with the spotfin hogfish, *Bodianus pulchellus* (Robins and Ray

1986 in Froese and Pauly 2002). Dammann (1969), in Froese and Pauly (2002), report that it can be ciguatoxic.

The Spanish hogfish is found to 70 m depth over rocky or coral reefs. Maximum reported size is 40 cm TL (male); maximum weight, 1,020 g (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 23.8 cm TL; natural mortality rate, 0.80 (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in February (Erdman 1976). This fish feeds on brittle stars, crustaceans, mollusks, and sea urchins. Juveniles actively pick parasites from larger fishes (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.18.2 Creole wrasse, *Clepticus parrae*

The creole wrasse occurs in the Western Atlantic, ranging from Bermuda and southern Florida (USA) to northern South America, including the Caribbean Sea. This species is believed to be of minor importance to commercial fisheries, but also is utilized in the aquarium trade (Cervigón 1993 in Froese and Pauly 2002).

The creole wrasse generally inhabits seaward reef slopes to depths of 40 m but, on occasion, it can be encountered on shallow patch reefs. Maximum reported size is 30 cm TL (male); maximum weight, 320 g (Cervigón 1993 in Froese and Pauly 2002). Size at maturity is estimated as 18.5 cm TL; natural mortality rate, 0.98 (Froese and Pauly 2002). This fish has been observed to spawn year-round in aggregations of hundreds of individuals off the southwest coast of Puerto Rico in depths of 10-30 m (Rielinger 1999). Also, it forms large midwater aggregations to feed on plankton, small jellyfishes, pteropods, pelagic tunicates, and various invertebrate larvae (Cervigón 1993 in Froese and Pauly 2002).

5.2.1.3.18.3 Yellowcheek wrasse, *Halichoeres cyanocephalus*

The yellowcheek wrasse occurs in the Western Atlantic, from Florida (USA) to Brazil, including the Caribbean Sea. Its small average size generally makes it of no interest to fisheries. But it is occasionally taken by recreational fishermen and also is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

The yellowcheek wrasse is generally found over hard substrates, from 27-91 m depth. Maximum reported size is 30 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 18.5 cm TL; natural mortality rate, 0.98 (Froese and Pauly 2002). Juveniles up to 8 cm tend defined cleaning stations sought by several species of reef fishes including damselfishes, goatfishes, and surgeonfishes (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.18.4 Yellowhead wrasse, *Halichoeres garnoti*

The yellowhead wrasse occurs in the Western Atlantic, from Bermuda and southern Florida (USA) to southeastern Brazil (Robins and Ray 1986 in Froese and Pauly 2002), including the Caribbean Sea. This species is generally of no interest to fisheries because of its small average size. But it is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

The yellowhead wrasse is commonly found from depths of 2-80 m, on shallow and deep reefs and exposed rocky ledges. Maximum reported size is 19.3 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 12.5 cm TL; natural mortality rate, 1.34 (Froese and Pauly 2002). This fish feeds on a variety of invertebrates. It is constantly on the move, but easily attracted by divers (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.18.5 Clown wrasse, *Halichoeres maculipinna*

The clown wrasse occurs in the Western Atlantic, from North Carolina (USA) and Bermuda to Brazil (Robins and Ray 1986 in Froese and Pauly 2002), including the Caribbean Sea. This species generally is of no interest to commercial fisheries because of its small average size. But it is utilized in the aquarium trade. The tri-colored pattern of the initial phase is similar to that of the juveniles of the yellowmouth grouper, *Mycteroperca interstitialis*, an aggressive mimic (Robins and Ray 1986 in Froese and Pauly 2002).

The clown wrasse is usually found in shallow rock areas and on reef tops, to depths of at least 25 m. It can also be found in seagrass (*Sargassum*) beds. But its solitary and cautious behavior can make it difficult to approach. Maximum reported size is 18 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 11.8 cm TL; natural mortality rate, 1.41 (Froese and Pauly 2002).

5.2.1.3.18.6 Puddingwife, *Halichoeres radiatus*

The puddingwife occurs in both the Western and Eastern Central Atlantic. In the Western Atlantic, it ranges from Bermuda and North Carolina (USA) to Brazil, including the Gulf of Mexico (Robins and Ray 1986 in Froese and Pauly 2002) and Caribbean Sea. This species is believed to be of minor importance to commercial fisheries, but also is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002). Olsen *et al.* (1984), in Froese and Pauly (2002), report that it can be ciguatoxic.

Adult puddingwife wrasses are found on shallow patch or seaward reefs down to 55 m. Juveniles usually occur in shallower (1-5 m) coral reefs. Maximum reported size is 51 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 25.5 cm TL and 1.2 years, respectively. Approximate life span is 4.8 years; natural mortality rate, 1.09 (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in March, April, and December (Erdman

1976). Prey items include mollusks, sea urchins, crustaceans, and brittle stars (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.18.7 Pearly razorfish, *Hemipteronotus novacula*

The pearly razorfish occurs in both the Western and Eastern Atlantic Oceans. In the Western Atlantic, it ranges from North Carolina (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is considered to be of minor importance to commercial fisheries. But it is also taken in recreational fisheries and is utilized in the aquarium trade (Gomon and Forsyth 1990 in Froese and Pauly 2002).

The pearly razorfish is a demersal species. It can be found to depths of 90 m, but most commonly inhabits clear shallow areas with sandy bottoms, usually in the vicinity of seagrass beds and corals. It builds nests with coral debris, and dives head first into the sand when frightened. Maximum reported size is 38 cm TL (male) (Gomon and Forsyth 1990 in Froese and Pauly 2002). Size at maturity is estimated as 22.8 cm TL; natural mortality rate, 0.63 (Froese and Pauly 2002). This fish is a protogynous hermaphrodite. Its diet is composed primarily of mollusks, but also of crabs and shrimps (Gomon and Forsyth 1990 in Froese and Pauly 2002).

5.2.1.3.18.8 Green razorfish, *Hemipteronotus splendens*

The green razorfish occurs in the Western Atlantic, from Bermuda and southern Florida (USA), to Brazil, and throughout the Caribbean Sea . This species generally is of no interest to commercial fisheries because of its small average size. But it is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

A demersal species, the green razorfish is most commonly encountered in shallow, sandy areas in and around seagrass beds, from 3-15 m depth. It prefers clear waters. Maximum reported size is 17.5 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 11.5 cm TL; natural mortality rate, 0.99 (Froese and Pauly 2002).

5.2.1.3.18.9 Hogfish, *Lachnolaimus maximus*

The hogfish occurs in the Western Atlantic, from Nova Scotia (Canada) to northern South America, including the Gulf of Mexico and Caribbean Sea (Robins and Ray 1986 in Froese and Pauly 2002). This species is taken in both commercial and recreational fisheries, is utilized in the aquarium trade, and has been reared in captivity. It can be ciguatoxic (Robins and Ray 1986 in Froese and Pauly 2002).

The hogfish is found from 3-30 m depth, over open bottoms or coral reef habitats. It is often encountered where gorgonians are abundant. This species is of low resilience, with a minimum population doubling time 4.5 - 14 years (K=0.09; Fec=100,00). Maximum reported size is 91 cm TL (male); maximum weight, 10,000 g (Robins and Ray 1986 in Froese and Pauly 2002). Size at

maturity and age at first maturity are estimated as 46.1 cm FL and 6.9 years. Approximate life span is 31.9 years (Froese and Pauly 2002). Natural mortality rate is estimated at 0.25 (Ault *et al.* 1998). Spawning aggregations have been documented to occur at 16+ m depth off La Parguera, Puerto Rico from December through April (Rielinger 1999). Garcia-Cagide *et al.* (1994) reported that hogfish spawn off Cuba during May through July. Colin (1982) found that peak spawning of hogfish off Puerto Rico is during December through April. Mollusks constitute the primary prey item, but this species also feeds on crabs and sea urchins (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.18.10 Bluehead wrasse, *Thalassoma bifasciatum*

The bluehead wrasse occurs in the Western Atlantic, from Bermuda and Florida (USA) to northern South America, including the Gulf of Mexico and the Caribbean Sea. The small average size of this fish generally makes it of no interest to commercial fisheries. But it is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

This species inhabits reef areas, inshore bays, and seagrass beds, to depths of 40 m. Maximum reported size is 25 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 15.7 cm TL (Froese and Pauly 2002). Maximum age is 3 years (Robins and Ray 1986 in Froese and Pauly 2002). Estimated natural mortality rate is 1.09 (Froese and Pauly 2002). This fish is reportedly hermaphroditic, and spawns at midday throughout the year. It feeds mainly on zooplankton and small benthic animals, but may also feed on ectoparasites of other fishes (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.19 Snappers, Lutjanidae

The Lutjanidae family contains 103 species in 17 genera, distributed in the tropical and subtropical Atlantic, Indian, and Pacific Oceans (Nelson 1984 in Froese and Pauly 2002). These fishes are generally slow-growing and moderately long-lived. Sexes are separate (Thompson and Munro 1974a). Some species are sequential hermaphrodites, but no indications of hermaphroditism have been observed for Caribbean Council-managed species. Genera represented in the Caribbean reef fish fishery management unit include *Apsilus*, *Etelis*, *Lutjanus*, *Ocyurus*, *Pristipomoides,* and *Rhomboplites*.

Most species are believed to exhibit sexually dimorphic growth rates and sizes at maturity (Thompson and Munro 1974a). These fishes are generally serial spawners, releasing several batches of eggs over a spawning season that sometimes extends year round (SAFMC 1999). Spawning activity generally peaks in the spring and summer months in the northeastern Caribbean (Erdman 1976). Annual fecundity reportedly ranges from one hundred thousand eggs released by young snappers and smaller species, to millions of eggs released by older snappers and larger species (SAFMC 1999; Thompson and Munro 1974a).

All species have complex life histories, with most dependent on different habitats during the egg, larval, juvenile, and adult phases of their life cycle. Eggs and early larvae are typically pelagic (AFS 2001). No long-lived oceanic larval or post-larval phases have been reported for snappers, as have been reported for many other reef fish families. Thus, they probably have a relatively short planktonic larval or post-larval life (Thompson and Munro 1974a). Larvae settle into various nearshore nursery habitats such as seagrass beds, mangroves, oyster reefs, and marshes (AFS 2001). Very early juvenile stages of snappers are not often seen but do not appear to be as secretive as hinds and groupers (Thompson and Munro 1974a).

Adults are generally sedentary and residential. Movement is generally localized and exhibits an offshore-inshore pattern, usually associated with spawning events. Many species have been reported to form mass spawning aggregations, where hundreds or even thousands of fish convene to reproduce (Rielinger 1999). Other species also aggregate to swim (Froese and Pauly 2001; SAFMC 1999). Generally, larger snapper inhabit deeper areas than smaller snapper, although there are many exceptions.

Juveniles occupying inshore areas generally feed on shrimp, crab, worms and small fish. Fish becomes a more important component of their diet as they grow and move offshore (SAFMC 1999). On reefs, snappers must certainly compete among themselves for food and space. A 1967 study reported that snappers in the Virgin Islands feed primarily on crabs and fishes, with shrimps, lobsters, gastropods, stomatopods and octopus completing the diet (Thompson and Munro 1974a). Competition with groupers (Serranidae), jacks (Carangidae), moray eels (Muraenidae) and grunts (Pomadasyidae) probably also occurs, although the extent of competition is not known. Predators of juvenile snappers include large carnivorous fishes, such as jacks, groupers, sharks, barracudas, and morays, as well as large sea mammals and turtles (SAFMC 1999). Major reef predators such as sharks, groupers and barracuda are probably the most important predators of adult snappers (Thompson and Munro 1974a).

5.2.1.3.19.1 Black snapper, *Apsilus dentatus*

The black snapper occurs in the Western Central Atlantic, off the Florida Keys (USA), and in the western Gulf of Mexico and Caribbean Sea. This species is considered to be a good food fish (Allen 1985 in Froese and Pauly 2002). But Halstead (1970), in Froese and Pauly (2002), report that it can be ciguatoxic.

A demersal species, the black snapper is primarily found over rocky bottom habitat, although juveniles are sometimes found near the surface (Allen 1985 in Froese and Pauly 2002). It moves offshore to deep-water reefs and rocky ledges as it grows and matures (SAFMC 1999). Allen (1985), in Froese and Pauly (2002) reports depth range as 100-300 m. The findings of a Caribbean study indicate that it is most abundant at depths of 60-100 m off Jamaica (Thompson and Munro 1974a).

Maximum reported size is 65 cm TL (male). Maximum reported weight is 3,170 g (Allen 1985 in Froese and Pauly 2002). Size at maturity and age at first maturity estimated in Froese and Pauly (2002) are 34.9 cm TL and 1 year, respectively. Observed maximum fork lengths of catches taken in a Jamaican study were 56 cm FL and 54 cm FL for males and females, respectively; estimated mean sizes of maturity, 43-45 cm FL and 39-41 cm FL for males and females, respectively (Thompson and Munro 1974a). Aida Rosario (unpublished data; personal communication) reports that females with ripe gonads were collected from December to May and from August to September, and were collected with the highest frequency in March and September. In the northeastern Caribbean, individuals in spawning condition have been observed from February through April, and in September (Erdman 1976). Thompson and Munro (1974a) reports that, off Jamaica, the greatest proportions of ripe fishes were found in January-April and September-November (Thompson and Munro 1974a).

Approximate life span is 4.4 years; natural mortality rate, 0.30 (Ault *et al.* 1998). Large catches occasionally obtained over a short period of time suggest a schooling habit for this species (Thompson and Munro 1974a). Prey includes fishes and benthic organisms, including cephalopods, tunicates (Allen 1985 in Froese and Pauly 2002), and crustaceans (Thompson and Munro 1974a).

5.2.1.3.19.2 Queen snapper, *Etelis oculatus*

The queen snapper occurs in the Western Atlantic, ranging from Bermuda and North Carolina (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. It is commonly found near oceanic islands, and is particularly abundant in the Bahamas and the Antilles. This species is considered to be a good food fish (Allen 1985 in Froese and Pauly 2002)

The queen snapper is a bathydemersal species (Allen 1985 in Froese and Pauly 2002). It moves offshore to deep-water reefs and rocky ledges as it grows and matures (SAFMC 1999). Allen (1985), in Froese and Pauly (2002) indicate it is primarily found over rocky bottom habitat, in depths of 100-450 m. Thompson and Munro (1974a) report it was caught on mud slopes of the south Jamaica shelf at a depth of 460 m (Thompson and Munro 1974a). This fish is a moderately resilient species, with a minimum population doubling time 1.4-4.4 years (K = 0.29 - 0.61). Maximum reported size is 100 cm TL (male). Maximum reported weight is 5,300 g (Allen 1985 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 53.6 cm TL and 1 year, respectively. Spawning is reported to occur during April and May off St. Lucia (Murray *et al.* 1992). Approximate life span is 4.7 years; natural mortality rate, 0.76 (Froese and Pauly 2002). Primary prey items include small fishes and squids (Allen 1985 in Froese and Pauly 2002).

5.2.1.3.19.3 Mutton snapper, *Lutjanus analis*

The mutton snapper occurs in the Western Atlantic, ranging as far north as Massachusetts (USA), southward to southeastern Brazil, including the Caribbean Sea and the Gulf of Mexico. It is most

abundant around the Antilles, the Bahamas, and off southern Florida (USA). This fish is considered to be of high importance to commercial fisheries, and also is taken by recreational anglers (Allen 1985 in Froese and Pauly 2002). According to Olsen *et al.* (1984), in Froese and Pauly (2002), it can be ciguatoxic.

According to Allen (1985), in Froese and Pauly (2002), the mutton snapper can be found in both brackish and marine waters from 25-95 m depth. Thompson and Munro (1974a) report that this species was captured on mud slopes off the southeast coast of Jamaica at depths of 100-120 m (Thompson and Munro 1974a). Juveniles generally occur closer to shore, over sandy, vegetated (usually *Thalassia*) bottom habitats, while large adults are commonly found offshore among rocks and coral habitat (Allen 1985 in Froese and Pauly 2002).

This fish is of low resilience, with a minimum population doubling time of 4.5-14 years (K = 0.13-0.25) (Allen 1985 in Froese and Pauly 2002). Allen (1985), in Froese and Pauly (2002), reports maximum size as 94 cm TL (male); maximum weight, 15.6 kg (Allen 1985 in Froese and Pauly 2002). The largest male and female observed in a study conducted in Puerto Rico between February 2000 and May 2001 measured 70 cm FL and 69 cm FL, respectively (Figuerola and Torres 2001). Approximate life span is 14 years (Allen 1985 in Froese and Pauly 2002); natural mortality rate, 0.214 (Ault *et al.* 1998). Maximum reported age is 17 years (Figuerola and Torres 2001).

Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 47.3 cm TL and 3.1 years, respectively. Figuerola and Torres (2001) estimate size at 50% maturity as 33 cm FL and 41.4 cm FL for males and females, respectively, based on the Puerto Rican survey. They indicate that all males and females are probably mature at 43.1 cm FL and 45 cm FL, respectively. That study, which was based on fishery dependent data, notes that 53% of males and 72% of females were taken prior to achieving sexual maturity. One study estimated that the ovary of an individual fish contained about 1,355,000 eggs (Thompson and Munro 1974a).

Spawning occurs in aggregations (Figuerola and Torres 2001). Erdman (1976) reports that individuals have been observed in spawning condition in the U.S. Caribbean from February through July (Erdman 1976). Figuerola and Torres (2001) report that some degree of reproduction occurs from February to June, but that spawning activity generally peaks during the week following the full moon in the months of April and May. Spawning aggregations are known to occur north of St. Thomas and south of St. Croix, USVI in March, April, and May (Rielinger 1999).

This fish wanders a bit more than other snapper species (SAFMC 1999). But the extent of its movement is unknown. It forms small aggregations which disband during the night (Allen 1985 in Froese and Pauly 2002). It feeds both day and night on fishes, shrimps, crabs, cephalopods, and gastropods (Allen 1985 in Froese and Pauly 2002).

5.2.1.3.19.4 Schoolmaster snapper, *Lutjanus apodus*

The schoolmaster snapper occurs in both the Western and Eastern Atlantic Oceans. In the Western Atlantic, its range extends as far north as Massachusetts (USA), southward to Trinidad and northern Brazil, including the Gulf of Mexico and Caribbean Sea. This species is considered to be a good food fish (Allen 1985 in Froese and Pauly 2002). But Dammann (1969), in Froese and Pauly (2002), report that it can be ciguatoxic.

The schoolmaster snapper is found in shallow, clear, warm, coastal waters over coral reefs, from 2-63 m depth. Adults often seeks shelter near elkhorn corals and gorgonians. Juveniles are encountered over sand bottoms with or without seagrass (*Thalassia*), and over muddy bottoms of lagoons or mangrove areas. Young sometimes enter brackish waters (Allen 1985 in Froese and Pauly 2002).

Allen (1985), in Froese and Pauly (2002), reports maximum sizes as 67.2 cm TL and 75 cm FL for males and females, respectively. The maximum fork length of females captured in a Jamaican study was 57 cm (Thompson and Munro 1974a). Maximum reported weight is 10.8 kg (Allen 1985 in Froese and Pauly 2002). Size at maturity is estimated as 37.7 cm TL; natural mortality rate, 0.25 (Ault *et al.* 1998). Ripe and/or recently spent fishes have been collected in nearshore and oceanic habitats off Jamaica in February-June and August-November (Thompson and Munro 1974a). Erdman (1976) reports the occurrence of ripe males and females in September. Schoolmaster are reported to spawn during April-June off Cuba (Garcia-Cagide *et al.* 1994).

This schoolmaster snapper sometimes forms resting aggregations during the day (Allen 1985 in Froese and Pauly 2002). Schools of this species observed over reefs off Florida dispersed at dusk in search of food (Thompson and Munro 1974a). Prey items include fishes, shrimps, crabs, worms, gastropods and cephalopods (Allen 1985 in Froese and Pauly 2002).

5.2.1.3.19.5 Blackfin snapper, *Lutjanus buccanella*

The blackfin snapper occurs in the Western Atlantic, as far north as North Carolina (USA) and Bermuda, south to Trinidad and northern Brazil, including the Gulf of Mexico and Caribbean Sea (Allen 1985 in Froese and Pauly 2002). This species is very common in the Caribbean, particularly in the Antilles. It is considered to be a good food fish, but can be ciguatoxic (Allen 1985 in Froese and Pauly 2002).

The blackfin snapper is a demersal species, found from 20-200 m depth. Adults inhabit deeper waters over sandy or rocky bottoms, and near drop-offs and ledges. Juveniles occur in shallower waters, often between about 35 and 50 m (Allen 1985 in Froese and Pauly 2002), and sometimes in small schools (Thompson and Munro 1974a). Suitable bottom type is probably more important than depth in influencing the distribution of this species. Most fish taken in fish traps

during a 1978 survey off Puerto Rico were captured at 75-110 m depth (Boardman and Weiler 1979).

This species is moderately resilient, with a minimum population doubling time of 1.4-4.4 years (K = 0.10 - 0.70). Maximum reported size is 75 cm TL (male); maximum weight, 14 kg (Allen 1985 in Froese and Pauly 2002). The modal lengths for male and female blackfins taken in the Puerto Rican survey were 26 cm FL and 23 cm FL, respectively. Maximum size was 47 cm FL. Estimated lengths of maturity for females and males were 20 cm FL and 38 cm FL, respectively (Boardman and Weiler 1979). Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 34 cm TL and 1.9 years, respectively. Approximate life span is 8.2 years; natural mortality rate, 0.23 (Ault *et al.* 1998).

The findings of Boardman and Weiler (1979) indicate that spawning occurs year-round in the U.S. Caribbean, in relatively large numbers. In the northeastern Caribbean, individuals in spawning condition have been observed in February, April, and September (Erdman 1976). Ripe fishes have been observed in Jamaican waters in February-May and in August-November, with maxima in April and September (Thompson and Munro 1974a). Allen (1985), in Froese and Pauly (2002) identify fishes as the primary prey. Thompson and Munro (1974a) report that the main items in the stomachs of this species taken at the Virgin Islands were isopods (37.5%) and fish (33.3%), with shrimps, spiny lobsters, crabs, octopus and squid making up the rest of the diet. Tunicates have been found in the stomachs of some adults (Thompson and Munro 1974a).

5.2.1.3.19.6 Gray snapper, *Lutjanus griseus*

The gray snapper occurs in the Western Atlantic, ranging from Massachusetts (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. A good food fish, this species is taken in both commercial and recreational fisheries. It also is utilized in the aquarium trade and has been reared in captivity (Allen 1985 in Froese and Pauly 2002). Halstead (1970), in Froese and Pauly (2002), report that it can be ciguatoxic.

The gray snapper occurs from 5-180 m depth, in coral reef habitat, rocky areas, estuaries, mangrove areas, and sometimes in the lower reaches of rivers (especially the young). This fish is easily approached. It often forms large aggregations (Allen 1985 in Froese and Pauly 2002). This fish is moderately resilient, with a minimum population doubling time of 1.4-4.4 years (K = 0.10; tm = 2-3; tmax = 21). Maximum reported size is 89 cm TL (male); maximum weight, 20 kg (Allen 1985 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 47 cm TL and 6.2 years (Froese and Pauly 2002). Maximum age is 21 years (Allen 1985 in Froese and Pauly 2002). Estimated natural mortality rate is 0.30 (Ault *et al.* 1998). Thompson and Munro (1974a) report that this species spawned at the Florida Cays in July and August. In the northeastern Caribbean, individuals in spawning condition have been observed in May, August, and September (Erdman 1976). Off Cuba, Garcia-Cagide *et al.*(1994) reported that gray snapper spawn during June through October with a peak in July. In Key West, FL, the

spawning season for female gray snapper ranges from June to September with a peak in July (Domeier *et al.* 1993).

The gray snapper feeds mainly at night on small fishes, shrimps, crabs, gastropods, cephalopods, and some planktonic items (Allen 1985 in Froese and Pauly 2002). The stomachs of 18 juveniles collected off the south coast of Jamaica contained 60% by volume of larval fish and 40% crabs and shrimp (Thompson and Munro 1974a).

5.2.1.3.19.7 Dog snapper, *Lutjanus jocu*

The dog snapper occurs in both the Western and Eastern Atlantic. In the Western Atlantic, it ranges from Massachusetts (USA), southward to northern Brazil, including the Gulf of Mexico and Caribbean Sea. This species is taken in commercial fisheries and also is utilized in the aquarium trade. It can be ciguatoxic (Allen 1985 in Froese and Pauly 2002).

The dog snapper is found from 5-30 m depth. Adults are common around rocky or coral reefs. Young are found in estuaries, and occasionally enter rivers (Allen 1985 in Froese and Pauly 2002). This species is of low resilience, with a minimum population doubling time of 4.5 - 14 years (K = 0.10; tm = 5.5). Maximum reported size is 128 cm TL (male); maximum weight, 28.6 kg (Allen 1985 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 47.6 cm TL and 6.2 years, respectively. Approximate life span is 28.7 years; natural mortality rate, 0.333 (Ault *et al.* 1998). Dog snapper are reported to spawn throughout the year off Cuba (Garcia-Cagide *et al.* 1999). A Caribbean study collected ripe females in February-March, and one ripe female and one spent male in November (Thompson and Munro 1974a). In the northeastern Caribbean, individuals in spawning condition have been observed in March (Erdman 1976). The dog snapper feeds mainly on fishes and benthic invertebrates, including shrimps, crabs, gastropods and cephalopods (Allen 1985 in Froese and Pauly 2002).

5.2.1.3.19.8 Mahogany snapper, *Lutjanus mahogoni*

The mahogany snapper occurs in the Western Atlantic, ranging from North Carolina (USA) to Venezuela, including the Gulf of Mexico and Caribbean Sea. This species is common in the Caribbean. It is taken in both commercial and recreational fisheries (Allen 1985 in Froese and Pauly 2002). According to Olsen *et al.* (1984), in Froese and Pauly (2002), it has been known to cause ciguatera poisoning.

The mahogany snapper is found to 100 m depth. It usually occurs in clear shallow waters over rocky bottoms in the vicinity of coral reefs, and is less frequently found in sandy or seagrass areas. It often forms large aggregations during the day (Allen 1985 in Froese and Pauly 2002) and has been observed to school in association with the white grunt, *Haemulon plumieri*, at Grand Cayman (Thompson and Munro 1974a). Maximum reported size is 48 cm TL (male); maximum weight, 1,300 g (Allen 1985 in Froese and Pauly 2002). Size at maturity is estimated as 28 cm TL; natural mortality rate, 0.30 (Ault *et al.* 1998). Erdman (1976) reports the

occurrence of ripe females in August in the northeastern Caribbean. This fish feeds at night mainly on small fish, shrimps, crabs and cephalopods (Allen 1985 in Froese and Pauly 2002).

5.2.1.3.19.9 Lane snapper, *Lutjanus synagris*

The lane snapper occurs in the Western Atlantic, ranging from Bermuda and North Carolina (USA) to southeastern Brazil, including the Gulf of Mexico and Caribbean Sea. It is most common around the Antilles, on the Campeche Bank, off Panama, and the northern coast of South America. This species is taken in commercial and recreational fisheries, and also is utilized in the aquarium trade. It is considered to be a good food fish (Allen 1985 in Froese and Pauly 2002). According to Olsen *et al.* (1984), in Froese and Pauly (2002), it can be ciguatoxic.

The lane snapper can be found over all types of bottom, but is usually encountered around coral reefs and on vegetated sandy areas, in turbid as well as clear water, from 10-400 m depth (Allen 1985 in Froese and Pauly 2002). This species is moderately resilient, with a minimum population doubling time of 1.4-4.4 years (K = 0.13-0.26; tm = 2; tmax = 10). Maximum reported size is 60 cm TL (male); maximum weight, 3,530 g (Allen 1985 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 26.9 cm TL and 3 years, respectively. Figuerola and Torres (1997) estimate size at 50% maturity as 14.7 cm FL (males) and 18.5 cm FL (females) based on fishery dependent and independent data collected in the U.S. Caribbean. Allen (1985), in Froese and Pauly (2002), report maximum age as 10 years. Studies from northeast Brazil and Cuba used otoliths to estimate ages of this species up to 6 years (Thompson and Munro 1974a). Estimated natural mortality rate is 0.30 (Ault *et al.* 1998).

This fish often forms large aggregations, especially during the spawning season (Allen 1985 in Froese and Pauly 2002). Spawning season is protracted, with some degree of reproductive activity occurring practically year-round (Figuerola and Torres 1997). But most spawning occurs from March to September in the U.S. Caribbean (Erdman 1976; Figuerola and Torres 1997) and, with greater intensity, between April and July. Spawning is believed to peak in June and July around the full moon (Figuerola and Torres 1997). Fecundity ranged from 347,000 to 995,000 eggs per fish in a study of six individuals captured off Cuba (Thompson and Munro 1974a). This species feeds at night on small fishes, bottom-living crabs, shrimps, worms, gastropods and cephalopods (Allen 1985 in Froese and Pauly 2002).

5.2.1.3.19.10 Silk snapper, *Lutjanus vivanus*

The silk snapper occurs in the Western Atlantic, as far north as Bermuda and North Carolina (USA), southward to central Brazil. It is most abundant around the Antilles and the Bahamas. A good food fish, this species is taken in both commercial and recreational fisheries. It can be ciguatoxic (Allen 1985 in Froese and Pauly 2002).

The silk snapper is mainly found from 90-140 m depth, commonly near the edge of the continental and island shelves, but also beyond the shelf edge to depths of 300 m. Adults are generally distributed further offshore than juveniles (SAFMC 1999), and usually ascend to shallow water at night (Allen 1985 in Froese and Pauly 2002). Suitable bottom type is probably more important than depth in influencing the distribution of this species. According to Rivas (1970), silk snapper are the only deep water snappers found over mud substrate in the Western Atlantic. Most fish taken in fish traps during a 1978 survey off Puerto Rico were captured at 112-165 m depth. Silk snapper have been reported to school in size groups (Dammann *et al.* 1970). Boardman and Weiler (1979) suggest that silk snapper are commonly associated with blackfin snapper and vermillion snapper, though silk snapper are usually found at a slightly deeper depth.

This species is of low resilience, with a minimum population doubling time of 4.5 - 14 years (K = 0.09-0.32; tm = 5). Maximum reported size is 83 cm TL (male); maximum weight, 8,320 g (Allen 1985 in Froese and Pauly 2002). The predominant lengths for males and females surveyed with trap gear in Puerto Rican waters were 29 cm FL and 26 cm FL, respectively, as determined from length-frequency curves. But trap-caught silk snapper tend to be smaller than those caught by hook and line gear. The maximum size of fish taken in that study was 71 cm FL. Females and males appeared to mature at 50 cm FL and 38 cm FL, respectively (Boardman and Weiler 1979). Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 43.4 cm TL and 6.3 years, respectively. A Jamaican study estimates mean sizes of maturity as 55-60 cm FL (males) and 50-55 cm FL (females) (Thompson and Munro 1974a). The approximate life span of this fish is 28.7 years; natural mortality rate, 0.23 (Ault *et al.* 1998). However, Tabash and Sierra (1996) suggested a maximum life span of seven years and estimated an M using Ralston's (1987) method to be 0.86, which was also advocated by the SEDAR process.

The findings of Boardman and Weiler (1979) indicate that this species spawns year-round in the U.S. Caribbean, in low percentages. But the small number of ripe fish observed in that study may have been due to the majority of the catch being smaller than estimated size at maturity. Apparent peaks in spawning in July-September and October-December were probably due to chance collection of spawning groups of a few large fishes (Boardman and Weiler 1979). In the northeastern Caribbean, individuals in spawning condition have been observed from February through April, and in September and November (Erdman 1976). Ripe fishes have been observed off the coast of Jamaica in March-May and August, September and November (Thompson and Munro 1974a).

Prey items include mainly fishes, shrimps, crabs, gastropods, cephalopods, tunicates and some pelagic items, including urochordates (Allen 1985 in Froese and Pauly 2002). The main items in the stomachs of fishes captured off the Virgin Islands consisted of fish (50.1%), shrimp (17.8%), and crabs (11%), with isopods and other invertebrate groups completing the diet (Thompson and Munro 1974a).

5.2.1.3.19.11 Yellowtail snapper, *Ocyurus chrysurus*

The yellowtail snapper occurs in the Western Atlantic, ranging from Massachusetts (USA) to southeastern Brazil, including the Gulf of Mexico and Caribbean Sea. This species is most common in the Bahamas, off south Florida, and throughout the Caribbean. It is taken in both the commercial and recreational fisheries, is cultured commercially, and is utilized in the aquarium trade (Allen 1985 in Froese and Pauly 2002). Dammann (1969), in Froese and Pauly (2002), reports that it can be ciguatoxic.

The yellowtail snapper inhabits waters to 180 m depth, and usually occurs well above the bottom (Allen 1985 in Froese and Pauly 2002). A Jamaican study reports this species was most abundant at depths of 20-40 m near the edges of shelves and banks (Thompson and Munro 1974a). Early juveniles are usually found over seagrass beds (Allen 1985 in Froese and Pauly 2002; Thompson and Munro 1974a). Later juveniles inhabit shallow reef areas. Adults are found on deeper reefs (Thompson and Munro 1974a). This fish wanders a bit more than other snapper species (SAFMC 1999). But the extent of its movement is unknown. It also exhibits schooling behavior (Thompson and Munro 1974a).

This species is of low resilience, with a minimum population doubling time of 4.5-14 years (K = 0.10-0.16; tm = 2; tmax = 14). Maximum reported size is 86.3 cm TL (male); maximum weight, 4,070 g (Allen 1985 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 42.5 cm TL and 4 years, respectively. Figuerola and Torres (1997) estimate size at 50% maturity as 22.4 cm FL (males) and 24.8 cm FL (females), based on fishery independent and dependent data collected off Puerto Rico. Maximum reported age is 14 years (Allen 1985 in Froese and Pauly 2002); estimated natural mortality rate, 0.21 (Ault *et al.* 2002).

Spawning extends over a protracted period (Allen 1985 in Froese and Pauly 2002; Figuerola and Torres 1997), peaking at different times in different areas (Allen 1985 in Froese and Pauly 2002). Figuerola and Torres (1997) report that, in the U.S. Caribbean, the reproductive season of this fish extends from February to October, with a peak from April to July. Erdman (1976) reports that 80% of adult yellowtails captured off San Juan from March through May, and over Silver Bank in early September, had ripe or sub-ripe gonads. Evidence indicates that spawning occurs in offshore waters (Figuerola and Torres 1997; Thompson and Munro 1974a) and during the new moon (Figuerola and Torres 1997). Fecundity ranged from 100,000 to 1,473,000 eggs per fish in four individuals captured off Cuba (Thompson and Munro 1974a).

Juvenile yellowtail snappers feed primarily on plankton (Allen 1985 in Froese and Pauly 2002; Thompson and Munro 1974a). Adults feed mainly at night on a combination of planktonic (Allen 1985 in Froese and Pauly 2002), pelagic (Thompson and Munro 1974a), and benthic organisms, including fishes, crustaceans, worms, gastropods and cephalopods (Allen 1985 in Froese and Pauly 2002).

5.2.1.3.19.12 Wenchman, *Pristipomoides aquilonaris*

The wenchman occurs in the Western Atlantic, ranging from North Carolina (USA) to Guiana, including the Caribbean Sea. Although considered to be a good food fish, this species is believed to be of minor importance to commercial fisheries (Allen 1985 in Froese and Pauly 2002). Olsen *et al.* (1984), in Froese and Pauly (2002), report that it can be ciguatoxic.

The wenchman is a demersal species, found from 24-370 m depth. Maximum reported size is 56 cm TL (male); maximum weight, 1,990 g (Allen 1985 in Froese and Pauly 2002). Size at maturity is estimated as 32.1 cm TL; natural mortality rate, 0.44 (Froese and Pauly 2002). Its diet is composed primarily of small fishes (Allen 1985 in Froese and Pauly 2002).

5.2.1.3.19.13 Vermilion snapper, *Rhomboplites aurorubens*

The vermilion snapper occurs in the Western Atlantic, ranging from Bermuda and North Carolina (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea (Allen 1985 in Froese and Pauly 2002).

The vermilion snapper is a demersal species, commonly found over rock, gravel, or sand bottoms near the edge of the continental and island shelves (Allen 1985 in Froese and Pauly 2002). Suitable bottom type is probably more important than depth in influencing the distribution of this species (Boardman and Weiler 1979). According to Allen (1985), in Froese and Pauly (2002), this fish is found in moderately deep waters from 180-300 m. But most fish taken in fish traps during a 1978 survey off Puerto Rico were captured at 75-110 m depth (Boardman and Weiler 1979). Vermilions often form large schools; particularly the young, which generally occur at shallower depths (Allen 1985 in Froese and Pauly 2002).

This fish is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K = 0.20; tm = 3; tmax = 10) (Allen 1985 in Froese and Pauly 2002). Maximum size and weight reported by Allen (1985), in Froese and Pauly (2002), is 60 cm TL (male) and 3,170 g, respectively. The modal length of both males and females collected in a three-year fish trap survey in Puerto Rican waters was 23 cm FL; maximum size, 38 cm. Size at maturity was 14 cm FL (males) and 20 cm FL (females) (Boardman and Weiler 1979). Size at maturity and age at first maturity for this species are estimated in Froese and Pauly (2002) as 34.5 cm TL and 3.3 years, respectively. Maximum reported age is 10 years (Allen 1985 in Froese and Pauly 2002); natural mortality rate, 0.23 (Ault *et al.* 1998).

According to Boardman and Weiler (1979), this fish spawns year-round in the U.S. Caribbean and in relatively large numbers. Erdman (1976) reports that the majority of fishes collected off the south coast of Puerto Rico in February, March, April, and June had sub-ripe or ripe gonads. A study off Jamaica captured one active male during May, and one ripe and three active females during October (Thompson and Munro 1974a). Prey items include fishes, shrimps, crabs,

polychaetes, other benthic invertebrates, cephalopods, and planktonic organisms (Allen 1985 in Froese and Pauly 2002).

5.2.1.3.20 Tilefishes, Malacanthidae

The Malacanthidae family contains 40 species in 5 genera, distributed in the Atlantic, Indian, and Pacific Oceans (Nelson 1984 in Froese and Pauly 2002). Only two genera are represented in the Caribbean reef fish fishery management unit: *Caulolatilus* and *Malacanthus*. All tilefish live in a burrow, some in a large rubble mound of their own construction, in pairs or colonies (Nelson 1984 in Froese and Pauly 2002).

5.2.1.3.20.1 Blackline tilefish, *Caulolatilus cyanops*

The blackline tilefish occurs in the Western Atlantic, from North Carolina (USA) and Bermuda to northern South America, and throughout the Caribbean. Highly appreciated as a food fish, this species is taken in both commercial and recreational fisheries (Dooley 1978 in Froese and Pauly 2002).

A demersal species, the blackline tilefish inhabits sandy and muddy bottom habitats from depths of 45-495 m. Maximum reported size is 60 cm TL (male); maximum weight, 11 kg (Dooley 1978 in Froese and Pauly 2002). Size at maturity is estimated as 34.1 cm TL; natural mortality rate, 0.42 (Froese and Pauly 2002). Prey items include invertebrates and small fishes (Dooley 1978 in Froese and Pauly 2002).

5.2.1.3.20.2 Sand tilefish, *Malacanthus plumieri*

The sand tilefish occurs in the Western and Southeast Atlantic. In the Western Atlantic, it ranges from North Carolina (USA) and Bermuda to Venezuela, Brazil, and to Rio de la Plata in Uruguay, including the Gulf of Mexico and Carribean Sea. This species is generally believed to be of minor importance to commercial fisheries. It tends to bite when handled (Dooley 1978 in Froese and Pauly 2002).

The sand tilefish can be found from 10-153 m depth, but is described as primarily a shallow-water benthic species. It generally occurs on sand and rubble bottoms, and is known to build mounds of rubble and shell fragments near reefs and grass beds, in which it hides its head when frightened. Maximum reported size is 70.0 cm SL (male); maximum weight, 1,020 g (Dooley 1978 in Froese and Pauly 2002). Size at maturity is estimated as 39.1 cm TL (Froese and Pauly 2002). No estimate of natural mortality rate is available for this species. Prey items include stomatopods, fishes, polychaete worms, chitons, sea urchins, sea stars, amphipods, and shrimps (Dooley 1978 in Froese and Pauly 2002).

5.2.1.3.21 Goatfishes, Mullidae

The Mullidae family contains 55 species in 6 genera, distributed in the Atlantic, Indian, and Pacific Oceans (Nelson 1994 in Froese and Pauly 2002). Only two genera are represented in the Caribbean reef fish fishery management unit: *Mulloidichthys* and *Pseudupeneus*. A Jamaican study reports that juveniles of these species are commonly observed in association with schools of juvenile grunts and that they might be, to some extent, competitive for the same foods. Other obvious competitors include wrasses, and small jacks, particularly the bar jack, C*aranx ruber*. Goatfishes probably fall prey to most of the larger reef predators including sharks, groupers, snappers, and jacks. Studies of age and growth and population structures indicate that these species do not likely survive more than 5 years (Munro 1974b).

5.2.1.3.21.1 Yellow goatfish, *Mulloidichthys martinicus*

The yellow goatfish occurs in both the Western and Eastern Atlantic. In the Western Atlantic, it ranges from Bermuda to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is believed to be of minor commercial importance (Robins and Ray 1986 in Froese and Pauly 2002). Olsen *et al.* (1984), in Froese and Pauly (2002), report that it can be ciguatoxic.

The yellow goatfish is found over sandy areas of lagoon and seaward reefs to depths of 49 m. Juveniles are common in seagrass beds (Robins and Ray 1986 in Froese and Pauly 2002), and have been observed to form large schools (Munro 1974b). Maximum reported size is 39.4 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated in Froese and Pauly (2002) as 23.5 cm TL; natural mortality rate, 0.89. Age at first maturation, as reported by a Jamaican study, is about 18.5 cm FL (118 g) and at or before 17.5 cm FL (90 g) for males and females, respectively; full maturity, within one cm of those lengths. Spawning in that area occurs mostly in March-April and September-October (Munro 1974b). In the northeastern Caribbean, individuals in spawning condition have been observed from February through May (Erdman 1976). The yellow goatfish feeds on benthic invertebrates (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.21.2 Spotted goatfish, *Pseudupeneus maculatus*

The spotted goatfish occurs in the Western Atlantic, ranging from New Jersey (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. The flesh of this species is highly esteemed (Cervigón 1993). According to Olsen *et al.* (1984), in Froese and Pauly (2002), it can be ciguatoxic.

The spotted goatfish inhabits shallow waters to depths of 90 m, and is usually found over sand and rock bottoms in reef areas. Young juveniles are often found on seagrass (e.g., *Thalassia*) beds. Maximum reported size is 30 cm TL (male) (Cervigón 1993). Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 17.3 cm TL and 1.1 years, respectively. The smallest ripe male collected in a Jamaican study measured about 17.5 cm FL. Size at full

maturity was estimated as 18.5-19.5 cm FL (116-137 g) for males, and probably less than 16 cm FL (80 g) for females (Munro 1974b). Approximate life span is 4.1 years; natural mortality rate, 1.33 (Froese and Pauly 2002). This fish spawns in large aggregations (Erdman 1976). One spawning aggregation site has been documented in the USVI National Marine Park off St. John, USVI. About 300-400 individuals have been observed to spawn at that site during the month of March at about 21 m depth (Rielinger 1999). Spotted goatfish in the northeastern Caribbean also have been observed in spawning condition in January, February, and October (Erdman 1976). Peak spawning season in Jamaican waters is January to April, with a subsidiary peak in October. Larvae and post-larvae are pelagic, and metamorphose and transfer to demersal habitat at sizes of around 4-8 cm (Munro 1974b). Its diet consists of small invertebrates (Cervigón 1993).

5.2.1.3.22 Morays, Muraenidae

The Muraenidae family contains 200 species in 15 genera, distributed in tropical and temperate seas worldwide (Nelson 1994 in Froese and Pauly 2002). Only two genera are represented in the Caribbean reef fish fishery management unit: *Echidna* and *Gymnothorax*. These fishes are solitary, benthic species (Robins and Ray 1986 in Froese and Pauly 2002), and are utilized primarily in the aquarium trade.

5.2.1.3.22.1 Chain moray, *Echidna catenata*

The chain moray occurs in the Western Atlantic, the Eastern Atlantic , and around the southern Atlantic islands. In the Western Atlantic, it ranges from Bermuda to Brazil, including the Caribbean Sea. This species is believed to be of minor importance to commercial fisheries, but also is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

The chain moray is commonly found on reefs and rocky shore areas to depths of 12 m. Maximum reported size is 165 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 83.4 cm TL; natural mortality rate, 0.29 (Froese and Pauly 2002). This fish feeds on small fishes and crustaceans (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.22.2 Green moray, *Gymnothorax funebris*

The green moray occurs in the Western and Eastern Atlantic, and in the Eastern Pacific Oceans. In the Western Atlantic, it ranges from New Jersey (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. It was once reported in Nova Scotia, Canada. This species is marketed both fresh and salted, but is generally believed to be of minor importance to commercial fisheries. It also is utilized in the aquarium trade. Large individuals are reportedly ciguatoxic (Robins and Ray 1986 in Froese and Pauly 2002).

The green moray occurs along rocky shorelines, reefs, and mangroves, usually at less than 30 m depth. It is aggressive. Capable of reaching 2.5 m (male) in length, and up to 29 kg weight, its

bites are particularly dangerous (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 12 m TL; natural mortality rate, 0.22 (Froese and Pauly 2002).

5.2.1.3.22.3 Goldentail moray, *Gymnothorax miliaris*

The goldentail moray occurs in the Western and Eastern Atlantic Oceans, and also around the mid-Atlantic islands. In the Western Atlantic, it ranges from Bermuda to northern South America, including the Caribbean Sea. This species is believed to be of minor importance to commercial fisheries, but also is utilized in the aquarium trade (Robins *et al.* 1991 in Froese and Pauly 2002).

The goldentail moray inhabits coral reefs and rocky shorelines, to depths of 60 m. Maximum reported size is 70 cm TL (male) (Robins *et al.* 1991 in Froese and Pauly 2002). Size at maturity is estimated as 39.1 cm TL; natural mortality rate 0.37 (Froese and Pauly 2002).

5.2.1.3.23 Batfishes, Ogcocephalidae

The Ogcocephalidae family contains 62 species in 9 genera, distributed in all tropical and many subtropical seas. These demersal fishes are capable of walking on the bottom using their large armlike pectorals and smaller pelvic fins. Some achieve up to 40 cm in length. But most do not grow longer than 20 cm. They feed on small invertebrates and fishes (Nelson 1994 in Froese and Pauly 2002).

Only *Ogcocephalus* species are included in the Caribbean reef fish fishery management unit. Little is known about batfish biology. Known depth ranges of *Ogcocephalus* species known to occur in Caribbean waters are 29-126 m (*O. parvus*), 28-228 m (*O. rostellum*), and 35-348 m (*O. pumilus*). Maximum reported size ranges from 6.1 cm SL (*O. pumilus*; male) (Bradbury 1980 in Froese and Pauly 2002) to 30.5 cm TL (*O. vespertilio*; male) (Claro 1994 in Froese and Pauly 2002). Erdman (1976) reports that *O. parvus* and *O. vespertilio* spawn in the northeastern Caribbean from January to April.

The status of batfish has not been assessed relative to the pre-SFA definitions of overfished and overfishing. Under these definitions, the stock would be overfished when the transitional SPR is less than 20% SPR. Overfishing is defined as a fishing mortality rate in excess of that corresponding to a 20% SPR level (NMFS 2002). These fishes are aquarium trade species. The SFA Working Group classified the status of the Aquarium Trade Species Complex as "unknown." The methodology used to make this determination is described in Section 4.2.2.

5.2.1.3.24 Snake eels, Ophichthidae

The Ophichthidae family contains 250 species in 52 genera (Nelson 1994 in Froese and Pauly 2002). Only one species, the goldspotted eel (*Myrichthys ocellatus*) is included in the Caribbean reef fish fishery management unit. It is utilized in the aquarium trade.

5.2.1.3.24.1 Goldspotted eel, *Myrichthys ocellatus*

The goldspotted eel has been reported in both the Western and Eastern Atlantic. In the Western Atlantic, its range extends from Bermuda to northern South America, including the Caribbean Sea (Robins *et al.* 1991 in Froese and Pauly 2002).

The goldspotted eel is common near islands and in rocky or coral areas. It is also found in seagrass beds, and areas with sand and coral rubble. It may move beneath the sand. Maximum reported size is 11 m TL (male) (Robins *et al.* 1991 in Froese and Pauly 2002). Size at maturity is estimated as 5.8 m TL; natural mortality rate, 0.39 (Froese and Pauly 2002). This species forages at night, feeding primarily on crabs (Robins *et al.* 1991 in Froese and Pauly 2002).

5.2.1.3.25 Jawfishes, Opistognathidae

The Opistognathidae family contains 60 species in 3 genera, distributed in the Western and Central Atlantic, Indian, and Pacific Oceans (Nelson 1994 in Froese and Pauly 2002). Both species included in the Caribbean reef fish fishery management unit belong to the genus *Opistognathus*.

5.2.1.3.25.1 Yellowhead jawfish, *Opistognathus aurifrons*

The yellowhead jawfish occurs in the Western Central Atlantic, from southern Florida (USA) to northern South America, including the Caribbean Sea. This species is utilized in the aquarium trade and has been reared in captivity (Robins and Ray 1986 in Froese and Pauly 2002).

A demersal species, occurring from depths of 3-40 m, the yellowhead jawfish inhabits burrows made of crushed coral or sand, where it hovers vertically, above or near its hole. Maximum reported size is 10 cm TL (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 7 cm TL; natural mortality rate, 2.12 (Froese and Pauly 2002). The males brood eggs orally (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.25.2 Dusky jawfish, *Opistognathus whitehursti*

The dusky jawfish occurs in the Western Atlantic, from southern Florida (USA) to northern South America, including the Caribbean Sea. This species is utilized in the aquarium trade (Böhlke and Chaplin 1993).

A demersal species, the dusky jawfish occurs to 12 m, inhabiting rock and sand bottoms or the eroding edges of weed beds. Maximum reported size is 14 cm TL (male) (Böhlke and Chaplin 1993). Size at maturity is estimated as 9.4 cm TL; natural mortality rate, 1.67 (Froese and Pauly 2002). Egg masses are incubated in the mouths of males (Böhlke and Chaplin 1993).

5.2.1.3.26 Boxfishes, Ostraciidae

The Ostraciidae family contains 33 species in 14 genera, distributed in the Atlantic, Indian and Pacific Oceans. These fishes are territorial and haremic, spawning pelagic eggs at dusk (Nelson 1994 in Froese and Pauly 2002). All five species in the Caribbean reef fish fishery management unit belong to the genus *Lactophrys*.

5.2.1.3.26.1 Spotted trunkfish, *Lactophrys bicaudalis*

The spotted trunkfish occurs in both the Western and Eastern Atlantic. In the Western Atlantic, it ranges from Florida (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is utilized in the aquarium trade and is probably marketed fresh locally (Robins and Ray 1986 in Froese and Pauly 2002). According to Dammann (1969), in Froese and Pauly (2002), it can be ciguatoxic.

The spotted trunkfish is found to depths of 50 m, in clear water around coral reefs and, sometimes, under ledges and near small holes. Maximum reported size is 48 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 28 cm TL; natural mortality rate, 0.49 (Froese and Pauly 2002). This fish feeds on a variety of small bottom invertebrates such as mollusks, crustaceans, starfishes, sea urchins, sea cucumbers, sessile tunicates, seagrasses, algae, crabs and brittle stars. It releases toxins when excited, which are capable of killing other fishes (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.26.2 Honeycomb cowfish, *Lactophrys polygonia*

The honeycomb cowfish occurs in the Western Atlantic, ranging from New Jersey (USA) to Brazil (Cervigón *et al.* 1992 in Froese and Pauly 2002), including the Caribbean Sea. It is reportedly absent in the Gulf of Mexico. This species is taken in commercial fisheries and also is utilized in the aquarium trade (Cervigón *et al.* 1992 in Froese and Pauly 2002). Olsen *et al.* (1984), in Froese and Pauly (2002), report that it can be ciguatoxic.

The honeycomb cowfish occurs in clear water around coral reefs, from 3-80 m depth. Maximum reported size is 50 cm NG (male) (Cervigón *et al.* 1992 in Froese and Pauly 2002). Size at maturity is estimated as 29 cm NG (Froese and Pauly 2002). No estimate of natural mortality is available for this species. Prey items include sponges, alcyonarians, tunicates, and shrimp (Cervigón *et al.* 1992 in Froese and Pauly 2002).

5.2.1.3.26.3 Scrawled cowfish, *Lactophrys quadricornis*

The scrawled cowfish occurs in tropical and temperate waters of the Atlantic. In the Western Atlantic, it ranges from Massachusetts (USA) to southeastern Brazil, including the Gulf of Mexico (Smith 1986 in Froese and Pauly 2002) and Caribbean Sea. It has also been reported off the tip of South Africa. Considered an excellent food fish, it is marketed fresh. It also is utilized

in the aquarium trade (Smith 1986 in Froese and Pauly 2002). According to Olsen *et al.* (1984), in Froese and Pauly (2002), it can be ciguatoxic.

The scrawled cowfish is found in shallow water down to about 80 m. Seagrass beds are reportedly its preferred habitat. Maximum reported size is 55 cm TL (male) (Smith 1986 in Froese and Pauly 2002). Size at maturity is estimated as 31.6 cm TL; natural mortality rate, 0.44 (Froese and Pauly 2002). Ruiz *et al.* (1999) reported that January and February as well as June through September were the times of peak spawning of scrawled cowfish off Venezuela. This fish feeds on sessile invertebrates such as tunicates, gorgonians, and anemones, as well as on slow-moving crustaceans, sponges, hermit crabs and marine plants (Smith 1986 in Froese and Pauly 2002).

5.2.1.3.26.4 Trunkfish, *Lactophrys trigonus*

Also known as the "buffalo trunkfish," the trunkfish occurs in the Western Atlantic, from Massachusetts (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is a highly esteemed food fish in the Caribbean, and also is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002). Halstead *et al.* (1990), in Froese and Pauly (2002), report that it can be ciguatoxic.

The trunkfish inhabits seagrass beds, coral rubble areas, and offshore reefs down to about 50 m depth. Maximum reported size is 55 cm TL (male); maximum weight, 3,310 g (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 31.6 cm TL; natural mortality rate, 0.44 (Froese and Pauly 2002). This fish feeds on a wide variety of small benthic invertebrates such as mollusks, crustaceans, worms and sessile tunicates, as well as some seagrasses (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.26.5 Smooth trunkfish, *Lactophrys triqueter*

The smooth trunkfish occurs in the Western Atlantic, ranging from Canada to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is marketed fresh locally, but is generally believed to be of minor importance to commercial fisheries. It also is utilized in the aquarium trade (Coad 1995 in Froese and Pauly 2002). According to Dammann (1969), in Froese and Pauly (2002), it can be ciguatoxic.

The smooth trunkfish is found on coral reefs to depths of 50 m. It is easily approached, and is solitary or occurs in small groups. Maximum reported size is 47 cm TL (male) (Coad 1995 in Froese and Pauly 2002). Size at maturity is estimated as 27.5 cm TL; natural mortality rate, 0.49 (Froese and Pauly 2002). This fish preys on a wide variety of small bottom invertebrates such as mollusks, crustaceans, worms, sessile tunicates and sponges exposed by a jet of water ejected through the mouth. It releases toxins when excited, which are capable of killing other fishes (Coad 1995 in Froese and Pauly 2002).

5.2.1.3.27 Angelfishes, Pomacanthidae

The Pomacanthidae family contains 74 species in 9 genera, distributed in the tropical Atlantic, Indian, and (mainly western) Pacific Oceans. All species studied to date are protogynous hermaphrodites with a haremic social system (Nelson 1994 in Froese and Pauly 2002). Genera represented in the Caribbean reef fish fishery management unit include *Centropyge*, *Holacanthus*, and *Pomacanthus*.

5.2.1.3.27.1 Cherubfish, *Centropyge argi*

The cherubfish occurs in the Western Atlantic, ranging from Bermuda to French Guiana, including the Gulf of Mexico and Caribbean Sea . This species is utilized in the aquarium trade and has been reared in captivity (Allen 1985 in Froese and Pauly 2002).

The cherubfish occurs from 5-80 m depth, and is normally encountered in rubble areas, where it feeds on various types of algae. It has been observed to retreat into holes when frightened. Maximum reported size is 8 cm TL (male) (Allen 1985 in Froese and Pauly 2002). Size at maturity is estimated as 5.8 cm TL; natural mortality rate, 1.72 (Froese and Pauly 2002).

5.2.1.3.27.2 Queen angelfish, *Holacanthus ciliaris*

The queen angelfish occurs in both the Western and Eastern Central Atlantic Oceans. In the Western Atlantic, its range extends from Florida (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is believed to be of minor importance to commercial fisheries, but also is utilized in the aquarium trade (Allen 1985 in Froese and Pauly 2002). It can be ciguatoxic (Olsen *et al.* 1984 in Froese and Pauly 2002).

This sedentary species generally occurs solitarily or in pairs on coral reefs to depths of 70 m. Maximum reported size is 45 cm TL (male); maximum weight, 1,600 g (Allen 1985 in Froese and Pauly 2002). Estimated size at maturity is 26.5 cm TL; natural mortality rate, 0.51 (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in January, March, April, and August (Erdman 1976). The queen angelfish has been reported to prey almost exclusively on sponges, supplemented by small amounts of algae, tunicates, hydroids and bryozoans. Juveniles have been observed to pick ectoparasites from other fishes (Allen 1985 in Froese and Pauly 2002).

5.2.1.3.27.3 Rock beauty, *Holacanthus tricolor*

The rock beauty occurs in the Western Atlantic, ranging from Georgia (USA) and Bermuda to Brazil, including the Gulf of Mexico (Allen 1985 in Froese and Pauly 2002) and Caribbean Sea. This species is considered to be of minor importance to commercial fisheries. It also is utilized in the aquarium trade (Allen 1985 in Froese and Pauly 2002). It can be ciguatoxic (Olsen *et al.* 1984 in Froese and Pauly 2002).

This sedentary species inhabits rock jetties, rocky reefs, and rich coral areas, from 3-92 m depth. Juveniles are often associated with fire corals. Maximum reported size is 35 cm TL (male) (Allen 1985 in Froese and Pauly 2002). Estimated size at maturity is 21.2 cm TL; natural mortality rate, 0.88 (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in February, March, and May (Erdman 1976). Dietary items include tunicates, sponges, zoantharians, and algae (Allen 1985 in Froese and Pauly 2002).

5.2.1.3.27.4 Gray angelfish, *Pomacanthus arcuatus*

The gray angelfish occurs in the Western Atlantic, ranging from New England (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. Although its flesh is reported to be of excellent quality, this species is considered to be of minor importance to commercial fisheries. It has been reared in captivity, and is utilized in the aquarium trade (Allen 1985 in Froese and Pauly 2002). It can be ciguatoxic (Olsen *et al.* 1984 in Froese and Pauly 2002).

The gray angelfish is common in coral reefs, from depths of 2-30 m. It is usually solitary, but occasionally occurs in pairs, and is known to approach divers. Maximum reported size is 60 cm TL (male); maximum weight, 1,830 g (Allen 1985 in Froese and Pauly 2002). Estimated size at maturity is 34.1 cm TL; natural mortality rate, 0.42 (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in February, March, May, and June (Erdman 1976). Juveniles are part-time cleaners. The gray angelfish feeds mainly on sponges, but also takes tunicates, algae, zoantharians, gorgonians, hydroids, byrozoans, and seagrasses (Allen 1985 in Froese and Pauly 2002).

5.2.1.3.27.5 French angelfish, *Pomacanthus paru*

The French angelfish occurs in both the Western and Eastern Atlantic. In the Western Atlantic, it ranges from Florida (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. Although its flesh is considered to be of good quality, this species is believed to be of minor importance to commercial fisheries. It is also utilized in the aquarium trade and has been reared in captivity (Allen 1985 in Froese and Pauly 2002). It can be ciguatoxic (Olsen *et al.* 1984 in Froese and Pauly 2002).

The French angelfish occurs from 3-100 m depth, but is common in shallow reefs. It usually occurs in pairs, often near sea fans. It is generally sedentary. This fish is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.21). Maximum reported size is 41.1 cm TL (male) (Allen 1985 in Froese and Pauly 2002). Estimated size at maturity and age at first maturity are 26.7 cm TL and 3.2 years, respectively. Approximate life span is 13.6 years; natural mortality rate, 0.50 (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in March and May (Erdman 1976). This fish feeds on sponges, algae, bryozoans, zoantharians, gorgonians and tunicates. Juveniles tend cleaning stations, servicing jacks, snappers, morays, grunts, surgeonfishes, wrasses, and other reef fish (Allen 1985 in Froese and Pauly 2002).

5.2.1.3.28 Damselfishes, Pomacentridae

The Pomacentridae family contains 321 species in 28 genera, distributed in all tropical seas across the globe, but primarily in the Indo-Pacific (Allen 1991 in Froese and Pauly 2002). Nest-guarding behavior is characteristic of all males (Allen 1991 in Froese and Pauly 2002). Four genera are represented in the Caribbean reef fish fishery management unit: *Abudefduf*, *Chromis*, *Microspathodon*, and *Pomacentrus*.

5.2.1.3.28.1 Sergeant major, *Abudefduf saxatilis*

The sergeant major occurs in the Atlantic and Western Pacific Oceans. In the Western Atlantic, it ranges from Rhode Island (USA) to Uruguay, including the Carribean Sea. This species is believed to be of minor importance to commercial fisheries, but also is utilized in the aquarium trade, and has been reared in captivity (Allen 1991 in Froese and Pauly 2002).

A sedentary species, the sergeant major is found to depths of 15 m. Juveniles are common in tide pools; adults are found over shallow reef tops. Maximum reported size is 22.9 cm TL (male); maximum weight, 200 g (Allen 1991 in Froese and Pauly 2002). Estimated size at maturity is 14.6 cm TL; natural mortality rate, 0.82 (Froese and Pauly 2002). Males are known to brood eggs. These fishes feed on algae, small crustaceans, and fish, and various invertebrate larvae. Adults frequently form large feeding aggregations of up to several hundred individuals (Allen 1991 in Froese and Pauly 2002).

5.2.1.3.28.2 Blue chromis, *Chromis cyanea*

The blue chromis occurs in the Atlantic Ocean, off Bermuda, southern Florida (USA), in the Gulf of Mexico, and throughout the Carribean Sea, including the Bahamas, and Antilles. This species is utilized primarily in the aquarium trade (Allen 1991 in Froese and Pauly 2002).

The blue chromis is encountered in 3-60 m depth, but commonly occurs above deep outer reefs. It is sedentary, and retreats into coral crevices when frightened. Maximum reported size is 15 cm TL (male) (Allen 1991 in Froese and Pauly 2002). Estimated size at maturity is 10 cm TL; natural mortality rate, 1.60 (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in April (Erdman 1976). This fish feeds on zooplankton, primarily copepods. It often associates with the creole wrasse (Allen 1991 in Froese and Pauly 2002).

5.2.1.3.28.3 Sunshinefish, *Chromis insolata*

The sunshinefish occurs in the Atlantic Ocean, off Bermuda, Florida (USA), and the Bahamas, and throughout the Caribbean Sea. This species is utilized primarily in the aquarium trade, but also may be taken incidentally in traps and small-meshed beach nets (Allen 1991 in Froese and Pauly 2002).

A sedentary species, the sunshinefish inhabits outer and seaward reefs, from 20-100 m depth. Maximum reported size is 16 cm TL (male) (Allen 1991 in Froese and Pauly 2002). Estimated size at maturity is 10.6 cm TL; natural mortality rate, 1.53 (Froese and Pauly 2002). This fish feeds on plankton (Allen 1991 in Froese and Pauly 2002).

5.2.1.3.28.4 Yellowtail damselfish, *Microspathodon chrysurus*

The yellowtail damselfish occurs in the Atlantic Ocean, ranging from Bermuda to Venezuela and Brazil, and throughout the Caribbean Sea, including the Antilles. This species is taken by subsistence fishermen and is utilized in the aquarium trade. It is occasionally marketed fresh, and has been reared in captivity (Allen 1991 in Froese and Pauly 2002).

The yellowtail damselfish can be encountered to 120 m depth, but is generally found in very shallow waters of coral reefs, usually near top of outer edge where there are caves, holes, and abundant fire coral. Maximum reported size is 21 cm TL (male) (Allen 1991 in Froese and Pauly 2002). Estimated size at maturity is 13.5 cm TL; natural mortality rate, 0.87 (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in March (Erdman 1976). Fire coral polyps, and other invertebrate animal materials, constitute a portion of its diet. But this territorial and sedentary species feeds primarily on algae. Juveniles, in particular, associate with fire coral, and occasionally pick parasites from other species of fish (Allen 1991 in Froese and Pauly 2002).

5.2.1.3.28.5 Dusky damselfish, *Pomacentrus fuscus*

Some authors describe the dusky damselfish as belonging to the genus *Stegastes* (e.g., *S. fuscus*). It also is described as the species, *dorsopunicans* (e.g., *P. dorsopunicans*; *S. dorsopunicans*). This fish occurs in the Western Atlantic, off southern Florida (USA), the Bahamas, and in the Caribbean Sea. It is utilized primarily in the aquarium trade, but also may be taken incidentally in traps and small-meshed beach nets (Allen 1991 in Froese and Pauly 2002).

This sedentary and territorial species inhabits rocky shores that are exposed to wave action. It occurs to depths of 3 m, and is often encountered in tide pools. Maximum reported size is 15 cm TL (male) (Allen 1991 in Froese and Pauly 2002). Estimated size at maturity is 8.6 cm TL; natural mortality rate, 1.81 (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in January, June, and September (Erdman 1976). Algae and detritus are the main components of its diet (Allen 1991 in Froese and Pauly 2002).

5.2.1.3.28.6 Beaugregory, *Pomacentrus leucostictus*

Some authors describe this species as belonging to the genera *Stegastes*. It occurs in the Western Atlantic, ranging from Bermuda to Brazil, including the northern Gulf of Mexico (Allen 1991 in Froese and Pauly 2002) and Caribbean Sea. The beaugregory is utilized primarily in the aquarium trade, but also may be taken incidentally in traps and small-meshed beach nets.

The beaugregory occurs in seagrass beds, coral or rocky reefs, and sandy areas, to depths of 10 m. It also can be encountered around mangrove shores and sponge beds. It is less common on flourishing coral reefs. A sedentary species, it usually remains within about 50 cm from the substrate. Maximum reported size is 10 cm TL (male) (Allen 1991 in Froese and Pauly 2002). Estimated size at maturity is 7 cm TL; natural mortality rate, 2.12 (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in September (Erdman 1976). Juveniles feed on copepods, nemerteans and polychaetes; adults, on algae, polychaetes, amphipods, foraminiferans, and gastropods (Allen 1991 in Froese and Pauly 2002).

5.2.1.3.28.7 Bicolor damselfish, *Pomacentrus partitus*

Some authors describe this species as belonging to the genera *Stegastes*. It occurs in the Western Atlantic, ranging from southern Florida (USA) southward to (possibly) Brazil, including the Bahamas and the Caribbean Sea. The bicolor damselfish is primarily an aquarium trade species. But it also may be taken incidentally in traps and small-meshed beach nets (Allen 1991 in Froese and Pauly 2002).

This species inhabits shallow coral reefs and isolated patch reefs in waters as deep as 100 m. A sedentary and territorial fish, it feeds primarily on algae, but also on polychaetes, hydroids, copepods, and ascidians. Maximum reported size is 10 cm TL (male) (Allen 1991 in Froese and Pauly 2002). Estimated size at maturity is 7 cm TL; natural mortality rate, 2.12 (Froese and Pauly 2002).

5.2.1.3.28.8 Threespot damselfish, *Pomacentrus planifrons*

Some authors describe this species as belonging to the genera *Stegastes*. It occurs in the Western Atlantic, off southern Florida (USA), and throughout the Caribbean Sea. The threespot damselfish is utilized primarily in the aquarium trade, but also may be taken incidentally in traps and small-meshed beach nets (Allen 1991 in Froese and Pauly 2002).

Also a sedentary and territorial species, the threespot damselfish inhabits inshore and offshore coral reefs. It can be found to 30 m depth, often in tangles of staghorn coral. It tends to seek the shelter of caves at night. This fish is highly resilient, with a minimum population doubling time of less than 15 months (K=0.33-0.58). Maximum reported size is 13 cm TL (male) (Allen 1991 in Froese and Pauly 2002). Estimated size at maturity and age at first maturity are 9.3 cm TL and 1.4 years, respectively. Approximate life span is 4.8 years; natural mortality rate, 1.38 (Froese and Pauly 2002). Juveniles feed on the external parasites of fishes. Adults feed mainly on algae, but also consume copepods, small gastropods, mollusk eggs, sponges, polychaetes, and hydroids (Allen 1991 in Froese and Pauly 2002).

5.2.1.3.29 Bigeyes, Priacanthidae

The Priacanthidae family contains 18 species in 4 genera, distributed in the tropical and subtropical Atlantic, Indian, and Pacific Oceans (Starnes 1988 in Froese and Pauly 2002). The two species included in the Caribbean reef fish fishery management unit belong to the genus *Priacanthus*.

5.2.1.3.29.1 Bigeye, *Priacanthus arenatus*

Also known as the "Atlantic bigeye," this species occurs in tropically influenced areas of the Atlantic Ocean. In the Western Atlantic, it ranges from Bermuda and North Carolina (USA), southward to northern Argentina (Starnes 1988 in Froese and Pauly 2002), including the Caribbean Sea. Its flesh, considered to be of excellent quality, is marketed fresh. This species also is taken in recreational fisheries and is utilized in the aquarium trade (Starnes 1988 in Froese and Pauly 2002). It can be ciguatoxic (Halstead 1970).

The bigeye is an epibenthic species, inhabiting coral reefs and rocky bottoms from 10-200 m depth. It has been observed to form small aggregations near the sea bottom. Maximum reported size is 50 cm TL (male); maximum weight, 2,850 g (Starnes 1988 in Froese and Pauly 2002). Estimated size at maturity and age at first maturity are 26.8 cm TL and 1 year, respectively. Approximate life span is 4.2 years; natural mortality rate, 1.17 (Froese and Pauly 2002). Eggs, larvae and early juvenile stages are pelagic. It feeds at night, primarily on larvae, small fishes, crustaceans, and polychaetes (Starnes 1988 in Froese and Pauly 2002).

5.2.1.3.29.2 Glasseye snapper, *Priacanthus cruentatus*

Also known simply as the "glasseye," this species is widely distributed in tropical and tropically influenced areas around the globe. In the Western Atlantic, it ranges from Florida (USA) to Argentina, including the Gulf of Mexico and Caribbean Sea. This species is marketed fresh, but is believed to be of minor importance to commercial fisheries. It also is utilized in the aquarium trade (Starnes 1988 in Froese and Pauly 2002). According to Dammann (1969), in Froese and Pauly (2002), it can be ciguatoxic.

The glasseye snapper is found from 5-300 m depth. It most commonly occurs in lagoon and seaward reefs, primarily around islands, and can be found under or near ledges by day. Juveniles are pelagic; adults demersal. Maximum reported size is 50.7 cm TL (male); maximum weight, 2,725 g (Starnes 1988 in Froese and Pauly 2002). Estimated size at maturity is 29.4 cm TL; natural mortality rate, 0.47 (Froese and Pauly 2002). This fish is usually solitary or occurs in small groups during the day. But at dusk it may gather in large numbers (Starnes 1988 in Froese and Pauly 2002). Spawning aggregations composed of about 200 individuals have been observed to occur at 21 m depth in the USVI National Park, off St. John, USVI (Rielinger 1999). A nocturnal species, the glasseye snapper feeds primarily on octopi, pelagic shrimp, stomatopods, crabs, small fish, and polychaetes (Starnes 1988 in Froese and Pauly 2002).

5.2.1.3.30 Parrotfishes, Scaridae

The Scaridae family contains 83 species in 9 genera, distributed in the Atlantic, Indian, and Pacific Oceans (Nelson 1994 in Froese and Pauly 2002). The 10 species in the Caribbean reef fish fishery management unit belong to one of two genera: *Scarus* or *Sparisoma*. All these species are marketed for food, but are considered to be of minor importance to commercial fisheries. With the exception of the midnight parrotfish, *Scarus coelestinus*, all are utilized in the aquarium trade.

Parrotfishes are tropical shallow-water fishes, which commonly occur on or adjacent to coral reef habitat, but also can be found over rocky shores and substrates. They have a tendency to exhibit residential behavior for variable periods of time, but may move over distances of up to several hundred meters during feeding (Reeson 1975b). These fishes are herbivores. Most species feed on algae scraped from dead coral substrates. The common practice of consuming and crushing bits of rock along with the algae to aid in the digestive process make these fishes some of the most important producers of sand on coral reefs (Nelson 1994 in Froese and Pauly 2002).

Parrotfishes are diurnally active, feeding during the day and resting at night. They tend to aggregate in shallow waters near dusk, then move to deeper areas before nightfall. Mixed-species aggregations may occur, or the schools may also contain representatives of other families. For example, it is common around Jamaica to find members of the Surgeonfish (Acanthuridae), Goatfish (Mullidae), Grunt (Pomadasyidae) and Wrasse (Labridae) families in association with the usually numerically dominant striped parrotfish (*Scarus croicensis*) (Reeson 1975b).

Many species undergo sex reversal, with an initial phase of both males and females, and the latter changing into a brilliantly colored male terminal phase. Terminal males dominate several females. These fishes are pelagic spawners (Nelson 1994 in Froese and Pauly 2002); some spawn in pairs; others in small groups or aggregations (Reeson 1975b). Juveniles are present in the northeastern Caribbean year-round (Erdman 1976). Moray eels are believed to be important predators. Other predators include groupers, jacks, and snappers (Reeson 1975b). With the exception of the midnight parrotfish, all species in the Caribbean fishery management unit have been known to cause ciguatera poisoning.

5.2.1.3.30.1 Midnight parrotfish, *Scarus coelestinus*

The midnight parrotfish occurs in the Western Atlantic, ranging from Bermuda to Brazil, including the Caribbean Sea (Robins and Ray 1986 in Froese and Pauly 2002).

The midnight parrotfish occurs from rocky coastal reefs to seaward reefs, in depths of 5-75 m. It is often encountered in schools, feeding on algae along with surgeonfishes. Maximum reported size is 77 cm TL (male); maximum weight, 7,000 g (Robins and Ray 1986 in Froese and Pauly 2002). The midnight parrotfish has been observed to spawn in pairs. A Jamaican study reported that the highest proportion of active and ripe fishes was confined to the period between January

and May. Spawning seems to be confined to the warmer months of the year in Bermuda (Reeson 1975b).

5.2.1.3.30.2 Blue parrotfish, *Scarus coeruleus*

The blue parrotfish occurs in the Western Atlantic, ranging from Maryland (USA) and Bermuda to Brazil, including the Caribbean Sea (Robins and Ray 1986 in Froese and Pauly 2002).

The blue parrotfish inhabits coral reef habitat, occurring from 3-25 m depth. Juveniles are found on seagrass (*Thalassia*) beds. Maximum reported size is 120 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Estimated size at maturity is 62.9 cm TL; natural mortality rate, 0.43 (Froese and Pauly 2002). This fish is known to form large spawning aggregations (Robins and Ray 1986 in Froese and Pauly 2002). In Jamaican waters, the highest proportion of active and ripe fishes occurs between January and May (Reeson 1975b). Dietary items include benthic plants and small organisms in the sand (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.30.3 Striped parrotfish, *Scarus croicensis*

The striped parrotfish occurs in the Western Atlantic, ranging from Bermuda to northern South America (and possibly Brazil), including the Gulf of Mexico and Caribbean Sea (Böhlke and Chaplin 1993).

The striped parrotfish is found over shallow, clear waters, from 3-25 m depth. It is a schooling species, and generally occurs over seagrass (*Thalassia*) beds, but also is found in rocky or coral areas. Maximum reported size is 35 cm TL (male) (Böhlke and Chaplin 1993). Size at maturity is estimated in Froese and Pauly (2002) as 21.2 cm TL; natural mortality rate, 0.61. A study conducted in Bermuda reports that males mature at 11-13 cm SL and females, at 9-10 cm SL (Reeson 1975b). Supermales spawn individually with striped females, while sexually mature males in the striped phase spawn in aggregations (Böhlke and Chaplin 1993) of up to 400 individuals (Reeson 1975b). One spawning aggregation site has been documented off the southwest coast of Puerto Rico. Striped parrotfish have been observed to spawn at that site in winter months at about 20-30 m depth (Rielinger 1999). This species has been observed to spawn in the Virgin Islands in February, March, April, June, and August. Deeper reef fronts (15-20 m) appear to be the focal points for spawning groups. It has been observed to migrate daily among specific routes (Reeson 1975b). It feeds on plants (Böhlke and Chaplin 1993).

5.2.1.3.30.4 Rainbow parrotfish, *Scarus guacamaia*

The rainbow parrotfish occurs in the Western Atlantic, ranging from Bermuda to Argentina, including the Caribbean Sea (Robins and Ray 1986 in Froese and Pauly 2002).

The rainbow parrotfish species is found from 3-25 m depth. Juveniles are commonly encountered in mangrove areas. It inhabits a home cave at night and when threatened.

Maximum reported size is 120 cm TL (male); maximum weight, 20 kg (Robins and Ray 1986 in Froese and Pauly 2002). Estimated size at maturity is 62.9 cm TL; natural mortality rate, 0.43 (Froese and Pauly 2002). In Jamaican waters, the highest proportion of active and ripe fishes appear to be confined to the period between January and May (Reeson 1975b). In the northeastern Caribbean, individuals in spawning condition have been observed in June and July (Erdman 1976). This fish feeds primarily on benthic algae (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.30.5 Princess parrotfish, *Scarus taeniopterus*

The princess parrotfish occurs in the Western Atlantic, ranging from Bermuda to Brazil, and throughout the Caribbean Sea (Robins and Ray 1986 in Froese and Pauly 2002).

The princess parrotfish is found on coral or rock bottoms, from 2-25 m depth. Juveniles often occur in association with seagrass (*Thalassia*). Maximum reported size is 35 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 21.2 cm TL; natural mortality rate, 0.88 (Froese and Pauly 2002). This species appears to spawn throughout the year in Jamaican waters, with the highest proportion of ripe fishes occurring in December and January (Reeson 1975b). It feeds on plants in large aggregations, and sleeps in a mucus cocoon (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.30.6 Queen parrotfish, *Scarus vetula*

The queen parrotfish occurs in the Western Central Atlantic, ranging from Bermuda to northern South America, and throughout the Caribbean Sea (Robins and Ray 1986 in Froese and Pauly 2002).

The queen parrotfish inhabits coral reefs and adjacent habitats, from 3-25 m depth. It is often observed in groups of one supermale with several young adults, most of which are believed to be females. Maximum reported size is 61 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 30.6 cm TL and 1.1 years, respectively. Approximate life span is 4.8 years; natural mortality rate, 1.05 (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in January, February, May, June, and August (Erdman 1976). Spawning pairs have been observed in August and January off the Virgin Islands and Puerto Rico, respectively (Reeson 1975b). The queen parrotfish feeds on algae and sleeps in a mucus cocoon (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.30.7 Redband parrotfish, *Sparisoma aurofrenatum*

The redband parrotfish occurs in the Western Atlantic, ranging from Bermuda to Brazil, and throughout the Caribbean Sea (Robins and Ray 1986 in Froese and Pauly 2002).

The redband parrotfish inhabits coral reefs, occurring from 2-20 m depth. Juveniles are usually found in adjacent seagrass beds. It is often observed resting on the sea bottom, either solitary or in small groups. This species is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.20). Maximum reported size is 28 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity is estimated as 17.4 cm TL; natural mortality rate, 1.14 (Froese and Pauly 2002). Reeson (1975b) reports that spawning has been observed to occur off the Virgin Islands in the months of March, April, June, and August. Erdman (1976) reports that individuals also have been observed in spawning condition in the northeastern Caribbean in February and December (Erdman 1976). Ripe fishes have been caught in both the nearshore and offshore environment. And pair spawning has been observed (Reeson 1975b). It feeds on plants (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.30.8 Redtail parrotfish, *Sparisoma chrysopterum*

The redtail parrotfish occurs in the Western Atlantic, ranging from southern Florida (USA) to Brazil, and throughout the Caribbean Sea (Robins and Ray 1986 in Froese and Pauly 2002).

The redtail parrotfish occurs in coral reefs and adjacent habitats to depths of 15 m. Juveniles most commonly inhabit seagrass beds. Maximum reported size is 46 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 23.9 cm FL and 0.9 years, respectively; approximate life span, 3.6 years. Estimated size at 50% maturity based on fishery independent and dependent data collected from Puerto Rican waters is 23.5 cm FL (females). Transitional fish ranged from 20.1 cm FL to 24.8 cm FL (Figuerola and Torres 1997). No estimate of natural mortality rate is available for this species. Spawning period is protracted. According to Figuerola and Torres (1997), no peaks are apparent in the U.S. Caribbean, but spawning activity appears to decrease during the summer (May through August). Data from a Jamaican study indicate that the highest proportion of active and ripe fishes occurs between January and May (Reeson 1975b). The redtail parrotfish feeds on benthic algae and seagrasses (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.30.9 Redfin parrotfish, *Sparisoma rubripinne*

The redfin parrotfish occurs in both the Eastern and Western Atlantic. In the Western Atlantic, this species ranges from Massachusetts (USA) to Brazil, and throughout the Caribbean Sea. It is apparently absent in the Gulf of Mexico (Randall 1990 in Froese and Pauly 2002).

The redfin parrotfish inhabits coral reefs and seagrass beds to depths of 15 m. Maximum reported size is 47.8 cm TL (male) (Randall 1990 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 28.3 cm TL and 1.2 years, respectively. Approximate life span is 4.9 years; natural mortality rate, 1.05 (Froese and Pauly 2002). Spawning usually occurs in small groups (Randall 1990 in Froese and Pauly 2002), but also in pairs. Deeper reef fronts (15-20 m) appear to be the focal points for spawning groups. Data collected in a Jamaican study indicate that the highest proportion of active and ripe fishes occurs between January and

May. Ripe males and females have been collected in all months of the year off the Virgin Islands (Reeson 1975b). The redfin parrotfish feeds on benthic algae and seagrasses (Randall 1990 in Froese and Pauly 2002).

5.2.1.3.30.10 Stoplight parrotfish, *Sparisoma viride*

The stoplight parrotfish occurs in the Western Atlantic, ranging from southern Florida (USA) to Brazil, and throughout the Caribbean Sea (Cervigón *et al.* 1992 in Froese and Pauly 2002).

The stoplight parrotfish inhabits clear water coral reefs, occurring from 3-49 m depth. Juveniles may be found in seagrass beds and other heavily vegetated bottoms. This species is strictly diurnal, and spends the night resting on the sea bottom. It occurs singly or in small groups. Maximum reported size is 64 cm TL (male); maximum weight, 1,600 g. This fish is a protogynous hermaphrodite, functioning first as a female and, later, as a male (Cervigón *et al.* 1992 in Froese and Pauly 2002). Size at maturity is estimated in Froese and Pauly (2002) as 36.1 cm TL; natural mortality rate, 0.66. Size at 50% maturity estimated from a survey conducted off Puerto Rico is 20.5 cm FL (females) (Figuerola and Torres 1997). A Bermuda study reports that males mature at 16-20 cm SL and females at 16.3 cm SL (Reeson 1975b).

Spawning period is protracted. According to Figuerola and Torres (1997), no peaks are apparent in the U.S. Caribbean, but spawning activity appears to decrease during the summer (May through August). Pair spawning has been observed in May off the Virgin Islands (Reeson 1975b). This fish feeds primarily on soft algae, but also has been observed to graze on live corals, such as *Montastrea annularis*. It produces a significant amount of sediment through bioerosion using its strong beak-like jaws and constantly regrowing teeth (Cervigón *et al.* 1992 in Froese and Pauly 2002).

5.2.1.3.31 Drums, Sciaenidae

The Sciaenidae family contains 270 species in 70 genera, distributed in the Atlantic, Indian and Pacific Oceans (Nelson 1994 in Froese and Pauly 2002). Only the genus *Equetus* is represented in the Caribbean reef fish fishery management unit.

5.2.1.3.31.1 High-hat, *Equetus acuminatus*

The high-hat occurs in the Western Atlantic, ranging from North Carolina (USA) and Bermuda, southward to Brazil. This species is believed to be of minor importance to commercial fisheries, but also is utilized in the aquarium trade. It has been reared in captivity (Robins and Ray 1986 in Froese and Pauly 2002).

The high-hat occurs in clear waters of tropical islands, usually near coral reefs, but also in adjacent bays over rough bottom. It also is often found under the eroded edges of seagrass beds.

Maximum reported size is 23 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Estimated size at maturity is 14.6 cm TL; natural mortality rate, 1.18 (Froese and Pauly 2002).

5.2.1.3.31.2 Jackknife-fish, *Equetus lanceolatus*

The jacknife-fish occurs in the Western Atlantic, ranging from Bermuda and North Carolina (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. This species is believed to be of minor importance to commercial fisheries, but also is utilized in the aquarium trade. It has been reared in captivity (Robins and Ray 1986 in Froese and Pauly 2002). Olsen *et al.* (1984), in Froese and Pauly (2002), report that it can be ciguatoxic.

A demersal species, the jacknife-fish inhabits bays, sounds, and coral reefs, occurring from 10-60 m depth. This fish is easily approached. Maximum reported size is 25 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Estimated size at maturity is 15.7 cm TL; natural mortality rate, 1.11 (Froese and Pauly 2002). It feeds primarily on small shrimps and crabs, but also consumes polychaete worms and gastropod mollusks (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.31.3 Spotted drum, *Equetus punctatus*

The spotted drum occurs in the Western Atlantic, ranging from Bermuda to Brazil, including the Caribbean Sea. This species is believed to be of minor importance to commercial fisheries, but also is utilized in the aquarium trade. It has been reared in captivity (Robins and Ray 1986 in Froese and Pauly 2002). Olsen *et al.* (1984), in Froese and Pauly (2002), reports that it can be ciguatoxic.

The spotted drum occurs from 3-30 m depth; primarily on coral reefs. It is secretive and, usually, solitary, found under ledges or near small caves. It is often observed during the day around the bases of corals, and is easily approached. Maximum reported size is 27 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Estimated size at maturity is 16.9 cm TL; natural mortality rate, 1.05 (Froese and Pauly 2002). This fish feeds at night on crabs, shrimps, and polychaetes (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.32 Scorpionfishes, Scorpaenidae

The Scorpaenidae family contains 172 species in 23 genera, distributed in all tropical and temperate seas (Nelson 1994 in Froese and Pauly 2002). All species are utilized in the aquarium trade.

Scorpionfishes are benthopelagic fishes. Most species live in the shallow water of the continental shelves, although a few species occur on the continental slope (MBARI 2003). Fertilization is internal for most species. Some lay eggs in a gelatinous balloon. Larvae are planktonic (Nelson 1994 in Froese and Pauly 2002). The majority of scorpaenids are sit and wait

predators that either lie on the bottom or hover above a reef or rock outcrop waiting for prey such as fish, crustacean, or cephalopods to swim by (MBARI 2003).

5.2.1.3.33 Groupers, hinds, and sea basses, Serranidae

The Serranidae family contains 449 species in 62 genera, distributed in tropical and temperate oceans across the globe. These species are monoecious, with some functional hermaphrodites (Nelson 1994 in Froese and Pauly 2002). Protogynous hermaphroditism is known to occur in several species of groupers, although in related serranids synchronous hermaphroditism is also encountered. A broad overlap of the length distributions of the sexes is encountered in most species and suggests that there is no close correlation of age or size with sexual transition (Thompson and Munro 1974b). Seven genera are represented in the Caribbean reef fish fishery management unit: *Epinephelus*, *Mycteroperca*, *Hypoplectrus*, *Liopropoma*, *Paranthias*, *Rypticus*, and *Serranus*. Many groupers, but especially the largest Epinephelus species, appear to be the resident apex predators of the reef systems that they inhabit (Huntsman *et al.* 1999).

5.2.1.3.33.1 Rock hind, *Epinephelus adscensionis*

The rock hind occurs in both the Western and Eastern Atlantic. In the Western Atlantic, it ranges from Massachusetts (USA) to southern Brazil, including the Gulf of Mexico and Caribbean Sea. This species is taken in both commercial and recreational fisheries. Its flesh is considered to be of good quality (Heemstra and Randall 1993 in Froese and Pauly 2002). But Halstead (1970), in Froese and Pauly (2002), reports that it can be ciguatoxic.

The rock hind is a demersal species, inhabiting rocky reef habitat to depths of 120 m. It is usually solitary and is difficult to approach. This fish is of low resilience, with a minimum population doubling time of 4.5 - 14 years (K=0.11). Maximum reported size is 61 cm TL (male); maximum weight, 4,080 g (Heemstra and Randall 1993 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 28 cm TL and 6.1 years, respectively. Approximate life span is 25.9 years; natural mortality rate, 0.25 (Ault *et al.* 1998). This fish has been observed to spawn in aggregations near the shelf edge off the southwest coast of Puerto Rico, at 20-30 m depth, in the month of January (Rielinger 1999). Off Cuba, rock hind have been reported to spawn during January through March (Garcia-Cagide *et al.* 1994). Crabs comprise the majority of its diet, but it also has been observed to feed on fishes and young sea turtles (Heemstra and Randall 1993 in Froese and Pauly 2002).

5.2.1.3.33.2 Graysby, *Epinephelus cruentatus*

The graysby occurs in the Western Central Atlantic, from North Carolina to southern Florida (USA), off Bermuda, and in the Gulf of Mexico and Caribbean Sea. Its small size generally makes it of minor importance to commercial fisheries (Heemstra and Randall 1993 in Froese and Pauly 2002). Olsen *et al.* (1984), in Froese and Pauly (2002), reports that it can be ciguatoxic.

The graysby inhabits seagrass (*Thalassia*) beds and coral reefs, and can be found to 170 m depth. It is sedentary, solitary, and secretive, usually hiding during the day, and feeding at night. But it is easily approached and fed by divers. This fish is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.34-0.35; tm=3.5-5.5; tmax=9; Fec=260,000). Maximum reported size is 42.6 cm TL (male); maximum weight, 1,130 g. The graysby is hermaphroditic (Heemstra and Randall 1993 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 19.8 cm TL and 2 years, respectively (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in March, and in May through July (Erdman 1976). Nagelkerken (1979) determined that graysby collected in the Caribbean were in spawning condition from July through October. Approximate life span is 8.1 years; natural mortality rate, 0.20 (Ault *et al.* 1998). Juveniles feed on shrimp; adults, primarily on fishes. The brown chromis, *chromis multilineata*, has been identified as a preferred food item (Heemstra and Randall 1993 in Froese and Pauly 2002).

5.2.1.3.33.3 Yellowedge grouper, *Epinephelus flavolimbatus*

The yellowedge grouper occurs in the Western Atlantic, ranging from North Carolina (USA) to southern Brazil, including the Gulf of Mexico and the Caribbean Sea. Its flesh is considered to be of good quality, and is marketed fresh. It is taken in both commercial and recreational fisheries (Heemstra and Randall 1993 in Froese and Pauly 2002).

A solitary and demersal species, the yellowedge grouper occurs in rocky areas and on sand mud bottom, ranging from 64-275 m depth. On soft bottoms, it is often seen in or near trenches or burrow-like excavations. This fish is of low resilience, with a minimum population doubling time of 4.5 - 14 years (K=0.10; tmax=35). Maximum reported size is 115 cm TL (male); maximum weight, 18.6 kg (Heemstra and Randall 1993 in Froese and Pauly 2002). Estimated size at maturity and age at first maturity are 50.5 cm TL and 6.2 years, respectively (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in April (Erdman 1976). Spawning is reported to occur during April through October in the South Atlantic (Keener 1984) and May through September in the Gulf of Mexico (Bullock *et al.*1996). Maximum reported age is 32 years (Heemstra and Randall 1993 in Froese and Pauly 2002). Natural mortality rate is estimated as 0.20 (Ault *et al.* 2002). It feeds on a wide variety of invertebrates (mainly brachyuran crabs) and fishes (Heemstra and Randall 1993 in Froese and Pauly 2002).

5.2.1.3.33.4 Coney, *Epinephelus fulvus*

The coney occurs in the Western Atlantic, ranging from South Carolina (USA) and Bermuda to southern Brazil, including Atol das Rocas. Wary, but approachable, this species is taken in commercial fisheries and also is utilized in the aquarium trade (Heemstra and Randall 1993 in Froese and Pauly 2002). Olsen *et al.* (1984), in Froese and Pauly (2002), report that it can be ciguatoxic.

The coney is a sedentary species. It prefers coral reefs and clear water, and can be found to depths of 150 m. This fish is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.14-0.63; Fec=67,000). Maximum reported size is 41 cm TL (male). It is a protogynous hermaphrodite (Heemstra and Randall 1993 in Froese and Pauly 2002). Size at maturity and age at first maturity estimated in Froese and Pauly (2002) is 19.8 cm TL and 1.1 years, respectively. Size at 50% maturity for female coneys sampled off the west coast of Puerto Rico is 13 cm FL (Figuerola and Torres 2000). Heemstra and Randall (1993), in Froese and Pauly (2002), report that females mature at 16 cm TL and transform to males at about 20 cm TL. The approximate life span of this fish is 4.5 years; natural mortality rate, 0.18 (Ault *et al.* 1998).

Several studies have indicated that the coney does not form spawning aggregations. Spawning occurs in pairs within small groups composed of one male and multiple females. Although ripe ovaries are found from November to March off the west coast of Puerto Rico, spawning activity appears to be limited to several days around the last quarter and new moon phases during January and February (Figuerola and Torres 2000). The diet of this fish is composed primarily of small fishes and crustaceans. It may follow morays and snake eels to feed on flushed preys (Heemstra and Randall 1993 in Froese and Pauly 2002).

5.2.1.3.33.5 Red hind, *Epinephelus guttatus*

The red hind occurs in the Western Atlantic, ranging from North Carolina (USA) to Venezuela, including the Caribbean Sea. An excellent food fish, this species is readily caught on hook and line, and is easily speared by divers. It is taken in both commercial and recreational fisheries, and is utilized in the aquarium trade (Heemstra and Randall 1993 in Froese and Pauly 2002). Halstead (1970), in Froese and Pauly (2002), reports that it can be ciguatoxic.

The red hind is found in shallow reefs and rocky bottoms, from 2-100 m depth. It is usually solitary and territorial. This species is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.12-0.24; tm=3; tmax=17; Fec=96,000). Maximum reported size is 76 cm TL (male); maximum weight, 25 kg (Heemstra and Randall 1993 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 31.4 cm TL and 5.5 years, respectively. Figuerola and Torres (2000) estimate size at maturity as 21.7 cm FL based on data collected in a study conducted off the west coast of Puerto Rico. The approximate life span of this fish is 23.8 years; natural mortality rate, 0.18 (Ault *et al.* 1998). One study showed 233,273 eggs for a specimen of 35.8 cm SL (Thompson and Munro 1974b).

The red hind is a protogynous hermaphrodite (Thompson and Munro 1974b). Thompson and Munro (1974b) report that mean size at sex reversal appears to be in the region of 38 cm TL. But, according to Heemstra and Randall (1993), in Froese and Pauly (2002), some individuals have been observed to undergo sexual inversion at just 28 cm TL. CFMC (1985) reports size at sex reversal as 35 cm TL. Most fish larger than 40 cm are males, which is important in terms of numbers caught and total weight of landings in the Caribbean (Heemstra and Randall 1993 in Froese and Pauly 2002).

This species aggregates in large numbers during the spawning season (Coleman *et al.* 2000; Sadovy *et al.* 1994). A number of spawning aggregation sites have been documented in the U.S. Caribbean. Three sites are located off the western coast of Puerto Rico. A fourth site is located near the shelf edge off the southwest coast of Puerto Rico, El Hoyo and La Laja, and is utilized by as many as 3,000 individuals at 20-30 m depth. A fifth site is located on the Lang Bank, north-northeast of St. Croix, and is characterized by aggregations from 38-48 m depth. Finally, a sixth site is located south of St. Thomas, USVI. That aggregation also generally occurs at 38-48 m depth. The timing of aggregations is somewhat variable. Aggregations off Puerto Rico generally occur from January through March in association with the full moon, while those off the USVI generally occur from December through March in association with the full moon (Rielinger 1999). The red hind feeds mainly on crabs and other crustaceans, fishes, such as labrids and haemulids, and octopus (Heemstra and Randall 1993 in Froese and Pauly 2002).

5.2.1.3.33.6 Goliath grouper, *Epinephelus itajara*

The Goliath grouper, formerly known as the "jewfish," occurs in the Western and Eastern Atlantic, and in the Eastern Pacific Ocean. In the Western Atlantic, its range extends from Florida (USA) to southern Brazil, including the Gulf of Mexico and the Caribbean Sea. Considered to be of excellent quality, its flesh is marketed both fresh and salted. It is targeted in both commercial and recreational fisheries (Heemstra and Randall 1993 in Froese and Pauly 2002). But the take and possession of the Goliath grouper has been prohibited in both federal and state waters of the USVI. Puerto Rico implemented new regulations on March 12, 2004, to prohibit the possession or sale of Goliath grouper.

A solitary species, the Goliath grouper inhabits rock, coral, and mud bottom habitats, from shallow, inshore areas to depths of 100 m (Heemstra and Randall 1993 in Froese and Pauly 2002) or 150 m (NMFS 2001a). Juveniles are generally found in mangrove areas and brackish estuaries. Large adults also may be found in estuaries. They appear to occupy limited home ranges with little inter-reef movement (Heemstra and Randall 1993 in Froese and Pauly 2002).

This species is of low resilience, with a minimum population doubling time of 4.5 - 14 years (K=0.13; tm=5.5-6.5). Maximum reported size is 250 cm TL (male); maximum weight, 455 kg (Heemstra and Randall 1993 in Froese and Pauly 2002). NMFS (2001a) reports that males generally range in size between 80-210 cm TL; females, from 30-220 cm. Estimated size at maturity and age at first maturity are 98 cm TL and 4.3 years, respectively (Froese and Pauly 2002). In the eastern Gulf of Mexico, males were found to mature at 110-115 cm TL, and females at 120-135 cm TL (Bullock *et al.*, 1992), at approximately 6 years of age.. Ault *et al.* (2002) estimate natural mortality rate to be 0.13. Fish taken from exploited populations range to 37 years of age. But it is likely that this species could live much longer than 40 years if left unexploited (NMFS 2001a).

This species exhibits definite or strongly suggestive indications of sex reversal (protogynous hermaphrodite) (Thompson and Munro 1974b). It forms consistent aggregations (always

containing the largest, oldest individuals in the population), but only during the spawning season (Coleman *et al.* 2000). Aggregations off Florida declined in the 1980s from 50-100 fish to less than 10 per site. Since the harvest prohibition, aggregations have rebounded somewhat to 20-40 fish per site. Spawning in that area occurs in July through September over full moon phases. Fish may move up to 100 km from inshore reefs to the offshore spawning aggregations in numbers of up to 100 or more on ship wrecks, rock ledges, and isolated patch reefs along the southwest coast (NMFS 2001a). In the northeastern Caribbean, individuals in spawning condition have been observed in July and August (Erdman 1976). Bullock *et al.* (1992) reported that goliath grouper spawn during June through December with a peak in July to September in the eastern Gulf of Mexico.

This fish feeds primarily on crustaceans, particularly spiny lobsters, as well as turtles and fishes, including stingrays.

5.2.1.3.33.7 Red grouper, *Epinephelus morio*

The red grouper occurs in the Western Atlantic, ranging as far north as Massachusetts (USA) to southern Brazil, including the Gulf of Mexico and Caribbean Sea. This species is taken in both commercial and recreational fisheries, and is utilized in the aquarium trade. It is marketed both fresh and frozen (Heemstra and Randall 1993 in Froese and Pauly 2002).

A sedentary species, the red grouper is usually found resting on rocky and muddy bottoms, from 5-300 m depth. It is uncommon around coral reefs. Juveniles can be found in shallow water, but adults are usually taken in waters deeper than 60 m. This fish is of low resilience, with a minimum population doubling time of 4.5 - 14 years (K=0.1-0.18; tm=4-6; tmax=25; Fec=1.4 million). It is a protogynous hermaphrodite. Maximum reported size is 125 cm TL (male); maximum weight, 23 kg. The world record for hook and line is 17.7 lbs, from Cape Canaveral, Florida (Heemstra and Randall 1993 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 47.1 cm TL and 5.2 years, respectively (Froese and Pauly 2002). Most females transform to males between ages 7 to 14. Maximum reported age is 25 years (Heemstra and Randall 1993 in Froese and Pauly 2002). Estimated natural mortality rate is 0.18 (Ault *et al.* 1998). In the northeastern Caribbean, individuals in spawning condition have been observed from February through May (Erdman 1976). It feeds on a wide variety of fishes and invertebrates (Heemstra and Randall 1993 in Froese and Pauly 2002).

5.2.1.3.33.8 Misty grouper, *Epinephelus mystacinus*

The misty grouper occurs in both the Western and Eastern Atlantic Ocean. In the Western Atlantic, it ranges from Bermuda and North Carolina (USA) to Mexico, including the Gulf of Mexico and Caribbean Sea. This species is taken in both commercial and recreational fisheries, and is marketed fresh (Heemstra and Randall 1993 in Froese and Pauly 2002).

The misty grouper is a solitary, bathydemersal, deep-water species, ranging from 30-400 m depth. Juveniles occur in shallower waters. Virtually nothing is known about the age, growth, and reproduction of this species. Maximum reported sizes are 160 cm TL and 100 cm TL for males and females, respectively. Maximum reported weight is 107 kg (Heemstra and Randall 1993 in Froese and Pauly 2002). Estimated size at maturity is 81.1 cm TL; natural mortality rate, 0.14 (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in January, April, August, and November (Erdman 1976). Prey items include fishes, crustaceans, and squids (Heemstra and Randall 1993 in Froese and Pauly 2002).

5.2.1.3.33.9 Nassau grouper, *Epinephelus striatus*

The Nassau grouper occurs in the tropical Western Atlantic, ranging from Bermuda, the Bahamas, and Florida (USA) to southern Brazil. It is not known from the Gulf of Mexico, except at the Campeche Bank off the coast of Yucatan, at Tortugas, and off Key West. This species is a popular food fish and also is utilized in the aquarium trade (Heemstra and Randall 1993 in Froese and Pauly 2002). However, the take and possession of Nassau grouper is prohibited in federal waters. Furthermore, Puerto Rico implemented new regulations on March 12, 2004, to prohibit the possession or sale of Nassau grouper. Its flesh is marketed fresh (Heemstra and Randall 1993 in Froese and Pauly 2002). Olsen *et al.* (1984), in Froese and Pauly (2002), report that it can be ciguatoxic.

The Nassau grouper occurs from the shoreline to at least 90 m depth. It is a sedentary, and reef-associated species, usually encountered close to caves; although juveniles are common in seagrass beds (Heemstra and Randall 1993 in Froese and Pauly 2002). Adults lead solitary lives outside of spawning aggregations (NMFS 2001b).

This fish is of low resilience, with a minimum population doubling time of 4.5 - 14 years (Musick *et al.* 2000 in Froese and Pauly 2002). Maximum reported size is 122 cm TL (male); maximum weight, 25 kg (Heemstra and Randall 1993 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 47.5 cm TL and 6.9 years, respectively. Approximate life span is 31.9 years (Froese and Pauly 2002); maximum reported age, 16 years (Heemstra and Randall 1993 in Froese and Pauly 2002). Ault *et al.* (1998) estimate natural mortality rate to be 0.18.

This fish was initially characterized as a protogynous hermaphrodite. But recent investigations of histological and demographic data, and the nature of the mating system, indicates that Nassau grouper may not be strictly protogynous. Thus, it has been characterized as gonochoristic (separate sexes), with a potential for sex change (NMFS 2001b). One study reported 785,101 eggs for a specimen of 35.8 cm SL (Thompson and Munro 1974b).

The Nassau grouper aggregates to spawn at specific times and locations each year (Coleman *et al.* 2000; Sadovy *et al.* 1994), reportedly at some of the same sites utilized by the tiger, yellowfin, and black groupers (Sadovy *et al.* 1994). Concentrated aggregations of a few dozen (NMFS

2001b) up to 30,000 Nassau groupers have been reported from the Bahamas, Jamaica, Cayman Islands, Belize, and the Virgin Islands (Heemstra and Randall 1993 in Froese and Pauly 2002). Spawning aggregations composed of about 2000 individuals have been documented north and south of St. Thomas, USVI, at 10-40 m depth, from December through February, around the time of the full moon (Rielinger 1999).

According to NMFS (2001b), spawning aggregations occur in depths of 20-40 m at specific locations of the outer reef shelf edge always in December and January around the time of the full moon in waters 25-26 degrees Celsius. Thompson and Munro (1974b) indicate that the spawning season probably extends from January to April in Jamaican waters. They report that spawning aggregations lasting up to two weeks have been encountered annually during late January to early February around the Cayman Islands (Thompson and Munro 1974b). In the northeastern Caribbean, individuals in spawning condition have been observed in March (Erdman 1976).

It is a top-level predator. Juveniles feed mostly on crustaceans, while adults (>30 cm) forage alone, mainly on fish (NMFS 2001b), but also on crabs and, to a lesser extent, other crustaceans and mollusks (Heemstra and Randall 1993 in Froese and Pauly 2002).

5.2.1.3.33.10 Butter hamlet, *Hypoplectrus unicolor*

The butter hamlet occurs in the Western Central Atlantic, off Florida (USA), the Bahamas, and throughout the Caribbean. It is apparently absent from the Gulf of Mexico. This species is utilized in the aquarium trade, and has been reared in captivity (Domeier 1994 in Froese and Pauly 2002).

The butter hamlet reaches 12.7 cm TL (male) (Domeier 1994 in Froese and Pauly 2002). Estimated size at maturity is 8.6 cm TL; natural mortality rate, 1.80 (Froese and Pauly 2002). This fish is mainly carnivorous (Domeier 1994 in Froese and Pauly 2002).

5.2.1.3.33.11 Swissguard basslet, *Liopropoma rubre*

Also known as the "peppermint bass," this species occurs in the Western Atlantic, ranging from southern Florida (USA) to northern South America, including the Caribbean Sea. It is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

Little is known about the biology of this solitary species, which inhabits coral reefs, from 3-45 m depth. Although fairly common, it is secretive and rarely seen. Maximum reported size is 100 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Estimated size at maturity is 53.5 cm TL; natural mortality rate, 0.42 (Froese and Pauly 2002).

5.2.1.3.33.12 Yellowfin grouper, *Mycteroperca venenosa*

The yellowfin grouper occurs in the Western Atlantic, ranging from Bermuda to Brazil and Guianas, including the Gulf of Mexico and Caribbean Sea. This species is taken in both commercial and recreational fisheries, and also is utilized in the aquarium trade. Although often implicated in ciguatera poisonings, it is a desirable food fish. Even large (5-10 kg) fish taken from areas that are considered to be safe are sold in markets (Heemstra and Randall 1993 in Froese and Pauly 2002).

The yellowfin grouper occurs from 2-137 m depth. Juveniles are commonly found in shallow turtle grass beds; adults, on rocky and coral reefs. This fish is of low resilience, with a minimum population doubling time of 4.5 - 14 years (K=0.09-0.17; tmax=15; Fec=400,000). Maximum reported size is 100 cm TL (male); maximum weight, 18.5 kg (Heemstra and Randall 1993 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 45.6 cm TL and 3.7 years, respectively. Approximate life span is 16.9 years; natural mortality rate, 0.18 (Ault *et al.* 1998). This fish is believed to be a protogynous hermaphrodite. One studied specimen contained a total of 1,425,443 eggs (Thompson and Munro 1974b). The yellowfin grouper reportedly aggregates at some of the same sites utilized by the tiger, Nassau, and black groupers (Sadovy *et al.* 1994). Three spawning aggregation sites have been documented off the USVI. Sites located north and south of St. Thomas are utilized from February through April. A third site located in the USVI National Park off St. John, USVI, is utilized year-round. Individuals aggregating at that site number about 200 (Rielinger 1999). Spawning has been observed in Puerto Rican waters in March. Most spawning appears to occur in Jamaican waters between February and April (Thompson and Munro 1974b). It feeds mainly on fishes (mostly on coral reef species) and squids (Heemstra and Randall 1993 in Froese and Pauly 2002).

5.2.1.3.33.13 Tiger grouper, *Mycteroperca tigris*

The tiger grouper occurs in the Western Atlantic, ranging from Bermuda and south Florida (USA) to Venezuela and, possibly, Brazil, including the Gulf of Mexico and Caribbean Sea. Easily approached, this species is taken in commercial fisheries and also is utilized in the aquarium trade (Heemstra and Randall 1993 in Froese and Pauly 2002). Dammann (1969), in Froese and Pauly (2002), reports that it can be ciguatoxic.

A solitary species, the tiger grouper inhabits coral reefs and rocky areas, from 10-40 m depth. This fish is of low resilience, with a minimum population doubling time of 4.5 - 14 years (K=0.11; tm=6.5-9.5). Maximum reported size is 101 cm TL (male); maximum weight, 10,000 g (Heemstra and Randall 1993 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 39.9 cm TL and 5.8 years, respectively. Approximate life span is 26 years; natural mortality rate, 0.116 (Ault *et al.* 2002). The size-sex ratios described in a Bermuda study indicate this fish is probably a protogynous hermaphrodite (Heemstra and Randall 1993 in Froese and Pauly 2002). It forms aggregations at specific times and locations each year, but only during the spawning season (Coleman *et al.* 2000; Matos and Posada 1998). A presumptive courting

group of three tiger groups also has been observed off the Bahamas, indicating that courtship also may occur in small groups (Sadovy *et al.* 1994).

One known aggregation site in the U.S. Caribbean is a well-defined promontory of deep reef known as "El Seco," which is located about 4.7 nm east of Vieques Island, Puerto Rico. This site was discovered in the early 1980s by a local diver-fisher who also encountered large numbers of yellowfin grouper at the site. The site differs from other aggregation sites described for western Atlantic groupers in that it is relatively level, rather than near a distinct shelf-edge break. Other aggregation sites also have been reported, but not confirmed, including one site north of Vieques Island and another off St. Thomas, USVI. Apparently, both of those sites are used by the yellowfin grouper as well. Aggregating tiger and yellowfin grouper were observed at a site off Guanaja Island, Honduras, that is also used by aggregating Nassau and black grouper (Sadovy *et al.* 1994).

The "El Seco" tiger grouper aggregation is routinely targeted by fishermen using spear guns and hook and line gear. This fish is only infrequently taken outside of the aggregation season and is not taken by fish traps in the area (Matos and Posada 1998; Sadovy *et al.* 1994). The aggregation begins about two days after the full moons of February and March and last for about 5-6 days (Matos and Posada 1998). Females taken from the "El Seco" aggregation in 1997 and 1998 averaged 46.2 cm TL and 48.2 cm TL, respectively; males averaged 53.4 cm TL and 54.0 cm TL, respectively. The female to male ratio was 1:6.4 in 1997 and 1:12.0 in 1998 (Matos and Posada 1998). White *et al.* (2002) reported that spawning aggregations of tiger grouper occur one week following the full moon during January through April off Puerto Rico.

The tiger grouper ambushes a variety of fish species, and frequents cleaning stations (Heemstra and Randall 1993 in Froese and Pauly 2002). Off the island of Vieques, predation on tiger groupers by sharks at the time of capture is high (one for every six tiger grouper caught during the seasons of 1997 and 1998), and should be considered in the estimation of the number of fish that are being removed, directly or indirectly, from the fishery (Matos and Posada 1998).

5.2.1.3.33.14 Creole-fish, *Paranthias furcifer*

The creole-fish occurs in both the Western and Eastern Atlantic. In the Western Atlantic, it ranges from Bermuda to Brazil, including the Gulf of Mexico and Caribbean Sea. It is reportedly absent in the northern Bahamas. This fish is used for food, but more often for bait, and also for the aquarium trade (Heemstra and Randall 1993 in Froese and Pauly 2002).

A benthopelagic species, the creole-fish inhabits coral reefs and hard bottom areas, from 8-100 m depth. This fish is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.22-0.28). Maximum reported size is 30 cm SL (male) (Heemstra and Randall 1993 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 24.9 cm TL and 3.1 years, respectively. Approximate life span is 12.9 years; natural mortality rate, 0.49

(Froese and Pauly 2002). This fish feeds on zooplankton, including copepods, pelagic tunicates, shrimps, and shrimp larvae (Heemstra and Randall 1993 in Froese and Pauly 2002).

5.2.1.3.33.15 Greater soapfish, *Rypticus saponaceus*

The greater soapfish occurs in the Western and Eastern Atlantic. In the Western Atlantic, it ranges from Bermuda to Brazil (Robins and Ray 1986 in Froese and Pauly 2002), including the Caribbean Sea. This species is fished for subsistence, and also is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

A solitary species, the greater soapfish generally occurs in shallow water, on bottoms with eroded limestone or mixed sand and rocks, as well as around reefs. It can be found to depths of 60 m. This fish is nocturnal, and is often encountered lying motionless against rocks, or around the bases of coral colonies and near the mouths of caves. When disturbed, it secretes a mucus that contains a toxic protein. Maximum reported size is 35 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Estimated size at maturity is 21.2 cm TL; natural mortality rate, 0.88 (Froese and Pauly 2002).

5.2.1.3.33.16 Orangeback bass, *Serranus annularis*

The orangeback bass occurs in the Western Atlantic, ranging from Bermuda to northern South America (Robins and Ray 1986 in Froese and Pauly 2002), including the Caribbean Sea. This species is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

The orangeback bass inhabits rocky and reef habitats, from 10-70 m depth. Maximum reported size is 9 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Estimated size at maturity is 6.4 cm TL; natural mortality rate, 2.29 (Froese and Pauly 2002). This fish occurs in pairs, and is reportedly synchronously hermaphroditic, having both sexes in the same individual at the same time (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.33.17 Lantern bass, *Serranus baldwini*

The lantern bass occurs in the Western Atlantic, from southern Florida (USA) to northern South America, including the Caribbean Sea. It is utilized in the aquarium trade (Böhlke and Chaplin 1993 in Froese and Pauly 2002).

This reef-associated species inhabits rocky and weedy areas, to depths of 80 m. Maximum reported size is 12 cm TL (male) (Böhlke and Chaplin 1993 in Froese and Pauly 2002). Estimated size at maturity is 8.2 cm TL; natural mortality rate, 1.87 (Froese and Pauly 2002). The lantern bass is reportedly synchronously hermaphroditic, having both sexes in the same individual at the same time. Its diet is composed of shrimp and small fishes (Böhlke and Chaplin 1993 in Froese and Pauly 2002).

5.2.1.3.33.18 Tobaccofish, *Serranus tabacarius*

The tobaccofish occurs in the Western Atlantic, ranging from Bermuda to northern Brazil, including the Caribbean Sea. This species is believed to be of negligible value to commercial fisheries because of its small size. But it is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

The tobaccofish inhabits shallow rocky or coral bottoms, from 4-70 m depth. It prefers clear water, and usually occurs in groups on deeper reefs. Maximum reported size is 22 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Estimated size at maturity is 14.1 cm TL; natural mortality rate, 0.84 (Froese and Pauly 2002). This fish is a synchronous hermaphrodite, having both sexes in the same individual at the same time. It reportedly sometimes follows goatfishes (family Mullidae) as they probe the sand for invertebrates (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.33.19 Harlequin bass, *Serranus tigrinus*

The harlequin bass occurs in the Western Atlantic, ranging from Bermuda to northern South America, and throughout the Caribbean. This species is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

The harlequin bass is most common in areas with rock or scattered coral. It occurs singly, or in pairs, to 40 m depth. Maximum reported size is 29 cm FL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Estimated size at maturity is 17.9 cm FL (Froese and Pauly 2002). No estimate of natural mortality rate is available for this species. This fish is a synchronous hermaphrodite. It feeds primarily on crustaceans (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.33.20 Chalk bass, *Serranus tortugarum*

The chalk bass occurs in the Western Atlantic, off southern Florida (USA), the Bahamas, Honduras, and probably throughout Caribbean reef areas. It is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

This demersal species is often found in small groups, over rubble, silty, or sandy bottoms, from 12-396 m depth. It is difficult to approach. Maximum reported size is 8 cm TL (male) (Robins and Ray 1986 in Froese and Pauly 2002). Estimated size at maturity is 5.8 cm TL; natural mortality rate, 2.48 (Froese and Pauly 2002). The chalk bass is a synchronous hermaphrodite. It and feeds on plankton (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.34 Soles, Soleidae

The Soleidae family contains 89 species in 22 genera (Nelson 1994 in Froese and Pauly 2002). Only one species, the Caribbean tonguefish (*Symphurus arawak*), is included in the Caribbean reef fish fishery management unit.

5.2.1.3.34.1 Caribbean tonguefish, *Symphurus arawak*

The Caribbean tonguefish occurs in the Western Atlantic, ranging from Florida (USA) and the Bahamas to Curaçao and Colombia. It is utilized primarily in the aquarium trade (Munroe 1998 in Froese and Pauly 2002).

This demersal species inhabits bays and coastal waters, from 3-30 m depth. Maximum reported size is 5.1 cm TL (male) (Munroe 1998 in Froese and Pauly 2002). Estimated size at maturity is 3.9 cm TL; natural mortality rate, 3.42 (Froese and Pauly 2002). This fish is a pelagic spawner, and feeds on benthic invertebrates and fishes (Nelson 1994 in Froese and Pauly 2002).

5.2.1.3.35 Porgies, Sparidae

The Sparidae family contains 112 species in 35 genera, distributed in tropical and temperate waters of the Atlantic, Indian, and Pacific Oceans. These fish are premier food and game fishes. Many species have been found to be hermaphroditic; some have male and female gonads simultaneously; others change sex as they get larger (Nelson 1994 in Froese and Pauly 2002). The spawning season of these fishes is limited (Erdman 1976). Only two genera are represented in the Caribbean reef fish fishery management unit: *Archosargus* and *Calamus*.

5.2.1.3.35.1 Sea bream, *Archosargus rhomboidalis*

Also known as the "Western Atlantic sea bream," this species occurs in the Western Atlantic, ranging from New Jersey (USA) to the northern coast of South America, including the Gulf of Mexico (Robins and Ray 1986 in Froese and Pauly 2002) and Caribbean Sea. This species is reportedly absent in the Bahamas. This species is fished commercially (Robins and Ray 1986 in Froese and Pauly 2002).

The sea bream is commonly found over mud bottoms in mangrove sloughs and on vegetated sand bottoms, sometimes in brackish water and, occasionally, in coral reef areas near mangroves. This fish is highly resilient, with a minimum population doubling time of less than 15 months (K=1.27; tm=0.4; tmax=2). Maximum reported size is 33 cm TL (male); maximum weight, 550 g (Robins and Ray 1986 in Froese and Pauly 2002). Estimated size at maturity and age at first maturity are 16.6 cm TL and 0.6 years, respectively (Froese and Pauly 2002). Maximum reported age is 2 years (Robins and Ray 1986 in Froese and Pauly 2002). Natural mortality rate is estimated as 2.10 (Froese and Pauly 2002).

Erdman (1976) reports that over 100 sea breams crowded into one fish pot set in less than 3.7 m of water at La Parguera in February 1954, the majority of which were ripe females measuring 20-22 cm SL. He notes that February continued to be the peak spawning month of this species in continuing years, although spawning extended from November to March. In the southern Gulf of Mexico, Chavance *et al.* (1986) reported that sea bream were in spawning condition from October to July with greater spawning activity occurring during February through May. The sea bream feeds on benthic invertebrates, such as small bivalves and crustaceans, and of plant material (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.35.2 Jolthead porgy, *Calamus bajonado*

The jolthead porgy occurs in the Western Atlantic, ranging from Rhode Island (USA), southward to Brazil, including parts of the Gulf of Mexico and Caribbean Sea. An excellent food fish, this species is taken in both commercial and recreational fisheries (Robins and Ray 1986 in Froese and Pauly 2002). According to Lieske and Myers (1994), in Froese and Pauly (2002), it can be ciguatoxic.

The jolthead porgy inhabits coastal waters, from 3-200+ m depth. It can be found on vegetated sand bottoms, but occurs more frequently on coral bottoms. Large adults are usually solitary. This fish is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (tm=3). Maximum reported size is 76 cm FL (male); maximum weight, 10.6 kg (Robins and Ray 1986 in Froese and Pauly 2002). Estimated size at maturity is 42 cm FL (Froese and Pauly 2002). Jolthead porgy have been reported to spawn during October through June off Cuba with a peak during March and April (Garcia-Cagide *et al.* 1994). No estimate of natural mortality rate is available for this species. Sea urchins, crabs, and mollusks are primary prey items (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.35.3 Sheepshead porgy, *Calamus penna*

The sheepshead porgy occurs in the Western Atlantic, ranging from Florida (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea (Robins and Ray 1986 in Froese and Pauly 2002). This species is fished commercially, and is marketed both fresh and frozen (Robins and Ray 1986 in Froese and Pauly 2002). Olsen *et al.* (1984), in Froese and Pauly (2002), report that it can be ciguatoxic.

This species occurs from 3-87 m depth, in clear reef areas over soft or semi-hard bottoms. Juveniles are encountered in seagrass (*Thalassia*) beds. Maximum reported size is 46 cm TL (male); maximum weight, 1,000 g (Robins and Ray 1986 in Froese and Pauly 2002). Estimated size at maturity is 27 cm TL; natural mortality rate, 0.72 (Froese and Pauly 2002). In the northeastern Caribbean, individuals have been observed in spawning condition in February and March (Erdman 1976).

5.2.1.3.35.4 Pluma, *Calamus pennatula*

The pluma occurs in the Western Atlantic, from the Bahamas to Brazil, including the southern part of the Gulf of Mexico and throughout the Caribbean Sea. This species is an important food fish (Cervigón 1993 in Froese and Pauly 2002). Olsen *et al.* (1984), in Froese and Pauly (2002), report that it can be ciguatoxic.

Adult pluma porgies are often observed over rocky areas or reefs, but also on flat bottoms to about 85 m depth. Juveniles inhabit shallower waters. Maximum reported size is 37 cm TL (male) (Cervigón 1993 in Froese and Pauly 2002). Estimated size at maturity is 22.3 cm TL; natural mortality rate, 0.84 (Froese and Pauly 2002). In the northeastern Caribbean, individuals have been observed in spawning condition in February and March (Erdman 1976). Prey items include crabs, mollusks, worms, and brittle stars (Cervigón 1993 in Froese and Pauly 2002).

5.2.1.3.36 Seahorses and pipefishes, Syngnathidae

The Syngnathidae family contains 215 species in 52 genera, distributed in mostly warm temperate to tropical waters of the Atlantic, Indian, and Pacific Oceans (Nelson 1994 in Froese and Pauly 2002). Only *Hippocampus* (seahorses) and *Syngnathus* (pipefishes) species are represented in the Caribbean reef fish fishery management unit. These species are utilized primarily in the aquarium trade.

Little is known about the biology of the Syngnathids. These species are usually limited to shallow water and do not grow more than 60 cm in length. They feed on minute invertebrates sucked into a tubular snout. Males have a brood pouch in which the eggs are laid and where they are fertilized and incubated (Nelson 1994 in Froese and Pauly 2002).

5.2.1.3.37 Lizardfishes, Synodontidae

The Synodontidae family contains 55 species in 5 genera, distributed in the Atlantic, Indian, and Pacific Oceans (Nelson 1994 in Froese and Pauly 2002). Only one species, the sand diver (*Synodus intermedius*), is included in the Caribbean reef fish fishery management unit

5.2.1.3.37.1 Sand diver, *Synodus intermedius*

The sand diver occurs in the Western Atlantic, ranging from Bermuda and North Carolina (USA) to Guianas, including the Gulf of Mexico and Caribbean Sea. This species is believed to be of minor importance to commercial fisheries, but also is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

The sand diver is found on the sandy bottom around boulders, or in sandy corridors in patch reefs, from 3-320 m depth. It is uncommon near the shore. Maximum reported size is 46 cm TL (male); maximum weight, 1,000 g (Robins and Ray 1986 in Froese and Pauly 2002). Estimated

size at maturity is 27 cm TL; natural mortality rate, 0.50 (Froese and Pauly 2002). This fish is a voracious predator of small fishes (Nelson 1994 in Froese and Pauly 2002).

5.2.1.3.38 Puffers, Tetraodontidae

The Tetraodontidae family contains 121 species in 19 genera, distributed in tropical and subtropical areas of the Atlantic, Indian, and Pacific Oceans (Nelson 1994 in Froese and Pauly 2002). Only two genera, *Canthigaster* and *Diodon*, are represented in the Caribbean reef fish fishery management unit.

5.2.1.3.38.1 Sharpnose puffer, *Canthigaster rostrata*

The sharpnose puffer occurs in both the Western and Eastern Atlantic. In the Western Atlantic, it ranges from Bermuda to northern South America, including the Gulf of Mexico (Robins and Ray 1986 in Froese and Pauly 2002) and Caribbean Sea. This species is utilized in the aquarium trade (Robins and Ray 1986 in Froese and Pauly 2002).

The sharpnose puffer occurs to 30 m depth. It is found in clear waters of coral reefs and reef flats; also in tide pools and seagrass beds. Maximum reported size is 12 cm TL (male) (Nelson 1994 in Froese and Pauly 2002). Estimated size at maturity is 8.2 cm TL; natural mortality rate, 1.87 (Froese and Pauly 2002). This fish is believed to be a "nest-guarding" species (Nelson 1994 in Froese and Pauly 2002). Its diet consists mainly of seagrass. But it also has been reported to consume invertebrates, sponges, crabs and other crustaceans, mollusks, polychaete worms, sea urchins, starfishes, hydroids, and algae (Robins and Ray 1986 in Froese and Pauly 2002).

5.2.1.3.38.2 Porcupinefish, *Diodon hystrix*

Also known as the "spot-fin porcupinefish," this species is widely distributed in tropical oceans around the globe. It has been reported in the Eastern Pacific, and in the Western and Eastern Atlantic. In the Western Atlantic, it ranges from Massachusetts (USA) to Brazil, including the Gulf of Mexico (Randall *et al.* 1990 in Froese and Pauly 2002) and Caribbean Sea. It is poisonous (Halstead *et al.* 1990 in Froese and Pauly 2002) and, thus, not normally eaten. But it is utilized in the aquarium trade (Randall *et al.* 1990 in Froese and Pauly 2002).

This species occurs in lagoon and seaward reefs, to at least 50 m. It is commonly observed in caves and holes in shallow reefs. Maximum reported size is 91 cm TL (male); maximum weight, 2,800 g. It is pelagic until it reaches about 20 cm in length, after which time it is benthic (Randall *et al.* 1990 in Froese and Pauly 2002). Estimated size at maturity is 49.3 cm TL; natural mortality rate, 0.31 (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in February and March (Erdman 1976). This fish is solitary and nocturnal, and feeds on hard shelled invertebrates, such as sea urchins, gastropods, and hermit crabs (Randall *et al.* 1990 in Froese and Pauly 2002). It also is presumed to exhibit nest-guarding behavior (Nelson 1994 in Froese and Pauly 2002).

5.2.1.4 Caribbean coral reef resource

The Caribbean coral reef resource comprises more than 160 species of invertebrates and plants. This diverse group of organisms includes sponges, a variety of reef-building (hermatypic) and non-reef building (ahermatypic) corals, anemones, annelid worms, mollusks, arthropods, bryozoans, echinoderms, tunicates, algae, and seagrasses. Over 67 species are utilized in the aquarium trade. These include the sponges, anemones, colonial anemones, false corals, annelid worms, mollusks (with the exception of the gastropods described in Section 5.2.1.2.2), crustaceans, echinoderms, tunicates, and algae. The remaining species have been classified as prohibited species, the take or possession of which is prohibited under the Caribbean Council's Coral FMP. Prohibited species, include over 94 species of hydroids, soft corals, gorgonians, hard corals, black corals, bryozoans, and seagrasses.

This section provides a summary description of each category of organisms that comprises the coral reef resource, along with information on their classification and status. In-depth summaries on the biology of these Caribbean reef invertebrates and plants can be found in Colin (1978) and in Sefton and Webster (1986). The section concludes with a broader description of the distribution of these organisms throughout the coral reef environment.

5.2.1.4.1 Sponges, Phylum Porifera

Sponges are classified into four classes, though only the class Demospongiae is represented in the Caribbean coral reef fishery management unit. This is the largest class of sponges, both in number of species and range of distribution (Colin 1978). Species included in the Caribbean coral reef fishery management unit are *Aphimedon compressa* (erect rope sponge; also known as *Haliclona rubens*), *Chondrilla nucula* (chicken liver sponge), *Cynachirella alloclada*, *Geodia neptuni* (potato sponge), *Haliclona* spp. (finger sponges), *Myriastra* spp., *Niphates digitalis* (pink vase sponge), *N. erecta* (lavender rope sponge), *Spinosella policifera*, *S. vaginalis*, and *Tethya crypta*.

Sponges are the least complex of all multi-cellular animals (Sefton and Webster 1986), typically attached to hard substrates and possessing various specialized cells but lacking organization of such cells into organs and tissues (Colin 1978). They are all sessile and exhibit little detectable movement (CFMC 1994).

Demosponges range from intertidal to abyssal depths in the ocean. *C. nucula* is found in shallow waters of reef areas, where it sometimes overgrows large areas of corals. *Haliclona rubens* occurs from 1-20 m depth (Colin 1978) on shallow to deep reefs, where it may intertwine with other species of finger sponge (Sefton and Webster 1986). *H. hogarthi* occurs from mangrove areas to reefs, at depths to 30 m (Colin 1978). But this species is most commonly found on reefs at moderate depths (Sefton and Webster 1986). *T. crypta*, a black, inconspicuous sponge, occurs in back reef areas or on limestone shelves in sheltered areas, from 1-8 m depth (Colin 1978).

The sponges display great variability in size and shape, with growth rates and body form highly dependent on space availability, the inclination of the substrate, and current velocity (CFMC 1994). Although their basic body plan is simple, some species attain surprising size (hundreds of pounds in weight out of water). The demosponges are encrusting to massive, ranging from nearly microscopic to over 2 m in diameter (Colin 1978).

Fingers of *H. hogarthi* may reach 1 m or more in length. And thickets formed by this species sometimes measure 2 m across. It usually reaches its greatest size on fore reef slopes and on buttresses below the level where strong wave action is likely to occur (Sefton and Webster 1986). The branches of *H. rubens* may reach 40 cm in length and 1-4 cm in diameter (Colin 1978).

Sponges reproduce sexually as well as asexually, by fragmentation or budding. Sperm are released to the sea, sometimes in numbers so great that the sponges seem to be "smoking," and many sponges of the same species may release sperm simultaneously. Fertilization is internal. Larvae are planktonic for some period of time before settling and growing in some unoccupied patch of reef habitat. As newly settled individuals, *T. crypta* is open to predation by sea urchins, but once beyond a critical size, this species may live to an age of at least 20 years or more (Colin 1978).

While the sponges are ancient in origin (abundant in reef habitats for at least 200 million years), their biological importance should not be underestimated. In some areas of the reef, the biomass of sponges present can exceed that of any other group, including reef-building corals (Colin 1978). They are important colonizers of bare reef rock, shipwrecks, and other newly available space. In turn, they house an amazing array of commensal "guests" such as worms, shrimps, brittle stars, fishes, and algae. At night, and in dimly lit water, brittle stars may be seen on the surface of *H. rubens* (Sefton and Webster 1986).

Some species bore into the limestone reef framework, weakening its structure and making it more susceptible to storm damage. Others produce extensive, nearly stony skeletal structures which cement and stabilize reef rubble and add to the structure of the reef. All combine in their nearly constant filtering activity to remove bacteria, small planktonic organisms, and larger organic particles from the water and are, thus, partially responsible fo the clarity of the water above the reef (Sefton and Webster 1986).

5.2.1.4.2 Coelenterates or Cnidaria, Phylum Coelenterata

The Coelenterates are among the most widely represented of all the invertebrate phyla on the coral reef. The phylum is divided into three classes: Hydrozoa (hydroids, fire corals, siphonophores); Anthozoa (corals, anemones, black corals, gorgonians); and Scyphozoa (true jellyfishes), of which only Hydrozoa and Anthozoa are represented in the Caribbean coral reef fishery management unit (Sefton and Webster 1986).

Basic coelenterate structure is fairly straightforward. The polyp (such as an anemone or solitary coral) is a bag with a hole (mouth-anus) at the top surrounded by a ring of tentacles. Polyps are usually attached to the bottom or some other hard substrate, such as a colonial skeletal framework. Most polyps divide asexually to produce colonies (colonial corals, zoanthids, gorgonians, hydroids, etc.) consisting of hundreds to thousands of individuals (Sefton and Webster 1986). Most reef-dwelling Hydrozoa are colonial, although solitary species do exist. More than one type of polyp may exist in a colony, with specializations for feeding, reproduction, or defense (Colin 1978).

All reef-building corals contain symbiotic algae, called zooxanthaellae, in their tissues, as do most of the sea fans and other gorgonians. These microscopic dinoflagellates help to nourish the coelenterate host and, in the case of corals, aid in the process of calcium carbonate secretion to form the coral exoskeleton (Sefton and Webster 1986).

5.2.1.4.2.1 Hydrocorals, Class Hydrozoa

The Class Hydrozoa is divided into five orders, of which only three are of any significance on Atlantic reefs: Athecatae (hydroids), Milleporina (fire corals), and Stylasterina.

The Athecatae, which include most species of the Hydrozoa, are solitary or colonial with the polypoid generation much more extensively developed than the medusoid generation. The solitary hydroids are not important on Caribbean reefs, but the colonial species can be conspicuous members of the reef community (Colin 1978).

Milleporina species represented in the Coral FMP are the fire corals (*Millepora* spp.), which belong to the family Milleporidae. Their name derives from the powerful stinging cells they possess, which enable them to paralyze and capture prey. These colonial corals are found from deep fore reef areas to back reefs (Colin 1978), and are considered to play a significant role in coral reef construction, particularly in shallow windward substrates, where they have a buffering effect (Goenaga and Boulon 1992).

Three described species of western Atlantic *Millepora* exist: *M. alcicornis*, *M. complanata*, and *M. squarrosa*. They differ only in the morphology of the skeleton and are often considered ecological variants of a single species. The branched form, *M. alcicornis*, occurs somewhat deeper than the others, while *M. squarrosa* is found in heavy surf or in areas exposed to air in the troughs of waves. Under extreme wave conditions or when covering the remains of another organisms, *Millepora* can be encrusting. Colonies sometimes cover entire sea fans and may also grow on the outer portion of the stalks of dead gorgonians. Barnacles and serpulid worm tubes may occur on the sides of the blade-like forms of *Millepora* (Colin 1978).

Stylasterina species represented in the Coral FMP belong to the family Stylasteridae. These corals are also colonial but do not contain zooxanthallae. They have been used frequently as ornamental pieces (Goenaga and Boulon 1992). Only one species, the rose lace coral (*Stylaster*

roseus) is represented in the Caribbean coral reef fishery management unit. *S. roseus* occur at depths of 6 m to at least 30 m. These small, fragile, fan-like colonies reach 10 cm in height. They commonly occur in caves or crevices, often growing on inverted surfaces and occasionally (as at Mona Island) on open vertical rock faces (Colin 1978).

5.2.1.4.2.2 Anthozoans, Class Anthozoa

The second class of Coelenterata in the management unit, anthozoans include black corals (Order Antipatharia), gorgonians, sea fans (Sub-class Octocoralia), sea anemones and other similar organisms (Orders Actinaria, Zoanthidea and Corallimorpha), as well as the true reef-building corals (Order Scleractinia) (CFMC 1994). Anthozoans has its life cycle restricted to the polyp phase exclusively, with no medusa stage occurring. They typically attach to a substrate and have the oral end expanded into a flattened oral disk. A calcareous skeleton may be constructed. Further, a planula larvae may be produced, which is capable of being transported some distance by ocean currents.

5.2.1.4.2.2.1 Octocorals, Orders Alcyonacea and Gorgonacea

Due to the large numbers of species in these two orders, please refer to Table 4 for a list of all managed species. The following discussion on octocoral biology is offered to represent the order.

These two orders consist of sea fans, sea whips and other gorgonian species. Alcyonacea, also known as soft corals, includes species with skeletons consisting of spicules but no axial skeleton (Goenaga and Boulon 1992). Gorgonacea is the more dominant group of Octocorallia, occurring in abundance on Caribbean reefs (Colin 1978). All gorgonian colonies possess an axial skeletal structure of either a horny or calcareous central cylinder or a zone of tightly bound spicules. Most species have an erect skeletal structure attached to a solid substrate by a holdfast, by a smaller number of species may occur as an encrusting mat (Colin 1978). Gorgonians may live for more than 20 years with annual growth rates ranging from 0.8 - 4.5 cm/yr for 13 species studied in southeastern Puerto Rico over a five-year period (CFMC 1994). At study sites on southeastern Puerto Rico, mortality was found to be higher in small colonies, as compared to larger specimens, the major causes of death being damage to the colony base or detachment (CFMC 1994). Two species of sea whips, *Ellisella barbadensis* and *E. elongata*, reach sizes of nearly 2 m and can occur in dense stands on rocky, often vertical substrates at about 20 to at least 250 m. Three other smaller species may also occur within diving depths on deep reefs. Most species have wide geographic ranges, generally from southern Florida to the Caribbean.

The common sea fan, *Gorgonia ventalina*, has the widest distribution, both on the reef and geographically, of any gorgonian species. It can be found on nearly ever reef and is a characteristic part of reef environments in the Atlantic. It can occur near shore in areas of extreme wave action and on deeper outer reefs at 15 m or more in depth. It can reach a height of nearly 2 m and shows a somewhat "clumped" (non-random) distribution of individuals on a reef

(Colin 1978). This species is known from Bermuda to Curacao, including the Florida Keys and western Caribbean.

The Venus sea fan, *G. flabellum*, is often restricted to shallow water with very strong wave action. It occurs in areas generally somewhat shallower and rougher than *G. ventalina* where the two occur in the same geographic area. It is seldom found below 10 m depth and can reach sizes near those of *G. ventalina*. Its known geographic distribution is somewhat odd. It is abundant and easily distinguished from *G. ventalina* in the Bahamas, but becomes scarce and less distinctive in Florida and the Lesser Antilles. It is common on the windward reef flats and back reef zones where fire corals are abundant. This species is known to fall prey to the flamingo tongue snail (Sefton and Webster 1986).

G. mariae, the wide-mesh sea fan, is the smallest of the sea fans, the fan-like form reaching only about 30 cm in height. There are two other growth forms of this species. One has short free branchlets form one or both faces, while the plumose form, which may reach 40 cm in height, has the inner and lower branches anastomosed, but the terminal branches free. This is generally a deeper water species than the *G. ventalina* and *G. flabellum* and has been encountered as deep as 47 m and as shallow as 5 m. Known from Cuba, Jamaica, Puerto Rico, the Virgin Islands, and the northern Lesser Antilles (Colin 1978).

There are several species of *Pseudopterogorgia* (sea plumes) on Caribbean reefs. Most are tall, plume-like colonies. On the leeward side of some islands in the Caribbean, a zone of dense growth of these species can occur at 7-10 m, with colonies reaching heights over 1.5 m. They are pinnately branched, with no interconnections between branches, and some are slimy to the touch with abundant mucus. *Pseudopterogorgia spp.* may be so common as to be the dominant feature of some reefs. Flamingo tongue snails are also common predators of sea plumes (Sefton and Webster 1986). The bipinnate plume produces planulae in Jamaica in late January an dearly February. Unlike stony coral planulae, those of the bipinnate plume do not contain zooxanthellae. In the laboratory, they settle 11 days after release and must acquire their initial zooxanthellae from the environment, as these plant cells are abundant in the adult colonies (Colin 1978).
The genus *Eunicea* (sea rods) is an important group of reef-dwelling alcyonarians. Most occur from a few meters depth to a maximum of about 30 m (Colin 1978). *Eunicea spp.* occur at shallow and moderate depths. These gorgonians have single-celled algae (zooxanthellae) in the tissues of the polyps, as do most other gorgonians, corals, and anemones of the reef community. These symbiotic algae aid in the nutrition of the host colony (Sefton and Webster 1986).

Muricea spp. are common at moderate depths, particularly in spur and groove systems of the reef. They may also be attached to coral rubble in sandy areas (Sefton and Webster 1986). Sea rods, *Plexaura spp.*, occur to depths of 50 m. *P. homomalla* has recently been the subject of much study since it was discovered to contain high amounts of a type of chemical (prostaglandins) valuable in the pharmaceutical industry. Advances in chemical synthesis of prostaglandins have not made such considerations less important. This species is tan in color and

can reach nearly 12 m in height. Trumpet fishes sometimes hide by aligning themselves with the branches of *Plexaurella* colonies (Sefton and Webster 1986). Most *Plexaurella spp.* in the Caribbean commonly occur from about 10 to 50 m depth.

Gorgonian life history is noted by low and variable recruitment of small specimens. Given this uncertain recruitment, the predictable survival of adults is critical to the persistence of gorgonian populations (CFMC 1994). Further, gorgonian species can play an important role as habitat for other managed species. Fire coral, *Millepora spp*., may encrust entire colonies, particularly the sea fans of the genus *Gorgonia*. Bivalve mollusks, sponges, and algae may grow upon dead sections of gorgonian skeletons; whether these organisms simply take advantage of already dead substrate or themselves kill a portion of the gorgonian is not known. The gastropod mollusk, *Cyphoma gibbosum*, feeds on gorgonian polyps by crawling slowly over the skeleton, grazing at will. Other organisms, such as basket starfishes and brittlestars, climb tall gorgonians to reach a position more advantageous for filter-feeding in reef areas (Colin 1978). These factors warrant the prohibition on their harvest.

5.2.1.4.2.2.2 Anemones, Orders Actiniaria and Zoanthidea

The Orders Actinaria and Zoanthidea represent what are commonly known as anemones, which may be either solitary or colonial. The polyps vary greatly in morphology and colonial structure. Actinarians consist of six anemone species: *Aiptasia tagetes* (Pale anemone); *Bartholomea annulata* (Corkscrew anemone); *Condylactis gigantea* (Giant pink-tipped anemone); *Hereractis lucida* (Knobby anemone); *Lebrunia spp.* (Staghorn anemone); *Stichodactyla helianthus* (Sun anemone). These species are found throughout the Caribbean, and occur on reefs, rocky areas, and lagoonal areas from 1 - 43 m in depth. *Condylactis gigantea* is known to provide shelter for a variety of juvenile and adult fishes and crustaceans. This particular species spawns in late spring in Florida, and may become reproductively active as small as 4.5 g (CFMC 1994). There is no available information on age and growth.

Zoanthus spp. (Sea mat) comprise the only species (e.g., *Zoanthus pulchellus*, *Z. sociatus*) of Zoanthids in the management unit. These colonial organisms form resilient mats which can cover extensive areas in shallow water (i.e., less than 5 m), and are particularly abundant on the back side of shallow reef flats.

5.2.1.4.2.2.3 Hard or stony corals, Order Scleractinia

Almost 50 species belonging to 12 different families are represented in the Caribbean coral reef fishery management unit. Due to the numerous scleractinian species included in the coral reef fishery management unit, and that the ecological importance of corals is widely accepted and understood by the public, the following is only a survey of the major species and species groups.

Scleractinians are the principal reef builders. They are calcium secreting, anemone-like animals that can form colonies comprised of many physically and physiologically linked polyps or else

can be solitary or consisting of one polyp. Tentacles occur in multiples of six and the digestive cavities are divided by partitions (sclerosepta and sarcosepta) that radiate from the center of the polyp. The polyps of stony corals are somewhat similar to those of sea anemones but produce a calcium carbonate cup (the corallite) and are usually colonial, producing a massive calcareous skeleton (the corallum) from the many corallites. In contrast to anemones they produce calcium carbonate, aragonitic skeletons that can reach considerable sizes (e.g., over 5 m in diameter and height in individuals of *Montastrea annularis*). The skeleton is internal, in contrast to other skeleton forming cnidarians (Goenaga and Boulon 1992). Often scleractinians are considered in two informal groups, the hermatypic or reef-building corals (those making a significant contribution to reef structure) and ahermatypic or non-reef building corals (often small, solitary species without large skeletons) (Colin 1978).

Many stony corals, particularly those that are hermatypic, contain small unicellular plants called zooxanthellae (dinoflagellata) in their gastrodermis. These zooxanthellae are pigmented, giving corals most of their color, and play a role in the production of calcium carbonate by the coral polyp. The exact nature of their contribution is not known and seems to vary within species of corals. Generally, however, ahermatypic corals lack zooxanthellae while hermatypic species possess large numbers. The zooxanthellae can be expelled by a coral (usually termed bleaching) when under stress (Colin 1978).

It is believed that the requirement of light for the zooxanthellae is the reason why coral reefs are limited to fairly shallow waters. With increasing depth below about 30 m corals are generally less heavily calcified than in shallower water and the ability to form reef structures is much less than in shallow water. Reef corals may occur to depths approaching 90-100 m in extremely clear water, but below 45-50 m in their constructional abilities are severely limited and may be surpassed by those of other groups of organisms such as the sclerosponges (Colin 1978).

Within a colony, all reproduction is asexual. New polyps are budded from other polyps as the colony increases in diameter or length. The rate of growth is variable between species, with branched species generally growing faster than massive species, and is strongly influenced within each species by environmental conditions. Sexually produced larvae, termed planulae, result in the establishment of new colonies. Larvae may either swim (entering the plankton and covering large distances) or crawl (staying close to the parent) until they attach to the bottom to initiate a new colony (Colin 1978).

A number of organisms prey directly on corals. Certain fishes pick polyps from the surface of the colony (butterflyfishes) while others ingest or scrape portions of skeleton with their attached polyps (puffers, parrotfishes). Some gastropod mollusks feed on coral polyps by inserting their proboscis into the polyp, and a few polychaete worms feed on branched corals by engulfing the tip of a branch in their mouth (Colin 1978). Boring sponges and clams occur in the skeleton and weaken it by their mechanisms of removing calcareous material (Colin 1978).

Acropora cervicornis (staghorn coral), found throughout the Caribbean, is characteristic of seaward facing reefs, but generally occurs on reefs below 6 to 9 m depth. It occurs from low water to 50 m but is most common at 12 to 22 m. This is one of the most rapidly growing corals. Length increases of nearly 30 cm per year have been recorded for single branches under optimal conditions. This species can also occur in shallow, quiet back reef areas where the water is fairly clear. Damselfishes frequently stake out their territories in staghorn, as well as elkhorn coral (Sefton and Webster 1986).

A. palmata (elkhorn coral) is also characteristic of seaward facing reefs. It is the most abundant stony coral in shallow water areas, often growing up to low water levels. The "*A. palmata* zone" is a characteristic component of most West Indian reefs, and it thrives where wave conditions are rough. Severe storms such as hurricanes can have disastrous effects on reefs comprised of this species. Entire reefs may be reduced to rubble, much of this transported over the reef crest or piled above low water levels. Large colonies may be overturned and often renew their growth in the inverted position. *A. palmata* is strictly a shallow-water coral. Seldom are colonies found below 15 m, and its greatest abundance is in the top 6 m of the water. It can occur in surprisingly turbid water, but may be limited in some areas by low winter temperatures. The fast-growing branching colonies of *A. palmata* are sometimes 4 m or more across. One of the dominant corals in the Caribbean, elkhorn coral competes by growing rapidly and by shading or over-topping its neighbors. Entire barrier reefs, with no adjacent reef flat, may be built of this coral. The famous barrier reef at Buck Island, St. Croix, is an excellent example of such a situation, but similar reefs are found in many areas of the Caribbean. Occasionally, the branches of *A. palmata* will have lumpy growths of polyps, termed "neoplasms," on the normally flattened branches. If any portion of the coral surface dies this provides a site of attachment for a wide variety of organisms, and branches of *A. palmata* with algae, hydroids, and actinians in sections have been observed. Certain crabs, such as *Domecia acanthophora*, form cavities in the junctions of branches by preventing the coral from growing in these areas (Colin 1978).

Corals of the genus *Agaricia* and *Leptoseris*, commonly known as the "lettuce corals," are among the most fragile corals occurring on reefs. However, they play an important role in reef construction, particularly in the deeper sections. Various species are also important elements of the shallow reef environment (Colin 1978). While *Agaricia tenuifolia* is generally restricted to depths shallower than 18 m, other species are found on reefs down to 80 m in depth.

Two species of Caryophyllidae are in the coral reef fishery management unit, *Eusmilia fastigiata* (flower coral) and *Tubastrea aurea* (cup coral). *E. fastigiata* colonies, found widely in the Caribbean, grow up to 50 cm in diameter. This species has a wide depth range from 1-65 m, but is most common at 3-30 m depth. It can occur in a variety of habitats from back reefs to fore reefs, and under overhanging sides of larger corals. Encrusting sponges, algae, and tubeworms often grow on the dead branches from which the polyps grow (Sefton and Webster 1986). *T. aurea* is non-reef building (ahermatypic) but is, on occasion, abundant on reefs in the proper habitat. It is not solitary, with clumps containing a few to hundreds of polyps occurring on undercut wave-swept rocks, on overhanging faces in deeper water and in fairly dimly lit caves.

One pier off western Puerto Rico has all the area available on the inside of the pilings, beneath a platform providing shade, completely covered by this coral to a depth of 1.5 m. This species lacks zooxanthellae.

Diploria spp. include *D. clivosa* (knobby brain coral), *D. labyrinthiformis* (grooved brain coral), and *D. strigosa* (symmetrical brain coral). In Bonaire, *D. clivosa* is one of the dominant corals on the leeward side of a fringing reef of *Acropora palmata*, but is not as significant a constructor on reefs as are the other two species of *Diploria*. It does not occur as deep as *D. strigosa*, with its maximum depth begin about 15 m and its distribution centered around 1 to 3 m. This species grows in shallow to moderately deep areas, often in quiet back reef and lagoon habitats. Where wave action is stronger, it exhibits a more plate-like growth and becomes an important structural element of the reef community in some locations (Sefton and Webster 1986). *D. labyrinthiformis* forms sizeable heads over 1 m in diameter. This species is a minor reef constructor on the seaward slope of reefs and is the most restricted species of *Diploria* in its distribution on reefs. It occurs as deep as 43 m, but is most common at 2-15 m depth. This common coral is found from shallow to deep locations, but is most abundant at moderate depths on windward reef terraces (Sefton and Webster 1986). *D. strigosa* can form immense heads well over 2 m across and is capable of making a significant contribution to reef structure. This species, like most brain corals, is slow growing, with an annual increase of size of a head estimated at up to 1 cm per year. This means specimen of 2 m in diameter would be at least 100 years old and probably several hundred with all factors considered. This species occurs from low water to at least 40 m but is most abundant above 10 m. It is perhaps the most widely distributed species of *Diploria* on the reef and has even been reported from muddy bays where few other corals grow. This species occurs at all scuba depths from shallow nearshore reefs to moderately deep fore reef slopes (Sefton and Webster 1986).

Montrastrea annularis (boulder star coral) and *M. cavernosa* (great star coral) are generally the most common species of coral on Atlantic reefs at moderate depths (Colin 1978). *M. annularis* forms massive boulders or heads reaching several meters across in shallow water (1-20 m) and flattened heads or plate-like colonies in deeper water (below 20 m). It reaches depths of at least 60 m (Colin 1978). There is great variation in this species, and much of it seems related to depth. This species is slow growing compared to branching corals such as *A. cervicornis*, but rates of 1.0-2.5 cm per year increase in height have been recorded. *M. annularis* is attached by a wide variety of organisms other than corals. Boring sponges are quite abundant in this species, gastropod mollusks of the genus *Coralliophila* feed either on the polyps or on plankton ingested by the polyps, and filamentous algae occur on areas where coral tissue was removed by mechanical action. This star coral often forms massive mounds that are important structural elements of buttresses and other fore reef elements at moderate depth. Colonies become more plate-like as depth increases. This is frequently the dominant reef-builder in buttresses and fore reef slopes (Sefton and Webster 1986).

In many localities at moderate depths, *M. cavernosa* is the predominant species of coral present. Either this species or *M. annularis* is generally the most common coral between 10-30 m in

buttressed or sloping areas of Atlantic reefs lacking sizable thickets of *A. cervicornis*. Below 30 m, *M. cavernosa* clearly predominates over *M. annularis*, but increasing importance of agariciid corals and sclerosponges in reef construction somewhat diminishes its contribution. *M. cavernosa* is one of the most effective zooplankton feeders among stony corals. It is one of the deepest occurring hermatypic corals, found at depths from only a few meters to at least 90 m (Colin 1978). *M. cavernosa* is somewhat less common than *M. annualris* but, nevertheless, is an important reef-builder in many areas (Sefton and Webster 1986).

Dendrogyra cylindricus (pillar coral) is one of the most spectacular stony corals found on West Indian reefs. Colonies may contain dozens of upright cylindrical branches and reach a total height of nearly 3 m. If a single one of the "pillars" is broken off and comes to rest in a position where it continues to live, the branch will give rise to several new pillars which again grow vertically. This species is unusual in that the polyps with their tentacles are expanded in the daytime unlike most other stony corals. Pillar coral varies considerably in abundance throughout its range and is a very minor constructor of reefs. It is found on flat or gently sloping reef bottoms between 1 and 20 m. Colonies form spires 3 m or more tall. Distribution is spotty throughout the Caribbean (Sefton and Webster 1986).

Four Poritidae species are represented in the management unit: *Porites astreoides (*Mustard hill coral); *Porites branneri* (Blue crust coral); *Porites divaricata* (Small finger coral); and *Porites porites* (Finger coral). *P. asteroides* can occur in a variety of growth forms. In shallow water it can be encrusting, while at deeper depths the colonies are either rounded or flattened with the surface facing towards the light. Fam worms often occur with *P asteroides* and the sponge *Mycale laevis*, which grows on the undersurfaces of certain corals, can also be associated with it. Asexual reproduction is accomplished either through extratentacular budding or intratentacular budding. *P. asteroides* occurs abundantly in nearly all reef zones to depths of over 50 m. *P. branneri* colonies are encrusting and found from 0.1-12 m of depth, generally associated with bank reef types. *P. divaricata* is a delicate species of *Porites*. The branches are about 6 mm in diameter and form, at most, a small clump with widely spaced branches. *P. divaricata* are typical of back reef areas in shallow water, but occur rarely as deep as 15 m (Colin 1978). *P. porites* have thick branches, often 25 mm in diameter, that resemble stubby fingers, hence the name. *P. porites* can occur in many reef situations including back and clear water fore reef areas, It common throughout the Caribbean, but is rare below 20 m (Colin 1978).

5.2.1.4.2.2.4 Black corals, Order Antipatharia

Entire colonies are harvested for artisanal purposes in some regions of the Caribbean. In 1970, the local precious coral jewelry industry (black and pink coral) was estimated to have a retail value of more than 4 million dollars. Their axial skeleton is polished and attains considerable thickness in some species, rendering them commercially valuable in the jewelry trade to humans. Species that do not branch are bent for making necklaces. In Puerto Rico and the Virgin Islands, commercial harvesting is apparently uncommon but is known to occur (Goenaga and Boulon 1992).

The ecology and life history of these organisms is, for the most part, unknown. Taxonomy, to a large extent, is also unknown. Two genera are represented in the Caribbean coral reef fishery management unit: *Antipathes spp.* (bush black corals) and *Stichopathes spp.* (wire corals) (Goenaga and Boulon 1992). Black corals are typically deep sea, slow growing colonial anthozoans usually occurring under ledges, possibly because their larvae is negatively phototactic. The axial skeleton is black, spiny and scleroproteinaceous, and is secreted in concentric layers around a hollow core. The polyps overlay the horny skeleton, are interconnected and possess six non-retractile, unbranched tentacles. They usually contain a diverse array of internal and external unstudied commensal organisms that include palaemonid crustaceans, lichomolgid copepods, and pilargiid polychaetes. Available evidence suggests that recruitment is infrequent.

Thick stemmed, branched, and large (i.e., potentially important economically) bush black corals occur in water depths below 50 m in La Parguera, Puerto Rico. Unbranched, thin stemmed wire corals are present at depths of 20 m. Both genera can also occur sparsely in very shallow, turbid waters off Mayaguez, western Puerto Rico and in La Parguera, southwestern Puerto Rico. Individual *Antipathes spp.* have been observed above depths of 8 m south of Arrecife La Gata, La Parguera, indicating that adult colonies of these species do not require deep waters. In the Virgin Islands, these species are most common at depths exceeding 30 m but can be found on the north shore of St. Croix and north of St. John (e.g., Haulover Bay) at depths of less than 20 m. Some of these colonies have been observed to have been harvested over a several year period which would indicate either cautious harvesting (some of these areas being within the VI National Park) or personal collecting for low level jewelry production (Goenaga and Boulon 1992).

5.2.1.4.2.2.5 False corals, Order Corallimorpharia

The corallimorpharians are a small order of Hexacorallia. They lack a skeleton but they form sheet-like colonies or can occur singularly. While they occur on Carribean reefs, they are of minor importance (Colin 1978).

Discosoma spp. are often found in groups on rocky substrates, and they may reach 10 cm in diameter. Generally occurring in shallow waters 2 to 30 m in depth, it can be found growing on vertical shaded areas, on dead branches of coral, and symbiotically growing on sponges (Colin 1978). The Florida false coral, *Ricordia florida*, covers large areas of rocky substrates on the back and fore reef from 0 to 20 m of water, and can consist of hundreds of polyps. Individual specimens of *R. florida* are no large than 5 cm in diameter, and has short, rounded tentacles.

5.2.1.4.3 Bryozoans

The bryozoans are colonial, largely marine animals numbering around 1,000 species which occur attached to a substrate (Colin 1978). The individual animal in a bryozoan colony is called a zooid. Zooids have polyp-like tentacles encircling the mouth, but they have developed a complete digestive system, including an anus that lies outside the ring of tentacles. Bryozoan

colonies of different species vary greatly in appearance. Some look like a clump of seaweed or moss, while others grow as lacy fans (e.g., *Reteporellina evalinae*). Still other species simply form a low-lying encrustation (e.g., *Trematooecia aviculifera*). Colonies can be either rigid or flexible. Rigid colonies, while calcareous, are often extremely fragile. Because of the many variable, members of the phylum are not easily recognized as a group; many species can only be differentiated by the shape of the individual zooid, which often requires microscopic examination.

5.2.1.4.4 Aquarium trade species

The aquarium trade, occurring primarily in state waters where shallow water depth facilitates specimen collection by divers, includes species of sponges, anemones, false corals, annelid worms, mollusks, crustaceans, echinoderms, and algae. A description of sponge, anemone, and false coral biology and status was included in Sections 4.2.2.1.4.1 and 4.2.2.1.4.2.2. The status of the annelid worms, mollusks, crustaceans, echinoderms, has not been assessed relative to the pre-SFA definition of overfishing. Under that definition, these stocks are experiencing overfishing when annual catch exceeds OY. No definition of overfished has been developed for these stocks (NMFS 2002). The SFA Working Group classified the status of the Aquarium Trade Species Complex as "unknown." The methodology used to make this determination is described in Section 4.2.2. The following offers biological information on these remaining groups.

5.2.1.4.4.1 Annelid worms, Phylum Annelida.

Polychaetes are a large class of segmented marine worms numbering over 10,000 species. They are easily divided into the sedentary tube dwellers (Subclass Sedentaria) and the free-moving species (Subclass Errantia) (Colin 1978). Both families represented in the Caribbean coral reef fishery management unit belong to the Subclass Sedentaria. These include the Sabellidae (feather duster worms) and Serpulidae.

Species in the Coral FMP that belong to the Sabellidae family include *Sabellastarte* spp. (tube worms) and *S. magnifica* (magnificent duster). *S. magnifica*, the largest of the Caribbean feather dusters, is found in the Caribbean at depths of 1 to at least 20 m, and may be abundant on pilings and on reefs among corals where there is a fair amount of suspended material in the water. Other Sabellidae on reefs may occur in groups of dozens of individuals (Colin 1978).

Only one species in the Coral FMP, *Spirobranchus giganteus* (Christmas tree worm), belongs to the Serpulidae family. Abundant on all areas of the reef, *S. giganteus* can be found from 1 to 25 m of depth.

5.2.1.4.4.2 Mollusks (with the exception of the Caribbean Conch Resources)

Mollusk species that are included in the management plan include gastropod and bivalve representatives, as well as octopi. The lettuce sea slug (*Tridachia crispata*) is common species found on reefs and other areas, and are generally found in shallow water, with a maximum depth of 15 m. The netted olive (*Oliva reticularis*) is a colorful gastropod whose shell is common in curio shops and collected along the beach. It is also found in shallow water, with a maximum depth of 10 m. It inhabits sandy areas near shallow patch and back reefs. Several species of Strombidae are also included in the Coral FMP, but a discussion on their biology and status can be found in Section 3.2.1.2.2. The flamingo tongue (*Cyphoma gibbosum*) is a colorful gastropod and is commonly associated with gorgonian species, which it feeds on. As with the other mollusk species, it is found in shallow water, with a maximum depth of approximately 15 m. The Atlantic triton trumpet (*Charonia tritonis*; *Charonia variegata*) is a large gastropod that is most likely prized more for its shell by specimen collectors, than by aquarists. It is found occasionally throughout the Caribbean, but has become rare in other regions due to over-collecting. It inhabits sandy bottoms and reefs, usually hiding in reef recesses during the day but actively feeding on sea cucumbers in the open at night. It typically is found in 6 to 20 m of water.

Three species of fileclams can be found in the Caribbean region. The rough fileclam (*Lima scabra*) is common throughout the Caribbean, and inhabits cracks, crevices, and recesses in 1 to 40 m of water. While it can attach itself to substrate with byssal threads typical of mussels, it can also swim with jerky motions by repeatedly snapping its valves open and shut. In contrast to the fileclam, the spiny fileclam (*Lima lima*) and the Antillean fileclam (*Lima pellucida*) are typically found in shallow waters from 1 - 9 m. The spiny fileclam is common throughout the region, while the Antillean fileclam is only occasionally encountered. Both generally hide under rocks and reef debris, but can swim like the spiny fileclam by opening and closing its valves.

Included in the management unit are several species of octopi. Five managed species are known to exist in the Caribbean, though only one is common. The Caribbean reef octopus (*Octopus briareus*) can reach a size of 30 to 60 cm, weight of 1 kg, and lives in 5 to 25 m of water. *O. briareus* spawns only once; the male dies after mating and the female after the eggs have hatched. Its eggs are large, up to 1.59 cm long, and in clusters usually numbering less than 1,000. The eggs hatch in about to months and the young quickly take up a bottom-dwelling habit. The lifespan of *O. briareus* is typically around one year. Other managed species that are uncommon to rare in the Caribbean are the white spotted octopus (*O. macropus*), the Caribbean two-spot octopus (*O. filosusi*), the Atlantic pygmy octopus (*O. joubini*), and the brownstripe octopus (*O. burryi*).

5.2.1.4.4.3 Crustaceans

A diverse and numerous group (22 species) of crustaceans, such as hermit crabs and cleaner shrimp, are included in the management unit. Cleaner shrimp such as the scarlet-striped cleaning

shrimp (*Lysmata grabhami*) inhabit reefs and the recesses of sponges, and serve an important ecological role by cleaning numerous finfish species of parasites. Most shrimp are associated with reef habitat, and some, such as the squat anemone shrimp (*Thor amboinensis*), the Pederson cleaner shrimp (*Periclimenes pedersoni*), and the spotted cleaner shrimp (*P. yucatanicus*), live in association with anemones. As such, these shrimp species are typically found in depths of 1 to 40 m, with most found in water less than 30 m of depth.

Hermit crabs (e.g., *Paguristes cadenati*, *P. erythrops*) utilize abandoned gastropod shells as mobile shelter. They occupy the shell by wrapping their abdomen around the internal spirals of the shell and extend only their head, antennae, and legs from the opening. The occur in a wide variety of habitats, including reefs, and can be found in depths from 1 to 40 m of water. Similar in body structure to the hermit crabs, in that they posses a long abdomen, are the mantic crabs. The swollen claw mantis (*Gonodactylus oerstedii*) and the dark mantis (*G. curacaoensis*) are found on reefs, under ledges, and other recesses from 1 to 25 m in depth.

Also included are several other species of true crabs, such as the green clinging crab (*Mithrax sculptus*), the banded clinging crab (*M. cinctimanus*), and the nimble spray crab (*Percnon gibbesi*), that are common throughout the Caribbean. Generally found in rocky and coral reef areas, they can be found in 1 to 40 m in depth. The nimble spray crab is commonly associated with sea urchins, and seeks shelter under their long spines.

5.2.1.4.4.4 Echinoderms

Echinoderms are a large group of marine invertebrates possessing an inner skeleton of calcareous plates and a water-vascular system of fluid-filled vessels and appendages. The body structure often consists of multiples of five in skeletal plates, spines, arms, etc. Tube feet, the tactile extensions of the water-vascular system, occur on the arms and body. Managed echinoderm species include crinoids (feather stars), sea stars, brittle stars, sea urchins, and sea cucumbers.

Four species of crinoids, *Davidaster rubiginosa* (golden crinoid), *D. discoidea* (beaded crinoid), *Nemaster grandis* (black and white crinoid), and *Analcidometra armata* (swimming crinoid) are included in the management unit. These are filter feeding organisms and use the fine pinnules on the arms for straining material from the water. *D. rubiginosa* is perhaps the most abundant crinoid species in the Caribbean, and is found on reefs from 10 to 40 m of depth. The other species are all common to occasional throughout the management area, and are also found on reef habitat. *A. armata* has developed the unique ability to coordinate arm movements, which enables it to swim in open water. It is commonly found attached to branches of sea plumes and sea whips.

Sea stars typically are found on sandy of mud bottoms, though *Linckia guildingii*, an occasional Caribbean species, is found on reefs from 7 to 40 m of water. They are not important animals of Caribbean coral reefs (Colin 1978). They are star shaped and the number of arms vary within and between species. The mouth is on the under surface and the anus is generally on the upper

surface. The cushion sea star (*Oreaster reticulatus*) is frequently found just offshore in 2 to 11 m of water, amongst sand flats and grass beds. Due to its robust size, it is commonly collected as a curio by tourists. Similar to sea stars, brittle stars have numerous arms radiating from its central body. The arms are also commonly used for locomotion, and in many species are used from filter feeding. When handled, brittle stars tend to break off their arms, hence their common name. The arms will regenerate after a time. Six species are included in the Coral FMP, and all inhabit reefs. The species in the management unit all are found in relatively shallow water, from 2 to 35 m of water.

Urchins, such as the long-spined urchin (*Diadema antillarum*) can play an important role on the reefs as herbivores. They are found in all habitats from 0 to 45 m of water, though they tend to hide in sheltered locations during the day, waiting to feed openly on algae after dark. Densities of *D. antillarum* can be high on reefs, with as many as 13/m^2 having been reported (Colin 1978). Aside from grazing on reef algae, urchins can denude areas of seagrass beds as well. This grazing on the reefs is an important factor in coral reef health and stability. In some instances where *D. antillarum* was not present, algae were literally taking over the reef from the corals. At least 15 species of fishes are known to prey on *D. antillarum*. Some juvenile fishes and shrimp and known to utilize the long spines of this urchin species as shelter. *D. antillarum* are known to aggregate and spawn throughout the year in the Caribbean. The remaining species of urchin, such as *Echinometra lucunter* and *Lytechinus variegatus*, occur in shallower water than *Diadema antillarum*, generally from 0 to 20 m in depth, and do not play as critical a role as the latter species. The West Indian sea egg (*Tripneustes ventricosus*) also inhabits seagrass beds, but its numbers have been greatly reduced in some areas of the Caribbean due to harvest for its roe.

While there are about 25 species of sea cucumbers that occur in shallow Caribbean water, only three species of sea cucumbers are also in the management unit; the donkey dung sea cucumber (*Holothuria mexicans*) is perhaps the most common of the three. It inhabits seagrass beds and sandy areas around reefs from 3 to 20 m of water. Sea cucumbers feed by passing sediment through the gut and digesting any organic material contained in it, or by catching detritus or small planktonic organisms on mucous-covered tentacles centered around the mouth. The body wall of sea cucumbers often contain a toxin, called holothurin, which makes them distasteful to predators. The slender sea cucumber (*H. impatiens*) and the tiger tail cucumber (*H. thomasi*) occur on reefs are rubble areas from 7 to 45 m of water.

5.2.1.4.4.5 Tunicates (Class Ascidiacea)

Ascidians are bottom dwelling organisms on hard substrates generally in shallow water. However, there are several species of pelagic tunicates, such as sea salps, that are free-swimming. They are sac-like or irregular in shape and vary from a few millimeters to several centimeters in length. They may occur singularly or colonially. Most ascidians are hermaphroditic, producing a larvae which resembles vertebrate larvae. It possesses a notochord which is lost after metamorphosis, and the larva eventually attaches to the substrate. It then transforms into the typical sea squirt. Probably close to 100 species of Ascidiacea occur in the

Caribbean, many of which occur on reefs (Colin 1978). Ascidians are found at all depths on the reef ad most species are widespread in their distribution.

5.2.1.4.5 Marine plants

Marine plants encompass a wide spectrum of the plant kingdom. Generally, there are three groups: flowing plants or spermatophytes, algae, and fungi. Spermatophytes, such as seagrass, consist of relatively few species in the Caribbean, but where they occur they are abundant and of great importance in shallow water communities. Algae are much more diverse and divided into green, red, and brown algae, plus other groups such as diatoms and dinoflagellates; only green and red algae are included in the management unit.

Photosynthetic marine plants are limited in depth they can inhabit by available light. In even the clearest tropical waters, macroalgae are essentially absent below approximately 100 m (Colin 1978).

5.2.1.4.5.1 Algae

Algae lack true roots, stems, leaves, and flowers associated with plants. The vegetative portion of the plant is often divisible into root-like rhizoids, a stem-like stipe, and leaf-like blades. *Caulerpa racemosa*, like other species of *Caulerpa*, has erect branches arising from a horizontal stolon attached to the sediment at intervals by descending rhizomes (Colin 1978). *C. racemosa*, the most ubiquitous plant of the genus, have branches rising every few centimeters, reaching as much as 30 cm in height. It occurs from shallow muddy bays to clear water reef environments.

Another important algae is *Halimeda spp.* The highly calcified segments of *Halimeda* can be a very significant contributor of material to the sediments in many areas. *H. opuntia*, the most predominant species of the genus to depths of 20 m, is found in all tropical oceans. In deeper depths, *H. copiosa* is the most abundant algae species, growing on steep coral-overgrown slopes. Its contribution to deep reef sediments is extremely high; their production of carbonate material at these depths may well exceed that produced by stony corals (Colin 1978).

Other species are found throughout algal plains and sandy fore reef areas, such as *Udotea spinulosa* and *U. cyathiformis*. Unlike *Halimeda*, the elements making up the skeleton in this genus are relatively small, and are not particularly important in the sediments of sloping fore reef areas. Species in this genus can be found in depths of 10 to 90 m.

Red algae posses chlorophyll like other algae, but they derive their color from phycoerythrin, a red pigment. This algae constitutes a large class with a wide range of diversity. Included are many species capable of producing calcium carbonate reef structures and also tiny filamentous species. Included in this group is coralline algae such as *Lithophyllum congestum*, *Porolithon pachydernum*, and *Neogoniolithon spp.*, which are important algae ridge constructors in St. Croix (Colin 1978).

5.2.1.4.5.2 Seagrasses

The primary production of seagrass beds is extremely important in tropical marine ecosystems. Seagrass beds play a significant role as habitat, nursery, and food source for ecologically and economically important fauna and flora. Direct grazing on seagrasses is limited to a number of species (e.g., sea turtles, parrotfish, surgeonfish, sea urchins, and pinfish). Other grazers (e.g., queen conch) scrape the epiphytic algae on the seagrass leaves.

Turtle grass, *Thalassia testudinum*, is the most ubiquitous plant in shallow water areas of the Caribbean, and forms large meadows. It is often mixed with manatee grass, *Syringodium filiforme*. *Thalassia testudinum* undergoes seasonal fluctuations in productivity; productivity, standing crop, blade length, and density reach a maximum during the warm summer months. Blades of *Thalassia testudinum* can grow rapidly, up to 1 in per week under ideal conditions. Average growth rates for *Thalassia* were also estimated at 2 to 4 mm/leaf/day, with maximum growth at 12.5 mm/leaf/day (Zieman 1975). Turtle grass requires water of high salinity in areas sheltered from extreme wave action.

Shoot longevity and rhizome turnover, rather than capacity to support dense meadows, are key elements in determining either pioneer species (*Halodule wrightii* and *Syringodium filiforme*) versus climax species (*Thalassia testudinum*) of seagrass (Gallegos *et al.* 1994). Because of stored starch in the rhizomes, *Thalassia* can withstand environmental stress for some time (Zieman 1975). However, it was estimated that it takes approximately 2 to 5 years for a *Thalassia testudinum* bed to recover from physical disturbance of the rhizome system, most often caused by motor boat propellers.

Halophila decipiens occurs in Salt River Canyon, St. Croix, USVI. Although the net production of *H. decipiens* is less than other Caribbean seagrasses, in Salt River Canyon, *H. decipiens* represents a major source of primary production. It has been shown that bacteria attached to *H. decipiens* detritus do not efficiently recycle primary production of this seagrass in Salt River Canyon (Kenworthy *et al.* 1989). *H. decipiens* is monoecious, with male and female flowers occurring on the same spathe. Female flowers produce approximately 30 seeds. *Halophila decipiens* is considered a stenohaline species, in that it is intolerant of variation in salinity. When *Halophila johnsonii*, an intertidal to shallow subtidal species, was compared with deeper water populations of *H. decipiens*, *H. johnsonii* showed greater tolerance to higher irradiances, and to variations in temperature and salinity (Dawes *et al.* 1989). *H. baillonis* and *H. engelmanni* both occur in silty, muddy substrates, and reach depths of 9 to 30 m (Colin 1978).

5.2.2 Other affected species

5.2.2.1 Protected species

In addition to Nassau and Goliath grouper described in Sections 5.2.1.3.33.9 and 5.2.1.3.33.6, respectively, other protected species occur in the management area. Protected species under the

ESA, MMPA, and MBTA include various species of cetaceans, sea turtles, and other animals, such as the West Indian manatee and seabirds. This section summarizes the available information on the biology and status of these species and describes the extent of their interaction with commercial and recreational fisheries in the U.S. Caribbean.

5.2.2.1.1 Marine Mammals

At least seventeen species of whales and dolphins have been reported in or near U.S. waters in the northeastern Caribbean (Mignucci-Giannoni 1998). ESA-listed species known to occur in this area include four baleen whales (humpback, fin, and sei), one toothed whale (sperm), and one sirenian (West Indian manatee). The area provides feeding grounds for some of these species, and reproductive grounds for others. Most cetacean species in this area are sighted during the winter and early spring, with the increase in sightings beginning in December, peaking in February, and gradually decreasing in March and April, with few sightings from May through November. Additionally, some species do not migrate, utilizing these waters for feeding and reproduction throughout the year (Mignucci-Giannoni 1998). Except for the humpback whale, which occurs in specific areas during winter to breed and calf, abundances and distributions of most of most marine mammals in the northeastern Caribbean are poorly known (Mignucci-Giannoni 1998).

Mignucci-Giannoni (1989) reviewed cetacean sighting data from published and unpublished records collected in the insular shelf waters of Puerto Rico, the USVI, and the British Virgin Islands (BVI) through 1989. Humpback whales were most commonly sighted, comprising nearly 80% of sightings records (79.22%, 1597 individuals), followed by bottlenose dolphins (7.49%, 151 individuals) shortfin pilot whales (3.42%, 69 individuals) sperm whales (2.13%, 43 individuals), spinner dolphins (2.03%, 41 individuals) and Atlantic spotted dolphins (1.54%, 31 individuals).

Mignucci-Giannoni *et al.* (1999) conducted an assessment of cetacean strandings in waters of Puerto Rico and the U.S. and BVI to identify, document, and analyze factors associated with 129 (159 individuals) reported mortality events through 1995. The bottlenose dolphin was the species most commonly found stranded, followed by Curvier's beaked whales, sperm whale, Atlantic spotted dolphin, and shortfinned pilot whale. Overall, causes of death were not determined in 62.8% of the case. Natural causes contributed 20.9% of the case, while human-related cases totaled 16.3%. The most common natural cause of death category was dependent calf. The most common human related cause categories observed were entanglement and accidental captures.

Under section 118 of the Marine Mammal Protection Act (MMPA), NMFS must publish, at least annually, a List of Fisheries that places all U.S. commercial fisheries into one of three categories based on the level of incidental serious injury and mortality of marine mammals that occurs in each fishery. The final rule for the 2003 List of Fisheries classifies all U.S. Caribbean commercial fisheries under the Caribbean Fishery Management Council's jurisdiction as

Category III fisheries, meaning that the annual mortality and serious injury of a stock resulting from each fishery is less than or equal to one percent of the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population (68 FR 41725). This classification is primarily due to lack of information, with limited stranding data providing the only information about incidental marine mammal mortality and serious injury in these fisheries. It is often difficult to attribute stranded marine mammals that show clear signs of gear interaction to a specific fishery. Gill nets and buoy lines are known to adversely affect marine mammals in other fishing areas in the U.S. EEZ and therefore, may be occurring in the U.S. Caribbean as well, but are undocumented.

A summary of the biology and status of endangered and threatened marine mammals found in the U.S. Caribbean is included below. Additional information on these species and on the other marine mammals and their occurrence in the U.S. Caribbean may be found in Mignucci-Giannoni (1998). More general information on the biology and status of marine mammals may be found in Perry *et al.* (1999) and on NMFS' website: http://www.nmfs.noaa.gov/prot_res/PR2/Stock_Assessment_Program/individual_sars.html.

5.2.2.1.1.1 Humpback whale, *Megaptera noveangliae*

Humpback whales inhabit all major ocean basins from the equator to subpolar latitudes. They generally follow a predictable migratory pattern in both hemispheres, feeding during the summer in the higher near-polar latitudes and migrating to lower latitudes where calving and breeding takes place in the winter (Perry *et al.* 1999).

5.2.2.1.1.1.1 Biology

In the western Atlantic, humpback whales feed during spring, summer, and fall over a range which encompasses the eastern coast of the United States, including the Gulf of Maine, the Gulf of St. Lawrence, Newfoundland/Labrador and western Greenland (Katona and Beard 1990 in Waring *et al*. 2002). Other North Atlantic feeding grounds are found off Iceland and northern Norway (Christensen *et al*. 1992 and Palsbøll *et al*. 1997 in Waring *et al*. 2002). It is believed that these six regions represent relatively discrete subpopulation which are matrilineally determined (Clapham and Mayo 1987 in Waring *et al*. 2002). Humpback whales are described as opportunistic feeders, foraging on a variety of food items including euphausiids and small schooling fish such as herring, sand lance and mackerel (Paquet *et al*. 1997; Payne *et al*. 1990). In the mid-latitudes during the winter, juvenile humpbacks are also known to eat bay anchovies and menhaden, *Brevoortia tyrannus* (Wiley *et al*. 1995). Feeding on wintering grounds is considered a rare event.

In winter, whales from all six feeding areas mate and calve primarily in the West Indies, where spatial and genetic mixing among subpopulations occurs (Clapham *et al.* 1993; Katona and Beard 1990; Palsbøll *et al.* 1997). In the West Indies, the majority of whales are found in the

waters of the Dominican Republic, notably on Silver Bank, on Navidad Bank, and in Samana Bay (Balcomb and Nichols 1982; Mattila *et al.* 1989). Humpback whales are also found at much lower densities throughout the remainder of the Antillean arc, from Puerto Rico to the coast of Venezuela (Price 1985; Mattila and Clapham 1989). Calves are born from December through March and are about 4 m at birth. Sexually mature females give birth approximately every 2 to 3 years. Sexual maturity is reached between 4 and 6 years of age for females and between 7 and 15 years for males. Size at maturity is about 12 m (NMFS 1991).

Mignucci-Giannoni (1998) observed two major areas of humpback whale concentration: one along the northwestern coast of Puerto Rico, and the second widely spread around the northern Virgin Islands. Humpbacks are sporadically seen between St. Thomas and St. Croix, off St. Croix itself, and on the southern coast of Puerto Rico. Humpbacks were also reported near Isla de Mona, Isla Desecheo, and along the north coast of Puerto Rico, at times close to San Juan and Arecibo. Off the northwestern coast of Puerto Rico, humpbacks aggregated more often in two areas: off Punta Higuero in Rincon, and off Punta Agujereada (near Punta Borinquen) in Aguadilla. The only United States-controlled portions of the breeding range are along the northwest coast of Puerto Rico, including Punta Agujereada and nearby Punta Higuero and in the Virgin Islands (NMFS 1991). Females with calves and other whales exhibiting behaviors associated with mating occur along the northwest coast of Puerto Rico. Humpback whales have been sighted off Vieques Island, between Culebra and Vieques (e.g., Erdman *et al.* 1973 in Geo-Marine, Inc. 2001). Stevick *et al.* (1999) reported photographic matches of an individual in Puerto Rico and Dominica, demonstrating an exchange between the eastern Caribbean and more northerly breeding area in the Greater Antilles (Geo-Marine, Inc. 2001).

Humpback whales in the Caribbean are strongly associated with banks and other shallow waters with low sea floor relief (e.g., Mignucci-Giannoni 1998). Roden and Mullin (2000) noted, however, that humpback whales were also sighted in very deep water (water depth of all sightings averaged 2,877 m). There are nine stranding records for this species for Puerto Rico (Mignucci-Giannoni *et al.* 1999). The northwest and west coast of Puerto Rico have most of the strandings (Mignucci-Giannoni 1999).

It is apparent that not all western North Atlantic whales migrate to the West Indies every winter, and that significant numbers of animals are found in mid- and high-latitude regions at this time (Clapham *et al.* 1993; Swingle *et al.* 1993). Humpback whales use the Mid-Atlantic as a migratory pathway to and from the calving/mating grounds, and it may also be an important winter feeding area for juveniles. Since 1989, observations of juvenile humpbacks in the Mid-Atlantic have been increasing during the winter months, peaking January through March (Swingle *et al.* 1993; Wiley *et al.* 1995).

5.2.2.1.1.1.2 Status

Humpback whales are listed as endangered under the ESA of 1973, as amended. They are also protected under the MMPA of 1972. Because of their nature to aggregate near coasts on both

summer and winter grounds, humpbacks were relatively easy prey for shore-based whalers. As a result, their populations were severely depleted by the time they achieved protection from commercial hunting in 1966.

Photographic mark-recapture analyses from the Years of the North Atlantic Humpback (YONAH) project conducted in 1992-1993, gave an ocean-basin-wide estimate of 11,570 individuals (CV=0.069), which to date is regarded as the best available estimate for the North Atlantic (Waring *et al*. 2002). However, because the YONAH sampling was not spatially representative in the feeding grounds, this estimate is considered negatively biased. It appears that the humpback whale population is increasing though it is unclear whether this increase is ocean-wide or confined to specific feeding grounds.

Although habitat degradation, such as chemical and noise pollution, may be adversely affecting the recovery of humpbacks, the major threats appear to be vessel collisions and entanglements with fishing gear (see Waring *et al*. 2002 for synopsis of mortality/injury). Wiley *et al*. (1995) examining stranding data obtained principally from the mid-Atlantic, found that in the 20 cases where evidence of human impact was discernable, 30% had major injuries possibly caused by a vessel collision and 25% had injuries consistent with entanglement in fishing gear.

There are insufficient data to reliably establish population trends for humpback whales in the North Atlantic, overall. The total level of human-caused mortality or serious injury for the Gulf of Maine (formerly the western North Atlantic stock) stock is not less than 10% of the calculated Potential Biological Removal level (PBR) of 1.3, and therefore cannot be considered to be insignificant (Waring *et al*. 2002). PBR is a calculation required under the MMPA which estimates the number of animals that can be removed annually from the population or stock, in addition to natural mortality, while allowing that stock to remain at an optimum sustainable population level (OSP). The high mortality of humpbacks off the mid-Atlantic states (52 mortalities recorded between 1990 and 2000) is of concern as some of these animals are known to be from the Gulf of Maine population. A recovery plan was published in 1991 and is in effect (NMFS 1991).

Whaling data indicate that the eastern and southern Caribbean Sea formerly supported a large-scale fishery for humpback whales (Price 1985; Geo-Marine, Inc. 2001). During February-March 2000, acoustic detections of singing humpback whales in the eastern and southern Caribbean Sea formed the basis of a preliminary estimate of the relative abundance of humpback whales in the islands and coastal areas surveyed to be 116 whales in February and 123 in March (Swartz *et al.* 2000). Results of that survey suggest that the abundance of humpbacks in the eastern and southern Caribbean Sea is lower than it was during the 19th century. Observed densities were one or two orders of magnitude lower than those recorded from the primary wintering areas in the eastern Greater Antilles.

5.2.2.1.1.2 Sperm Whale, *Physeter macrocephalus*

Sperm whales are typically found throughout the world's oceans in deep waters between about 60° N and 60° S latitudes (Leatherwood and Reeves 1983). For the purposes of management, the International Whaling Commission (IWC) defines four stocks: the North Pacific, the North Atlantic, the Northern Indian Ocean, and Southern Hemisphere. However, Dufault *et al.* (1999) review of the current knowledge of sperm whales indicates no clear picture of the worldwide stock structure of sperm whales. In general, females and immature sperm whales appear to be restricted in range, whereas males are found over a wider range and appear to make occasional movements across and between ocean basins (Dufault *et al.* 1999).

In the western North Atlantic they range from Greenland to the Gulf of Mexico and the Caribbean. Sperm whales generally occur in waters greater than 180 m in depth. While they may be encountered almost anywhere on the high seas, their distribution shows a preference for continental margins, sea mounts, and areas of upwelling, where food is abundant (Leatherwood and Reeves 1983). Waring *et al.* (1999) suggest sperm whale distribution in the Atlantic is closely correlated with the Gulf Stream edge.

Sperm whales are widely distributed in the Caribbean and are common in the deep water passages between the islands and along continental slopes (Taruski and Winn 1976; Watkins and Moore 1982 in Geo-Marine, Inc. 2001). In the Puerto Rico/Virgin Islands area, sperm whales were observed 64% of the time near the shelf edge, in areas of high bottom relief (Mignucci-Giannoni 1998). Sperm whales have been sighted off Vieques Island (Erdman *et al.* 1973; Mignucci-Giannoni 1998). Despite the fact that recorded sightings and acoustical contacts would indicate that sperm whales appear to be more common during the fall (October-November) and winter/spring (as early as mid-January, but rarely in May) (Erdman *et al.* 1973; Watkins and Moore 1982; Watkins *et al.* 1985), a review of stranding records actually suggests a year-round presence of this species (Mignucci-Giannoni 1998). There are a total of 13 reported strandings of sperm whales for 1867 through 1995 for Puerto Rico and the Virgin Islands (Mignucci-Giannoni *et al.* 1999).

5.2.2.1.1.2.1 Biology

Sperm whales are the largest of the odontocetes (or toothed whales). Males reach a length of 18.3 m, with females reaching lengths of up to 12.2 m (Odell 1992 in Perry *et al.* 1999). Sperm whales have huge, blunt, squarish heads comprising 25-35% of their total body length. Females attain sexual maturity at a mean age of nine years and a length of about 9 m, while males have a prolonged puberty and attain sexual maturity at about age 20 and a body length of 12 m (Waring *et al.* 1999). Male sperm whales may not reach physical maturity until they are 45 years old (Waring *et al.* 1999).

Sperm whales have a distinct social structure. Sperm whale populations are organized into two types of groupings: breeding schools and bachelor schools. Breeding schools consist of females

of all ages, calves and juvenile males. Bachelor schools consist of maturing males who leave the breeding school and aggregate in loose groups of about 40 animals. As the males grow older they separate from the bachelor schools and remain solitary most of the year (Best 1979). During the time when females are ovulating (April through August in the Northern Hemisphere) one or more large mature bulls temporarily join each breeding school. A single calf is born after a 15-month gestation. A mature female will produce a calf every 4-6 years (Waring *et al.* 1999).

Sperm whales typically prefer deep-water habitats (>300 m), however, they are periodically found in coastal waters (Scott and Sadove 1997). Their occurrence closer to shore is usually associated with the presence of food. Sperm whales prey primarily on large sized squid but also occasionally take octopus and a variety of fish including shark and skate (Leatherwood and Reeves 1983).

5.2.2.1.1.2.2 Status

The sperm whale was listed as endangered under the ESA in 1973, as amended. They are also protected under the MMPA of 1972. The primary factor for the species' decline, that precipitated ESA listing, was commercial whaling. Sperm whales were hunted in America from the 17th century through the early 1900s, but the exact number of whales harvested in the commercial fishery is not known (Townsend 1935). The IWC estimates that nearly a quarter-million sperm whales were killed worldwide in whaling activities between 1800 and 1900 (IWC 1969). With the advent of modern whaling the larger rorqual whales were targeted. However as their numbers decreased, greater attention was paid to smaller rorquals and sperm whales. From 1910 to 1982 there were nearly 700,000 sperm whales killed worldwide from whaling activities (Committee for Whaling Statistics). The IWC prohibited commercial hunting of sperm whales in 1981, although the Japanese continued to harvest sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997).

Whitehead (2002) used a population model based on one used by the IWC's Scientific Committee which considers uncertainty in population parameters and catch data and estimates population trajectories. Results suggest that pre-whaling numbers were about 1,100,000 whales (95% CI: 672,000 to 1,512,000) and that in 1999 the global sperm whale population was at about 32% (95% CI: 19% to 62%) of its original population. The best estimate that is currently available for the western North Atlantic sperm population 4,702 (CV=0.36) but is likely to be an underestimate (Waring *et al.* 2002). Currently, the population trend for this species is undeterminable due to insufficient data.

Since the ban of nearly all hunting of sperm whales, there has been little evidence that human-induced mortality or injury is significantly affecting the recovery of sperm whale stocks (Perry *et al.* 1999; Waring *et al.* 1999). Due to their more offshore distribution and benthic feeding habits, sperm whales seem less subject to entanglement in fishing gear than some cetacean species. Documented interactions have primarily involved offshore fisheries such as pelagic drift gill nets and longline fisheries. Overall, the fishery-related mortality or serious injury for the western

North Atlantic stock is considered to be less than 10% of PBR. The estimated PBR for the western North Atlantic sperm whale is 7.0 (Waring *et al.* 2002). Other impacts known to kill or injury sperm whales include ship strikes and ingestion of foreign material (e.g., fishing line, plastics).

5.2.2.1.1.3 Fin whale, *Balaenoptera physalus*

Fin whales have a worldwide distribution and are most commonly sighted where deep water approaches the coast (Jefferson *et al.* 1993). The fin whale makes regular seasonal migrations between temperate waters, where it mates and calves in late fall and winter, and the more polar feeding grounds occupied in the summer months. In the Atlantic, Clark (1995) reported a general southward pattern of fin whale migration in the fall from the Labrador-Newfoundland region, south past Bermuda, and into the West Indies. They are common in the waters of the U.S. Atlantic EEZ primarily from Cape Hatteras northward (Waring *et al.* 2002). Fin whales in Puerto Rico have only been observed north of Isla de Mona and south of Cayo Ratones in Salinas. Most sightings have been from the Virgin Islands, equally distributed in the shelf, near shelf edge and offshore waters, in areas of low sea floor relief. The majority of sightings have been from the winter or early spring and from the Virgin Islands (Geo-Marine, Inc. 2001).

5.2.2.1.1.3.1 Biology

The fin whale is the second largest whale species by length. Mature animals range from 20 to 27 m in length, with mature females being approximately1.47 m longer than mature males (Aguilar and Lockyer 1987). Fin whales achieve sexual maturity at 5-15 years of age (Perry *et al.* 1999), although physical maturity may not be reached until 20-30 years (Aguilar and Lockyer 1987). Conception is believed to occur during the winter with birth of a single calf after a 12-month gestation (Mizroch and York 1984). The calf is weaned 6-11 months after birth (Perry *et al.* 1999). The mean calving interval is 2.7 years (Agler *et al.* 1993).

The predominant prey of fin whales varies greatly in different geographical areas depending on what is locally available (IWC 1992). In the western North Atlantic, fin whales feed on a variety of small schooling fish (e.g., herring, capelin, sand lance) as well as squid and planktonic crustaceans. As with humpback whales, fin whales feed by filtering large volumes of water for their prey through their baleen plates. Foraging areas tend to occur along continental shelves in waters to 200 m (650 ft) deep (Wynne and Schwartz 1999).

5.2.2.1.1.3.2 Status

Fin whales are listed as endangered under the ESA of 1973, as amended. They are also protected under the MMPA of 1972. Modern whaling depleted most stocks of fin whales. Commercial hunting in the North Atlantic ended in 1987 though Greenland still conducts an "aboriginal subsistence" hunt allowed under the IWC.

For management purposes, NMFS recognizes only a single stock of fin whales in the U.S. waters of the western North Atlantic, though genetic data support the idea of several subpopulations (see Bérubé *et al.* 1998). A survey conducted in 1999 from Georges Bank northward to the Gulf of St. Lawrence, led to an estimate of 2,814 (CV=0.21) individuals for the western North Atlantic population. This however, is considered a conservative estimate due to the extensive range of the fin whale throughout the entire North Atlantic and the uncertainties regarding population structure and exchange between surveyed and non-surveyed areas. To date, there is insufficient information in order to determine population trends.

Aside from the threat of illegal whaling or increased legal whaling, potential threats affecting fin whales include collisions with vessels, entanglement in fishing gear and habitat degradation from chemical and noise pollution. Fin whales are known to have been killed or seriously injured by inshore fishing gear (i.e., gill nets and lobster lines) off eastern Canada and the United States (NMFS 1998a). A draft recovery plan for fin whales is available but the plan has not yet been finalized.

5.2.2.1.1.4 Sei whale, *Balaenoptera borealis*

Sei whale are a widespread species in the world's temperate, subpolar, subtropical, and even tropical marine waters. However, they appear to be more restricted to temperate waters than other baleen whales. The Western North Atlantic is comprised of three stocks, including the Nova Scotia, Iceland-Denmark Strait, and Northeast Atlantic (Perry *et al.* 1999).

In the western North Atlantic, it is thought that a large segment of the population is centered in northerly waters, perhaps the Scotian Shelf during the summer feeding season (Mitchell and Chapman 1977 in Waring *et al.* 2002). Their southern range during the spring and summer includes the northern areas of the U.S. Atlantic EEZ (i.e., Gulf of Maine and Georges Bank). Strandings along the northern Gulf of Mexico and in the Greater Antilles, indicate those areas to be the southernmost range for this population (Mead 1977 in Waring *et al.* 1999).

5.2.2.1.1.4.1 Biology

The sei whales is the third largest balean whale, ranging from 12-18 m in length at maturity. They are believed to undertake seasonal north/south movements, with summers spent in higher latitudes feeding and winters in lower latitudes, though the location of winter areas remains largely unknown (Perry *et al.* 1999). Sei whales reach sexual maturity between 5-15 years of age. Similar to the fin whale, conception occurs during a five–month period in the winter of either hemisphere. The calving interval is believed to be 2-3 years (Lockyer and Martin 1983).

The sei whale is generally found in deeper waters though they are known for periodic excursions into more shallow and inshore waters when food is abundant (Payne *et al.* 1990). They consume primarily copepods, but they also feed on euphausiids and small schooling fishes (Mizroch *et al.* 1984 in Perry *et al.* 1999).

5.2.2.1.1.4.2 Status

Sei whales are listed as endangered under the ESA of 1973, as amended. They are also protected under the MMPA of 1972. Sei whales began to be regularly hunted by modern whalers after the populations of larger, more easily taken species (i.e., humpbacks, right whales and gray whales) had declined. Most stocks of sei whales were also reduced, in some cases drastically, by whaling efforts throughout the 1950s into the early 1970s. International protection for the sei whale began in the 1970s, though populations in the North Atlantic continued to be harvested by Iceland until 1986 when the IWC's moratorium on commercial hunting in the Northern Hemisphere came into effect.

Since the cessation of commercial whaling, threats to sei whales in the western North Atlantic appear to be few although do include ship collisions and entanglement in fishing gear. Because of their offshore distribution and overall scarcity in U.S. Atlantic waters, reports of entrapments and entanglements tend to be low. It is unknown whether sei whales are less prone to interact with fishing gear or if they break through or carry the gear away with them causing mortalities that go largely unrecorded. There were no reported fishery-related mortalities or serious injuries observed by NMFS during 1994-1998 (Waring *et al.* 2002). The total level of human- caused impacts on sei whales is unknown but due to the rarity of mortality reports it is thought to be insignificant (Waring *et al.* 2002).

5.2.2.1.1.5 West Indian manatee, *Trichechus manatus*

The West Indian manatee occurs in the Atlantic Ocean (UNEP-WCMC 2003). In the western Atlantic, this species ranges as far north as Georgia (USA), southward to coastal areas of South America, including the Gulf of Mexico and Caribbean Sea. In the U.S. Caribbean, this species is known to occur around the southern and eastern end of Puerto Rico and around nearby Vieques Island. Except for rare sightings, manatees seem to be absent from the Virgin Islands at present, but fossils have been found in middens on St. Croix (USFWS 2003a).

5.2.2.1.1.5.1 Biology

The West Indian manatee inhabits both marine and fresh water environments, generally from 1.5 to less than 6 m depth. It is usually found in canals, rivers, estuarine habitats, and saltwater bays, but has been observed, on occasion, as many as 3.7 mi offshore. Habitat usage appears to be tied to food supply, water depth, and proximity to fresh water. Florida manatees exhibit movement patterns associated with changing weather patterns, migrating south when water temperatures drop below about 21 to 22° C, or forming large aggregations in natural springs and industrial outfalls. Severe cold fronts have been known to kill manatees when the animals did not have access to warm-water refuges. There is no evidence of any periodicity in manatee habitat use in Puerto Rico (USFWS 2003a).

Adults average about 3 m in length and weigh about 1,000 lbs. Observations of mating herds indicate that females mate with a number of males during their 2- to 4-week estrus period. Gestation period is 12-14 months. Births occur year-round, but decrease slightly during winter months. Manatee cows usually bear a single calf, but 1.5% of births are twins. Calves reach sexual maturity at 3 to 6 years of age. Mature females may give birth every 2 to 5 years. Weaning generally occurs between 9 and 24 months of age, although a cow and calf may continue to associate with each other for several more years. There is little information on the life-time reproductive output of females, although they may live over 50 years. Manatees are primarily herbivores, feeding on a wide variety of aquatic vegetation, but also occasionally feed on fish. They may consume 4-9% of their body weight each day (USFWS 2003a).

5.2.2.1.1.5.2 Status

The West Indian manatee was listed under the ESA as endangered throughout its range on March 11, 1967. On January 7, 1975, this species (including all populations) was listed in CITES Appendix I (UNEP-WCMC 2003). Appendix I includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances. This species also was classified as vulnerable on the 1996 IUCN Red List of Threatened Species. A vulnerable listing indicates that the manatee faces "a high risk of extinction in the wild in the medium-term future." This determination is based on a reduction of at least 20%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer, based on (and specifying) actual or potential levels of exploitation (IUCN 2003).

Initial population decreases probably resulted from commercial take. Today, hunting is prohibited and is not considered a problem, although there is an occasional incidence of poaching. But heavy mortality does occur from accidental collisions with boats and barges, and from canal lock operations. The combination of high mortality rates and low reproductive rates have led to serious doubts about the species' ability to survive in the United States. Habitat degradation and loss caused by coastal development is also identified as a threat; particularly the destruction of seagrass beds by boating facilities. In Puerto Rico, where the manatee population numbers about 60-100, the primary cause of mortality seems to be entanglement in gill nets (USFWS 2003a). According to 68 FR 1414, the incidental take of at least one manatee in Caribbean gill net fisheries has been documented. The incidental take of this marine mammal by Caribbean haul/beach seines has been documented as well (68 FR 1414). Collisions with boats and illegal killing of manatees for food may also be affecting the Puerto Rican population to some extent, but supporting data are limited (USFWS 2003a).

5.2.2.1.2 Sea Turtles

The U.S. Caribbean provides nesting, foraging, and developmental habitat for three species of marine turtles: the leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), and green (*Chelonia mydas*). Loggerhead sea turtles (*Caretta caretta*) are only occasionally seen, but are transitory (Hillis-Star *et al.* 1998) and rare olive ridleys (*Lepidochelys olivacea*) have

been reported in the area only twice (Caldwell and Erdman 1969; Diez pers. comm. in Flemming 2001). The Kemp's ridley has never been reported in the Caribbean region.

Hillis-Starr *et al.* (1998) reports that the greatest threats to sea turtles in Puerto Rico and the USVI are coastal and upland development, introduction of domestic and exotic species, boating, incidental take in fisheries, illegal harvest of adults and eggs, ingestion and entanglement in marine debris, inadequate local protection and enforcement of laws, and insufficient regional cooperation for turtle protection. The BVI, which lie just one km from St. John and St. Thomas, maintain an open season of four months for harvesting green and hawksbill turtles; illegal fishing of turtles, and trade of turtles and turtle products between the USVI and BVI continue to be problematic.

Hillis-Starr *et al.* (1998) states that local fishing practice, such as trap fishing and gillnetting may adversely impact sea turtles in nearshore waters throughout the Virgin Islands. Offshore, longline fishermen targeting 100 fathoms set trap lines, which are 30 to 65 km in length and which hold more than 400 hooks on each line. Longlines are set to catch swordfish and tuna but incidentally catch sea turtles. Abandoned fishing gear entangles and drowns sea turtles, especially young females, which remain near shore between nestings. Young sea turtles also may become entangled in or ingest marine debris. In recent years, the number of sea turtles killed by boat collisions has increased, especially along ferry routes where turtles forage.

USVI records have documented at least 122 turtle strandings from 1982 through 1997, with boat strikes accounting for the greatest number of strandings (34.43%), followed by undetermined causes (29.51%), poaching (13.11%), other (12.3%), and fishing gear entanglement (10.66%) (Boulon 2000). Longlining is reported to be on the increase around St. Croix and several leatherback females have arrived at Sandy Point entangled in or scarred from the gear (Evans pers. comm. 2000)

In general, gill nets and traps and pots are known to adversely affect marine mammals and sea turtles by entangling and/or drowning them. Gill nets of just about any mesh size can catch, and have caught, sea turtles. The risk however, does increase with mesh size. NMFS has many strandings records, and some live incidental captures, of turtles that are entangled in trap and pot buoy lines.

Information on the biology and status of sea turtles that may occur in the U.S. Caribbean are included below. For additional information, see the references within.

5.2.2.1.2.1 Leatherback turtle, *Dermochelys coriacea*

The leatherback turtle occurs in the Atlantic, Indian, and Pacific Oceans, and in the Mediterranean and Black Seas (UNEP-WCMC 2003). Genetic analyses of leatherbacks to date indicate that within the Atlantic basin there are genetically different nesting populations: the St. Croix nesting population (USVI), the mainland nesting Caribbean population (Florida, Costa

Rica, Suriname/French Guiana), and the Trinidad nesting population (Dutton *et al.* 1999a; 1999b). In the western Atlantic, this species ranges from Nova Scotia (Canada) to the U.S. Caribbean, but tends to be found along the eastern seaboard, from the Gulf of Maine to middle Florida, during the summer months**.** Leatherback sea turtles are found in the Virgin Islands only during their nesting season. Sandy Point National Wildlife Refuge, St. Croix is the principal nesting beach for leatherbacks in the northern Caribbean. The waters adjacent to Sandy Point, St. Croix (up to and including waters from the hundred fathom curve shoreward to the level of mean high tide with boundaries at 17° 42' 12" N and 64° 50' 00" W), have been identified as critical habitat for the leatherback turtle.

5.2.2.1.2.1.1 Biology

The leatherback is the largest living turtle. Adults average 15.5 m curved CL and range in weight from 200-700 kg. Hatchlings average 6.13 cm long and 45.8 g in weight. When the hatchlings leave the nesting beaches, they move offshore but eventually utilize both coastal and pelagic waters. Very little is known about the pelagic habits of the hatchlings and juveniles, and they have not been documented to be associated with the sargassum as are other species. Based on a review of all sightings of leatherback sea turtles of <145 cm curved carapace length (CCL), Erkert (2001) found that leatherback juveniles remain in waters warmer than 26° C until they exceed 100 cm.

Leatherbacks live for over 30 years. They reach sexually maturity somewhat faster than other sea turtles, with an estimated age at sexual maturity of about 13-14 years for females, and an estimated minimum age at sexual maturity of 5-6 years, with 9 years reported as a likely minimum (Zug and Parham 1996) and 19 years as a likely maximum (NMFS SEFSC 2001), with an estimated range from 3-6 years (Rhodin 1985) to 13-14 years (Zug and Parham 1996). In the Caribbean, female leatherbacks nest from March through July. They nest frequently (up to 7 nests) during a nesting season and nest about every 2-3 years. They produce 100 eggs or more in each clutch and, thus, can produce 700 eggs or more per nesting season (Schultz 1975). However, a significant portion (up to approximately 30%) of the eggs can be infertile. Thus, the actual proportion of eggs that can result in hatchlings is less than this seasonal estimate. The eggs will incubate for 55-75 days before hatching.

Leatherbacks are the most pelagic of the turtles, but enter coastal waters on a seasonal basis to feed in areas where jellyfish are concentrated. Leatherback sea turtles feed primarily on cnidarians (e.g., medusae, siphonophores) and tunicates. Leatherbacks are deep divers, with recorded dives to depths in excess of 1,000 m (Eckert *et al.* 1989).

5.2.2.1.2.1.2 Status

The leatherback turtle was listed under the ESA as endangered throughout its range on June 2, 1970. On April 2, 1977, this species was listed in CITES Appendix I (UNEP- WCMC 2003). Appendix I includes species threatened with extinction. Trade in specimens of these species is

permitted only in exceptional circumstances. The leatherback also was classified as "critically endangered" on the 2000 IUCN Red List of Threatened Species.

The Pacific population is in a critical state of decline, estimated by Spotila *et al.* (2000) to number less than 3,000 total adults and subadults. The status of the Atlantic population is less clear. In 1996, it was reported to be stable, at best (Spotila *et al.* 1996), with numbers of nesting females in the western Atlantic reported to be on the order of 18,800. According to NMFS (2001j), the nesting aggregation in French Guiana has been declining at about 15% per year since 1987. However from 1979-1986, the number of nests was increasing at about 15% annually. Meaning that this current 15% decline could be part of a nesting cycle which coincides with the erosion cycle of Guyana beaches described by Schultz (1975). The number of nests in Florida and the U.S. Caribbean has been increasing at about 10.3% and 7.5%, respectively, per year since the early 1980s but the magnitude of nesting is much smaller than that along the French Guiana coast (NMFS 2001j). In summary, the conflicting information regarding the status of Atlantic leatherbacks makes it difficult to conclude whether or not the population is currently in decline. Numbers at some nesting sites are up, while at others they are down.

.In the USVI, where one of five leatherback strandings from 1982 to 1997 were due to entanglement (Boulon 2000), leatherbacks have been observed with their flippers wrapped in the line of West Indian fish traps (R. Boulon pers. comm.). Since many entanglements of this typically pelagic species likely go unnoticed, entanglements in fishing gear may be much higher.

5.2.2.1.2.2 Hawksbill turtle, *Eretmochelys imbricata*

The hawksbill turtle occurs in tropical and subtropical seas of the Atlantic, Pacific, and Indian Oceans (UNEP-WCMC 2003). In the western Atlantic, hawksbills range from Florida to Brazil, including the Gulf of Mexico and Caribbean Sea. This species has been recorded along all states bordering the Gulf of Mexico, and as far north as Massachusetts, but sightings north of Florida are rare. Within the United States, this turtle most commonly occurs in the U.S. Caribbean. NMFS has designated critical habitat for the hawksbill sea turtle as the waters extending seaward 3.4548 mi (3 nm or 5.6 km) from the mean high waterline of Culebra Island, Puerto Rico. The area around Culebra (specifically from Cayo Luis Peña to Culebra Island) is an important foraging ground for the hawksbill.

5.2.2.1.2.2.1 Biology

Reproductive females undertake periodic (usually non-annual) migrations to their natal beach to nest. Movements of reproductive males are less well known, but are presumed to involve migrations to the nesting beach or to courtship stations along the migratory corridor (Meylan 1999b). Females nest an average of 3-5 times per season (Meylan and Donnelly 1999). Clutch size is higher on average (up to 250 eggs) than that of other turtles (Hirth 1980). Reproductive females may exhibit a high degree of fidelity to their nest sites.

The life history of hawksbills consists of a pelagic stage that lasts from the time they leave the nesting beach as hatchlings until they are approximately 22-25 cm in straight carapace length (Meylan and Donnelly 1999), followed by residency in developmental habitats (foraging areas where immatures reside and grow) in coastal waters. Adult foraging habitat, which may or may not overlap with developmental habitat, is typically coral reefs, although other hard-bottom communities and occasionally mangrove-fringed bays may be occupied. Hawksbills show fidelity to their foraging areas over periods of time as great as several years (van Dam and Diez 1998).

Their diet is highly specialized and consists primarily of sponges (Meylan 1988) although other food items, including anemone-like corallimorphs and zooanthids, have been documented as important elements of their diet in some areas of the Caribbean (van Dam and Diez 1997; Leon and Diez 2000).

5.2.2.1.2.2.2 Status

The hawksbill turtle was listed under the ESA as endangered in 1970. On April 2, 1977, this species was listed in CITES Appendix I (UNEP-WCMC 2003). Appendix I includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances. The hawksbill also was classified as "critically endangered" on the 1996 IUCN Red List of Threatened Species.

There has been a global population decline of over 80% during the last three generations (105 years) (Meylan and Donnelly 1999). In the Western Atlantic, the largest hawksbill nesting population occurs in the Yucatán Península of Mexico, where several thousand nests are recorded annually in the states of Campeche, Yucatán, and Quintana Roo (Garduño-Andrade *et al.* 1999). Important but significantly smaller nesting aggregations are documented elsewhere in the region in Puerto Rico, the USVI, Antigua, Barbados, Costa Rica, Cuba, and Jamaica (Meylan 1999b). Estimates of the annual number of nests for each of these areas are of the order of hundreds to a few thousand. Nesting within the southeastern U.S. and U.S. Caribbean is restricted to Puerto Rico (>650 nests/yr), the USVI (~400 nests/yr), and, rarely, Florida (0-4 nests/yr)(Eckert 1995; Meylan 1999b; Florida Statewide Nesting Beach Survey database 2003). At the two principal nesting beaches in the U.S. Caribbean where long-term monitoring has been carried out, populations appear to be increasing at Mona Island, Puerto Rico, or stable at Buck Island Reef National Monument, St. Croix, USVI (Meylan 1999b).

5.2.2.1.2.3 Green turtle, *Chelonia mydas*

Green turtles are distributed circumglobally. In the western Atlantic they range from Massachusetts to Argentina, including the Gulf of Mexico and Caribbean, but are considered rare north of Cape Hatteras (Wynne and Schwartz 1999). The complete nesting range of the green turtle within the NMFS' Southeast Region includes sandy beaches of mainland shores, barrier islands, coral islands, and volcanic islands between Texas and North Carolina and the USVI and

Puerto Rico (NMFS and USFWS 1991a). Principal United States nesting areas for green turtles are in eastern Florida, predominantly Brevard through Broward counties (Erhart and Witherington 1992). Green turtle nesting also occurs regularly on St. Croix, USVI, and on Vieques, Culebra, Mona, and the main island of Puerto Rico (Mackay and Rebholz 1996). NMFS has designated critical habitat for the green sea turtle as the waters extending seaward 3.4548 mi (3 nm or 5.6 km) from the mean high waterline of Culebra Island, Puerto Rico.

5.2.2.1.2.3.1 Biology

The green sea turtle is the largest hard-shelled sea turtle, with adults commonly reaching 100 cm (39.4 in) in carapace length and 150 kg (330.7 lbs) in weight (Hirth 1997). Hatchlings are about 50 mm in length and weigh about 25 g. Age at sexual maturity is estimated at 20-50 years (NMFS and USFWS 1991a).

Age at sexual maturity is estimated to be between 20-50 years (Balazs 1982; Frazer and Erhart 1985). Green sea turtle mating occurs in the waters off the nesting beaches. Each female deposits 1-7 clutches (usually 2-3) during the breeding season at 12-14 day intervals. Mean clutch size is highly variable among populations, but averages 110-115 eggs/nest. Females usually have 2-4 or more years between breeding seasons, while males may mate every year (Balazs 1983). After hatching, green sea turtles go through a post-hatchling pelagic stage where they are associated with drift lines of algae and other debris.

Green sea turtles are primarily herbivorous, feeding on algae and sea grasses, but also occasionally consume jellyfish and sponges. The post-hatchling, pelagic-stage individuals are assumed to be omnivorous, but little data are available. Green turtle foraging areas in the southeastern United States include any coastal shallow waters having macroalgae or sea grasses near mainland coastlines, islands, reefs, or shelves, and any open-ocean surface waters, especially where advection from wind and currents concentrates pelagic organisms (Hirth 1997; NMFS and USFWS 1991a).

5.2.2.1.2.3.2 Status

The green sea turtle was listed under the ESA on July 28, 1978. The breeding populations off Florida and the Pacific coast of Mexico were listed as endangered. All other populations were listed as threatened. Green turtles were traditionally highly prized for their flesh, fat, and eggs, and shell, and directed fisheries in the United States and throughout the Caribbean are largely to blame for the decline of the species. On June 6, 1981, this species (including all populations) was listed in CITES Appendix I (UNEP-WCMC 2003). Appendix I includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances. This species also was classified as "endangered" on the 1996 IUCN Red List of Threatened Species.

Recent population estimates for the western Atlantic are not available. However, the pattern of green turtle nesting shows biennial peaks in abundance, with a generally positive trend during the ten years of regular monitoring since establishment of nesting beach index beaches in 1989, (Meylan *et al.* 1995; Florida Marine Research Institute Statewide Nesting Database 2002). Total nest counts and trends at index beach sites during the past decade suggest that green sea turtles that nest within the southeastern United States are recovering.

Observations of green turtle nesting populations have been collected opportunistically by both leatherback and hawksbill turtle research programs in the USVI and Puerto Rico since the 1980s. The number of green turtle nests remains low, however, there appears to have been a gradual increase in the number of juveniles observed in the foraging grounds since the 1970s (Hillis-Starr *et al.* 1999).

5.2.2.1.3 Seabirds

The northeast Caribbean provides nesting habitat for at least 13 seabird species, including shearwaters (*Puffinus* spp.), gulls (*Larus* spp.), brown pelicans (*Pelecanus occidentalis*), and various tern species (*Sterna* spp.) (Halewyn and Norton 1984). Two species of seabirds are considered endangered: the brown pelican and roseate tern.

While considerable information is available on bird populations and behavior in this area, little information is available on fishery interactions. The primary threat to Caribbean seabirds in the heavily populated Caribbean has been human encroachment. Not only direct human predation, but species associated with human such as rats and feral cats and pigs have proven destructive. A 1984 assessment of fishery interactions in the Caribbean viewed them to be a major threat on Puerto Rico or other Caribbean Islands, except possibly off Venezuela. The nature of Caribbean fisheries have changed substantially since then, however, warranting reassessment in the future. Based on feeding behavior of many tropical species, terns are unlikely to interact with fisheries, however, shearwater and gull interactions are possible.

5.2.2.1.3.1 Brown Pelican, *Pelecanus occidentalis*

Brown pelicans typically inhabit coastal waters and nest on islands. Brown pelicans breed on Pacific coast islands; off of Costa Rica and Panama; in the Galapagos; along the Atlantic, Gulf, and Caribbean coasts; in the northwestern Bahamas, Greater and Lesser Antilles, southern Veracruz, Yucatan Peninsula, and Belize; and along parts of the South American coast. The brown pelican's range includes the Pacific coast of the Americas and parts inland while it occurs casually in the interior of the southwestern U.S. and throughout the Atlantic, Gulf, and Caribbean coastal and insular areas (American Ornithologists' Union 1983).

5.2.2.1.3.1.1 Biology

The brown pelican is usually found in shallow estuarine water and seldom ventures further than 20 mi (32 km) out to sea. This bird uses sand pits and offshore sandbars for daily loafing and nocturnal roost areas. Nesting commonly occurs on small coastal islands that provide protection from predation and that are of sufficient elevation to prevent nests from flooding. Pelicans generally feed on blue fry (*Jenkinsia lamprotaenia*), shark mouth fry (*Anchoa lyolepis*), sprat (*Harengula* spp.), and whalebone anchovy (*Centengaulis edentulis*). The adult pelican is dark gray-brown in color with white about the head and neck. Immature birds are gray-brown on the upper body and neck and have white underparts. Caribbean pelicans often have dark plumage. The brown pelican reaches a weight of up to 8 lbs (3.6 kg) and has a wingspan of over 2.1 m (Collazo no date; USFWS 1986).

5.2.2.1.3.1.2 Status

The brown pelican was listed as an endangered species in 1970, except the U.S. Atlantic coast, Florida, and Alabama.

5.2.2.1.3.2 Roseate Tern, *Sterna dougallii*

5.2.2.1.3.2.1 Biology

The Virgin Islands and islets off southwestern Puerto Rico support the largest population of roseate terns in the tropical Atlantic (Raffaele *et al.* 1998 in Geo-Marine, Inc. 2001). The roseate tern inhabits coastal waters, bays, and estuaries. It breeds along the Atlantic coast of North America; in the Florida Keys, Bahamas, Cuba, Jamaica, Hispaniola, Puerto Rico, Virgin Islands, Lesser Antilles; and on islands off Venezuela, Belize, and other parts of the Caribbean and the world. The roseate tern winters in the Americas along the eastern Caribbean and also in other parts of the Atlantic coast and the world. It migrates at sea off the Atlantic coast of North America to the Florida area. The roseate tern nests on sandy beaches, open bare ground, and grassy areas and under tumbled boulders primarily on islands. It is mostly pelagic and occurs rarely along seacoasts, bays, and estuaries during the non-breeding season (American Ornithologists' Union 1983 in Geo-Marine, Inc. 2001). Distinguishing characteristics of the roseate tern include its very long, deeply forked tail, pale gray mantle and primaries, tail extending well beyond wing tips when at rest, and the underside primary feather tips with little or no blackish coloration. The breeding adult has a black bill with some red and a black cap; the non-breeding adult has a blackish bill and indistinct dark marking on the shoulder and forehead. The juvenile has a dark forehead and crown, a blackish bill, a mottled back, and a shoulder with indistinct marks (Raffaele *et al.* 1998 in Geo-Marine, Inc. 2001).

5.2.2.1.3.2.2 Status

The roseate tern was listed as an endangered species in 1987 (USFWS 1993).

5.2.2.2 Highly Migratory Species

This section summarizes the available information on the biology, life history, and status of Atlantic HMS, which are managed by NMFS under Secretarial authority. The MSFCMA defines HMS to be tuna species, marlin (*Tetrapturus* spp. and *Makaira* spp.), oceanic sharks, sailfishes (*Istiophorus* spp.), and swordfish (*Xiphias gladius*). Tuna species are further defined as albacore tuna (*Thunnus alalunga*), bigeye tuna (*Thunnus obesus*), bluefin tuna (*Thunnus thynnus*), skipjack tuna (*Katsuwonus pelamis*), and yellowfin tuna (*Thunnus albacares*). Thus, the Secretary currently has the authority to manage directly those species listed above without a Regional Fishery Management Council's FMP.

National Standard 3 of the MSFCMA requires that "to the extent practicable, and individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination." The HMS FMP (NMFS 1999b) developed U.S. policy and management for several interrelated stocks of fish and associated fisheries, throughout their ranges in the Atlantic Ocean and adjacent seas.

Following this guidance and the best available scientific information on the range of the stocks, the HMS management unit consists of the populations of north Atlantic swordfish (north of 5° N); west Atlantic bluefin tuna (west of 45° W above 10° N and at 25° W below the equator, with an eastward shift in the boundary between those parallels); Atlantic yellowfin tuna; Atlantic bigeye tuna; north Atlantic albacore tuna (north of 5° N); west Atlantic skipjack tuna; and the sharks that inhabit the northwest Atlantic Ocean. The management unit and fishing activity for these species, extend across federal, and in some cases, state and international jurisdictional boundaries.

Billfish (marlins, sailfish, and spearfish) are separated from swordfish for purposes of management because of the recreational nature of the billfish fishery. Thus, billfish, other than swordfish, are managed under a separate FMP. More information on the HMS management unit can be found in the HMS FMP (NMFS 1999b) and Amendment 1 to the Atlantic Billfish FMP (NMFS 1999c).

5.2.2.2.1 Biology

For biology and life history of Atlantic HMS, please refer to the HMS FMP (NMFS 1999b), Amendment 1 to the Atlantic Billfish FMP (NMFS 1999c), Amendment 1 to the HMS FMP (NMFS 2003b), and the 2004 Stock Assessment and Evaluation for Atlantic Highly Migratory Species (NMFS 2004).

5.2.2.2.2 Status

The status of stocks managed by the HMS Management Division are identified on a fishery-wide basis rather than a regional basis, such as the Caribbean Sea. With the exception of Atlantic sharks, stock assessments for Atlantic HMS are conducted by the International Commission for the Conservation of Atlantic Tunas (ICCAT) Standing Committee for Research and Statistics (SCRS). In 2003, the SCRS conducted a stock assessment for yellowfin tuna (SCRS 2003). ICCAT conducted a stock assessment on pelagic sharks, particularly blue, porbeagle, and shortfin mako sharks in 2004, but the results are not yet final.

5.3 Social and economic environment

The fisheries in the U.S. Caribbean are multi-species, multi-gear, artisanal in nature, and principally coral reef-based. Division of fishing activity into specific fisheries by species or gear is artificial, but general characterizations are presented in this section. The U.S. Caribbean fisheries cannot be set apart from the fisheries in the wider Caribbean region. The species targeted in the U.S. waters are also available in other countries and regions, and recruitment of these species may derive from areas distant from the area of the fishery.

5.3.1 Commercial fishing activity

5.3.1.1 Fleets

Before 1959, the Puerto Rican fleet was composed mainly of open wooden sailboats (average 27 ft in length) and open wooden rowboats. In 1931, a total of 1,403 active commercial fishermen were reported in Puerto Rico (Matos-Caraballo 1997). In 1959, the Puerto Rico Department of Agriculture, the Economic Development Bank, and the Agricultural Credit Corporation began extending loans to the commercial fishermen to "motorize" the fleet; by 1979, 75% of the commercial fishing fleet had outboard engines. In 1975, there were 865 commercial fishing vessels in Puerto Rico (Suárez-Caabro 1979).

At present, the artisanal commercial fishing fleets of Puerto Rico and the USVI are fairly uniform, in that, the fleets consist of small-sized, open wood or fiberglass fishing boats, which on average are 20 ft in length. There were 4,112 officially registered commercial fishing vessels in Puerto Rico in 1996, but the number of vessels actually fishing commercially in Puerto Rico was probably closer to 1,500, and most of these boats (61%) were between 16-21 ft long (Matos-Caraballo 1997). Only 1% of the fleet was greater than 30 ft long. Average horsepower for Puerto Rican commercial vessels was 43 h.p., and 1,218 motors were reported in 1996 (Matos-Caraballo 1997).

There are 342 registered commercial vessels in the USVI. In St. Thomas, most boats are "small vessels," 16-19 ft long and of wooden construction, with a much smaller number of "large vessels" (8-9 vessels) greater than 30 ft long. In St. Croix, the larger vessels are used for the

trap-based fisheries (as opposed to the gillnet-, vertical gear-, and dive-based fisheries) due to space requirements for traps and machinery (Tobias 2001). Registration fees increase with vessel size for commercial and recreational vessels.

5.3.1.2 Fishermen

Commercial fishermen are required by local laws to have a fishing license in both the USVI and Puerto Rico. In 1975, there were 1,230 commercial fishermen in Puerto Rico, but this had increased to an estimated 1,758 active commercial fishermen in 1996 (1,262 full-time and 496 part-time) with ages ranging from 38-63 and an average age of 46 years old (Matos-Caraballo 1997). In 1996, Matos-Caraballo (1997) concluded that while the number of Puerto Rican commercial fishermen was relatively stable, the amount of fishing effort was increasing. Matos-Caraballo (2002) predicted that the latest information from the pending Puerto Rico Fishery Census would show a loss of approximately 500 fishermen since 1996. However, more recent data showed 1,973 fishermen in 2000 and 2,023 in 2001 (NMFS 2002).

In addition to issues related to overfishing, storms and hurricanes (e.g., Hurricane Georges) have had a negative impact on Puerto Rican fishermen in the recent past (Matos-Caraballo 2001). In 1996, the west coast of Puerto Rico supported the highest number of fishermen (461), with Cabo Rojo having the largest number of fishermen among municipalities (213). In 1996, the percentage of Puerto Rican fishermen belonging to fishing associations had increased to 62%, indicating a greater willingness to unify in order to procure more fishing and social benefits (Matos-Caraballo 1997).

The Matos-Caraballo (1997) census of Puerto Rican fishermen reported 3,613 nets, of which 7% were beach seines, 38% were gill nets, 24% were trammel nets, and 31% were cast nets. In the line category 9,805 units were recorded, of which 9% were longlines, 69% were hand lines, 10% were trolling lines, and 12% were rod and reel. The census recorded 15,481 traps, of which 72% were fish traps and 28% were lobster traps, while 396 winches were used to haul traps. SCUBA divers (n=598) and skin divers (n=281) used 2,170 units of various fishing gear, of which 23% were spears, 61% were gaffs, 11% were snares, and 5% were conch-lifting baskets.

Puerto Rican commercial fishermen typically exploit more than one fishing zone and fishery (Matos-Caraballo 1997), with effort occurring on the shoreline (31%), on the shelf (70%), on the shelf edge (43%), and in oceanic waters beyond the shelf edge (46%). These fishermen pursue multiple species including reef fish, lobster, and conch (74%); pelagic species (68%); deep-water snappers (53%); and baitfish (23%). Fishing trips are generally a half-day long (Matos-Caraballo 2002).

In Puerto Rico, traps are still one of the primary fishing methods, although the most recent data shows traps landings now place second behind line-based fisheries (Matos-Caraballo 2002). Puerto Rico's trap fishermen have recently shown a trap reduction trend, altering the previous historical increase in numbers of traps per fisherman (Scharer *et al.* 2002). Presently, the number

of traps/fisher in Puerto Rico ranges from 10 to 300, with an average of 67 traps/fisher. Decreases in trap effort may be due to competition with other gears such as lines, trammel nets, gill nets, and diver-based fishing (Griffith and Valdés-Pizzini 2002). In Puerto Rico, 77% of trap fishermen target both reef fish and spiny lobster, 13% of trap fishermen target only reef fish, and 10% target only lobster (Scharer *et al.* 2002). According to Puerto Rican trap fishermen, habitats targeted for setting traps include areas surrounding coral reefs such as sand, algal plains, seagrasses, and especially low- to medium-relief hard bottom (known as "rastreal" and preferred by 38% of fishermen); but the coral reefs themselves are not targeted (Scharer *et al.* 2002). Most trap hauling is done via winches or other mechanical means (68%), with the remainder being done by hand. Puerto Rican fishermen stated that they pull traps straight up off the bottom to avoid dragging traps on the bottom and losing or damaging them (Scharer *et al.* 2002). Traps are set on the insular shelf in depths ranging from 9-181 m, with a mean depth of 40-62 m, but varying from one region of the island to another. The distribution of traps in a particular area also varies seasonally, based primarily on changing sea conditions and associated safety considerations (Valdés-Pizzini *et al.* 1997). Although trap fishery areas in Puerto Rico have typically been concentrated in the shallow nearshore zone, some fishermen are now exploiting offshore areas because of depleted resources and habitat degradation in the nearshore (Scharer *et al.* 2002). Among trap types, wooden pots (i.e., *cajones*) are used for spiny lobster, while wire-mesh traps (i.e., *nasas*) are used for fish and lobsters (Scharer *et al.* 2002). Only 1 of 47 Puerto Rican trap fishermen interviewed used GPS technology to navigate and locate traps; while local knowledge and landmarks were the principal techniques used by all other fishermen.

Among Puerto Rican trap fishermen, 53% set traps singly and 47% set a series of 2-6 traps connected by a trotline. Among trotline trap fishermen, 68% used buoys to mark the trap string and 32% did not use buoys at all, a technique known as *ahogado* or drowned traps (Scharer *et al.* 2002). The drowned trap technique is used to deter theft, but makes traps harder to recover, especially in areas where human activities have reduced water clarity. Predominant methods of trap recovery include grappling (34%) or diving (32%).

In the USVI, there is presently a moratorium on issuing new commercial fishing licenses. In the USVI during 1998-1999 there were 349 commercial fishermen (Valle-Esquivel and Díaz 2003). St. Thomas has both full- and part-time fishermen who use traps, handlines, and float fishing methods (Downs *et al.* 1997). In St. John, there are very few full-time fishermen (approximately 2-10), with most fishermen being of the part-time variety, who work other jobs and fish to supplement their income (Downs *et al.* 1997). St. John fishermen are concentrated in the Cruz Bay and Coral Bay areas of the island and are primarily West Indian, with some "continentals" from the mainland U.S. participating in the fishery as well (Downs *et al.* 1997). Each of these ethnic groups tends to target different fish species and use different techniques, with West Indians using traps and handlines/floatlines to capture reef species, while "continentals" tend to troll for pelagic species.

Based on St. Croix data (Tobias 2001), both reef fish and lobster fishermen fish approximately five hours per day and market their catch the same day. Fishing with traps, gill nets, diving, and

the majority of vertical gear occurred over the insular shelf (< 72 m deep), while additional vertical gear fishing for deepwater snapper occurs seaward of the shelf edge.

Anecdotal information indicates that a segment of the fishery may also include illegal foreign fishermen from Santo Domingo and other countries (*St. Croix Source*, December 5, 2002). The extent of this foreign participation in the U.S. Caribbean is currently unknown.

5.3.1.3 Markets

In Puerto Rico, fishermen may market their catch using two or more strategies including selling their catch to a fish buyer (33%), to an association (40%), to a restaurant (10%), selling it themselves on the street (41%), or selling the catch through their own business (13%), which is usually a fish store or eatery (Matos-Caraballo 1997). As of 1996, Puerto Rican fishermen were still using poor catch management strategies, with 51% gutting their catch at sea but only 1% utilizing ice.

St. Thomas fishermen sell their fish at markets, to restaurants and hotels, and to residential customers. Local demand exceeds local supply, so there is no exporting of fish from St. Thomas. St. John fishermen also sell their fish at informal markets, to restaurants and hotels, and to residential customers (Downs *et al.* 1997). In St. Croix, fishermen sell their catch at landing sites, along roadsides, or to hotels and restaurants (Tobias 2001).

5.3.1.4 Catch data

Commercial landing data used to be reported voluntarily in Puerto Rico, but due to revisions in the Puerto Rican fishing regulations in 2004, reporting is now mandatory. Puerto Rican landings are reported by species or species groups such as red hind, mutton snapper or groupers, snappers, etc. Currently, port samplers collect data from 42 coastal municipalities and 88 identified fishing centers in Puerto Rico (Matos-Caraballo 2002). The composition of the commercial catch (i.e., managed species) for Puerto Rico is documented in Table 5.

According to Matos-Caraballo (2002), the west coast of Puerto Rico produced the greatest catch (with 34% of the total landings) and Cabo Rojo was the most productive municipality (with 18% of the total landings). According to Table 5, the major fish and shellfish species in Puerto Rico as far as percentage of total commercial landings were: spiny lobster (13%), deep-water snappers (e.g., silk snapper, 12%), queen conch (11%), yellowtail snapper (14%), shallow-water snappers (e.g., lane snapper, 16%), grunts (6%), all groupers (7%), and parrotfishes and boxfishes (4%). A trend noticed since the early 1990s has been the retention and marketing of fish and shellfish species that in the past were usually discarded, such as squirrelfishes, surgeonfishes, angelfishes, and crabs (*Carpilius corallinus* and *Mythrax* spp.). These species formerly had little to no market value, but now fetch a reasonable market price (Matos-Caraballo 2002) due to a decline in the availability of formerly preferred species.

Matos-Caraballo (2002) summarizes the available data on total commercial landings in Puerto Rico from 1998-2001. These landings data were adjusted by correction factors, and include landings of species that are not managed by the Caribbean Council, such as tuna, mackerel, and dolphin. 1998 landings were estimated at 4,427,467 lbs and valued at $8,946,870; 1999 landings were estimated at 4,265,435 lbs and valued at $8,795,880; 2000 landings were estimated at 5,756,130 lbs and valued at $11,793,159; and 2001 landings were estimated at 5,233,859 lbs and valued at $10,800,657 (Matos-Caraballo 2002). During 1998-2001, line-based fisheries (handlines, rods and reels, trolled lines, and longlines) accounted for the highest percentage (40%) of the total commercial catch in Puerto Rico, followed by traps (fish and lobster traps) at 21%, nets (trammel nets, beach seines, gill nets, and cast nets) at 20%, and diver-based fisheries (SCUBA and skin-diving) at 19%. Commercial CPUE for Puerto Rico during 1998-2001 (lbs caught per individual fishing trip) ranged from 53-71 lbs per trip. This compares with estimates of 63-80 lbs per trip for 1994-1997, and contrasts with the 123 lbs per trip estimate for 1979-1982 (Collazo and Calderon 1988; Matos-Caraballo 2002). Prices paid per pound for fish and shellfish during 1998-2001 varied among municipalities in Puerto Rico (Matos-Caraballo 2002). Puerto Rico landings for species in the FMUs of the Caribbean FMPs averaged approximately 2.3 million lbs annually from 1997-2001 (Table 5).

Trap-based fisheries in Puerto Rico accounted for 22% of the overall catch in 2001 (Scharer *et al.* 2002). As is the case for U.S. Caribbean fisheries in general, because of lower trap-based catch of preferred species like groupers and snappers (i.e., *primera*), trap fishermen in Puerto Rico (and the USVI as well) are catching and marketing less desirable species (i.e., *segunda*) like parrotfishes, goatfishes, triggerfishes, and grunts (Scharer *et al.* 2002; Garrison *et al.* 1998). Studies in the La Parguera area (southwest Puerto Rico) found that spiny lobster was the most abundant species in the trap catch (Appeldoorn *et al.* 2000). Soak times in Puerto Rico are longer (about 5-7 days) than they were historically (about 1-3 days), most likely due to the effects of overfishing and low catch rates forcing fishermen to extend soak times (Juhl and Suarez-Caabro 1973; Appeldoorn *et al.* 2000; Scharer *et al.* 2002).

In the USVI, reporting is required by law to obtain or renew commercial fishing licenses. During 1998-1999, there were 349 total licensed commercial fishermen in the USVI, down from the reported peak of 846 fishermen in 1976-1977 (USVI DFW). In the USVI, landings are reported by categories – for example pot fish or net fish. With the exception of queen conch and spiny lobster, which are reported separately, it is difficult to describe specific fisheries in the USVI, and to determine how many fishermen are involved. Most commercial fishermen use a multiple number and type of gears – fish traps, hook and line, nets, and SCUBA, among others, which makes them non-specialized harvesters. An exception might be participants in the queen conch fishery. Conch are hand-harvested by a relatively small number of fishermen using SCUBA primarily. Conch fishermen harvest not only conch, but also lobster and fish while diving. Based on 1994-2002 average landings, USVI commercial catch is approximately 677,059 lbs (Table 5).

St. Croix biostatistical data on the commercial reef fish and spiny lobster fisheries collected during 1997-2000 indicated a 10% decrease in average weight of reef fish and a 12% decrease in the average weight of lobster specimens measured during the study period (Tobias 2001). Also, the mean number of fish/trap haul and weight of fish/trap haul decreased (drops of 19% and 13% respectively from 1997-1998 to 1998-1999, and of 40% and 47% respectively from 1998-1999 to 1999-2000). Hurricanes Hugo, Georges and Lenny had a deleterious effect on the St. Croix fisheries, especially trap fisheries, during the study period, because of lost traps and vessel damage. Due to the reduction of trap effort, almost ten times more spiny lobster were landed by divers than by traps from 1997-1999 (Tobias *et al.* 2000). Traps (fish and lobster) are still the most productive gear in St. Croix, with vertical gear taking second place. While traps represented 71% of the landings in 1985, they represented only 41-46% of the landings from 1997 through 1999 (Appeldoorn *et al.* 1992; Tobias *et al.* 2000). Fish traps in St. Croix landed grunts, surgeonfish, and parrotfish most often (Tobias 2001). Mean soak time for traps and pots, in general, was seven days.

The use of gill nets in the USVI has increased over the past 10 years, where they are used in conjunction with SCUBA divers to catch parrotfish (Tobias *et al.* 2000). Divers set nets in sandy offshore areas (between reefs at the shelf edge) where schools of fish congregate just before dark. The highest catches are made during peak spawning times (Tobias 2001). Between 1997-1999, parrotfish represented 74-78% of total net landings in St. Croix (Tobias *et al.* 2000). Gill nets appear to compete with fish traps for similar reef fish resources.

Table 5 reflects the best available data set for USVI managed species. USVI average landings (1994-2002) are based on Valle-Esquivel and Diaz (2003) for all species complexes except for the snapper, grouper, boxfish, and tilefish complexes. USVI landings of snapper and grouper are not identified by species. Therefore, it is not possible to determine precise landings for the various snapper and grouper FMU sub-units in Table 5. Similarly, boxfish and tilefish are not identified at all in USVI landings. USVI snapper and grouper sub-units are extrapolated using the 1994-2002 USVI average for snapper and grouper, and then multiplying that by the same percentage snapper and grouper appear in the sub-units for Puerto Rico landings (e.g., on average, Snapper Unit 1 consists of 26.76% of all Puerto Rican snapper landings). USVI boxfish and tilefish complexes are extrapolated using the same proportion that the species appear in Puerto Rican landings (% of group) out of the total average USVI landings (Valle-Esquivel and Diaz 2003; 673,436 pounds). These extrapolations are necessary due to the fact that those species are either lumped into one category (e.g., snapper, grouper) or not explicitly mentioned in the Valle-Esquivel and Diaz (2003) landings data (e.g., boxfish, tilefish).

5.3.2 Recreational Fishing Activity

5.3.2.1 Boats

All recreational vessels in Puerto Rico must be registered with the DNER. There are a number of charter boats (trolling and bottom fishing), diving boats, shoreline fishermen, and recreational

fishing boats (privately-owned vessels) but information on fishing effort, catch, or other information is largely not known. Most of the information available from the recreational fishing sector deals with tournament data on species such as marlin and dolphin.
The total number of recreational boats registered in Puerto Rico in 1995 (DNER 1995 unpublished data) was reported as 35,931 registered vessels – including personal watercrafts (jet skis). The total number of boats registered in Puerto Rico during 1996 was 44,049, indicating an increase of 8,118 boats in one year.

Eastern Caribbean Center (2002) reported 2,462 registered boat owners in the USVI, with 566 of these from St. Croix and 1,896 from St. Thomas/St. John. However, the number of recreational vessels registered in the USVI in 1997 was estimated to be 5,000 (L. Roberts, USVI/DPNR Division of Environmental Enforcement personal communication). In addition, numerous other recreational vessels are reported in transit through the USVI. Average USVI recreational boat length is 22.8 ft, with most (81.6%) less than 30 ft, while only 5% were 40 ft or greater in length (Eastern Caribbean Center 2002). Downs *et al.* (1997) found eight charter fishing businesses operating in St. Thomas and two in St. John run mostly by "continentals" from the mainland U.S., with vessel sizes ranging from 25-48 ft long. None of these vessels was licensed to carry more than six passengers, and the larger vessels were crewed by a captain and mate. These charter vessels tended to target pelagic fishes and sharks, and the catch not retained by customers was sold to restaurants and hotels.

García-Moliner *et al.* (2002) found that fishing charter activity has increased in the U.S. Caribbean since the survey by Downs *et al.* In 2000, a survey identified 46 year around charter-fishing operations, 27 in the USVI and 19 in Puerto Rico. These operations included 60 vessels. Additional seasonal operations exist during the June-September blue marlin fishery. Most of the charter vessels fish off shore and target pelagic species, but some offer inshore and reef fish trips. The charter industry considered reef fish availability as "fair." Charter and head boats are not required to maintain records and there is no information available to describe activities of these groups targeted at species under Council authority. Establishment of needed socioeconomic research is necessary to improve data with regard to charter and head boat fisheries.

Of over 100 dive-charter operations in the U.S. Caribbean, 37% of those in Puerto Rico and 21% of those in the USVI allowed fishing (García-Moliner *et al.* 2000). Fishing during dive trips targeted lobsters (hand harvest) and fish (spear fishing).

5.3.2.2 Fishermen

Presently, Puerto Rican recreational fishermen 13 years and older (excluding those fishing off charter or headboats) are required to have a license. Information on the recreational fleet, charter fleet, and fishing enterprises other than the licensed commercial fleet is scant. Queries run on the MRFSS dataset indicate that Puerto Rico had 222,128 recreational fishermen in 2001, and 28,757 of these were from out-of-state. In contrast, Schmied (1989) reported only 81,000 resident marine recreational fishermen (from about 23,000 boats) for Puerto Rico. A creel

census of 132 recreational shoreline anglers and 20 boat-based anglers was conducted in the area of Guanica State Forest between October 1997 and September 1998 (Silva *et al.* no date). The age of anglers was not dominated by any one group, but the 41-50 year old group (24.4%) was the most common. Shoreline-based angler effort was highest in August, June, and October; and lowest in January and March. Recreational anglers in Puerto Rico made approximately 1.4 million fishing trips in 2001 (NMFS 2002), of which 0.9 million were from shore, 0.5 million were from private boat, and 11,000 were from charter boat.

A telephone survey of a subset of USVI registered boat owners (n=120) who used their vessels for recreational fishing was conducted in 2000 (Eastern Caribbean Center 2002). Based on that survey the number of boat-based recreational fishermen was estimated at 2,509 for the USVI (712 from St Croix and 1,797 from St. Thomas/St. John). These fishermen were predominantly male (96.7%), with a mean age of 47.5 years old, and were of various ethnic heritages, education levels, and income levels. The number of recreational fishermen in the USVI (boat-based and shore-based fishermen) was estimated to be around 11,000 people in 1999, about 9.2% of the population, which is roughly the same proportion that Jennings (1992) found in 1986 (see Mateo 1999; Eastern Caribbean Center 2002). A survey of 312 boats taken at boat ramps stated that only 41 vessels (13%) reported fishing as one of their activities (Appeldoorn and Valdés-Pizzini 1996). Of these 41 vessels, 80% used hook and line/rod and reel gears.

A total of 814 recreational anglers were counted on St. Croix, of which 404 were interviewed (Eastern Caribbean Center 2002). The highest fishing effort took place in the afternoon hours and during the months of May through July. Most of the fishing areas however are nursery grounds where juveniles of species occur.

Eastern Caribbean Center survey (2002) found that trolling was reported as the most common boat-based fishing method in the USVI (59.7%), followed by bottom fishing (22.7%). However, Jennings (1992) states that bottom fishing (70%) was more common than trolling (20%) in 1986. Eastern Caribbean Center (2002) found that about half (53.3%) the USVI recreational fishermen fished in territorial waters (< 3 mi from shore), while 46.7% fished in federal waters. The most preferred fish group was snappers, followed by dolphin and tuna, and the majority of the catch (72.9%) was used for personal consumption. On average USVI boat-based fishermen make two fishing trips a month and fish about 4 hours per trip (Eastern Caribbean Center 2002). The total USVI boat-based recreational fishing hours in 2000 was estimated to be 320,204 hours.

The average cost of a USVI recreational fishing trip was $125.11, which included gear, bait, ice, refreshments, food, fuel, launching fees, lodging, auto transportation, and charter and guide fees, among other costs (Eastern Caribbean Center 2002). Most gear was purchased in the USVI (77%), but about half of the electronics were bought outside the USVI. Average USVI boat ownership costs were about $2,104.13 annually. Total boat-based recreational fishing expenditures in the USVI in 2000 were approximately $5.9 million, with St. Thomas/St. John contributing about $4.8 million to the total.

5.3.2.3 Catch

MRFSS was expanded to Puerto Rico at the end of 1999. Data from this survey indicate that total recreational landings in Puerto Rico were 2.8 million lbs and 1.7 million lbs in 2000 and 2001, respectively. Recreational fishermen landed, on average, 1.03 million lbs of Council-managed species, annually, in Puerto Rico during that time period (Table 6). The MRFSS does not collect data on USVI fisheries. Table 6 explains how data on the recreational fishery of Puerto Rico were used to help estimate average, annual, recreational landings in USVI fisheries of 85,252 lbs. Total average annual recreational landings for Puerto Rico and the USVI combined are estimated at 1.3 million lbs.

Total recreational finfish catch (i.e., of Council-managed species) for Puerto Rico was 43.77% of commercial finfish landings. For Puerto Rico, the majority of catch occurred in state waters. "Other Fishes" (not identified in the MRFSS data set) and snappers make up the majority of the recreational landings in state waters. Dolphin and tuna dominated the recreational catch in the EEZ. Recreational landings of spiny lobster in Puerto Rico reached 128,560 lbs in 2000 and 142,707 lbs in 2001. Recreational landings of queen conch in Puerto Rico are estimated at 140,157 lbs in 2000 and 124,085 lbs in 2001.

Except for MRFSS data for 2000 and 2001, there is little collection of recreational fishing data for local Puerto Rican waters. A survey of catch from 41 Puerto Rican recreational fishing vessels (Appeldoorn and Valdés-Pizzini 1996) found that, aside from clupeids taken for use as bait, the most caught species were silk snapper, red hind, and lane snapper. Most trips targeted groupers and snappers. This corroborates the available MRFSS data for Puerto Rico, which indicates that silk snapper, lane snapper, queen snapper, black durgon, and red hind were the predominate recreational species. Jacks also were a major recreational target, but were not identified by individual species.

Appeldoorn and Valdés-Pizzini (1996) conducted a three-month survey targeting Puerto Rican recreational boat users who trailered their boats. A total of 312 boats were surveyed; 41 reported fishing and four of these reported fishing for queen conch while snorkeling. They also sampled finfish during the survey and showed that many of the fishes harvested by the recreational sector were juveniles.

Recreational data collection for the USVI has included information from the logbooks voluntarily filled out by offshore recreational fishermen, and a survey of nearshore recreational fishermen. The offshore fishermen target primarily blue marlin, dolphin fish and wahoo. Of 563 recreational nearshore anglers interviewed in the USVI between 1995 and 1998, fishermen most frequently reported catch of french grunts, jacks, and yellowtail snappers (I. Mateo, USVI/DPNR).

The first quantitative report on the shoreline recreational fishery of St. Croix shows that the two (out of a total of 48 species reported) of the most frequently caught fishes (mojarras and

anchovies) were primarily used as bait for barracuda and yellowtail snapper (Adams 1997). It also suggests that the shoreline fishery is declining, with CPUE declining since 1995, with increased effort every year. Among the species landed were red hind, yellowtail snapper, and seven other species of snappers, grunts, etc. These were caught using hook and line and nets.

Jennings (1992), from a telephone survey conducted in 1986, estimated fish harvest by recreational fishermen in the USVI at 24,648 kg-fish annually (54,226 lbs./year). The most frequently reported species were yellowtail snapper and red hind, in addition to mackerels and tunas reported specifically from St. Croix. In the mid-1980s, 10% of the residents of the USVI fished recreationally. Jennings (1992) indicates that the proportion of anglers fishing from the shoreline in St. Croix was higher than in St. Thomas/St. John. Bottom fishing and trolling from recreational vessels were the most frequent fishing activities targeting reef fish and were most common in St. Thomas.

5.3.3 The spiny lobster fishery

The spiny lobster fishery in waters around Puerto Rico and the USVI occurs with gill and trammel nets, pots and traps, hand-harvest and beach seines. Available information on the status of that fishery is described in Section 5.2.1.1.2. Due to the predominance of fishable habitat in state waters, it is assumed that most of the commercial harvest occurs in state waters, but fishery statistics do not allow accurate separation of harvest in the EEZ from harvest in state waters. The overall average of 546,640 lbs for the entire U.S. Caribbean (Table 7) is approximately 66% of the MSY estimated in the original FMP, with traps accounting for the majority of those landings.

5.3.3.1 Puerto Rico

Although three species of spiny lobsters occur in the management area, landings of only the Caribbean spiny lobster (*Panulirus argus*) are of significance, and the management system described is restricted to that species. The annual average of commercial lobster landings from 1997-2001 in Puerto Rico is estimated at 290,554 lbs (Table 5). The current landings represent about 90% of the commercial landings reported by Bohnsack *et al.* (1991). There are no annual recreational spiny lobster harvest estimates by MRFSS for Puerto Rico. The SFA Working Group determined based on informed judgement that average recreational landings of spiny lobster were approximately 50% that of commercial landings (135,633 pounds).

The Overview of Puerto Rico`s Small-Scale Fisheries Statistics 1988-1989, published by the Natural Resources Department, reported total lobster landings of 186,423 lbs for 1989, or 23% of total pounds landed in 1979 (CFMC 1990b). Total ex-vessel value was $803,483, a 59% reduction. Bohnsack *et al.* (1991) reported that total annual lobster landings in Puerto Rico averaged 317,451 lbs for 1951, 1964, and 1969-1989, and fluctuated from143,761 to 512,000 lbs. Despite uncertainty about the accuracy of the data, Bohnsack *et al.* (1991) concluded that the data reflected the general landing trends.

Matos-Caraballo (2002) reported average price of commercial lobster landings from Puerto Rico during 1998 to 2001 as follows: 1998 average price was $5.24/pound; 1999 average price was $5.27/pound; 2000 average price was $5.05/pound; and 2001 average price was $5.50/pound. Spiny lobster represented 13% of the total commercial fishery landings (i.e., Council-managed species) in Puerto Rico during 1997-2001 (Table 5). During 1998-1999, the south and west coasts of Puerto Rico reported the highest lobster landings; during 2000-2001, the south and east coasts reported the highest lobster landings, as the west coast experienced a significant decrease in landings (Matos-Caraballo 2002).

According to Matos-Caraballo (2002), SCUBA divers, fish traps, lobster traps, and trammel nets caught the majority of commercial lobster in Puerto Rico from 1998-2001. In 1998, SCUBA divers landed 132,091 lbs, fish traps landed 101,266 lbs, lobster traps landed 40,086 lbs, and trammel nets landed 14,303 lbs. In 1999, fish traps landed 130,003 lbs, SCUBA divers landed 129,490 lbs, lobster traps landed 30,207 lbs, and trammel nets landed 23,253 lbs. In 2000, SCUBA divers landed 134,710 lbs, fish traps landed 93,809 lbs, lobster traps landed 18,908 lbs, and trammel nets landed 7,754 lbs. In 2001, SCUBA divers landed 138,565 lbs, fish traps landed 102, 003 lbs, lobster traps landed 32,198 lbs, and trammel nets landed 5,587 lbs (Matos-Caraballo 2002).

Among Puerto Rican trap fishermen, 77% were found to target both lobster and reef fish, while only 10% target lobster alone (Scharer *et al.* 2002). Wooden traps were used primarily for lobster, but wire mesh traps were used for both lobster and reef fish. Biodegradable panels are required for all traps, including those in state waters, but fishermen have not always followed this regulation.

Spiny lobster have been protected by federal and state management plans for 18 years, but fishing pressure has remained intense. Biostatistical sampling of Puerto Rican lobsters caught during 1998-2001 found that 18% were under the minimum state and federal size limit (89 mm carapace length), which is an improvement over the 36% found undersized during 1994-1997 (Matos-Caraballo 2002).

5.3.3.2 USVI

The annual average of commercial lobster landings from 1994-2002 in the USVI is 80,302 lbs (Table 5). Recreational lobster harvest extrapolated from the MRFSS database for 2000-2001 in Puerto Rico amounted to 40,151 lbs for the USVI (Table 6).

On St. Croix, Mateo and Tobias (2001) reported a steady increase in average commercial landings from 7,800 lbs during the 1980s to 29,600 lbs in the 1990s. However, mean carapace length in St. Croix exhibited a decrease between 1997 and 2000, going from 107.78 mm in 1997-1998 to 102.46 mm in 1999-2000, and in the USVI overall, the mean size of landed lobsters is decreasing, as are landings (Tobias *et al.* 2000; Bolden 2001). However, Tobias (2001) found that a greater number of lobster were being taken per trap haul in St. Croix from 1997 to 2000,

but that these lobster were smaller (12% decrease in weight). Tobias (2001) suggests that the spiny lobster resource is overfished based on growth and mortality parameters. Divers accounted for about 85% of total landings from 1990 to 1998. On St. Croix from October 1997 to December 2000, divers landed 74,976 lbs of lobster, while traps caught only 8,300 lbs (Tobias 2001). Total commercial USVI lobster landings averaged 36,534 lbs for St. Thomas/St. John, and 7,284 lbs for St. Croix between 1980 and 1988, and appeared relatively stable (Bohnsack *et al.* 1991).

Among lobster fishermen using traps in the USVI, mean crew size was 2-3 individuals, soak times were about 7 days, and vessels utilized ranged in length from 28-35 ft. In contrast, USVI fishermen harvesting lobster by diving, used vessels ranging from 18-20 ft in length (Tobias 2001).

5.3.3.3 Regulations

Concurrent regulations for spiny lobster apply in the EEZ and in state waters of Puerto Rico and the USVI. The minimum size limit specifies a 3.5-in carapace length. Current regulations prohibit harvest of lobster with spears or other piercing devices. Gaffs are often used to pin the animals down, but regulations prohibit piercing the lobsters. The use of poisons or explosives is also prohibited. Lobsters must be landed whole, and while berried females may be kept in traps, they may not be kept onboard of vessels. It is illegal to pull another fisher's trap without his express permission (except by authorized officers). Traps must be fitted with a biodegradable panel and fasteners. Buoy, boat, and trap identifications and markings must be as displayed according to specifications.

5.3.4 The queen conch fishery

The queen conch fishery in waters around Puerto Rico and the USVI occurs by hand-harvest only. Over-harvest of queen conch in shallow, nearshore waters since the use of SCUBA in the 1970s has led to commercial harvest primarily in waters with depths of 15-30 m (45-95 ft), although harvest can occur in depths in excess of 37 m. Available information on the status of the queen conch fishery is described in Section 5.2.1.2.1.2. Due to the predominance of fishable habitat in state waters, most of the commercial and recreational harvest occurs in state waters, but fishery statistics do not allow accurate separation of harvest in the EEZ from harvest in state waters. Most (92%) conch fishermen fish within 9 nm of the coast and 60% within 3 nm. The average conch fishing trip lasts four hours and 60% of the daily trip catch is in the 100-150 pound range (Rivera 1999).

The Council is promoting the pan-Caribbean management of queen conch, *Strombus gigas.* This is an international effort to evaluate the status of the conch stocks, and develop regional management measures for the sustainable fisheries of the species.

5.3.4.1 Puerto Rico

Rivera (1999) reported that Puerto Rico had 209 commercial conch fishermen, and 16 of them fished federal waters. Half of the Puerto Rico conch fishermen were from the Peñuelas/Cabo Rojo area on the south/southwest coast, another 25% were from the southeast coast (Naguabo, Ceiba, Fajardo, and Vieques Island), with a much smaller number of north coast fishermen (Rivera 1999). A conch biometric survey found that 24% of conch harvested from state waters in Puerto Rico were under the federal size limit (Rivera 1999).

The annual average of commercial queen conch landings from 1997-2001 in Puerto Rico is 248,437 lbs (Table 5). During 1997-2001 queen conch made up 11% of the total commercial landings for Puerto Rico (i.e., Council-managed species; Table 5). Matos-Caraballo (2002) reported commercial queen conch average price from Puerto Rico during 1998 to 2001 as follows: 1998 average price was $2.22/pound; 1999 average price was $2.25/pound; 2000 average price was $2.23/pound; and 2001 average price was $2.44/pound. The west coast of Puerto Rico exhibits the highest landings, followed by the east coast, and then the south coast, with only minimal landings from the Puerto Rican north coast. The southwest corner of Puerto Rico produced the largest catches, and 58% of Puerto Rico's commercial conch landings have come from the municipalities of Lajas, Cabo Rojo, and Mayagüez since 1983-2000 (Valle-Esquivel 2002). Almost all landings are made by SCUBA divers (between 92-99% from 1998-2001), followed by skin divers (between 1-6% from 1998-2001) in Puerto Rico (Matos-Caraballo 2002).

Historically, Puerto Rican commercial queen conch landings increased from 60,000 lbs in the 1970s to a 440,000 pound peak in 1983, than declined thereafter to around 100,000 lbs through the early 1990s (Valle-Esquivel 2002), with an increase since to 248,000 lbs in 2001 (Table 5). Densities of queen conch in Puerto Rico have decreased from 8.11 conch/hectare in 1987 to 5.68 conch/hectare in 1996. Pounds of conch meat landed per trip has also decreased from 160 lbs/trip in the mid 1980s to 72 lbs/trip for 1988-2001 (Valle-Esquivel 2002).

There are no annual recreational conch harvest estimates by MRFSS for Puerto Rico. The SFA Working Group determined based on informed judgement that average recreational landings of queen conch were approximately 50% that of commercial landings (i.e., 132,121 lbs). Statistics on recreational conch catches are not recorded by the Puerto Rican Research Laboratory, however, Appeldoorn and Valdés-Pizzini (1996) interviewed recreational fishermen at boat ramps (71 sites). Only 4 of 41 boats who reported fishing as an activity were recreationally fishing for conch (10 %), and all of these were by free-diving. Most conch were caught for personal consumption. Sixty specimens were examined, 73% were juveniles, and 55% of these had shell lengths less than 19 cm (the approximate minimum size for retention by commercial fishermen).

5.3.4.2 USVI

Rivera (1999) reported no full-time conch fishermen but 23 part-time conch fishermen from St. Thomas and St. John, with none of these fishing in federal waters. St. Croix had 16 full-time and 12 part-time fishermen, with two of these working in federal waters. A conch biometric survey found that 92% of conch harvested from state waters in St. Thomas and St. John were under the federal and state size limit, while in St. Croix 21% were undersized (Rivera 1999).

The annual average of commercial queen conch landings from 1994-2002 in the USVI is 38,927 lbs (Table 5). Queen conch harvest is considerably higher in St. Croix than in Thomas/St. John, and, proportionally, queen conch is more important in St. Croix making up 8% of total commercial landings there, but only 0.2% of commercial landings in St. Thomas/St. John (Valle-Esquivel and Diaz 2003). St. Croix commercial landings peaked in 1979 at 60,000 lbs, but have decreased since then to around 20,000-30,000 lbs per year. There are no annual recreational conch harvest estimates by MRFSS for the USVI. The SFA Working Group determined based on informed judgement that average recreational landings of queen conch were approximately 50% that of commercial landings (i.e., 19,464 lbs).

USVI fishery independent surveys conducted between 1981 and 1996 have found progressive decreases in queen conch densities from 40.87 conch/hectare (in 1981) to 14.71 conch/hectare (in 1996). In St. Croix, the average number of pounds of conch meat caught per commercial trip went from 83 lbs/trip in the 1980s, down to 57 lbs/trip in the 1990s, when effort nearly quadrupled (Valle-Esquivel 2002b). In general, conch fishermen in the U.S. Caribbean believe that search times are longer and that more offshore/deep water fishing has become necessary. In others words, they are spending more time to get less conch (Valle-Esquivel 2002a).

5.3.4.3 Regulations

Federal regulations for queen conch set the minimum size limit at 9 in for shell length or a lip thickness of more than 3/8 of an inch. Conch must be landed whole (in the shell). There is a closed season from July 1 through September 30. Recreational (non-commercial) fishermen may land up to three conch per day with a limit of 12 conch/boat. Commercial fishermen may land up to 150 conch per day. Use of hookahs to harvest conch is prohibited.

Regulations in USVI and Puerto Rican waters are the same as those for federal waters, except that the harvest for recreational fishermen is six conch per day with a limit of 24 conch/boat in the USVI, and Puerto Rican commercial fishermen are not required to land conch in the shell.

5.3.5 The reef fish fishery

Reef fishes targeted by nets and traps, including parrotfish and surgeonfish, were shown to be decreasing in mean size based on 1985-1990 data (Appeldoorn *et al.* 1992), and a new assessment utilizing 1990-2000 data is needed (Tobias 2001). No net restrictions are in place in the U.S. Caribbean federal waters.

It is difficult to describe specific reef fish fisheries in the U.S. Caribbean, and to determine how many fishermen are involved. Most commercial fishermen use multiple number and types of gears – fish traps, hook and line, nets, SCUBA, among others – that make them non-specialized harvesters. Additionally, divers collect aquarium trade species in Puerto Rico, principally in state waters.

Commercial landings data in the U.S. Caribbean have been collected since 1969 in Puerto Rico, and since 1974 in the USVI. In Puerto Rico and the USVI, trap fishing has been the traditional and most productive fishing method used (CFMC 2001b). In the late 1980s, hook and lines (hand, trot, etc.) became the most productive gear in Puerto Rico. Net fishing has been shown to be increasing (e.g., Valdés Pizzini *et al.* 1992) in Puerto Rico, and the trend has been reported for the USVI; in St. Croix nets are fished using SCUBA divers to herd fish into the nets, principally parrotfish (Tobias *et al.* 2000). The decline in the trap fishery is probably the most important factor contributing to the increase in the number and use of nets (re-direction of the fishery).

5.3.5.1 Puerto Rico

In Puerto Rico from 1997-2001, the commercially-caught fishes with the highest landings were snappers, groupers, grunts, jacks, and parrotfishes (Table 5). According to 1997-2001 commercial landings yellowtail snapper, silk snapper, lane snapper, and white grunt were especially important to the commercial fishery. In most years, the three main components of the reef fish landings in Puerto Rico have been snappers, groupers, and grunts, from the reef fish complex (CFMC 2001a). These species are found in both shallow and deep water. Other major fish groups taken commercially from reefs on the Puerto Rican platform (besides snappers and groupers) include jacks, parrotfishes, and boxfishes. Appeldoorn *et al.* (1992) reported that landings of all demersal fishes in Puerto Rico declined from a peak of 5,296,410 lbs in 1979 to 1,144,395 lbs in 1990.

The majority of the commercially caught reef fishes inhabit the insular shelf. The shallow-water reef fish fishery of Puerto Rico and the USVI extends from the shoreline of both States into the EEZ, though the fishery is generally limited to depths of 40 fathoms or less. Following the collapse of the Nassau grouper resource, red hind became an important species in the fishery; however, statistics show a decrease in the number of young fish in the population as concluded by the Stock Assessment Group (Appeldoorn *et al.*, 1992). Whenever possible, the Council relies upon closing aggregation sites during spawning seasons to enhance reproductive capacity. Most species that aggregate during spawning season are highly vulnerable to capture at that time. Fishermen have sometimes asked for the closure of spawning areas. Most commercial fishing occurs by hand-line fishermen in outboard-powered vessels less than 6 m in length; however, fish traps and most recently gill nets have been used to harvest mutton snapper in this area. Weather permitting, more than 30 fishing vessels can be seen nightly for one week after the full moon during the months of March through June. Fishing effort is most heavily concentrated at depths of 18-27 m. Mutton snapper appear to be especially vulnerable to harvest when aggregated for spawning.

In Puerto Rico during 1998-2001 (Matos-Caraballo 2002), the greatest commercial landings of yellowtail snapper were caught, ranked in order of landings, by vertical line gear, fish traps, gill nets, and longlines. The greatest commercial landings of lane snapper in Puerto Rico during 1998-2001, ranked in order of landings, were caught by fish traps, vertical line gear, gill nets, and longlines. This general pattern holds for the other shallow-water snapper species, except that SCUBA is used to take a substantial portion of some snapper landings (e.g., mutton snapper). The greatest commercial landings of red hind were caught during the same time period, ranked in order of landings, by vertical line gear, fish traps, and SCUBA. The highest landings of the other shallow-water grouper species are accomplished using these gears also. Grunts are harvested by, ranked in order of landings, fish traps, gill nets, vertical line gear, trammel nets, and beach seines. Jacks are captured mostly *via* bottom lines, gill nets, and also beach seines to a lesser extent. Parrotfishes are mostly caught by fish traps, gill nets, and SCUBA. Boxfishes are caught principally by fish traps, SCUBA, trammel nets, and gill nets.

The deep-water fishery ranges from the outer reaches of the shallow-water fishery (approximately 73 m) seaward to depths up to more than 550 m. Fishes inhabiting the deep-water reef areas of the slopes characterized by rocks, ledges, and corals generally are captured with heavy-duty traps, buoy gear, and by electronically-powered reels; bottom long-lines are deployed to a limited extent. The five major deep water reef fish species are silk snapper, queen snapper, vermilion snapper, misty grouper, and wenchman.

Commercial landings collected by the Fisheries Research Laboratory indicated that 8.1% of the total catch was comprised of silk snapper and blackfin snapper (Piñeiro *et al.* 2003). However, the importance of blackfin snapper may not be fully represented in the commercial landings (i.e., Table 5), but may be reported as "unclassified snapper." Vertical line gear accounts for the greatest amount of landing of deep water reef fish, though fish traps and longlines also harvest significant amounts of fish.

5.3.5.2 USVI

Trap-caught fish continue to make up the highest percentage of the USVI total catch but some changes have taken place since the late 1990s, at least in St. Croix. The DPNR has reported that 54 commercial fishermen from St. Thomas-St. John District were fishing 4,574 fish traps and 1,655 lobster pots, for a total of 6,229 traps/pots. The number of traps per fishermen ranged from a minimum of one to a maximum of 350, with 33% having less than 20 traps. The data available for the landings in the USVI (DPNR 1997) for the year 1995-1996 indicate that there were 182 commercial fishermen registered, of whom 149 reported landings from 4,909 trips made during the year. The average reported total catch per year in St. Thomas-St. John (1993-1996) was 367,788 lbs of fish and 64,668 lbs of lobster. The catch per trap (using the average for the last three years reported by DPNR) was 80 lbs per fish trap and 39 lbs of lobster per lobster pot, a combined average of 69 lbs per fish/lobster trap. However, mean catch per trip was reported to be of 110 lbs from 1993 through 1996. The estimated landings reported (over a million pounds per year from average for 3 years), result in an average of 130 lbs per trap. In the

1980s the CFMC had estimated the catch per trap to be less than 120 lbs. CPUE showed little variation through the 1980s and 1990s. The number of registered fishermen that did not report landings has consistently been decreasing since 1986-87 for St. John, and 1981-82 for St. Croix.

The CFMC currently prohibits the harvest of butterflyfish, seahorses, and juvenile red hind and mutton snapper for the aquarium trade (Reef Fish FMP Amendment 2, 1993). In state waters, both the Puerto Rico and USVI fishery agencies manage the take of aquarium trade species through a permit system, with associated reporting requirements. In USVI waters, collection for the commercial aquarium trade species is prohibited, but un-permitted collection of aquarium fishes can be made by individuals for their personal aquariums. Collection for educational purposes is authorized by permit. At present, the only permits active in the USVI are for educational facilities. Little activity is reported from federal waters off the USVI. In Puerto Rico, the trade and shipping lists for 1990-1991 indicate that over 150 species of fish (105 finfish) and invertebrates (45) were exported from Puerto Rico. Many of the species collected are juvenile species that are valued as adults in other fisheries, some of which are regulated. About 100 people are engaged in the marine aquarium trade in Puerto Rico. Most collectors are exporters, however, some collectors sell to exporters or to local shops. Major collectors have their own equipment, and collect from 3-4 days to 7 days a week depending on weather and demand. Collectors visit specific areas and generally rotate collecting sites to avoid overfishing an area. Collection are commonly made by SCUBA down to 20 m, but occasionally to 40 m for certain species; mask and snorkel are commonly used in shallow waters. Most collectors are based out of the northwest and southwest coastal regions; Isabela Aquadilla, Rincon, Cabo Rojo, La Parguera, and Ponce are the primary collecting areas (Ojeda-Serrano *et al.* 2001). The only allowable fishing gears for capturing aquarium-trade fish are hand-held dipnets, slurp guns, and barrier nets with a maximum length of 30 ft, a maximum height of 4 ft, and a minimum mesh size of 1/4 in. The use of poisons, drugs, other chemicals, and explosives is prohibited. Diver harvest in federal waters is probably limited to a small area of shelf-extension off southwestern Puerto Rico, while some deep water ornamentals may be taken by traps and also incidentally by commercial fishermen in federal waters. Puerto Rico implemented new regulations for the marine aquarium trade in 2004, which restricts the list of allowable species for harvest and also implements a quota for each allowable aquarium trade species.

From 1998-2000, 10 species accounted for 76% of all aquaria-trade fish exported from Puerto Rico, with the Royal Gramma (*Gramma loreto*) alone accounting for 42%. Other species on the list include yellowhead jawfish, blue chromis, redlip blenny, rock beauty, greenbanded goby, blue tang, longhorn blenny, bluehead wrasse, and cherubfish (Ojeda-Serrano *et al.* 2001). Most of the aquarium-trade exports (99.3%) during 1998-2000 went to the continental United States.

5.3.6 The coral reef fishery

The Coral FMP prohibits the harvest or possession of stony corals, soft corals, sea fans, gorgonians and any species in the fishery management unit if attached or existing upon live-rock; it prohibits the sale or possession of any prohibited species unless fully documented as to point of

origin; it prohibits the use of chemicals, plants or plant derived toxins, and explosives for harvest (consistent with the Council's Reef Fish FMP); and it limits harvest of other invertebrates to dip nets, slurp guns, by hand and other non-habitat destructive gear. Most harvest of species under the Coral FMP goes to the aquarium trade. The description of the aquarium trade industry in Section 5.3.5 also applies to invertebrates of the Coral FMP. The local governments prohibit the harvest of corals from state waters.

Amendment 1 to the Coral FMP established the Hind Bank MCD southwest of St. Thomas, USVI. The area is closed to all fishing and harvesting activities, protecting populations of groupers, snappers, other reef fish, and spiny lobster from fishing mortality and protecting coral from fishery-related impacts.

5.3.7 The HMS fishery

The revised list of authorized fisheries (LOF) and fishing gear used in those fisheries became effective December 1, 1999 (64 FR 67511). The rule applies to all U.S. marine fisheries, including Atlantic HMS. As stated in the rule, "no person or vessel may employ fishing gear or participate in a fishery in the exclusive economic zone (EEZ) not included in this LOF without giving 90 days' advance notice to the appropriate Fishery Management Council (Council) or, with respect to Atlantic highly migratory species (HMS), the Secretary of Commerce (Secretary)." Acceptable commercial HMS fisheries and authorized commercial gear types for Atlantic tunas, swordfish, and sharks include: shark bottom longline fishery (longline); shark drift gillnet fishery (gillnet); pelagic longline fishery (longline); swordfish handgear fishery (rod and reel, harpoon, handline, bandit gear); shark handgear fishery (rod and reel, handline, bandit gear); tuna handgear fishery (rod and reel, harpoon, handline, bandit gear); tuna purse seine fishery (purse seine).

The predominant HMS fishery in the Virgin Islands and Puerto Rico that could be impacted by the proposed actions in this EIS, in particular the actions to minimize adverse effects on EFH due to the proposed prohibition on bottom longlines in currently existing seasonal closed areas and on Grammanik Bank, is the commercial shark fishery. However, available data indicate that only a small volume of shark landings was derived from this region in recent years. A brief description of the commercial shark fishery is provided below. More detailed information regarding the other HMS fisheries, including economic information, may be found in the HMS FMP (NMFS 1999b) and the 2004 HMS SAFE Report (NMFS 2004).

5.3.7.1 Commercial Shark Fishery

Atlantic sharks are targeted primarily through the use of bottom longline and drift gillnet gears, and are often taken incidentally with pelagic longline gear. Although discussions of other HMS fisheries have been broken down by gear type, the nature of the shark catch and the method of data collection lend themselves to a stock-based analysis.

5.3.7.1.1 Bottom Longline Fishery

The Atlantic shark bottom longline fishery targets LCS with landings dominated by sandbar and blacktip sharks. Bottom longlines were the primary commercial gear-type used to catch LCS in all regions in recent years. Gear characteristics vary slightly by region, but in general, a ten mile long monofilament bottom longline, containing about 750 hooks is fished on the bottom, overnight. Various baits are used, including skates, sharks, and finfishes. The gear typically consists of a heavy monofilament mainline with lighter weight monofilament gangions (NMFS 2003b)

5.3.7.1.2 Gillnet Fishery

Gillnet fishing for sharks in the southeast United States has existed for many years. The southeast shark drift gillnet fishery is comprised of about five vessels that have been observed to use nets 456 to 2,280 meters long and 6.1 to 15.2 meters deep, with stretched mesh from 12.7 to 22.9 cm (NMFS 2003b).

Shark gillnet fishermen also use gillnet gear in a stikenet fashion. This is generally done by actively setting the net around a school of sharks or by setting the net in the wake of a shrimp vessel. Vessels fishing in a strikenet fashion have been observed to use nets 364.8 meters long, 30.4 meters deep, and with stretched mesh measuring 22.9 cm (NMFS 2003b).

5.3.7.1.3 Pelagic Longline Fishery

The U.S. pelagic longline fishery for Atlantic HMS primarily targets swordfish and yellowfin tuna or bigeye tuna but also catches sharks incidentally. See the HMS FMP (NMFS 1999b) and 2004 HMS SAFE Report (NMFS 2004) for more information specific to the pelagic longline fishery.

5.3.7.2 Commercial Shark Landings

Total commercial landings of LCS in 2002 was 4,114,179 lbs; the total commercial landings of SCS in 2002 was 579,880 lb; and the total commercial landings of pelagic sharks was 305,637 lb (NMFS 2004). The total ex-vessel value of sharks (including fins) landed in 2002 was 8.4 million dollars (NMFS 2004). The value of sharks landed in Puerto Rico and the Virgin Islands from 1997 through 2002 was negligible. According to dealer weigh-out data, landings totaled less than 3,200 lbs. and consisted of 66 individual fish for that six year period (Table 5.3.7.2). However, these data may not be reflective of the actual value of the Caribbean shark fishery due to possible unreported landings.

YEAR	NUMBER OF SHARKS	TOTAL WEIGHT (LBS)
1997	59	2,925
1998	--	--
1999	--	--
2000	6	230
2001	--	--
2002	1	13
TOTAL	66	3,168

Table 5.3.7.2. Caribbean Shark Landings 1997 - 2002. Source: Domestic Landings System maintained by the SEFSC.

5.3.7.3 HMS permits

HMS Management Division continues to monitor capacity in HMS fisheries. Due to the large number of HMS permits, overcapacity remains a concern in HMS fisheries. The HMS FMP outlined several objectives of a program that would limit access to the swordfish, shark, and tuna longline fisheries. This program was designed to prevent further overcapitalization of the fisheries with a longer-range goal of reducing latent effort without significantly affecting the livelihoods of those who are dependent on the fisheries.

The program implemented in the HMS FMP set up six different limited access permit types: 1) directed shark, 2) incidental shark, 3) directed swordfish, 4) incidental swordfish, 5) swordfish handgear, and 6) tunas longline. To reduce bycatch concerns in the pelagic longline fishery, these permits were designed so that the swordfish directed and incidental permits are valid only if the permit holder also holds both a tuna longline and a shark permit. Similarly, the tuna longline permit is valid only if the permit holder also holds both a swordfish (directed or incidental, not handgear) and shark permit. Swordfish handgear and shark permits are valid with out another limited access permit.

As of October 2004, one shark incidental permit is held by a vessel in the USVI, and no shark limited access permits are held by vessels in Puerto Rico. As of October 2004, one dealer holds an Atlantic shark dealer permit in the USVI, and no Atlantic shark dealer permits are held in Puerto Rico.

5.3.8 Fishing communities

The information available to describe commercial fishing communities has been reviewed in the Council's Coral Reef, Queen Conch, Reef Fish, and Spiny Lobster FMPs. There is no continuous program that collects information to describe these communities in great detail.

Sporadic and targeted surveys are conducted in the U.S. Caribbean to answer specific questions. Caribbean commercial fisheries are complex and harvest multiple species with a variety of gears and seasonal harvesting patterns. This complexity has not been analyzed in detail.

Matos-Caraballo (1997) provided the latest commercial fishing census (1995) for Puerto Rico and detailed information concerning regional landings, U.S. census information, and fishing participants in various fisheries by region. The 1,758 full- and part-time fishermen were distributed fairly evenly around Puerto Rico: 428 on the North Coast, 427 on the East Coast, 442 on the South Coast, and 461 on the West Coast. Only two communities reported more than 100 fishermen: Cabo Rojo (213) and Humacao (108). The total number of active commercial fishermen reported by the Puerto Rico Fisheries Research Laboratory has fluctuated without long-term trend since 1974 (Matos-Caraballo 1997).

No comparable document is available for the USVI, although Downs and Petterson (1997) obtained information for USVI during evaluation of a proposed Marine Conservation District off St. John. They reported that the two traditional fishing communities of St.Thomas are Hull Bay on the north side and Frenchtown on the south side; however, northside fishermen tend to keep vessels in the east or south coast areas. Most St. Thomas fishermen are of French descent. On St. John, fishermen cluster in Cruz Bay on the west end and in Coral Bay on the east end. Most St. John fishermen are recent arrivals, or of West Indian descent.

The Heinz Center (2000) report on roundtable discussions for improving federal fisheries management both nationally and for the Caribbean specifically, calls for enhanced social science research including the development of long-term, comprehensive social science data collection programs. In the U.S. Caribbean, the panel recommended more proactive use of social and economic information in the fishery management process and providing transition assistance to displaced fishermen. Emphasis was placed on the need for long-term research to collect information on community infrastructure, how fishermen learn and produce knowledge, cultural perceptions and politics, socioeconomic development of fishing communities, gender issues, fishery histories, ethnic composition and background of fishery participants, rules and regulations, and systems of jurisdiction and conflicts. They also suggested moving away from surveys to gather data and towards the idea of getting fishermen to participate more extensively in the data collection and assessment process. The panel believed that Puerto Rico and the USVI should have both commercial and recreational socioeconomic research programs.

5.4 Administrative environment

Section 2 provides an overview of the administrative environment in the U.S. Caribbean, including the federal (Section 2.1.1) and state (Section 2.1.2) fishery management systems and applicable laws, international issues (Section 2.1.3), and the history of federal fisheries management (Section 2.2).