Queen Conch, *Strombus gigas* (Linnaeus 1758)

Status Report

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PURPOSE

This document summarizes and synthesizes biological information covering queen conch, *Strombus gigas*, throughout its natural distribution. It seeks to present the best available information from published and unpublished sources (e.g., literature searches, interviews). This document does not represent a decision by NMFS on whether this taxon should be proposed for listing as threatened or endangered under the Endangered Species Act.

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1. Introduction and Background

1.1 Background

This status report was conducted in response to a petition to list the queen conch (*Strombus gigas*) under the Endangered Species Act (ESA). On February 27, 2012, the NMFS received a petition from the WildEarth Guardians requesting that we list the queen conch as endangered or threatened under the ESA and designate critical habitat for the species. NMFS evaluated the petitions to determine whether the petitioners provided substantial information as required by the ESA to list a species. The petitioner also requested that critical habitat be designated for this species concurrent with listing under the ESA. The petition asserted that overfishing is the greatest threat to queen conch and is the principal cause of population declines and that the existing regulations are ineffective and unable to prevent, the unsustainable and illegal harvest of queen conch. The petition asserted that biological characteristics (e.g., slow growth, late maturation, limited mobility, occurrence in shallow waters, and tendency to aggregate) rendered the species particularly vulnerable to overharvest, and that allee effects are preventing the recovery of overexploited stocks. The petitioner also asserted degradation of shallow water nursery habitat and water pollution, specifically high concentrations of zinc and copper, reduces juvenile recruitment and causes reproductive failure. The petition addressed four of the factors identified in section 4(a)(1) of the ESA as they pertain to the queen conch: (A) current or threatened habitat destruction or modification or curtailment of habitat or range; (B) overutilization for commercial purposes; (C) inadequacy of existing regulatory mechanisms; and (D) other natural or man-made factors affecting the species' continued existence.

On August 27, 2012, we determined that the petition presented substantial scientific and commercial information, or cited such information in other sources, that the petitioned action may be warranted and published a positive 90-day finding in the *Federal Register* (77 FR 51763). We also announced the initiation of a status review and requested information on the status of the queen conch throughout its range including: (1) Historical and current distribution and abundance of this species throughout its range; (2) historical and current population trends; (3) biological information (life history, genetics, population connectivity, etc.); (4) landings and trade data; (5) management, regulatory, and enforcement information; (6) any current or planned activities that may adversely impact the species; and (7) ongoing or planned efforts to protect and restore the species and its habitat. We received information from the public in response to the 90-day finding; the public responses received were considered in the Status Report. This Status Report provides a summary of the information gathered for the ESA review for queen conch.

2. Life History

2.1 Taxonomy and Distinctive Characteristics

Strombus gigas (Linnaeus, 1758) is a mollusk in the class Gastropoda, order Neotaenioglossa and family Strombidae. Synonyms include *Lobatus gigas* Linnaeus, 1758, *S. lucifer* Linnaeus, 1758, *Eustrombus gigas* Linnaeus, 1758, *Pyramea lucifer* Linnaeus, 1758, *S. samba* Clench, 1937, *S. horridus* Smith 1940, *S. verrilli* McGinty, 1946, *S. canaliculatus* Burry, 1949, and *S.pahayokee* Petuch, 1994. Recently, some taxonomic changes have been proposed within *Strombidae* that affect *S. gigas*. Simone (2005) separated the members of the *Strombus* genus into three different genera based on morphology (Figure 1) where *S. pugilis, S. alatus* and *S. gracilior* were retained in *Strombus*, and *S. goliath* and *S. gigas* were moved to the genus *Eustrombus* (previously a subgenus), and *S. costatus* and *S. gallus* were moved to the genus *Aliger*. Latiolais et al. (2006) proposed a similar phylogeny and classification using molecular techniques, but did not propose generic name changes. Direct comparison between these two studies proves difficult as Latiolais et al. (2006) did not include *S. goliath* and Simone (2005) did not include *S. raninus.* Most recently Landau et al. (2008) proposed that the genera *Eustrombus* and *Aliger* be combined into the genus *Lobatus.* Notably, these changes in nomenclature affect higher taxonomic classification and do not combine or split the classification of *S. gigas*.

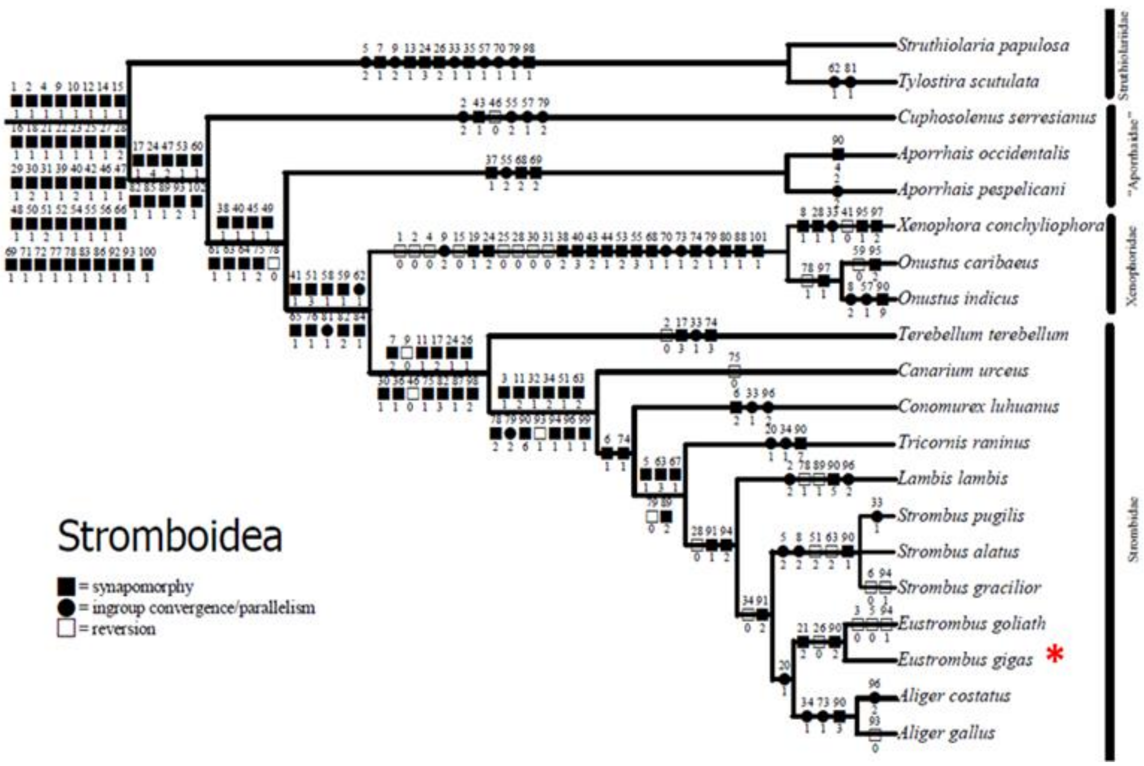

Figure 1: Phylogenetic tree illustrating relationship among members of the super family Stromboidea based on morphological analysis (Simone, 2005). Red asterisk illustrates node that includes both Strombus gigas and S. goliath.

The queen conch is identified by their large, whorl-shaped shell with multiple spines at the apex and the pink interior of the shell lip. The outside of the shell becomes covered by an organic periostracum layer, as the queen conch matures, that can be much darker than the natural color of the shell. Shell morphology is highly plastic and environmental conditions appear to be a strong influence on shell morphology and growth (Martin-Mora et al. 1995; McCarthy 2007); therefore shells can vary in size due to habitat and geographic nuances. Males and females are distinguished by either a verge or egg grove, and females are generally slightly larger than males (Cala de la Hera et al. 2012). The shell lip begins to flare with sexual maturity (3.5 to 4 years) and it can reach a thickness of 17-18 mm within one year, and is one of the defining characteristics of *S. gigas* (Appeldoorn 1988b; Stoner 1989a). Characteristics used to distinguish *S. gigas* from other family members include: (1) large, heavy shell; (2) short, sharp spires; (3)

brown and horny operculum and; (4) bright pink interior of the shell (Prada et al. 2008), as well as differences in geographic distribution and maximum size (Simone 2005).

Samba conch is a phenotypically different form of queen conch that is much shorter, very thick shelled and with dark skin (Randall 1964). Samba conch or "dwarves" have been reported throughout the Caribbean (Mitten et al. 1989; Clerveaux et al. 2003; Cala de la Hera et al. 2012). Samba conch are thought to have less fecundity due to their small size, which limits space for gonadal tissue (Stoner et al. 2012b). The samba conch phenotype differs from juvenile queen conch in that the samba conch are smaller in size, but have a very thick shell lip; whereas juvenile queen conch will grow in size until it reaches sexual maturity. Only then does it begin to add material to enlarge the shell lip (Cala de la Hera et al. 2012).

The condition is hypothesized to result from stunted growth in areas of high density or limited food resources or by the fishers selectively removing larger conchs. It is difficult to confirm or refute these hypotheses regarding the small queen conch phenotype (samba conch) without genetic testing to assist in interpreting the phenotype or without long-term research that can confirm any genetic shifts resulting from fishing pressure. It is known that limited food resources can cause conch to decrease their rate of shell growth, but thicken the shell tissue (Cala de la Hera et al. 2012). In the Exuma Cays, Bahamas, it was found that queen conch populations in different habitats (e.g., depth and aquatic vegetation, etc.) have conch with different shell forms including length, spine length, and spire shape (Stoner et al. 2009). Martin et al. (1995) transplanted juvenile conch between habitats and found that shell morphology will change to reflect the habitat type and quality. Queen conch that remained in shallow banks near Lee Stocking Island, Bahamas, were of smaller size than those that migrated into deeper waters offshore (Stoner and Schwarte 1994). Stoner et al. (2009) reported these differences in size between the conch that remained inshore and those that migrated offshore s could be related to the foraging environment, the occurrence of stressful water temperature conditions (>30°C in summer and <18°C in winter) on the shallow banks compared with more moderate temperatures in deep water, and inversely density-dependent growth where conch densities are high (Stoner et al. 2009).

The samba conch phenotypes have also been observed in locations with high fishing pressure. In Chinchorro Bank, Mexico, the samba conch phenotype was attributed to fishing effects, produced by fishers removing the largest conchs, because they represent more meat per conch (Cala de la Hera et al. 2012). This affects the conch population because it leads to smaller growth rates (Cala de la Hera et al. 2012). The hypothesis is that if large individuals are disproportionately removed by predators or fishing effort, then animals reproducing at a small size will have a selective advantage and genetic shifts would occur (Stoner et al. 2009). There is some evidence for this phenomenon occurring over many generations in marine fish that are subject to heavy fishing pressure (Stoner et al. 2009).

2.3 Range and Distribution

The queen conch occurs throughout the Caribbean Sea, the Gulf of Mexico, and around Bermuda (Figure 2) and includes the following countries and territories: Antigua and Barbuda, Aruba, Barbados, Bahamas, Belize, Bermuda, Caribbean Netherlands, Colombia, Costa Rica, Cuba, Dominican Republic, French West Indies, Grenada, Haiti, Honduras, Mexico, Montserrat, Nicaragua, Panama, Puerto Rico, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, the Turks and Caicos, the United States (Florida and Texas, Flower Garden Banks), both the U.S. and British Virgin Islands, and Venezuela (Theile, 2001). The geographic distribution of queen conch is bound by Bermuda to the north, Panama to the south, Barbados to the east, and the Gulf Coast of Mexico to the west. Queen conch have been reported from most islands within this geographic area at some time (Appeldoorn and Baker, 2013).

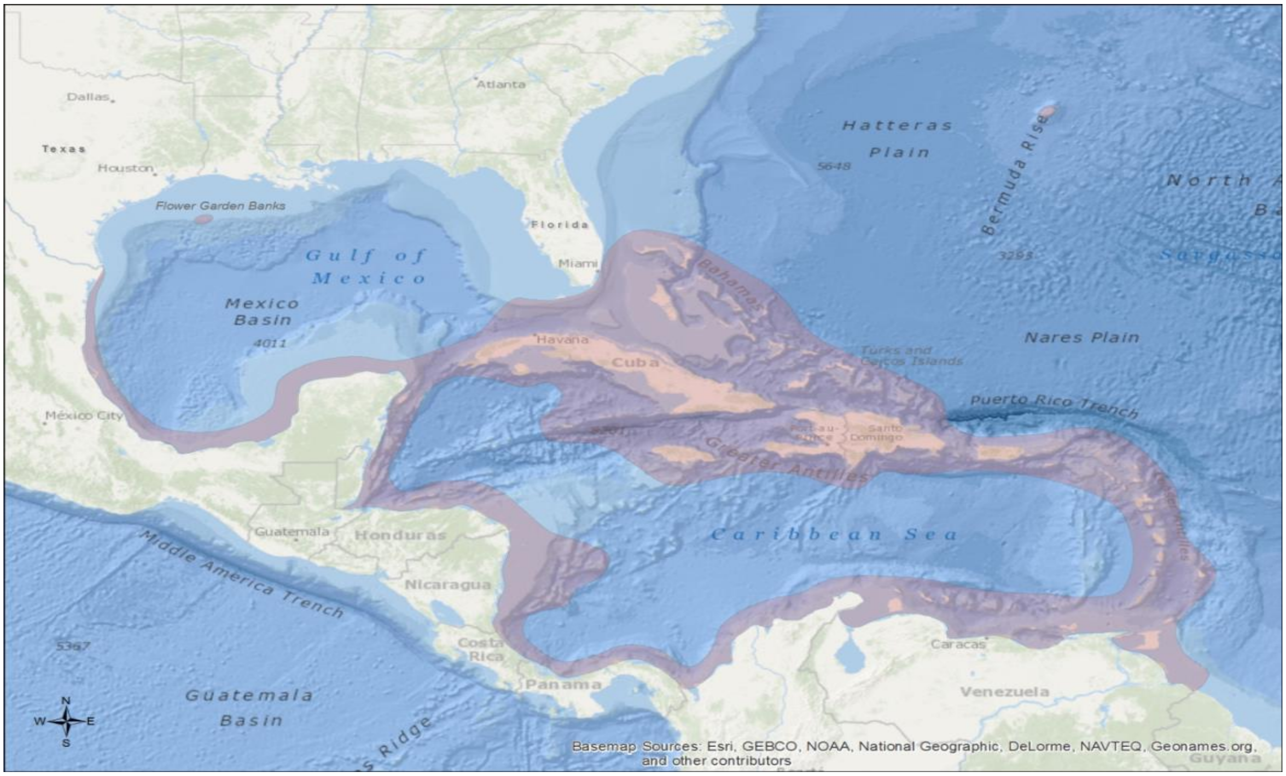

Figure 2: Geographic range of the queen conch (Strombus gigas). Habitat includes shoreline to insular or continental shelf throughout the indicated range.

2.4 Habitat Use and Movement

Queen conch inhabit a range of habitat types during their life cycle. During the planktonic life stage, queen conch larvae (veliger) feed on phytoplankton. Larvae must receive the right amount of nutrition during this stage or development can be delayed (Brownell 1977). To metamorphose into juveniles, veligers most often settle in seagrass areas, which have sufficient tidal circulation, and high macroalgae production. The success of nursery areas are influenced by physical and oceanographic processes, level of larvae retention and settlement, predator abundance, and related survivorship (Stoner et al. 1998; Stoner et al. 2003).

Juveniles occur primarily in back reef areas (i.e., shallow sheltered areas, lagoons, behind emergent reefs or cays) of medium seagrass density, depth between 2 to 4 m, strong tidal currents (at least 50 cm/s; Stoner 1989b) and frequent tidal water exchanges (Stoner and Waite 1991; Stoner et al. 1996). Posada et al. (1997) stated that the most productive nurseries for the queen conch tended to occur in shallow (< 5-6 m deep) seagrass meadows. However, there are, certain exceptions, such as in Florida, where many juveniles are found on shallow algal flats, or on certain deep banks such as in Pedro Bank, Jamaica. Seagrass is thought to provide both nutrition and protection from predators (Ray and Stoner 1995; Stoner and Davis 2010). Jones and Stoner (1997) found that optimal nursery habitat occurred in areas of medium density seagrass, particularly along the seagrass gradient. In The Bahamas, juveniles were only found in areas within 5 km from the Exuma Sound inlet, emphasizing the importance of currents and frequent tidal water exchange that affects both larval supply and growth of their algal food (Jones and Stoner 1997). Juveniles generally remain buried within the soft substratum until they approach a year in age. They emerge and then move to sand-algal plains with areas of mixed seagrass.

While juveniles appear to have specific habitat requirements, adults can tolerate a wider range of environmental conditions (Stoner et al. 1994). Adults prefer sandy algal flats but can also be found on gravel, coral rubble, smooth hard coral or beach rock bottoms (Torres-Rosado 1987; CFMC 1996a; Acosta 2001; Stoner and Davis 2010). Adult queen conch are rarely, if ever, found on soft bottoms composed of silt and/or mud, as well as areas with high coral cover (Acosta 2006). In Florida, reproducing queen conch generally preferred coarse sand substrates, rather than reef, coral rubble, or seagrass habitats (Glazer and Kidney 2004).

Conch distribution and density is influenced by fishing pressure (Glazer and Kidney 2004). Adult queen conch in shallow water are more vulnerable to harvest compared to those in deeper water because of fishery accessibility. In areas with fishing, adult conch are more commonly found in deep-waters, as prohibitions on Self-Contained Under Water Breathing Apparatus (SCUBA) or hookah gears have essentially created deep-water refuge areas (Glazer and Kidney 2004). On the other hand, adult conch were found in greater abundance and density in the shallow waters of a Marine Protected Area in The Bahamas, where harvest is prohibited, when compared to shallow-water densities in areas that allow fishing (Stoner and Ray 1996).

Adult conch are often found in shallow, clear water of oceanic or near-oceanic salinities at depths generally less than 75 m and are most often found in waters less than 30 m (McCarthy, 2008). It is believed that depth limitation is based mostly on light attenuation limiting their photosynthetic food source (Randall 1964; McCarthy 2008). In heavily exploited areas, greater abundance and densities are found in the 25-35 m depth range (Ehrhardt and Valle-Equivel 2008). Significant populations of queen conch have been found in three deep water sites (35-50 m) in the U.S. Exclusive Economic Zone (EEZ) off western Puerto Rico (García-Sais et al. 2012). These deep water populations were predominately associated with rhodolith reefs and were more abundant at the edge of the western shelf (Abrir La Sierra) that is contiguous with the Puerto Rican shelf. The two other study locations, Bajo de Sico and Desecheo, are separated from the Puerto Rican shelf by the Mona Passage and had lower densities of queen conch. Queen conch in these deep water areas were copulating, egg masses were observed, and overall densities ranged between 70/ha to 323/ha. Most queen conch in the deep waters were large adults; no juveniles were observed at Bajo de Sico or Desecheo. Similar results were reported in Martinique (Reynal et al. 2009) where adult queen conch in depths between 30-40 m were greater than 22 cm in length with lip thicknesses greater than 10 mm.

The average home range size for an individual queen conch is variable and has been measured at 5.98 ha in Florida (Glazer et al. 2003), 0.6 to 1.2 ha in Barbados (Phillips et al. 2011), and 0.15 to 0.5 ha in the Turks and Caicos Islands (Hesse 1979). Glazer et al. (2003) found that there was no significant difference in movement rate, site fidelity, or size of home range between adult males and females. There was a statistically significant difference in mean speed of the conch among the four seasons (winter, spring, summer and fall) of the year. Queen conch moves at a greater speed during the summer. This increase in speed may be due to the increased metabolic activity associated with warmer waters and increased movement related to their reproductive season (i.e., males searching mates and females moving into egg-laying habitat) (Glazer et al. 2003). Studies have suggested that adult conch move to different habitat types during their reproduction season, but afterwards return to feeding grounds (Stoner and Sandt 1992; Hesse 1979; Glazer et al. 2003). In general, adult conch do not move very far from their feeding grounds during their reproductive season (Stoner and Sandt 1992). The movements of adult conch are further associated with factors like change in temperature, expanding available food, resources, and predation.

When juvenile conch first emerge from the sediment and move to nearby seagrass beds, densities can be as high as 200-2000/ha (Stoner 1989a; Stoner and Lally 1994). It was originally thought newly emergent juvenile conch moved away from nursery areas to enhance feeding opportunity (Stoner 1989a). Stoner and Lally (1994) later hypothesized the juvenile aggregations served as protection from predators. The predator avoidance hypothesis was supported by a later study (Stoner and Ray 1993) that showed decreased predation mortality and higher survivorship in juvenile queen conch within dense aggregations, but at a cost of lower growth rates. The slow growth rate of juvenile conch in the presence of predators was subsequently confirmed in a laboratory study (Delgado et al. 2002).

Young juveniles tend to move in the direction of the ebb tide, and can be formed of a single or multiple year classes (Stoner and Sandt 1992). Aggregation appears to occur year round, but there may be some seasonality in the direction of movement (Stoner and Lally 1994). The maximum movement rate of conch juveniles (less than 2 years old) within the aggregation was 4.7 m/day in seagrass meadows during periods of high temperature and low wind speed. When water temperatures were low and wind conditions high juvenile aggregations stopped forward movement and broke into high density clusters during these weather periods (Stoner 1989a). The movement increased when juvenile aggregations encountered areas with low food supply, decreased when heavy algal mats were encountered, and may temporarily stop during high wave action and low temperatures which occur during winter months (Stoner 1989a; Stoner and Lally 1994).

Juvenile aggregations are found in depths of less than 4 m year round (with peak in March) and have been observed to be “well defined” or well-formed for at least 5 months, but are usually formed and active for 2 to > 3 months (Stoner and Lally 1994). Juvenile conchs have been shown to be gregarious, individuals move towards aggregations, while individuals within the aggregation tended to remain (Stoner and Ray 1993). Therefore aggregations increased in numbers as their movement progressed through nursery grounds (Stoner 1989a).

2.5 Life Stages and Growth

Female queen conch lay egg masses in shallow coastal waters that have sandy substrate and the eggs hatch in approximately 5 days (Weil and Laughlin 1984). The veligers are planktonic for generally 14 to 28 days, but up to 60 days (D’Asaro 1965), during which time there is high mortality (Chávez and Arreguín-Sánchez 1994). Depending on local currents, the larval queen conch can settle locally or drift to other locations (CFMC 1999). These veligers are found primarily in the upper few meters of the water column (Posada and Appeldoorn 1994; Stoner and

Davis 1994; Stoner 2003) in densities ranging between 0-9.1/100 m^3 in the Florida Keys to 2.3-32.5/100 m^3 in the Exuma Cays, Bahamas (Stoner et al. 1996), with higher densities at shallower depths (Posada and Appeldoorn 1994). At around 0.3 mm shell length, the veligers metamorphose into their post larvae stage and settle on the benthos when shell their length is between 1 to 2 mm (Davis et al. 1993; Prada et al. 2008). A chemical cue often associated with red algae or a similarly polar molecule is required to induce metamorphosis (Myanmanus 1988; Davis 1994). The post-larvae must come into contact with the bottom, undergo metamorphosis and survive the transition to benthic existence to enter the juvenile stage (Stoner 2003). The preferred habitat for larval settlement is shallow back reefs areas and sand bars near a seagrass meadow (Stoner et al. 1994). Larval settlement has also occurred in deeper areas (CRFM 2004). After the post-larvae settle on the bottom and they submerge into the sediment, they emerge about a year later (Stoner 1989a) as juveniles with around 60 mm shell length. This submerged life phase makes it difficult to survey and therefore they are often under-sampled (Hesse 1979; Appeldoorn 1987b).

Juveniles emerge from the sandy benthos during warmer summer months (Stoner et al. 1988). Nursery areas with shallow seagrass beds of intermediate densities (Jones and Stoner 1997) support juvenile conch in densities of 1000 to 2000/ha (Wood and Olsen 1983; Weil and Laughlin 1984) in depths less than 15 m (Stoner and Schwarte 1994). The structure of the seagrass beds decreases the risk of predation (Ray and Stoner 1995), which is very high for juveniles (Appeldoorn 1988a). Avoiding predation seems to be the most important factor for juveniles in determining their habitat, but good water quality is also necessary. Adults on the other hand, have fewer predators and are therefore found where there is a greater abundance of food in different habitats and at greater depths (Ray and Stoner 1995).

Growth rate and shell morphology of queen conch can vary depending on sex, depth, latitude, food availability food, age class, and habitat. Small outplanted hatchery-raised juveniles grew 0.21 mm/day at 17 m depth off southwest Puerto Rico (Appeldoorn 1985), while juveniles in hatcheries grew 0.3 mm/day (Brownell 1977; Ballantine and Appeldoorn 1983). Queen conch in Exuma grew an average of 0.12 mm/day (Wicklund et al. 1991) and 0.3 mm/day in Barbados (Phillips et al. 2011). In a protected area of Mexico, juveniles grew an average of 0.28 mm/day, conch 150 to 199 mm grew 0.19 mm/day and those greater than 200 mm grew 0.08 mm/day (Peel and Aldana Aranda 2012). On average, female queen conch grow more quickly than males (Alcolado 1976), to a bigger size (Randall 1964), and have a greater tissue weight, although overlap does occur. This species also exhibit periods of seasonal growth associated with water temperature and food availability. Summer growth rates are greater than winter growth rates (Stoner and Ray 1993). Juvenile growth rates were 4.4 to 16.3 mm/month in the summer and 1.8 to 3 mm/month for the rest of the year in The Bahamas (Iversen et al. 1987). Size at maturity can vary depending on local environmental conditions that promote or slow growth. Shell length continues to increase until the onset of sexual maturity. The queen conch reaches maturity at around 3.5 to 4 years, at which time the edge of the shell lip turns outward to form the flared lip (Stoner et al. 2012a). Once the shell lip is formed, the shell does not increase in length (Appeldoorn 1997; Tewfik et al. 1998). Future shell growth is limited to thickening of the shell, in particular the thickening of the flared lip (Appeldoorn 1988b). Studies indicate that shell thickness is a better indicator of sexual maturity than the formation of the flared lip (Stoner et al. 2012b; Appeldoorn 1994; Clerveaux et al. 2005). Lip thickness in reproducing adult queen conch was greater in queen conch in The Bahamas compared to those in Columbia (Stoner et al.

2012b). With the onset of sexual maturity, tissue growth decreases and switches from primarily thickening of the meat to increasing the weight of the gonads. Once the conch is around ten years of age, the shell volume starts to decrease, as layers of the shell mantle are laid down from the inside (Randall 1964). Eventually, the room inside the shell can no longer accommodate the tissue and conch will start to decrease their tissue weight (CFMC 1999). Stoner et al. (2012b) found that after shell lip thickness of 22 to 25 mm, both soft tissue and gonad weight decreased. Life span of queen conch is about 30 years (McCarthy 2007).

Queen conch are often considered to be adults when the lip is flared; nonetheless, Appeldoorn (1988b) observed that the verge of thin-lipped males in Puerto Rico was not functional at that time, and true reproductive maturity did not occur until at least 2 months after the lip flares outward at about 3.6 years of age. The result is that thin-lipped individuals probably do not mate or spawn in the first reproductive season after the shell lip flares, and are at least 4 years old before first mating. A shell thickness of 8 to 10 mm is a better indicator of actual reproductive maturity than the lip flare (Stoner et al. 2009; Stoner et al. 2012b). Because lip thickness can also depend on sex and geographic habitat, male conch in The Bahamas are not sexually mature before 10 mm lip thickness and females not before 15 mm lip thickness (Stoner et al. 2011). These morphological characteristics of reproductive maturity match histological observations of gametogenic activity (Egan 1985) and field observations (Buckland 1989). Based on histological examinations, Appeldoorn (1993) found that 100% of conch are not fully mature until over a year after complete lip formation and modeled the percent mature (PM) as a function of lip thickness (LT) with the following equation: PM=1-e-0.14(LT-1.9).

2.6 Reproduction

Conchs have a protracted spawning season, with maximum spawning occurring during summer months (Appeldoorn 1988c). Conch copulation occurs both day and night, potentially year-round dependent on water temperature (Randall 1964). Therefore the spawning periods vary by latitude and annually as weather conditions impact water temperature.

Females can store fertilized eggs for several weeks before laying (David et al. 1984). A single egg mass can be fertilized by multiple males (Medley 2008). Egg masses are laid over 24 to 36 hours (Randall 1964) from an egg tube that extrudes from the egg groove. The egg mass if formed by the egg tube folding back on itself and then becomes camouflaged when sand grains also stick to it (Brownell and Stevely 1981). When adequate food is available, female conch can lay an average of 13.6 egg masses, containing about 750,000 eggs each; resulting in about ten million eggs produced per individual per spawning season (Appeldoorn, 1993). Female conch that had less food available produced 6.7 egg masses, containing 500,000 eggs; resulting in about 3.3 million eggs per individual per spawning season (Appeldoorn, 1993). Female conch fecundity appears to be effected by the availability of food resources. Older individuals have reduced internal space for gonadal tissue; they may have a higher density of eggs in the extruded tube (Glazer pers. comm as cited in Appeldoorn and Baker, 2013). As the conch gets older, and the lip becomes thicker, gametogenic activity increases (Egan 1985). Appeldoorn (1993) tried to model total annual fecundity as a function of age, using lip thickness as a proxy for adult age, which resulted in the following equation:

$$\text{Log (Fecundity)} = 4.157 + 2.012 \text{ Log (Age)} \qquad r2 = 0.672; N = 10$$

However, this equation was only applicable during the first years following maturation when tissue weight was still increasing and lip thickness reflected age. There is no evidence of senescence with increasing lip thickness (Stoner et al. 2011; Stoner et al. 2012b).

Egg masses have been found in water depths from 3 to 45 m (Tewfik et al. 1998; García-Sais et al. 2012). Clean, low organic content, coarse sand flats are the preferred habitat for reproduction and egg laying (Randall 1964; Glazer and Kidney 2004). It is theorized that the adherence of sand grains to the egg mass provide camouflage and discourage predation (Randall 1964). Other than the greater availability of sand to adhere to eggs masses, possible advantages to conch leaving seagrass beds for sand flats to lay eggs is that there are more animals in seagrass beds hence the chances of predation on egg masses would be higher there (Randall 1964). The egg masses hatch into planktonic veligers after approximately 3 to 5 days (Davis 1994). The length of the breeding season varies geographically according to water temperature, but it generally occurs during the months of April to October (Figure 3).

Reproductive cycle												Duration (months)	Geographical area	Sources
J	F	M	A	M	J	Jl	A	S	O	N	D			
				◐	⊕	⊕	⊕	⊕				4.5	Florida	Davis et al., 1984
		⊕	⊕	⊕	⊕	⊕	⊕	⊕				7	Turks and Caicos	Davis et al., 1987
			◐	⊕	⊕	⊕	⊕	⊕				5.5	Bahamas	Wicklund et al., 1991
				⊕	⊕	⊕	⊕	◑				4.5	Bermudas	Berg et al., 1992
			⊕	⊕	⊕	⊕	⊕	⊕	⊕			7	Bahamas	Stoner et al., 1992
	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕			9	Virgin Islands	Randall, 1964
					⊕	⊕	⊕	⊕	⊕	⊕		6	Venezuela	Brownell, 1977
				⊕	⊕	⊕	⊕	⊕	⊕	⊕		7	Venezuela	Weil and Laughlin, 1984
			◐	⊕	⊕	⊕	⊕	⊕				5.5	St Kitts/Nevis	Wilkins et al., 1987
				◐	⊕	⊕	⊕	⊕	⊕	◑		6	Puerto Rico	Appeldoorn, 1988
			⊕	⊕	⊕	⊕						4	Santa Marta, Colombia	Botero, 1984
					◐	⊕	⊕	⊕	⊕			4.5	San Andres, Colombia	García-Escobar et al., 1992
			⊕	⊕	⊕	⊕	⊕	⊕				6	San Andres, Colombia	Márquez-Pretel et al., 1994.
⊕					⊕	⊕	⊕	⊕	⊕	⊕	⊕	8	San Bemardo, Colombia	Lagos-Bayona et al., 1996
	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕			9	Alacranes Reef, México	Pérez-Pérez and Aldana-Aranda, 2002

Figure 3: Reproduction cycle of Strombus gigas at specific locations in the Caribbean (Avila-Poveda and Baqueiro-Cardenas 2009)

Seasonal movements, usually associated with summer spawning, are known for queen conch. Weil and Laughlin (1984) reported that adult conch at Los Roques, Venezuela move from offshore feeding areas in the winter to summer spawning grounds in shallow, inshore sand. Movements to shallower summer habitats have also been reported for deep-water populations at St. Croix (Coulston et al. 1988). Near Lee Stocking Island, Bahamas, deep-water conch make seasonal movements from algae-covered hard grounds to spawning sites on bare sand (Wicklund et al. 1988; Stoner et al. 1992). Not all conch move into shallow waters during the reproductive periods; conch found in the deep waters near Puerto Rico and Florida are geographically isolated from nearshore, shallow habitats and remain offshore (Glazer et al. 2008; Garcia-Sais et al.

2012). Breeding aggregations are dominated by older individuals that produce large, viable egg masses (Berg et al. 1992a). Aggregations form in the same location year after year (Posada et al. 1997; Glazer and Kidney, 2004; Marshak et al. 2006). Aggregations of breeding conch were found to consist of 150 to 200 adults in Columbia (Appeldoorn et al. 2003) and average of 90 to 120 breeding individuals at Alacranes Reef in Mexico (Pérez Pérez and Aldana Aranda 2002).

Queen conch are often considered to be adults when the lip is flared; nonetheless, Appeldoorn (1988b) observed that the verge of thin-lipped males in Puerto Rico was not functional at that time, and true reproductive maturity did not occur until at least 2 months after the lip flares outward at about 3.6 years of age. The result is that thin-lipped individuals probably do not mate or spawn in the first reproductive season after the shell lip flares, and are at least 4 years old before first mating. A shell thickness of 8 to 10 mm is a better indicator of actual reproductive maturity than the lip flare (Stoner et al. 2009; Stoner et al. 2012b). Because lip thickness can also depend on gender and geographic habitat, male conch in The Bahamas are not sexually mature before 10 mm lip thickness and females not before 15 mm lip thickness (Stoner et al. 2011). These morphological characteristics of reproductive maturity match histological observations of gametogenic activity (Egan 1985) and field observations (Buckland 1989). Based on histological examinations, Appeldoorn (1993) found that 100% of conch are not fully mature until over a year after complete lip formation.

2.7 Diet and Feeding

Queen conch are herbivores and benthic grazers (Randall 1964; CFMC 2005) that feed on diatoms, seagrass detritus, and varies types of algal and epiphytes (Stoner et al. 1995; Stoner 2003). Juvenile queen conch feed mainly on seagrass detritus; as much as 57-67% of their diet is composed of seagrass detritus (Stoner and Waite 1991; Stoner 1989b). The epiphytes that live on seagrass also provide nutrition for juveniles (Stoner 1989a). In sand habitats, juveniles can also feed on diatoms and cyanobacteria that are found in the benthos (Creswell 1994; Ray and Stoner 1995). Adults feed on different types of filamentous alga (Ray and Stoner 1994; Creswell 1994). The presence of the green algae, *Batophora oerstedii*, in The Bahamas even caused an aggregation to change direction (Stoner and Ray 1993) and is also correlated to areas of higher conch densities (Stoner et al. 1994).

3. Threats

3.1 Commercial Harvest

Queen conch is one of the most important fishery resources in the Caribbean by annual landings and social and economic importance (Brownell and Steven 1981; Appeldoorn 1994; Asprea et al. 2009). Queen conch meat is consumed both domestically as well as exported overseas (FAO report 2012). Since the 1980s, commercial catch has increased in response to international market demand (Paris et al. 2008). Both fishing pressure and exports have increased over the past two decades resulting in diminishing population density across the range (Acosta 2006; Ehrhardt 2008).

Queen conch catch data are available in the FAO database (FAO report 2012). According to these data, queen conch catches reached a peak in 1995 followed by a progressive decline. Recent total catch is half of the mid-1990s maximum. According to the FAO report (2012), the level queen conch meat exported rapidly increased in the 1990s, culminating annual exports of around 3,000 tons in 1996 and 1997. Trade in queen conch meat then dropped in 1998 to less than 1,400 tons, subsequently increased to 2,600 tons in 2001 through 2003, then declined again in 2004 to less than 1,500 tons. The decline in exports in 2004 is believed to be the result of a trade suspension placed on Honduras, the Dominican Republic, and Haiti. Since then annual exports have remained below 2000 tons (FAO report 2012). Much of the increase was driven by demand from Caribbean countries, as well as the United States, which imported approximately 80% of the annual queen conch catch during that time (Cimo et al. 2012). It is important to note that the above numbers only reflect import data and does not account for conch harvested for domestic consumption.

The queen conch fishery encompasses the entire Caribbean and consists of both industrial and artisanal fleets (Appeldoorn et al. 2011). Industrial conch fisheries operate primarily in Jamaica, Colombia, Cuba, Honduras, Nicaragua, Belize, Turks and Caicos, and The Bahamas (Appeldoorn et al. 2011). Increased international demand for queen conch meat and conch pearls has resulted in overfishing and reduced stocks throughout the region (Appeldoorn et al. 2011). Fisheries management at international, national, and local levels has been slow to respond to the rapid growth of the queen conch fishery (Appeldoorn et al. 2011). Regulatory measures vary considerably throughout the Caribbean (Berg and Olsen 1989; Chakalall and Cochrane 1997). Management measures mostly include minimum size restrictions, closed seasons, harvest quotas, and gear restrictions, or a combination of these.

Many countries do not report a substantial recovery of queen conch populations despite, active conservation actions and international management policies, such as bans, catch quotas and fishery closures (Stoner and Ray 1996; Stoner 1997; De Jesus-Navarrette et al. 2003; Paris et al. 2008). For a complete review of the status queen conch populations, description of fisheries, and fisheries management throughout the Caribbean, see Section 6.

Despite conservation measures and regulations, the slow recovery observed in some queen conch populations, which have been subject to overexploitation, maybe due to reduced density that limit reproduction (Glazer 2008; FAO report 2012). Because fertilization is internal, a male must encounter a female queen conch. The minimum threshold density to ensure sustainability has been found to be 50 conch/ha minimum cross shelf density (Stoner and Ray-Culp 2000) and 185 conch/ha intra-aggregation density (Glazer 2008). In 2012, the report from the queen conch expert workshop recommended that a median or mean density of 100 adult conch /ha (or higher) should be used (QCEWR 2012). At density levels less than the critical threshold, mating will not occur at the frequency needed to sustain the stock which can lead to a populations collapse (Stoner and Ray-Culp 2000); this is known as an allee effect (see Section 3.2)

3.2. Limits to Reproduction and Recruitment

Studies have shown that the mating and egg-laying in queen conch are very well known to be directly related to the density of mature adults (Stoner and Ray-Culp, 2000; Stoner et al., 2011; Stoner et al., 2012), more specifically, below a critical density reproductive behavior (e.g., mating) will decline to zero and that mating will cease below a minimum density (Stoner et al., 2011). The absence of reproduction in low-density conch populations is related to encounter rate. The probability of encounters between male and receptive female conch in low density populations is significantly reduced (Stoner and Ray-Culp, 2000).

The density of mature adult queen conch directly impacts both reproduction and egg-laying (Stoner and Ray-Culp 2000; Stoner et al. 2012). No mating or spawning activity has been observed at mean density of less than 56 adult conch/ha (Stoner and Ray-Culp, 2000). A minimum of 100 adults/ha (or higher) was recommended to ensure adequate mating; below this density level there is a “significant risk that recruitment might be impaired” (QCEW 2012). Reproduction is negligible when conch densities are below 48-56 adult/ha (Stoner and Ray-Culp 2000), but the minimum threshold varies (Stoner et al. 2012). Stoner and Ray-Culp (2000) found that the optimum density for reproduction is approximately 200 adult conch/ha.

The relationship of density to probability of successful mating varies in different locations and is also dependent on the level of fishing pressure. For example, in the Exuma Cays Land and Sea Park (ECLSP) marine reserve, Bahamas, where fishing is not permitted, no mating was observed where adult densities were less than 47 adults/ha (Stoner et al., 2011). The minimum critical density for mating is approximately 50 adult/ha with a substantially higher density required to increase the probability of mating (Stoner et al., 2011). In the ECLSP densities at 100 adult conch/ha had a 90 percent probability of mating (Stoner et al. 2011). No mating was observed in any of the surveyed locations when densities were below 56 adults/ha (Stoner et al. 2011).

While density and mating success appear to be occurring in the ECLSP, Stoner et al. (2012) indicated a much higher density is necessary where fishing occurs (e.g., the Berry Islands and Andros Island, The Bahamas). The relationship between adult density and mating frequency has been found to be similar at fished and non-fished areas in The Bahamas, but the density required for the high mating frequency was much greater (570 conch/ha in Berry Islands and 350 conch/ha at Andros Islands) in areas where fishing occurred (Stoner et al. 2011). Stoner et al. (2011) hypothesize that “the higher density requirements are associated with small, thick-shelled adult “samba” that dominate the two fishing grounds. Samba conch are thought to have less fecundity due to their small size, which limits space for gonadal tissue (Stoner et al. 2012b).

The regional hydrodynamics of the Caribbean Sea that circulates larval queen conch influences local recruitment. For example, larvae spawned from conch in Bermuda are carried away by currents to other areas and local populates have not been able to recover due to low local densities and a lack of recruitment from other areas. Geographic areas near strong currents are dependent on queen conch recruits that are susceptible to changes in oceanographic currents. For example, Roselind Bank, Colombia, is nearby the Caribbean Current and annual variations in larval recruitment are influenced by the proximity (Regalado 2012). Queen conch larvae distribution and population connectivity are discussed in Section 3.3.

3.3 Population Connectivity and Genetics

Surface currents in the Caribbean region flow generally from east to west through the Caribbean Sea, then through the Yucatan Strait into the Gulf of Mexico and Florida Strait, and north along the east coast of Florida.

Queen conch larvae are photopositive (Barile et al. 1994) so they can orient to the surface currents. This dispersal of planktonic larvae is the primary mechanism for maintaining connectivity over large spatial scales (Appeldoorn et al. 2011). Based on allelic frequencies, most queen conch in the Caribbean are genetically similar, indicating high gene flows throughout the region (Mitton et al. 1989; Campton et al. 1992). That is, the Caribbean populations would show a high degree of genetic relatedness. In fact, the earliest broad-scale studies of queen conch genetics in the Caribbean (Mitton et al. 1989, Campton et al. 1992) suggested that there was relatively little genetic separation of conch stocks except between the Greater Caribbean and Bermuda.

Heterozygosity was observed at both a temporal and spatial scale across Florida and The Bahamas (Campton et al. 1992). Where queen conch larvae that settled in the same place in different years or in different places during the same year were found to have some level of genetic variation. The preservation of genetic diversity in small areas is good for the future success of any population, especially those that need to be successful in a variety of different environments, and environments that are currently changing.

Morales (2004) extended genetic studies to include an analysis of mtDNA structure of populations in the Caribbean region and similarly concluded that in general the population was panmictic (random mating with no evidence of selection for traits) with some local anomalies. This is consistent with larvae sample studies that indicate that conch larvae have the potential for long distance dispersal (Scheltema, 1993; Posada and Appeldoorn, 1994). However, more recently, observations indicate spatial variability and population structure in conch are probably more distinct and ecologically separate from one another than initially believed (unpublished Stoner and Banks, 2014).

Bermuda, Florida, and Barbados are at the geographic boundaries for the queen conch and may be isolated from any source of larvae. Circulation patterns in the Caribbean are complex with numerous gyres and fine-scale features that retain planktonic larvae within close proximity to the parental stocks, creating patterns of localized self-recruitment in marine species (Cowen et al. 2006; Kool et al. 2010). Compounding its northern extent of the range and limited recruitment into the area most known breeding aggregations of queen conch in Bermuda were located on the edge of the platform, near high current areas that would potentially carry the larvae away (Berg et al. 1992a). These two factors (geographic isolation and limited larvae recruitment) are thought to have greatly limited the recovery of queen conch in Bermuda. Florida, which is at the eastern extreme of queen conch distribution, is for the most part out of reach of the Gulf Stream, so there is lower access to recruiting larvae (Posada and Appeldoorn, 1994; Delgado et al., 2008). However, Florida is believed to receive occasional influxes of the Florida Current and queen conch larvae from Belize, Mexico, and Honduras. These are upstream sources of Florida conch based on the amount of late stage larvae present there (Stoner et al. 1997) as the small spawning stock in Florida would not be able to produce the amount of late stage larvae that were observed (Stoner et al., 1996; Hawtof et al., 1998). Recent data suggests that the Florida queen conch spawning population is increasing in number and locally produced larvae may, in fact, be contributing significantly to local larval supply with upstream sources of larvae being limited (Delgado et al. 2008; Glazer and Delgado, 2012). Barbados, at the western edge of the geographic distribution, is thought to have a self-sustaining population of queen conch as a consequence of hydrodynamics given its isolation from other breeding populations. Similar to damselfish (Cowen and Castro 1994), queen conch larvae from local conch populations near Barbados may be retained by local circulation patterns that keep marine larvae close to the point of origin (Mitton et al. 1989). Oceanographic models of larvae transport specific to queen conch show a low probability of connectivity between queen conch in Caribbean Mexico, Arrecife

Alacranes in the southern Gulf of Mexico, and downstream populations in Florida, Cuba, and northwest Bahamas (Paris et al. 2008)

Larval transport around the Caribbean is thought to occur either with immigration of queen conch larvae from areas upstream (Posada et al. 1997) or local recruitment through local circulation patterns from gyres and eddies (Appeldoorn, 1997). In any case, hydrodynamics and current patterns are the conduit for connectivity and dispersal of queen conch larvae and are likely more significant to dispersal than geographic distance. For example, two nearby populations of queen conch in St. Lucia were found to be genetically different from each other, most likely a result of the east and west currents that prohibit the exchange of larvae between the two locations (Mitton et al. 1989). Delgado et al. (2008), using drift vials, suggested that most queen conch larvae spawned in or along the Yucatan coast and Alacranes Reef remained locally or were transported to Texas. However, one drift vial released at Alacranes Reef was recovered in West Palm Beach, Florida, suggesting mechanisms of transport could facilitate advection of queen conch larvae towards Florida.

Areas where settlement of recruits occurs from upstream locations are known as sinks; the location where the larvae originate are known as sources. Locations in Mexico (e.g., southern Banco Chinchorro, in Quintana Roo) may be a sink for larvae spawned to the east, such as Jamaica. In contrast, a source population (e.g., northern Banco Chinchorro) is dependent on local recruitment, but also supplies larvae to Quintana Roo, Mexico, and a small percentage to Florida, Texas, Cuba, and The Bahamas (de Jesús-Navarrete and Aldana Aranda, 2000; Paris et al., 2008; Delgado et al., 2008). The recovery of queen conch on Serrano Bank after a five-year closure is thought to be the result of immigration of larvae from Roncador (Prada et al., 2008). The Windward Islands, Belize, and Pedro Bank, Jamaica, have all been hypothesized to be sources of larvae for other populations (Posada et al., 1997; Stoner, 2006). A large-scale gyre in the Belize-Honduras bight is thought to transport larvae and connect queen conch populations throughout Belize with the source population in the deep fore-reef (CRFM, 2004).

In the Exuma Cays, The Bahamas, queen conch larvae appear to be local and transported southeast to northwest, moving through the island passes and settling on the west side of the chain (Stoner, 2003). Density of larvae support this pattern of larval distribution in the Exuma Cays with high densities of early stage larvae in the north near Waderick Wells, and lower densities in the south near Cat Island (Stoner et al., 1998). High concentrations of larvae are also present in the northern Exuma Cays and southern Eleuthra, The Bahamas (Posada et al., 1997). Stoner and Banks (unpublished, 2014) completed a study showing that there is genetic separation between stocks in The Bahamas' that are only 500 km apart from one another (i.e., Grand Bahama and Jumentos Cays).

Elsewhere in the eastern Caribbean, local influxes of queen conch larvae must occur given there are no possible upstream currents for larvae immigration (Stoner, 2006).

Posada and Appeldoorn (1994) conducted a study of the larval composition of the eastern Caribbean that revealed no larvae present between Martinique and St. Lucia, as well as no larvae between St. Lucia and St. Vincent. Larvae were concentrated around the Grenadines. Nevis is identified as a regional queen conch larvae settlement sink (CFMC, 1999). Because the population source and sinks of queen conch in the Caribbean are unknown, Posada et al. (1997) recommended queen conch throughout the Caribbean should be managed as if they were self-recruiting. Medley (2008) agreed with this statement, as larval dispersal is restricted to a few hundred kilometers, and most likely stays within the same sub-region. Recent developments reported by Stoner and Banks (unpublished, 2014) further support the need evaluate queen conch population connectivity in the Caribbean region.

3.4 Water Pollution

The information presented in this section is based on research conducted on queen conch populations in south Florida. We are not aware of other investigations or ecotoxicology studies on queen conch that have been conducted outside of Florida.

The Florida Fish and Wildlife Conservation Commission (FWCC) and other researchers have documented a population of non-reproducing queen conch in the Florida Keys (Glazer and Quinterro 1998; Delgado et al. 2004). Queen conch found in nearshore locations did not have normal gonadal development, instead gonads were found to cease developing partway through the reproductive maturation cycle (J. McCawley, letter address to C.Horn, October 26, 2012). Spade et al. (2010) suggested that the halt in reproductive maturation of queen conch in nearshore areas in the Florida Keys was possibly a result of exposure to high levels of zinc and copper in their environments. Gastropod studies have related heavy metal exposure, particularly copper and zinc, to reduced fecundity measured in the terms of egg-laying (Laskowski and Hopkin 1996; Snyman et al. 2004; Ducrot et al. 2007; Coeurdassier et al. 2005). In the Florida Keys, mating and spawning did not occur among resident nearshore conch likely because of their lack of gonadal development (Delgado et al. 2004). Spade et al. (2010) documented a premature regression of male testis with a reduction in testis development in nearshore male queen conch in the Florida Keys. Translocation studies between nearshore and offshore sites in the Florida Keys established that queen conch in nearshore areas failed to develop adequate gonad tissue, but developed gonads within 3 months once relocated to offshore environments (McCarthy et al. 2002; Glazer et al. 2008; Spade et al. 2010). The converse has also been found to be true as gonad function ceased when offshore queen conch were relocated into nearshore areas (McCarthy et al. 2002; Glazer et al. 2008; Spade et al. 2010).

A subsequent study showed high concentrations of zinc in the digestive gland and gonad tissue of nearshore queen conch (Glazer et al. 2008); the concentration in reproductively healthy offshore queen conch was 70 ng/mg of zinc, compared to 1000 ng/mg in the nearshore conch that were not reproducing. Copper was also present in the digestive glands and gonads, but the levels were not as high as the levels of zinc. Glazer et al. (2008) found that the copper levels were not significantly different in nearshore and offshore conch. Metal was concentration is measured in the gastropod digestive gland, as it is believed to be a site of metal accumulation and detoxification and is located adjacent to the gonad (Spade et al. 2010). Spade et al. (2010) found that the concentrations of copper and zinc in nearshore conch tissues to be similar to those found in other gastropods studies where fecundity (measured in terms of egg-laying) was reduced. Given that heavy metals are documented to impair egg-laying in female gastropods, and that "point source for metal contamination exist close to shore in the Florida Keys," Spade et al. (2010) hypothesized that heavy metals are likely to contribute to the reproductive failure observed in nearshore conch.

Concurrently a genomic study on the male conch testes showed impact to mitosis, meiosis, spermatogenesis, cell death, and survival (J. McCawley, letter address to C.Horn, October 26, 2012). In addition, processes including protein metabolism, RNA metabolism, and cellular energetics were affected. Other possible stressors responsible for the reproductive failure include toxic stress, hypoxia, and temperature stress; however, more data are required to determine a causative link between gonad atrophy and a stressor (J. McCawley, letter address to C.Horn, October 26, 2012).

Because pesticides targeting mosquitoes are increasing in use, and aerial drift and runoff can carry these pesticides into non-targeted areas and nearshore waters in the Florida Keys (Hennessey et al. 1992; Pierce et al. 2005), a laboratory study was conducted to test the acute and chronic toxicity of chemicals in mosquito pesticides. Pesticide use in the Florida Keys is concurrent with the spring and summer spawning period of queen conch (Delgado et al. 2004). The presence of their larvae near the surface (Barile et al. 1994; Stoner and Davis 1997) may expose them to pesticides in run off (Rumbold and Snedaker 1997) and aerial drift.

Delgado et al. (2007) tested the acute and chronic toxicity of the chemicals associated with mosquito pesticides (i.e., naled and permethrin) on critical early life stages of queen conch in the laboratory. When exposed to naled and permethrin at concentration rates that would be utilized in mosquito control, both embryos and larvae experienced sublethal and chronic effects. Exposed embryos hatched, but many were deformed. The likelihood of survival in the natural conditions would be low and larvae exposed experienced slow growth. The acute effects were low, as embryos and larvae experienced "very little mortality."

McIntyre et al. (2006) subjected queen conch embryos and competent larvae (i.e., capable of undergoing metamorphosis) to concentrations of naled and permethrin at environmentally-relevant levels. Both permethrin and naled had significant toxicological effects on the development and survival of queen conch embryos. Irregularities were noted during embryogenesis, with slow development seen in all pesticide treatments. At increased concentrations, defects increased and resulted in deformed embryos that would not be viable (J. McCawley, letter address to C.Horn, October 26, 2012). Effects of naled and permethrin were greater on larval queen conch than larger embryos; no direct lethal effects to embryos were observed and there was normal metamorphosis. Consistent with other marine gastropods, the introduction of a natural metamorphic cue (extract of the red algae) induced a significantly higher proportion of larvae to undergo metamorphosis in the pesticide treatments than with algae alone as metamorphosis is triggered by 2 chemosensory pathways: the inductive-morphogenetic pathway, and a regulatory pathway that increases sensitivity to metamorphic cues (McIntyre et al. 2006; J. McCawley, letter address to C.Horn, October 26, 2012). These results suggest that pesticides may sensitize queen conch larvae to cues to mature (J. McCawley, letter address to C.Horn, October 26, 2012). Queen conch larvae are known to metamorphose in response to both habitat and trophic cues to ensure recruitment to areas that provide suitable forage for the post-larval juvenile (Davis and Stoner 1994; Boettcher and Targett, 1996; Stoner et al. 1996a). Settlement on suboptimal habitat would decrease survival (J. McCawley, letter address to C.Horn, October 26, 2012). Delgado et al. (2007) suggested that larvae exposed to these pesticides were slow growing, which would increase their chance of predation as larvae would remain adrift in the water column for an extended period of time before they reached competency (i.e., recruitment size).

3.5 Habitat Stressors

All different life stages of the queen conch have very specific habitat requirements. Most of the information on larval requirements is derived from larvae raised in aquaculture. These include adequate phytoplankton food source, water exchange, moderate densities and presence of metamorphosis inducing cues (Creswell 1994). Juveniles need food, structure, adequate water exchange, and the right bottom composition and sediment composition to bury (Stoner 2003). Adult conch, now generally found in deeper waters, require feeding habitats and habitats to aggregate and breed. Feeding habitats are primarily hard bottom substrates with macroalgae while breeding habitats are associated with clean, low organic content, and coarse sand (Randall 1964; Stoner et al. 1992). If any of these life stages' habitat requirements becomes disrupted, the whole life cycle would be imbalanced. Decreased larval survival could mean failure of a juvenile year class, reducing replenishment of the adult population that is most likely already subject to high fishing pressure. Low densities of adults are then unable to reproduce, which creates a positive feedback loop toward reduced recruitment.

Eutrophication can cause algal blooms in coastal areas. These algal blooms use up localized supplies of oxygen and decrease light penetration to the benthic habitats. Seagrass habitats depend on light and oxygen, and if these elements are reduced and seagrass dies, juvenile conch survival will be lower, as they depend on seagrass structure and nutrition to make it through the initial vulnerable phase of their life history. Destruction of coastal habitat for developments, prop scarring from recreational or commercial boat traffic and boat groundings physically destroy seagrass or could compromise juvenile habitat enough to affect food supply, predator avoidance or cues to settle and metamorphose. Habitat destruction was considered a cause for the initial decline in conch populations in Montserrat (Posada et al. 1997). There has also been a significant amount of seagrass loss on the west and south coast of Barbados (Valles and Oxenford 2012) which could be contributing to low conch densities (Stoner 2003). In 2002, population declines observed in Saint Kitts and Nevis were attributed to general habitat degradation, dredging, and hurricanes (CITES 2012). Similarly, nearshore queen conch populations in the Turks and Caicos have declined as a result habitat degradation and recent hurricanes (DEMA 2012).

Increased sedimentation as a result of coastal influxes also poses a problem for conch. Adult conch aggregation habitats are characterized by coarse, low organic content sand, and if these shallow, coastal areas are subject to deposition of fine sediment or sediment with high organic content, these habitats could become unsuitable (Appeldoorn and Baker, 2013). For example, the main island of Trinidad does not have a significant queen conch population, likely due to low salinities and high turbidity associated with continental rivers and streams (CITES 2012). In addition, habitat loss (e.g., construction and heavy sedimentation from coastal erosion) was identified by Gore and Llewellyn (2005) as a possible factor that contributed to the species decline in the British Virgin Islands.

Deep water habitats that currently support mesophotic populations or spawning stocks could be negatively affected if ocean acidification that promotes dissolution of aragonite occurs at a shallower depth (Doney 2006) (see Section 3.9). The carbonate compensation depth (boundary between calcification and dissolution) is projected to shift closer to the surface by 50 to 200 m (Doney 2006). Conch that are in deeper water habitats would then be subjected to either lower calcification rates and thinner shells, or in the worst case scenario, dissolution of their shells.

This could then subject adults that would normally be protected from a majority of predators to increased risk of predation. This could also divert a significantly higher portion of their energy budget to calcifying and maintaining their shell, detracting from other life processes such as reproduction. Protecting favorable habitat for each of these three life stages (larvae, juvenile, and adult) is critical in ensuring the sustainability of the queen conch in the Caribbean (Appeldoorn et al. 2011).

3.6 Parasites

Apincomplexa parasite could be affecting the gametogenesis activity in queen conch (CITES 2012). This parasite disperses through the feces of the host (Duszynski et al. 2004), and may spread to other benthic detritus feeders. The parasite may be an *Eimeriidae*, which would require 2 hosts to complete its entire life cycle, but it is not rare for it to complete its life cycle within 1 host (Aldana Aranda et al. 2007). The infection occurs year round with the maximum number observed in October and November (Aldana Aranda et al. 2007; Baqueiro-Cardenas et al. 2007; Castro Gonzalez et al. 2007).

The parasites are of common occurrence in invertebrates, especially in Mollusks (Aldana Aranda et al. 2009b). However, the parasites' abundance corresponds with irregularities observed in reproductive cycles, reduced gametogenesis, and maturity in Alacranes, Mexico, and no gonad activity was observed in conchs from San Andrés, Colombia (Aldana Aranda et al. 2007). Aldana Aranda et al. (2008) observed a negative correlation between the abundance of the parasites and gonad cycle. Aldana Aranda et al. (2009a) also found an inverse correlation between maturity and number of parasites in San Andres Islands, Colombia; specifically the frequency of gametogenesis, maturity, and spawn stages diminished with increasing number of parasites.

Histological analysis was conducted on samples sent from around the Caribbean on queen conch with lip thickness greater than 6 mm (Aldana Aranda et al. 2011). The geographic distribution and occurrence of the Apicomplexa parasite in queen conch was found to be "generalized and intense infection in various sites around the Caribbean." (Aldana Aranda et al. 2007). The Apicomplexa parasite was found in every conch sampled from several locations throughout the Caribbean (Table 1) (Aldana Aranda et al. 2011). The lowest occurrence for this parasite was found in the Gulf of Honduras, Mexican Caribbean and Campeche Bank, followed by the Colombian Archipelago and Venezuela Corridor, and with the highest occurred at French West Islands (Martinique and Guadeloupe) and Puerto Rico (Aldana Aranda et al. 2011). The parasites presence increased from west to east in the Caribbean (CITES 2012).

Table 1: Median number of Apicomplexa parasites per site per field site (Aldana Aranda et al. 2011)

Site	Country	Marine region in the Caribbean	Conch Sampled	Mean total of parasites per field site
Alacranes	Mexico	Bank of Mexico	20	17.12
Chinchorro	Mexico	Mexican Caribbean	20	17.88
San Pedro	Belize	Gulf of Honduras	20	22.70

Site	Country	Marine region in the Caribbean	Conch Sampled	Mean total of parasites per field site
San Andres	Columba	Colombia Archipelago	20	37.47
Margarita Island	Venezuela	Venezuelan Corridor	13	26.74
Martinique	French West Islands	Puerto Rico and Windward and Leeward Islands	20	45.39
Guadeloupe	French West Islands	Puerto Rico and Windward and Leeward Islands	20	44.90
Barthelemy	French West Islands	Puerto Rico and Windward and Leeward Islands	13	34.34
La Parguera	Puerto Rico, U.S.	Puerto Rico and Windward and Leeward Islands	13	53.95
La Habana	Cuba	NE and S Cuba	6	25.21

In Florida, the Apicomplexa parasite was also documented in offshore locations where queen conch reproduction is common (Pelican Shoal and Eastern Sambo) and in nearshore areas (East Sister Rock, Tinger Island) where queen conch reproduction has ceased. The parasite was present in conchs at every locality sampled, both offshore and nearshore. Conch sampled nearshore had an average of 32.34 and 30.35 parasites and the highest incidence of the infection. Conch located offshore had an average of 22.0 and 18.38 parasites, respectively (Aldana Aranda et al. 2009b). Samples came from adult conch in both nearshore and offshore areas; however, gametogenesis was low for conchs sampled at nearshore sites, which could be related to other factors effecting conch reproductive systems (see Section 3.2 and 3.4). Conchs sampled offshore showed gametogenesis activity and a high number of parasites (Aldana Aranda et al. 2009b). There was no correlation found between the incidence of parasite and gonadal development in Florida (Aldana Aranda et al. 2009b).

It appears that the parasite is widespread throughout the Caribbean, as it was found in the digestive gland of every conch that has been sampled (Aldana Aranda et al. 2007). Reproductive complications observed in San Andres, Colombia, and Mexico may be occurring in other locations. The presence of the infection and coincidence with reduced reproduction raises concerns about the Apicomplexa parasite effects to the queen conch reproductive systems and subsequently may be impacting the species ability to recover. The CITES (2012) stated that it is "necessary to investigate the relationship between the abundance of the parasites and the reproductive cycle of conch in other sites in the Caribbean."

3.7 Natural Mortality

Juvenile queen conch natural mortality rates are much higher than that of adults. Short-term instantaneous annual natural mortality rates (M) for juveniles can range from 4.34 to 12.31 for out-planted hatchery raised juveniles (Stoner and Glazer 1998). These variations were attributed to a number of factors including length of experiment, size, site, season and density. Natural mortality decreased until the onset of sexual maturity; for example, in southwest Puerto Rico, Appeldoorn (1988b) estimated a decline in M from 2.12 to 0.52 in juveniles to adults for the natural population. Appeldoorn (1988a) modeled the apparent decline in mortality across studies in relation to age (t) with the Weibull function (M = dtc-1) with the following parameters, c = 0.0774 and d = 4.001. During the adult phase, with their thick shell, mortality is low and constant for the remainder of their life (Appeldoorn 1988a; Chávez and Arreguín-Sánchez 1994). Mortality was estimated at 0.42 for individuals aged 4-10 (Tewfik et al. 2001) and at 0.3 for Pedro Bank Jamaica (Tewfik 1996; Tewfik and Appeldoorn 1998).

3.8 Predation

Similar to the larval stages of all marine organisms, the earlier life stages of queen conch are exposed to high rates of predation by a variety of predators. Eggs and larval conch undergo the heaviest predation pressure with juveniles having an estimated annual rate of 60 percent (Iversen et al., 1986). Prior to the time that larval queen conch drop onto the submerged bottom to begin their bottom dwelling existence, they experience a large reduction in numbers (Iversen et al. 1986). Physical environmental factors also play an important role in the survivorship of this early life stage (Iversen et al. 1986). Mortality due to predation deceases as the conch increases in size, specifically predation was noted to decrease once conch achieved a 10-15 cm shell length (Iversen et al. 1986). Juvenile queen conchs have relatively thin shells and are vulnerable to a wide variety of predators (e.g. sting rays, spiny lobster, hermit crabs, and predaceous snails such as tulip snails). Subsequently juveniles rely on several defensive behaviors in addition to their shell. Juvenile queen conch burrow under the sand to avoid being seen by predators and they also form dense aggregations which make individuals difficult for predators to flip over and consume. Predator induced mortality on juveniles outside aggregations is significantly higher (Ray-Culp 1993). The gregarious behavior observed in conch nurseries may provide an active mechanism for maintaining aggregated distribution and reducing mortality on earlier life stages (Ray-Culp 1993).

Adult queen conch are afforded better protection from predation than juveniles by their larger size and thicker shell. The hard shell is very important in avoiding predation as conch are slow moving and unable to escape most predators (Delgado and Glazer 2007). While large conch have a hard shell, small conch escape predators with a flight response by extending their foot forward, grabbing the substrate, and hopping forward (Parker 1922). Hopping across the substrate interferes with the chemical path left by the conch and disrupts the hunting success of the predators. Their nocturnal behavior (Randall 1964; Sandt and Stoner 1993) may also be a strategy to avoid visual detection.

Common predators are tulip snails (*Fasciolaria tulipa*), apple murex (*Phyllonotus pomum*), Common octopus (*Octopus vulgaris*), spiny lobsters (*Panulirus argus*), queen triggerfish (*Balistes vetula*), spotted eagle rays (*Aetobatus narinari*), a variety of hermit crabs and sharks (e.g., tiger sharks [*Galeocerdo cuvier*] and nurse sharks [*Ginglymostoma cirratum*]) (Jory and

Iversen 1983; Iversen et al. 1986; Stoner and Ray 1993). In the Berry Islands, Bahamas, tulip snails are common predators given the correlation of their abundance and the number of empty, undamaged conch shells (Iversen et al. 1986). In experimental releases of small hatchery-reared conch on an offshore algae plain, the most common method of predation (80%) involved crushing of the shell (Appeldoorn and Ballantine 1983). Predation decreases as the shell grows to 9 cm, as it is too strong to be crushed by the majority of predators (Davis 1992) and the number of predators is decreased to include only those able to destroy a strong shell such as sharks, rays, turtles, octopuses and large hermit crabs (Brownell and Stevely 1981).

3.9 Climate Change Implications

Two aspects of climate change are likely to impact queen conch: increasing sea temperatures and acidification. Queen conch utilize calcium carbonate in shell building; the effects of increasing acidification can affect shell production in one of two ways that are not mutually exclusive. The first is through the reduction of available carbonate for calcium carbonate production due to increasing amounts of carbon dioxide in the sea. When carbon dioxide dissolves, it combines with water to form carbonic acid, which subsequently forms bicarbonate ions and 2 hydrogen ions. These 2 hydrogen ions will bind with naturally occurring carbonate to form more bicarbonate ions and result in less carbonate available for calcium carbonate production. In response, the conch will utilize more energy in shell formation, at a cost to growth rate, in producing hydrogen ions (Doney 2006). Alternatively, the conch could use less calcium carbonate in shell making which would result in a less dense and thus weaker shell (Doney 2006). In addition, the composition of conch shells is 99% aragonite (Kamat et al. 2000), which is more soluble than calcite. Because solubility is influenced by pH, the saturation rate of aragonite is decreased as $CO2$ increases, which makes the conch shell susceptible to dissolution (Doney 2006; Kamat et al. 2000).

Changing climate may also have other, more subtle effects that could impact larval dispersal and habitat availability. Currents are expected to be affected under future climates (Liu et al. 2012) that could change the rate and condition of larval dispersal. Effects of these changes are not known; results could be either positive or negative to conch populations. Habitat may transition as a result of climate change and impact the settlement. Sea surface temperatures are expected to increase in the next 100 years and potential impacts to thermal thresholds or disassociation of contaminants from the substrate are not known. The increase in surface water temperature could influence the timing of conch reproduction. Hurricane activity has been found to negatively impact queen conch populations by reducing number as found in Turks and Caicos post two major hurricanes (DEMA 2012). If the frequency/intensity of extreme weather conditions increases with sea surface temperatures, similar reductions in the local queen conch populations may occur.

4. Existing Regulatory Mechanisms

4.1 Existing Regulation (Domestic)

Within U.S. waters, queen conch are found in the Florida Keys, Puerto Rico, and the U.S. Virgin Islands (U.S.V.I.) including St. Thomas, St. John and St. Croix. The U.S. Caribbean EEZ consists of those waters extending from the nine nautical mile seaward boundary of the Commonwealth of Puerto Rico and the three nautical mile seaward boundary of the territory of the U.S.V.I. out to 200 nautical miles offshore. In both Puerto Rico and the U.S.V.I., queen conch is regulated under the auspices of the Caribbean Fishery Management Council (CFMC).

In all but one area of the U.S. Caribbean EEZ, the annual catch limit for queen conch is zero, the exception being Lang Bank, St. Croix. Under the U.S. Code of Federal Regulations (CFR), no person may fish for or possess on board a fishing vessel a queen conch in or from the Caribbean EEZ, except in the area east of 64°34' W. longitude which includes Lang Bank east of St. Croix, U.S. Virgin Islands (the St. Croix management area), during November 1 through May 31 (see 50 CFR 622.32, paragraph (b)(1)(iv). Fishing in the EEZ west of 64°34' W has been closed for queen conch since 2005.

The annual catch limit for the harvest of queen conch in federal waters off St. Croix (e.g., Lang Bank) is 50,000 pounds (22,680 kg) of combined federal and territorial landings. Landing reports in the U.S. Virgin Islands usually do not distinguish if conch was harvested in territorial waters or in federal waters, therefore, when overall landings reach or are projected to reach 50,000 pounds, all harvest (commercial and recreational) in both territorial and federal waters is closed until the next fishing season (50 CFR 622.49, paragraph (c)(2)(i)(A)). The recreational bag limit for queen conch in or from the U.S. Caribbean EEZ is 3 per person per day or, if more than 4 persons are aboard, 12 per boat per day.

In Florida, state law prohibits harvest, possession, landing, purchase, sale, or exchange of queen conch from state and federal waters. It is not unlawful to take or possess queen conch shells from the land or waters of the State of Florida, so long as such shells do not contain living queen conch at the time of taking and the queen conch is not killed to obtain its shell.

4.2 Existing Regulations (Foreign Countries)

Across the Caribbean, several countries have been implementing national management measures, such as the introduction of export quotas and technical measures such as restrictions in the use of SCUBA and/or hookah gear, to limit conch fishers. Fishery management measures across the Caribbean generally applied to the queen conch fisheries include a cap on harvest, minimum size limit, and seasonal and spatial closures. The introduction of marine reserves and no take zones are believed to have benefited deep water queen conch stocks (CITES 2012). Each countries specific queen conch fishery management and related regulations are discussed in Section 6 (below) and are summarized in Appendix I.

4.3 International Trade Regulations

In 1990, the Parties to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention) included queen conch in Annex II of its Protocol Concerning Specially Protected Areas and Wildlife (SPAW Protocol) as a species that may be used on a rational and sustainable basis and that requires protective measures.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement (Convention) between governments established with the aim of ensuring that international trade in specimens of wild animals and plants does not threaten their survival. In 1992, the U.S. proposed queen conch for listing in Appendix II of CITES; this proposal was adopted, and queen conch became the first large-scale fisheries product to be regulated by CITES. Appendix II includes species that are not necessarily threatened with extinction, but unless trade is strictly controlled, may become extinct. In contrast a species listed under Appendix I of CITES are threatened with extinction and CITES prohibits international trade in specimens of these species except when the purpose of the import is not commercial (e.g., scientific research). International trade of Appendix II species is permitted when export permits are granted from the country of origin. In order to obtain an export permit, the CITES Management Authority of the exporting country must be satisfied that the specimens were legally obtained, and the CITES Scientific Authority of the exporting country must advise that the export will not be detrimental to the survival of the species in the wild (referred to as a "non-detriment finding"). International trade in specimens of Appendix II species may also be authorized by the granting of a re-export certificate; that is one country will export product they imported. No import permit is necessary for these species under CITES (although a permit is needed in some countries that have implemented stricter domestic measures than CITES requires).

Permits or certificates should only be granted if the relevant authorities are satisfied that certain conditions are met, including issuance of a non-detriment finding (CITES Article II). Non-detriment findings are based on resource assessment methodologies that may include consideration of species biology and life-history characteristics; species range; population structure, status, and trends; threats; historical and current levels and patterns of harvest and mortality; management measures and compliance; population monitoring; and conservation status (CITES Resolution 16.7, *Non-detriment findings*). The conditions under which trade in species included in Appendix II are detailed in Article IV, paragraph 1 of which provides that all trade in species included under this Appendix shall be in accordance with the provisions of this Article.

Article IV:

2. The export of any specimen of a species included in Appendix II shall require the prior grant and presentation of an export permit. An export permit shall only be granted when the following conditions have been met: (a) a Scientific Authority of the State of export has advised that such export will not be detrimental to the survival of that species (b) a Management Authority of the State of export is satisfied that the specimen was not obtained in contravention of the laws of that State for the protection of fauna and flora.

3. A Scientific Authority in each Party (Signatory Country) shall monitor both the export permits granted by that State for specimens of species included in Appendix II and the actual exports of such specimens. Whenever a Scientific Authority determines that the export of specimens of any such species should be limited in order to maintain that species throughout its range at a level consistent with its role in the ecosystems in which it occurs and well above the level at which that species might become eligible for inclusion in Appendix I, the Scientific Authority shall advise the appropriate Management Authority of suitable measures to be taken to limit the grant of export permits for specimens of that species.

In addition to the non-detriment finding under paragraph 2(a), the provisions of Article IV. 3 are essential for achieving the goals of CITES with regard to the prevention of species becoming threatened with extinction as a result of exploitation incompatible with their survival. The Scientific Authority should be able to assess the effects of trade on the populations of the species occurring in its country and must therefore be informed on any matter of relevance to that task. The text of paragraph 3 is detailed and adequately describes the obligation of the Scientific Authorities of exporting countries (i.e., countries of origin). However, many countries lack funding and /or scientific data, which makes it difficult for these countries to determine what the effects are to queen conch populations at different levels of exploitation and meet their obligations under CITES.

In 1995 and again in 2001, CITES undertook reviews of the biological and trade status of queen conch under its Significant Trade Review process. Significant Trade Reviews are undertaken when there is concern about levels of trade in an Appendix II species. The CITES Animals Committee reviewed queen conch following concerns about the continuing growth of the industry, and problems with enforcement in several range states (CITES 2003). The Review concluded that local queen conch populations, and hence fisheries, were over-exploited, despite the survival of the species as a whole not being at risk, and some countries not complying with their obligations under the Treaty. As a result, CITES recommended that importation of conch be prohibited from numerous countries at some time or another (e.g., Dominican Republic, Honduras, Haiti, Antiqua, and Barbuda, Barbados, Trinidad and Tobago, Barbados, Granada, etc.) (Acosta 2006). Today, most countries are a party to the CITES, with the exception of Anguilla, Haiti, and the Turks and Caicos (FAO report 2012). Poaching and illegal trade in queen conch is reported to be a significant problem in Colombia, The Bahamas, Honduras, the Dominican Republic, and offshore banks of Jamaica (e.g., Theile 2005; Prada et al. 2008; Hubbard and Lupert 2009; CITES 2012).

CITES Scientific Authorities have found it difficult to make the required non-detriment findings necessary for issuing export permits (Ehrhardt and Valle-Esquivel 2008). To address the issue, an International Expert Workshop on CITES Non-Detriment Findings was held in Cancun, Mexico in November 2008. At this workshop, a case study was conducted on queen conch that provided several recommendations: (1) account for illegal fishing when developing total allowable catch limits for queen conch; (2) establish regional cooperation in management; (3) include minimum spawning population density as a criterion for sustainability in management regimes; and (4) strengthen precautionary measures for certain populations.

A Queen Conch Expert Workshop was convened May 22-24, 2012, to develop recommendations for the sustainable and legal management of this species. The results of the Expert Group Workshop included recommendations on data collection, harvest strategies, precautionary controls (e.g., 8% of mean/median fishable biomass, conch densities 100 adult conch/ha or higher), fishing capacity, ecosystem management, decision-making and enforcement and compliance. Subsequently the recommendations were reviewed and adopted by the Working Group on Queen Conch of the Western and Central Atlantic Fisheries Commission of FAO (WECAFC), in collaboration with the Caribbean Fishery Management Council (CFMC), the Organization of the Fishing and Aquaculture Sector of Central America (OSPESCA) and the Caribbean Regional Fisheries Mechanism (CRFM), in Panama City, Panama, October 23-25, 2012. The Working Group recommendations were to be implemented, as applicable, immediately. Further, the working group made recommendations including support of the development of a regional plan for the management and conservation of queen conch, and that countries and inter-governmental organizations of the region collaborate more closely with CITES to support the sustainable and legal harvest and trade of the species.

In March 2013, at the Sixteenth Meeting of the Conference of the Parties to CITES, several decisions were adopted to promote regional cooperation on the management and trade of queen conch (CITES Decisions 16.141-16.148). Among the actions called for in these decisions, range States are encouraged to adopt the recommendations stemming from the meeting of the Working Group on Queen Conch (the Declaration of Panama) discussed above; participate in the development of national, sub-regional, and regional plans for queen conch management and conservation, including best practices and guidance for making non-detriment findings; develop and adopt conversion factors to standardize data reported on catch and trade of meat and other products of queen conch; explore ways to enhance traceability of queen conch in trade; and collaborate on joint research programs.

5. Life-History and Fisheries Management

Queen conch, and other gastropods, present challenges with developing criteria for determining maturity and sustainable harvest of a stock to conserve reproductive stocks (Stoner et al. 2012). While harvest quotas and total allowable catch limits are designed to provide adequate number of individuals and adult densities, most fisheries management plans include prohibitions related to minimum size at age of harvest. Studies of marine fish have determined the importance of maintaining a large and sexually mature spawning stock (e.g., Berkeley et al. 2004; Froese 2004; Heuper et al. 2010), studies have also determined the same for invertebrates (e.g., Rogers-Bennett et al. 2004; Gorman et al. 2011; Linnane et al. 2011; Stoner et al. 2012).

Stoner et al. (2012) explains that fisheries regulations that are responsible for managing queen conch stocks vary from country to country and are sometimes based upon objective biological information, like population models and the differences of age or size at maturity. However in other cases, Stoner et al. (2012) states that harvest decisions are “based upon best guesses.” Stoner et al. (2012) conducted a review of fishing regulations and concluded that “immature queen conch are being harvested legally in most Caribbean nations, providing at least a partial explanation for widespread depletion. While relationships between shell lip thickness, age, and maturity vary geographically, sustainable management of queen conch will require a minimum shell lip thickness for harvest no less than 15 mm, along with other urgently needed management measures.” Stoner et al. (2012) stated that shell thickness should be the criterion for harvest of queen conch, because a flared shell lip does not guarantee sexual maturity (Appeldoorn 1994; Clerveaux et al. 2005).

In addition, a number of species-specific life-history attributes make queen conch a particularly difficult species to manage using traditional fisheries modeling techniques (Ehrhardt and Valle 2008). The species vulnerability to overexploitation is increased by its tendency to form dense aggregations, strong density-dependent reproduction, and habitat and density-dependent plasticity that my result in large juveniles with greater meat weight than smaller adults. For these reasons, a number of researchers have suggested that ecosystem-based methods that employ closed fishing areas should be part of a comprehensive management approach (Glazer 2009; Appeldoorrn et al. 2011).

To highlight, the information in the following section which describes the species life-history traits and their implications for fisheries management was taken from Ehrhardt and Valle-Esquivel (2008):

Conch form discrete aggregations limited in depth by the distribution of seagrass and algae cover. They are more often found at depths less than 25 meters (82 ft), but in heavily exploited areas greater abundances and densities are found in the 25-35 meters (82-115 ft) depth range. The species is easily detected and caught by commercial fishers using SCUBA gear or by free diving in shallower areas. This makes the species highly vulnerable to exploitation and generates opportunities for artisanal fishers to exploit the queen conch for their own consumption and for commercial purposes. The nature of the fisheries is diverse from small canoes carrying one diver and the diver helper to commercial diving vessels that carry up to 40 divers and operate at sea for 10 to 15 days and landing most of the product as 85%-100% clean meat. Hyperstability in conch catch per unit of effort is a common issue where effort targets with greater intensity those areas where high conch densities still remain. Due to the low mobility of conch, there is no range contraction and local population density is not related to abundance but to the extent of localized habitat and how fishing intensity was temporarily deployed.

Diverse fishing conditions make difficult the implementation of formal statistical systems that could generate catch and fishing effort data for conch stock assessment purposes. Generally, there is lack of information on fishing effort and sometimes of catch. Most statistics are from exports that are registered for later reports to the CITES. However, the geographic identity of the conch and their limited migrations impose the need to separate landings according to the different fishing grounds visited by fishers. This may be easily accomplished in localized artisanal fisheries, but it would be very difficult in the case of the industrial fleets that operate in several fishing grounds during a fishing trip.

The best fishery statistics are from those fisheries controlled by fishing cooperatives or fisher groups. The most problematic fisheries are those carried out with industrial vessels that accumulate catch from different fishing grounds. Very few countries have an accurate enumeration of the fishing capacities that are directed to conch fishing, and in some countries conch fishing is complementary to spiny lobster diving. The collection of biological data from landings from these fisheries is very restricted and formal protocols on how to collect these data are available in very few locations. With few exceptions, the lack of formal fishery statistical systems to collect queen conch data represent the most critical and challenging issue regarding conch stock assessment in the Caribbean region.

Queen conch fertilization is internal and successful mating requires minimum population densities of at least 56 individuals per hectare as defined by the CITES and demonstrated with data provided by Stoner and Ray-Culp (2000). Successful mating observed in Florida conch stocks occurs when at least 200 conchs per hectare are present (Appeldoorn and Baker, 2013). Therefore, monitoring conch population densities is paramount to the long term sustainability of the species. Population density estimates are estimated from diving surveys that are designed to follow standardized statistical procedures and are allocated to each fishing ground independently.

Queen conch mate in summer and early fall in shallow, sandy areas. Mating generates large conch aggregations, which are highly visible and occur at a time coinciding with the seasonal closing of the spiny lobster fisheries in many of the conch exporting countries. This fortuitous event attracts idle spiny lobster fishing effort to conch fishing when conch catch ability is at its maximum. Therefore, catch ability changes seasonally as a function of population density. Spawning also occurs during this time of maximum exploitation with detrimental effects on the overall population fecundity. Embryos emerge after 3 to 4 days as free swimming larval veligers; however, the effective duration of larval phase is not known precisely. Laboratory reared larvae lasted from 12 to 75 days (D'Asaro 1965; Ballantine and Appledoorn 1983; Davis and Hesse 1983) and less than a month in the wild (Davis 1994). Consequently, larvae of *S. gigas* have the potential to be transported over neighboring fishing grounds in the strong sea currents that prevail in the Caribbean Sea. Such potential colonization is consistent with the similarity of allelic frequencies found among conch stocks in the region. This condition significantly affects the assessment of the impact of fishing in each fishing ground as local recruitment may be influenced by exploitation on spawning stocks extra territorially. Results from tagging studies show that queen conch has limited mobility (0.5 mile per month). Glazer et al. (2003) tracked adult conch with sonic tags for one year to estimate seasonal movement and home ranges in the Florida Keys. They report home ranges of <1 to approximately 60 hectares with most individuals moving over home ranges of less than eight hectares. This reduced mobility generates a geographic identity that mostly controls the character of growth. Therefore, *S. gigas* may exhibit small size shells among fully mature individuals in some places and large shelled but still immature conchs in some other neighboring areas. This condition mars the possibility of assessing conch stocks over an entire country jurisdiction and forces the assessments of localized fishing grounds. Geographic identity adds complexity to the stock assessment data collection requirements.

Conch cannot be accurately aged as seasonal discontinuities of the growth are not deposited (registered) in the shell. On the other hand, conch shell morphology is highly plastic and may be quite variable among populations separated over short spatial scales. This geographic identity regarding growth limits the possibility of using indirect methods to age queen conch (e.g., modal progression analysis of siphonal length). Tagging studies show that queen conch reaches its full size at the onset of maturity at about an age of 3 years. It then changes the axis of growth by forming a "lip" that flares away from the shell and by thickening the shell throughout the conch's lifespan. Therefore, siphonal length is a poor descriptor of growth after the age of first maturity. The normal queen conch life span is not known with any accuracy but is estimated at between 20 and 30 years. This growth characterization mars most stock assessment techniques based on size or age frequencies observed in the landings. It also precludes accurate assessments of the yield generated by age under different fishing mortality regimes.

6. Description of Fisheries and Management

6.1 Antigua and Barbuda

Fishing effort is concentrated in the southern villages of Antigua. In 2010, there were 11 full-time and 8 part-time conch-fishing vessels that supplied the local market and exported a small amount to Guadeloupe. Queen conch is commercially harvested using either free diving or SCUBA: a total of 72 individuals harvest conch, 40 of which use SCUBA. Fishers in both Antigua and Barbuda utilize SCUBA given the mean depth of the shelf is approximately 30 m. In Barbuda, there is one full-time commercial vessel operating and its own subsistence free diving fishery (Horsford et al. 2012).

Tewfik et al. (2001) surveyed the main geographic areas where commercial fishing for conch is conducted in Antigua. Average conch density was 17.2 conchs/ha and 78.4% of conch were juveniles. Based on this high percentage of juveniles, combined with low density of adults (3.7/ha), Tewfik et al. (2001) noted a concern in the reproductive potential of the population. Tewfik et al. (2001) estimated landings of queen conch from 1995-1999 to be 42-46 metric tons (mt) per year with a maximum yield between 9.3 -17.9 mt. This is in contrast to the total landings of 250-300 mt reported by the United Nations Food and Agriculture Organization (FAO 1990), but in agreement with a maximum yield estimate of 14.1 mt (FAO 1990). The FAO computation was based on a maximum sustainable yield (MSY) value of 0.06 mt/km^2/year taken from the U.S Virgin Islands (Appeldoorn 1987c) multiplied by the area of the entire shelf around both Antigua and Barbuda.

CITES suspended trade of queen conch from Antigua and Barbuda between 1997-2006 due to a lack of response to CITES committee recommendations (Horsford et al. 2012). The trade suspension was lifted in 2006, when the two countries agreed to implement CITES recommendations that included establishing protected areas, conducting abundance surveys, morphometric analysis, catch per unit effort (CPUE) data collection, and implementing size restrictions that are in conjunction with the Caribbean Regional Fisheries Mechanism (CITES 2006). Since then, conch production in Antigua and Barbuda has been increasing from 315 mt in 2000 to 764 mt in 2010 (FAO 2012).

The current regulations in Antigua and Barbuda prohibit harvest of queen conch without a flared lip, in shells less than 18 cm, or animals whose meat is less than 225 g without the digestive gland (Horsford et al. 2012). New regulations implemented in 2013, under provision of the Fisheries Act (2006), include a closed season (July 1 to August 31) and a minimal shell lip thickness of 5 mm. In addition, no persons shall fish, take, place for sale, purchase, or have in their possession queen conch parts without obtaining written permission from the Chief Fisheries Officer (Antigua and Barbuda Fisheries Regulations 2013). A report on the Socioeconomic Monitoring in Cades Bay Marine Reserve (James, 2007) acknowledged the harvest of undersized and immature conch within the reserve.

While fishermen and preliminary studies suggest the queen conch stock in Barbuda is healthy, no formal surveys have been conducted (Horsford et al. 2012; Appeldoorn and Baker, 2013). Horsford et al. reported a high level of compliance with fishery regulations which was "attributed to the small, homogenous nature of the fishery (fishers came from same community), the participatory approach taken with respect to management (including research), and the conservation awareness programme [sic] in fishers [sic] community."

6.2 Aruba

The queen conch fishery in Aruba has been closed since 1987 due to reduced abundance from overfishing. The fishery closure was one of the first laws made after Aruba left the Dutch Antilles on January 1, 1986. A survey was conducted from 2009-2011 to determine if the stock had recovered to support a fishery. The average density of queen conch on the west side of Aruba was 126 conch/ha, with abundance strongly influenced by three high density aggregations. Given the patchy distribution of queen conch coupled with the high percentage of juveniles (80%), recommendations were made to keep the fishery closed. However, the significant number of juveniles observed indicates strong recruitment and larval immigration. Illegal poaching observed during the survey is likely influencing the numbers of adults (Ho 2011).

6.3 The Bahamas

Fishers in The Bahamas primarily target queen conch when lobster season is closed (April 1 through July 31) as a way to supplement their income. Management measures for the queen conch fishery include banning the use of SCUBA, limiting the use of compressed air, an export quota system, and a network of marine protected areas (Gitten and Braynen 2012). While the use of SCUBA is curtailed, considerable effort goes into restricting the use of compressors during the summer months (April through July) and the permit requirements (Gitten and Braynen 2012).

Since the 1980s, queen conch landings have risen gradually by decade. Because the export of queen conch was illegal in The Bahamas until 1992, landings prior to 1992 reflect only domestic consumption (Figure 4). Export of queen conch meat was introduced in 1992 and comprised 0.5% of landings. Exports then peaked at 51% of landings by 1993, and have settled at 36% in 2010 and 2011. However, queen conch landings in The Bahamas may be grossly underreported. Taleaue-McManus and Hazell (Proc.11th International Coral Reef Symposium) reported that "the fisheries monitoring system in the Bahamas did not document 86% of the estimated total conch catch based on consumption and trade statistics." Over the last decade there has been a gradual rise in both export amount and export value (Figure 5). In 1995, The Bahamas implemented an export quota system for its conch fishery (Posada et al. 1997) that is shared between nine exporters with each share determined by prior exports. Of the queen conch exported by The Bahamas 99% is shipped to the United States (Gittens and Braynen 2012).

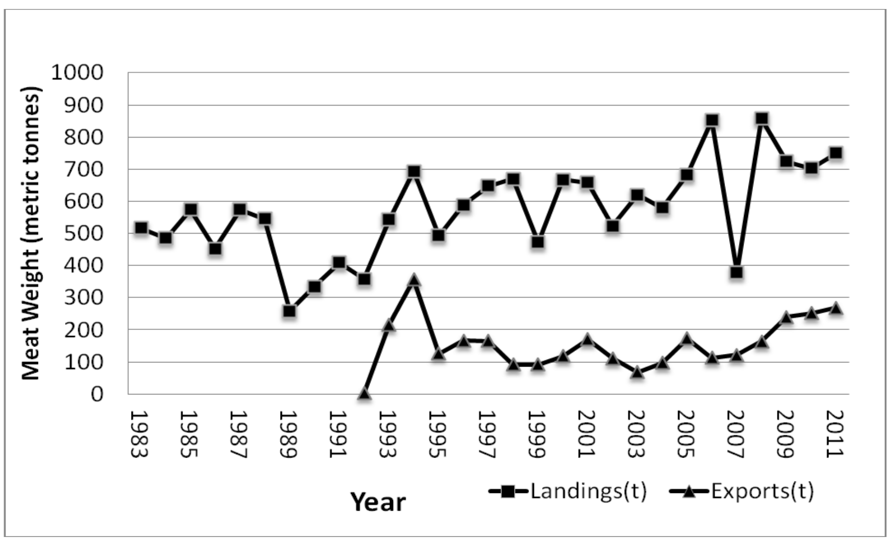

Figure 4: Strombus gigas meat weight landings and exports in the Bahamas.

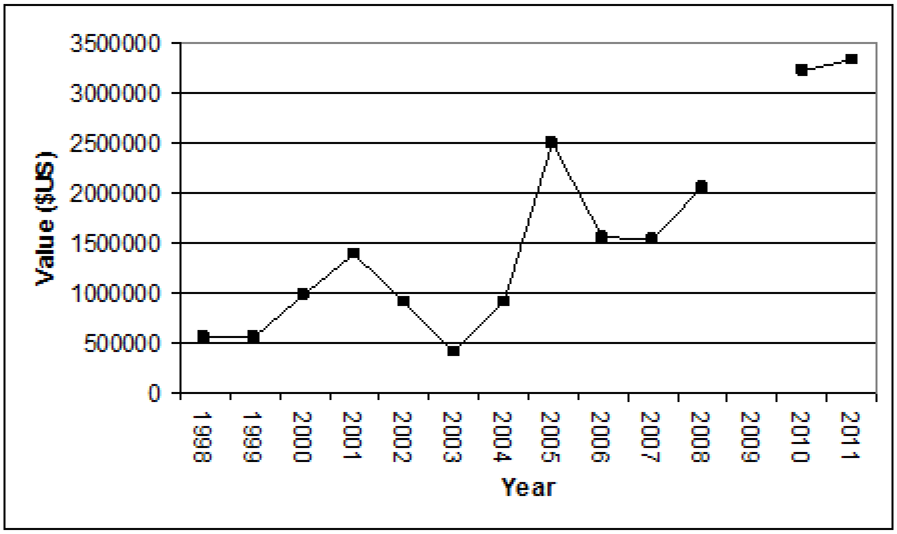

Figure 5: Value of meat exports in the Bahamas

Because The Bahamas is a large group of islands with a substantial conch population, it is generally believed that exploitation is low and spread over the entire stock (CFMC 1999). A national assessment of conch throughout The Bahamas is difficult due to differing morphometrics across individual islands as well as the unsuitability of traditional indicators such as catch per unit effort to assess localized fishing effort. The Department of Fisheries considered the conch stocks to be healthy in the late 1990s, but did not ignore the possibility of localized overexploitation in Abaco, Andros, and the Berry Islands where fishing efforts are concentrated (CFMC 1999). Boats travel around to these islands, as well as Eleuthera and Exuma, to collect and deliver conch to Nassau, Freeport, and Miami (Brownell and Stevely 1981). The outer islands are important conch sources in particular, since the populations around New Providence are at levels below those that are economically feasible to fish (Stoner et al. 2009). The conch fishery around other islands, such as Cat Island and Grand Bahama, are not strong fisheries given their unsuitable habitat.

Recent studies have assessed status queen conch populations at Andros Island, Berry Islands, Exuma Cays, Jumento Cays, and Ragged Islands. Low queen conch densities observed at Andros Island suggest that queen conch fishing is no longer viable there, with the exception of Grassy Creek Cays (Stoner and Davis 2010). The North Bight (tidal system complex) was identified as a juvenile nursery. The high numbers of queen conch at Grassy Creek were mostly samba conch (85% of total population, 97% of adults) that are rejected by fisherman. When these data from Grassy Creek (117 conch/ha) were removed from the analysis, overall adult density was 3 conch/ha for Andros Island with only 15% of the sites having total densities greater than 100 conch/ha. Even at the high density observed at Grassy Creek, reproductive capabilities would only be at 10% (Stoner et al. 2009). Recovery of the populations at North and Middle Bight maybe possible, but the juveniles there would need 2-3 years protection in order to reach reproductive status and perhaps recover the population (Stoner and Davis 2010).

In fishing areas around the Berry Islands queen conch populations are characterized as low density, with low mating frequency, having a high percentage of juveniles, and by the loss of historical nursery grounds (Stoner et al. 2009). Most queen conch (98% adults; 96% of subadults) are located in the southern section of the Berry Islands Bank. Sites to the north and west of the Berry Islands had low conch densities of 4 adults/ha and 8 subadults/ha with 50-75% of the sites having no conch. Conch were found at a small percentage of locations at densities high enough for successful reproduction; 7.8% of the sites > 50 conch/ha and 5.2% of the sites > 100 conch/ha) (Stoner et al. 2009).

A 2011 survey in the Exuma Cays, Bahamas (Stoner et al. 2011) allowed for historical comparisons, as well as illustrating the protections of the Exuma Cays Land and Sea Park (ECLSP). Queen conch densities outside ECLSP at Lee Stocking Island have decreased 91% since 1991 when densities were already very low at 4.9 adult conch/ha (Stoner et al. 2011; FAO report 2012). Lee Stocking Island was a major fishing ground in the late 1990s, but a decrease in density, as well as age and lip thickness, eliminated the fishery. This marked decline in abundance coupled with a decreased age of a population is indicative of overexploitation (Stoner et al. 2011). A high percentage of the conch surveyed in 2011 were not mature, and only 1% of adults were observed mating. No egg masses or egg laying females were observed during the surveys, which were conducted during the period of known peak reproductive activity (Stoner et al. 1992). Most observed adults were samba conch that have one-fourth the reproductive capacity of the normal phenotype. Density of juveniles at the nursery habitats had decreased by half, although the area is still functioning as a nursery (Stoner et al. 2011). A strong subadult population (2008 year class) was observed, and once this year class matures, the population may be able to recover (Stoner et al. 2011).

Stoner et al. (2011) found minimal influence of the ECLSP to nearby areas with approximately 10% of adults reproducing, and adult densities had decreased by 6% along the shelf-area and 69% along the bank area between 1994 and 2011 (FAO report 2012). Given adult conch density within the ECLSP decreased by 35% over a 17-year period, the population was no longer able to sustain itself and larvae were not available to seed the adjacent fishery areas. Despite the protection from fishing, the 2011 survey recorded low queen conch densities (45.9 adult conch/ha) at Warderick Wells, which is located in the center of the ECLSP (Stoner et al. 2011). Nursery areas near the ECLSP had decreased to a quarter of their past size (Stoner et al. 2011).

There have been no recent visual surveys around Eleuthra; the last visual survey was conducted in 2003 (Clark et al. 2005). The queen conch fishery appears to be active as discarded shells with very pink insides have been found (Clark et al. 2005). The 2003 (Clark et al. 2005) survey found that of 30% of the harvest consisted of juveniles, fisherman actively harvested juveniles from nursery grounds. Densities ranged from 0 to 3255 individuals/ha with a mean density of 993 conch/ha (Clark et al. 2005). These data indicate larval recruitment into Eleuthera is occurring (Clark et al. 2005).

In 2013, surveys on queen conch density, abundance and population structure were conducted in the Jumento Cays and Ragged Islands. Surveys were conducted in the shallow areas where commercial fishing occurs between Water Cay in the north and Little Ragged Island to the south. Average adult (flared-lip) density over the Jumento Cays and Ragged Islands was 122 conch/ha (Stoner et al. 2013), slightly higher than those observed in previous surveys conducted at the Grassy Cays (Andros Island) and the Berry Islands (Stoner et al. 2013). Within the survey area, queen conch density generally decreased from north to south, with Stoner et al. (2013) reporting queen conch densities that ranged from a high of 168 adults/ha near Flamingo Cay to just 10/ha in the southern sector encompassing Raccoon Cay to Little Ragged Island. Density of 3-year-old conch (i.e., "subadults" or "rollers") was reportedly relatively low, averaging 14.8/ha in the island chain (Stoner et al. 2013). The number of mating pairs observed in 176 survey lines throughout the study area revealed that most mating occurred at "adult" densities > 85/ha (Stoner et al. 2013) corresponding closely with other areas in The Bahamas considered as "lightly fished" and within the range recommended by conch experts for fishery management to achieve minimum densities of 100 adults/ha. (Table 2) (Stoner et al. 2013).

Table 2: Densities of adult and subadult queen conch on the shallow bank of the Jumentos and Ragged Islands, Bahamas. Values for each geographic region are reported as mean and standard deviations for the number of individuals per hectare (no./10,000 m2). Number of tows is equivalent to the number of 1-nautical-mile-square boxes surveyed in the region (Stoner et al. unpublished 2013)

Geographic region	Number of tows	Adult density	Subadult density
Water Cay	43	146 ± 151	9.6 ± 31.8
Flamingo Cay	39	168 ± 137	11.2 ± 17.4
Jamaica Cay	22	154 ± 148	26.0 ± 54.3
Seal Cay	22	126 ± 110	11.9 ± 20.8
Nurse Cay	23	91 ± 143	3.9 ± 6.9
Raccon Cay	27	10.0 ± 32.0	30.5 ± 105
Combined	176	122 ± 138	14.8 ± 49.1

Stoner et al. (2013 unpublished) further suggested that the higher densities of adult conch recorded at the Jumento Cays and Ragged Islands could be attributed to several factors: (1) in the northern Jumento Cays and Ragged Islands there is a "relatively low exploitation rate" given their distant geographic location from fishing communities located at Long Island and Exuma Cays; (2) the majority of the adult queen conch in the waters surrounding the Jumento Cays and Ragged Islands is deeper than 10 m which makes it difficult for free divers to collect; and (3) queen conch in the Jumento Cays and Ragged Islands are smaller, averaging 186 mm in shell length, and therefore not preferred by fishermen (Stoner et al. unpublished 2013).

6.4 Barbados

The conch fishery in Barbados is a small-scale, open-access, unregulated, artisan fishery (Oxenford and Willoughby 2012). Queen conch are generally harvested by fishers targeting other species (Oxenford et al. 2007). There are approximately 45 fishing sites around the island and the catch is all consumed domestically. This small scale fishery started in the 1950s and is now composed of approximately 49 fishers who mainly free dive during the summer on the south and west coasts, with a higher proportion of harvest taking place on the south coast (Oxenford et al. 2007; Vallès and Oxenford 2012). The higher rates of harvest occurring along the south coast is potentially the result of the low-relief algal habitats, which result in conch being more visible to fishers than in the coral habitats with more structure found predominantly along the west coast (Vallès and Oxenford 2012). SCUBA is used to access several deep-water sand and rubble areas located between fringing and bank reefs, particularly along the southwest coast (Oxenford and Willoughby 2012). Estimates of total processed conch meat weight are between 0.30-0.53 mt annually (Oxenford and Willoughby 2012). Although conch can be harvested year-around, most conch fishers harvest queen conch during the warmer months (e.g., July-October) when queen conch are present in the shallow waters and are easier to locate (Oxenford and Willoughby 2012). Based on a conservative minimum size at first maturity of a lip thickness greater than 4 mm, the majority of conch harvested (71%) are immature (Oxenford et al. 2008). Oxenford and Willoughby (2012) states that, "if the observed size at which 50% of queen conch individuals in Barbados are mature (LT_{50} = 19.5 mm; Bissada 2012) is used, than the percentage of immature animals in the catch maybe as high as 96%."

Phillips et al. (2011) conducted a survey of three nursery aggregations in Carlisle Bay, Barbados, and found a high juvenile conch densities (greater than 0.2 conch/m^2); normal juvenile conch aggregation densities are considered to be 0.1 to 0.2 conch/m (Stoner and Ray 1993; and Stoner et al. 1996). On a greater scale, surveys conducted around the Barbados in 2007-2008 encountered low overall densities of 14.4 conch/ha on the south coast and 4.3 conch/ha on the west coast (Vallès and Oxenford 2012). The Barbados queen conch population is located upstream from other population sources and is likely self-recruiting (Cowen et al. 2006). Together the patchy distribution, low density comprised of a high percentage of juveniles (90%), coupled with the self-recruitment based on the island's position relative to prevailing ocean currents (Mitton et al. 1989) reflects the poor condition of the conch populations around Barbados. The relatively low conch densities is likely the result of overexploitation through sustained and unregulated levels of fishing, over the last few decades (Valles and Oxenford 2012). "Even at the relatively low levels of exploitation by the current fishers could result in recruitment overfishing of an already depressed stock, leading to recruitment limitations and further contributing to the low conch densities observed" (Stoner et al. 1996a; as stated in Valles and Oxenford 2012). A reported significant amount of seagrass loss on the west and south coast of Barbados (Valles and Oxenford 2012) could also be contributing to low conch densities (Stoner 2003). Both Cowen et al. (2006) and Vallès and Oxenford (2012) question the long-term persistence of queen conch in Barbados, a predominantly self-recruiting island, due to the low density of conch found both coast-wide (less than 2 conch/ha) or at the site level (less than 10 conch/ha).

6.5 Belize

The Belize conch fishery began in the 1960s and occurs along the entire length of the reef system including its offshore atolls (Azueta 2012). A minimum shell length of 7 inches, weight of 3 oz. clean meat (85 g), a closed season (July 1 through September 30) was implemented in 1977. In 2003, Statutory Instrument No. 90 prohibited the use of SCUBA and also fillet and diced conch (Capture Fisheries Unit, Belize, 2013). There is some data that supports the hypothesis of unexploited deep water spawning stocks in Belize, but no systematic surveys have been conducted to confirm their presence (QCEWG 2012). The queen conch fishery in Belize is an open access, but a limited entry system is being proposed for introduction by fishing year 2015 (Capture Fisheries Unit, Belize, 2013).

Belize has established a network of 9 multiple use, marine reserves positioned along Belize Barrier Reef and 2 offshore atolls (Capture Fisheries Unit, Belize, 2013). In 2011, the Belize Fisheries Department started a plot project that authorized conch fishing within "general use zones" in 2 marine reserves (Glovers Reef and Port Honduras). The Belize Fisheries Department decided to implement this approach to its entire marine reserve network (Capture Fisheries Unit, Belize, 2013).

Since 2004, the Belize government has employed a national conch quota system. The 2012/2013 queen conch export quota was set at 479 mt. The quota is allocated to fishery cooperatives on a monthly basis (Azueta 2012). The amount of unreported catch is believed to be small as 90% of the catch is delivered to fishery cooperatives (Azueta 2012). Because of high export value (Brownell and Stevely 1981) most conch is exported out of Belize with the main market into the United States. There is a very high domestic demand, and a 1981 law requires at least 10% of harvested conch remain for domestic consumption; however, Gongora (2012) reports that domestic consumption is estimated to be 5%. In 2011, over 362 mt of conch meat was exported to the United States (Gongora 2012). The highest amount of export on record occurred in 1972 when 562.2 mt was exported to the United States (Gongora 2006).

Queen conch landings in Belize have increased by as much as 350% over the last 23 years, from 111 mt in 1989 to 388 mt in 2011 (Figure 6), which is due, in part, to increased effort (Azueta 2012; Gongora 2012). While effort increased from 1973-1978, catch (per diver, per 4-hour day) decreased from 35.6 kg (78.2 lbs) in 1975 to 10 kg (24 lbs) in 1978 (Brownell and Stevely 1981). Studies conducted in the early 1980s indicated that 70% of the legal catch consisted of juveniles (Gibson et al. 1983). By 1994, the Belize population of queen conch was considered overexploited (CITES 2012).

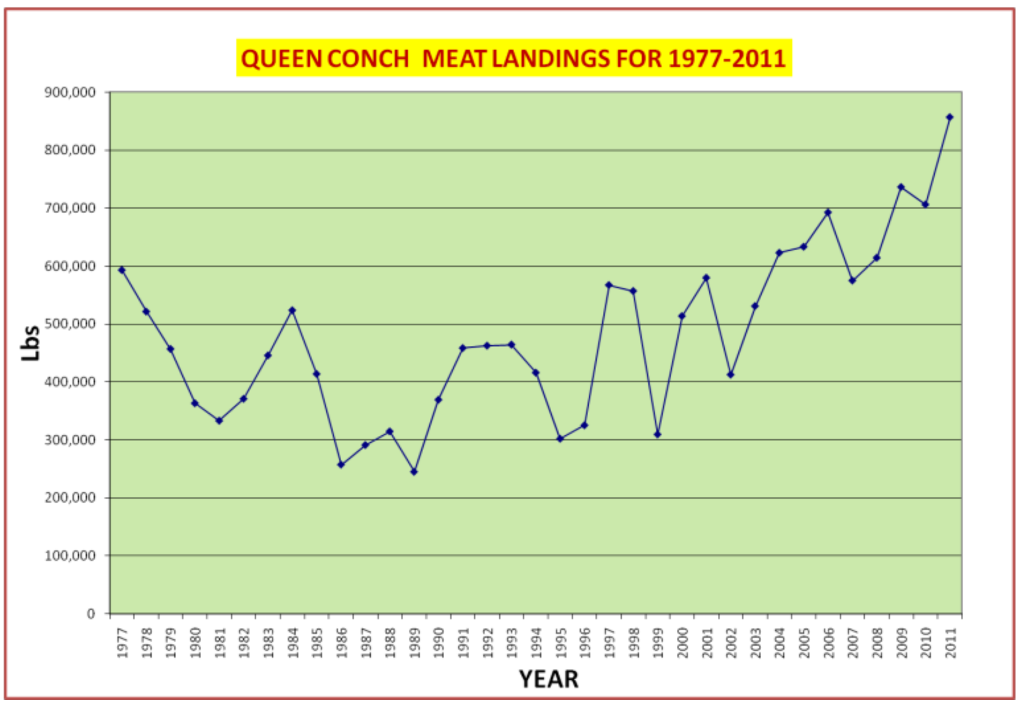

Figure 6. Belize queen conch landings 1977-2011 (Gongora 2012)

Surveys conducted in 1996 found the shallow water populations dominated by juveniles with few adults observed; it was suggested that the "population was seriously overexploited and in danger of stock collapse due to spawning failure" (CITES AC19 Doc 8.3 2003). It is thought the nearshore fishery relies on an offshore breeding population that has been protected by the ban on SCUBA gear. Surveys conducted in 2003 and 2004 indicated that the stock size increased and also confirmed the existence of an unexploited, reproductively active, deep water stock as well as high recruitment into back reef areas. CITES (2012) reported the population is at risk of spawning failure because there were not enough reproductively active adults, and adults that were reproductive were removed prior to spawning. The introduction of marine reserves and no-take zones likely benefit stocks (CITES 2012).

Variation in length at maturity has been reported. Gongora (2006) reported in Belize, "the average length of conch with a fully formed lip is 23.4 cm with a market clean weight of 110 g." Blakesly (1977) reported a conch size of 22 cm was found to be the most economical in terms of maximum meat total weight. If lipless conch are considered sexually mature, a significant percentage of immature conch can be legally harvested at the current size limit (Gibson et al. 1982). The average length and density of conch have increased from 2006-2012 (Figure 7) perhaps due to preferentially harvesting older individuals, which can increase landings while effort remains the same (CRFM 2004). The average length of a conch caught in the fishery was 134 mm in 2008, and 152 mm in 2012. The average density in 2006 was 106.3/ha and in 2012 was 337.4/ha (Figure 7) (Azueta 2012; Gongora 2012).

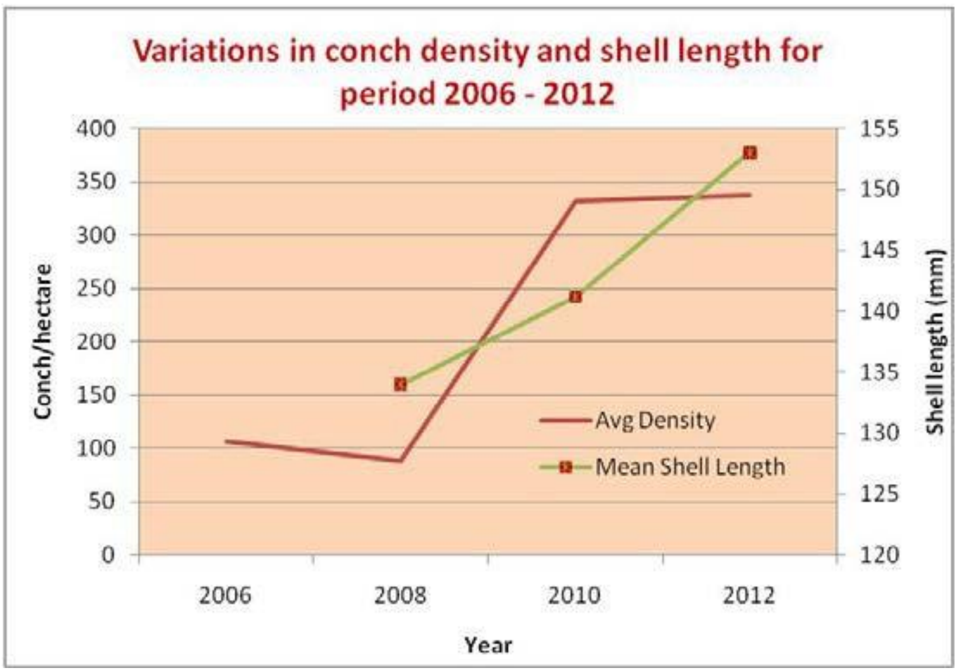

Figure 7: Belize queen conch trend in densities and shell length from fishery data (Gongora 2012).

In 2009, queen conch surveys were conducted in the Belize Barrier Reef area (Chan et al. 2013). Surveys were conducted in conservation zones (marine protected areas) and in general use zones, where queen conch are fished. Queen conch densities in a conservation zone were substantially higher for both juvenile and adult conch. Densities ranged from 2013 to 288 individuals/ha in the conservation zones to 529 juveniles/ha and 58 adults/ha in fished areas (Chan et al. 2013).

6.6 Bermuda

Due to low abundance, the Bermuda conch fishery was closed in 1978. Ten years later, Berg et al. (1992b) completed a study to determine the effects of the closure on the fishery and reported a mean density of 0.52 conch/ha. While there were no juvenile conch surveyed, they are often underreported due to being buried (Berg et al. 1992b). Towed-diver surveys at the edge of the Bermuda platform (Berg et al. 1992a) have reported 5 breeding aggregations (Figure 8).

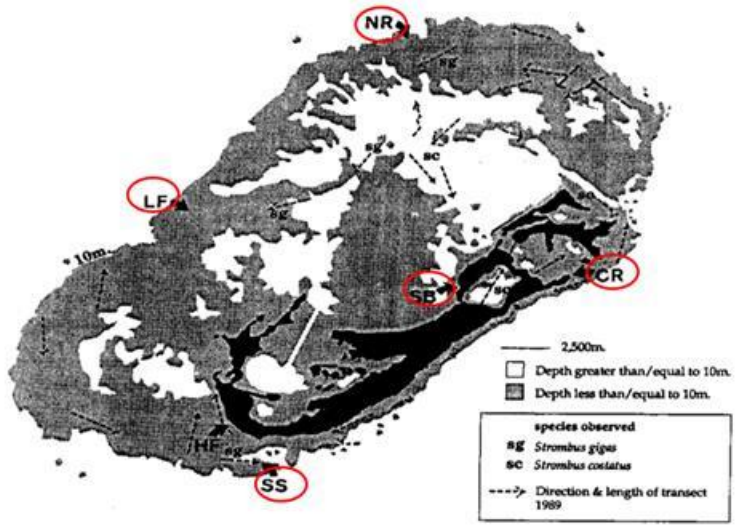

Figure 8: Locations of 5 breeding aggregations in Bermuda. Adapted from (Berg et al. 1992a).

Most observed conch were old adults actively mating and laying eggs (Berg et al. 1992a). Despite these seemingly healthy reproductive individuals, larvae are most likely transported off the platform and not retained as local recruits (Berg et al. 1992a). Because Bermuda is isolated and at the northern extent of the queen conch range, larval supply is dependent on the local breeding populations (Berg et al. 1992a). This is supported by genetic analyses that indicate divergence of the Bermuda population from the rest of the Caribbean (Mitton et al. 1989).

6.7 Brazil

Brazil is located at the southernmost extent of the queen conch range and little is known about the local population. Brazil reports no commercial exploitation and no trade is believed to take place (CITES 2012). The last reported trade information from Brazil was a license issued in 1994 for the export of 25 kg of meat to Martinique; however it is unclear whether this transaction ever took place as the export was never recorded (CITES 2012). There is no information available on management regulations for queen conch in Brazil.

6.8 The British Virgin Islands

Ancient conch shell mounds indicate conch meat was an important source of protein used by the Native Arawak people in the British Virgin Islands (B.V.I.) over 500 years ago (Blok 1993; Gore and Llewellyn 2005). Historically the queen conch fishery was a valuable resource in the B.V.I. as it supported local hotels, restaurants, and is a diet stable of the local population. Queen conch were traditionally harvested using a “looking glass and scoop bag” in nearshore areas surrounding the islands, but the introduction of SCUBA gear in the 1960s enabled fishers to fish more intensively and in deeper waters (Gore and Llewellyn 2005). In an effort to address concerns over possible declining queen conch stocks and the “imminent threat” to the future of the queen conch fishery, the B.V.I. government passed fishery regulations in 2003 that required a minimum 7-inch-length, a flared lip, a meat weight greater than or equal to 8 oz., and also established a closed season (June 1 through September 30) (Gore and Llewellyn 2005). In 2001, SCUBA gear was prohibited and Marine Protected Areas and Fishery Priority Areas were established (CITES 2012).

The current status of queen conch populations in the B.V.I. is largely unknown. There are no formal or consistent records of persons involved in the fishery. Gore and Llewellyn (2005) stated that “there is an absence of mechanisms to collect relevant information on a regular basis. There is little regulatory collected information on the inputs into the fishing industry and little to no information on the patterns of consumption of fish imports or exports.” The FAO database reports an average of 43,000 kg were landed annually between 1994 and 1997, which declined to an average 9,000 kg between 1997 and 2007 (CITES 2012). Currently the B.V.I. imports conch meat and export data shows that since 2002, 10,000 kg have been imported, mainly from St. Kitts and Nevis (CITES 2012).

Gore and Llewellyn (2005) speculated that it was “reasonable to believe that stocks have been exploited, particularly since an anonymous article stated fishermen took an average of 1,000 kg of conch per week during the mid-1980s (Blok 1993) and monthly catches were averaging less than 1,000 kg a month in 2002 (B.V.I. Fishing Complex 2002).” In addition to possible overexploitation, habitat loss (e.g., construction or heavy sedimentation from coastal erosion) was identified by Gore and Llewellyn (2005) as a possible factor contributing to the species’ decline.

From 1993 to 2003, an overall decline in the abundance and size of conch was observed on both a temporal and spatial scale (Tables 3 and 4) (Gore and Llewellyn 2005). Notably the methodologies used in the two studies (1993 and 2003) were replicated, but they occurred during different months of the year, and because queen conch migrate inshore during warmer months to aggregate and return to deeper waters during the fall, results of the 2003 survey, which occurred from August to October, may be skewed. No conch were reported from North Prickly Pear and Beef Islands (Bird Rock) in 2003, while total conch at both Anegada and Peter Islands increased, which may imply spatial variation of abundance over time (Gore and Llewellyn 2005). The 2003, survey recorded a total of 1,198 conch. The low population densities observed in both the 1993 and 2003 surveys have been found to result in a collapse of reproductive capacity leading to a potential collapse of its recruitment (Ehrardt 2008; CITES 2008).

Table 3: Descriptive statistics from 2003/1993 conch study sites (Gore and Llewellyn 2005)

Site and Survey Year	Mean length	Total # countered	Densities (conch/ha)
Peter Island 1993	14.22	257	.0257
Peter Island 2003	15.42	208	.0208
Anegada 1993	22.23	7	.0007
Anegada 2003	20.00	133	.0133
Beef Island (Bird Rock) 1993	21.36	41	.0041
Beef Island (Bird Rock) 2003	0.00	0	0

Prickly Pear North 1993	20.51	27	.0027
Prickly Pear North 2003	0.00	0	0

Table 4: Description statistics from the new conch study sites introduced in 2003 (Gore and Llewellyn 2005)

Site and Survey Year	Mean length	Total # counted	Densities (conch/ha)
Prickly Pear East 2003	12.84	89	.00089
Bluff Bay 2003	12.40	656	.0656
Great Camanoe 2003	18.28	96	.0096
Fallen Jeruselem 2003	20.09	16	.0016

6.9 Caribbean Netherlands / Netherlands Antilles

In 2010, the Netherlands Antilles were dissolved with the three smallest islands (Bonaire, Saba, and St. Eustatius) now called "The Caribbean Netherlands." The Caribbean Netherlands have two layers of government, a single national government and three public entity governments (FAO report 2012). The islands are responsible for fisheries in territorial waters and the national government is responsible for fisheries in the EEZ (Van Baren 2012). Saba is the only island with specific regulations on queen conch. Bonaire and St. Eustatius have incorporated fishery regulations into their marine ordinances (Van Baren 2012).

Bonaire

There is no commercial, recreational or subsistence harvest of queen conch in Bonaire. Queen conch densities in Bonaire are too low to allow for harvest. Bonaire and Curaçao have low densities of conch (rare in Curaçao and 21.8/ha in Bonaire) that are unable to sustain a commercial fishery (Van Buurt 2001; Van Baren 2012). Queen conch have been protected in Bonaire since 1985. Anyone who wishes to take queen conch from Bonaire waters is required to obtain a permit issued from the Bonaire Executive Council. Even so, this legislation was not enforced until the mid-1990s, when a number of permits were issued (FAO report 2012). The maximum number of permits issues is set by the Island Resolution Containing General Provision under advice from the Marine Environment Commission (Van Baren 2012).

There is currently a moratorium on issuing permits, due to the extremely low numbers of adult queen conch observed in Bonaire (FAO 2012; Van Baren 2012). Fishery legislation prohibits the harvest of queen conch with shells less than 18 cm in length, or if the animal has already been removed from its shell, a minimum meat weight of 225 g (Van Baren 2012). Illegal harvest and poaching is reportedly a significant issue in Bonaire (Van Baren 2012), which is likely a contributing factor that is impeding the population's recovery. Enforcement and compliance with the existing regulatory measures is low and subsequently their effectiveness is limited (Van Baren 2012)

In 2010, Bonaire initiated a 3-year queen conch restoration project investigating size and age structure through a mark and recapture program. As of October 2012, approximately 1,900 queen conch had been tagged, of which 88% were reported to be juveniles. The study documented 225 adult conchs in all of Lac Bay. Van Baren (2012) attributed the low adult densities to fishers targeting larger adult queen conchs and illegal poaching.

Saba

The island of Saba supported large conch fisheries until the mid-1990s. Intensive and unsustainable harvest during the mid-1980s and throughout the 1990s led to the declines on Saba Bank. The Saba Bank was also several overfished by foreign vessels (Van Baren 2012). In 1993, 2 containers that held queen conch meat were impounded at St. Maarten due to lack of proper CITES documentation. The U.S. Coast Guard patrols the Saba Bank and makes efforts to enforce the 1996 fishery legislation prohibiting commercial harvest (FAO report 2012). No surveys have been conducted to determine the status of queen conch or if the closure has been effective in rebuilding queen conch stocks (Van Baren 2012). Anecdotal evidence indicates that queen conch on the Saba Bank are fished by foreign vessels (FAO report 2012). The location of Saba Bank, combined with the prevailing currents in the area, indicate that the population of queen conch at Saba Bank were a source of larval recruitment for the entire region (FAO report 2012; Van Baren 2012).

Current fishery legislation prohibits the harvest of queen conch for commercial purposes, only Saban individuals can harvest queen conch for private use and consumption. Legislation prohibits the collection of more than 20 conch per person, per year and catch must be reported to the manager of the Saba Marine Park (Van Baren 2012). Nonetheless, collection and reporting laws are not enforced (Van Baren 2012). The harvest of queen conch with shells less than 19 cm in length or that do not have a "well developed lip" is prohibited and the use of SCUBA and hookah gears are also banned (Van Baren 2012.)

St. Eustatius

The island of St. Eustatius had a small commercial conch fishery that exported to St. Maarten. In 2010 the fishery was curtailed because St. Maarten began to require CITES permits for their imports (Van Baren 2012). As of October 2012, two fishermen harvested queen conch in St. Eustatius. Revised legislation authorizes the use of SCUBA, but hookah is prohibited. Illegal harvest and poaching of queen conch in St. Eustatius and its Marine Parks is a significant issue (Van Baren 2012). There are two Marine Parks near St. Eustatius, but these areas do not have significant conch populations (Van Baren 2012). Surveys were being conducted to assess the abundance and distribution of queen conch in October 2012, but no information is available on those findings (Van Baren 2012). The collection of queen conch is allowed in the Marine Parks, but hookah gear prohibited, conchs must be at least 19.5 cm or have a flared lip, and collection must be for private consumption and is limited to 20 conch per person per year.

6.10 The Cayman Islands

The Cayman Islands consists of 3 small islands located in the middle of the western Caribbean. The Cayman Islands imports the majority of their conch meat, but there is a small fishery limited to domestic consumption. The 1978 Marine Conservation Law (revised 2002) requires protected areas, a closed season (May 1 through October 31), and a 5-conch-per-person or 10-conch-per-vessel, per day bag limit. Queen conch is traditionally harvested using snorkel; the use of SCUBA and hookah gears to harvest marine life is prohibited in the Cayman Islands (Bothwell 2008; CITES Regional Workshop 2008).

The Department of Environment has surveyed a number of areas, both protected and not, around Grand Cayman and Little Cayman Islands (Bothwell 2008; Regional Workshop Report

2008). Concerns about overfishing of conch began in the early 1980's. In 1988 the Department of Environment began monitoring the status of queen conch populations by conducting surveys annually. The surveys include areas where queen conch are known to be prevalent and areas where conch would be less likely to be located (Bothwell 2008; CITES Regional Workshop 2008). These surveys recorded the number of conch, length, shell thickness, and whether or not the conch has a "flared lip" to indicate its maturity (Bothwell 2008; CITES Regional Workshop 2008). The Department of Environment stated that the results indicate that the mean density of conch is decreasing throughout the Cayman Islands and is most likely due to increasing human population, tourism, and illegal pouching (Bothwell 2008; http://www.doe.ky/marine/conch/). Conch population trends are relatively independent of each other in both the fished and unfished zones (Bothwell 2008). Local poaching and illegal harvest is likely significant issue and regularly occurs in protected areas with illegal, unregulated, or unreported fished or exported queen conch from neighboring countries (Bothwell 2008). Overharvest, both legal and illegal, is likely the leading cause of the declines in queen conch within the Cayman Islands (Bothwell 2008).

6.11 Costa Rica

In Costa Rica, the harvest and export of queen conch has been prohibited since 1989 (CITES 2003; Mora 2012). Nonetheless, a single CITES trade data report shows 4,309 kg queen conch meat as imported from Costa Rica to the United States in 1997 (UNEPWCMC 2002). Small quantities of illegal subsistence fishing is reported to occur (Anon. 1996; CITES 2003). In 2000, regulatory measures (e.g., Decree No. 19203-MAG) were ratified to include a prohibition on the capture and sale of all queen conch in territorial waters (Mora 2012). Queen conch collected as bycatch[1] can be used for personal consumption, but cannot be sold (Mora 2012).

There is limited information available on the status of queen conch in Costa Rica. Queen conch populations are reported to be declining around Costa Rica, but limited information is available (CITES 2003). To date, there have been no population surveys and there is no information available on the status of queen conch population in Costa Rica. Mora (2012) recommended that population studies be conducted, that the local consumption be surveyed, that coordination amongst management authorities increase to monitor, control and promote conservation of the species.

6.12 Colombia

Regulatory mechanisms for the queen conch fishery in Colombia include total allowable catch limits for artisanal collection and the issuance of commercial permits based on a quota system. The stock size only considers adult individuals (lip greater than 5 mm), and fishing is permitted only when the total density of adults exceeds 50 conch/ha, preferably 100 conch/ha. A 225g unclean minimal weight is required; SCUBA and hookah gears are prohibited, and closed season occurs June 1–October 31 (Castro et al. 2012). The first annual fishing quota was set at 203 mt in 1997, reduced to 98 mt in 2001, and increased to 112 mt in 2009 (Castro et al. 2009).

The Archipelago of San Andrés, Providencia, and Santa Catalina (ASPC) area is the source of almost all domestic production since the start of industrial fishing in the early 1980s and

[1] The term "bycatch" is defined as the unwanted fish and other marine creatures caught during commercial fishing for a different species.

landings have decreased from 813 mt in 1988, to 465 mt in 1993, to 81 mt in 2003 (Prada et al. 2008). However, declining catch may reflect the implementation of catch quotas and management measures established in 2001. The fishery was closed from 2004–2007 due to illegal trade, conflicts between industrial and artisanal fishers, and discrepancies between landings and exports (Castro et al. 2009). The fishery reopened in 2008 for Roncador and Serrana Banks, with annual production set at 100 mt (Castro et al. 2012).

Areas with current or historic populations of conch in Colombia are San Andres, Providence, and banks of the San Andres archipelago, which is composed of Quitasueño, Serrana, Serranilla and Roncador islands (Figure 9). The fishery shifted towards these northern archipelagos in the 1970s after San Bernardo and Rosario in the southern Caribbean were fished to local extinction and subsequently closed in 1977 (Mora 1994). In 1987, Colombia began establishing management regulations, and as a result, the Quitasueño area was closed to fishing (Prada et al. 2008). In 1993 and 1994, surveys of the fishing areas revealed densities of 160 conch/ha at Quitasueño, 410 conch/ha at Roncador and 500 conch /ha at Serrana (Ospina et al. 1996). However, in spite of these higher densities, effort has increased while landings decreased. In 1997, a total allowable catch of 203 mt was set for the Archipelago and 300 mt for all of Colombia. In 1999, visual surveys were repeated and reported significantly lower densities: 2.4 conch/ha at Quitasueño, 317.5 conch/ha at Serrana (Serrana is estimated to contain 80% of the biomass of the area), and 33.7 conch/ha at Roncador (Valderrama and Hernández 2000). Catch per unit effort also decreased from 56kg/day/diver in 1998 to 27kg/day/diver in 2002 (Prada and Castro-Gonzalez, unpublished). Following the 1999 surveys, the fisheries at Serranilla and Roncador were closed and the export quota was reduced by 50% (CITES 2003).

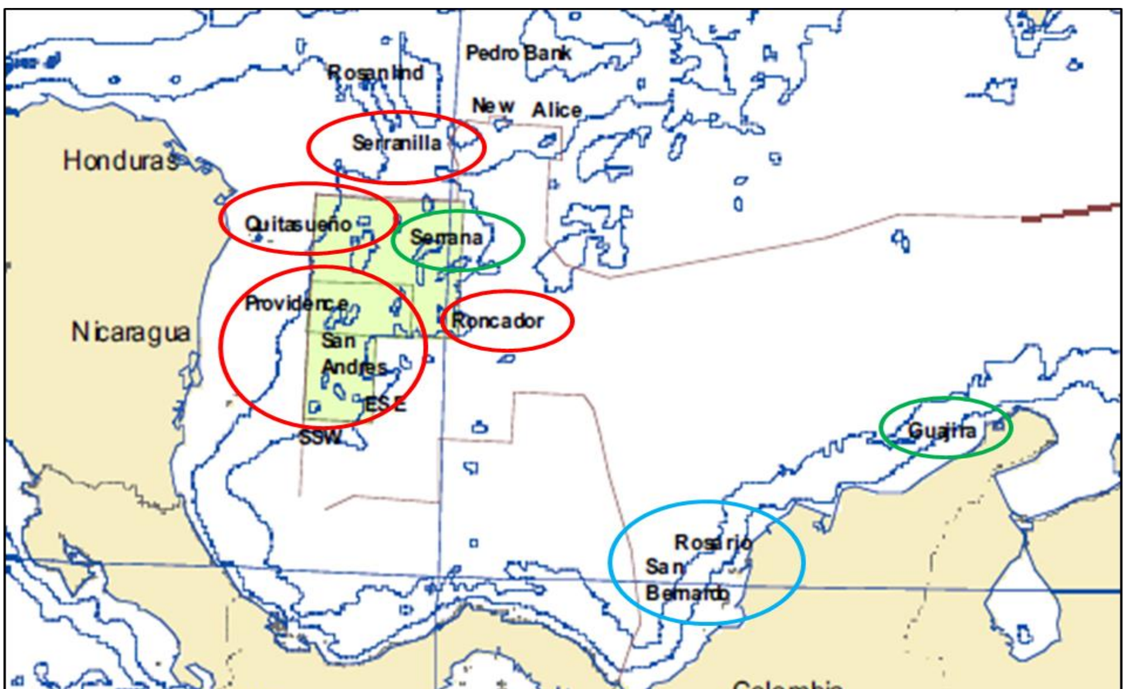

Figure 9: Map adapted from (Prada et al. 2008) illustrating important historical and current fishing areas in Colombia. Historic areas are circled in blue; present areas are circled in green; closed areas are circled in red.

Fishery monitoring surveys conducted in 2002, in the south section of the Seaflower Marine Protected Area (San Andres, Bolivar, and Albuquerque Keys) found conch densities at less than 20 conch/ha (Gutierrez 2003; Castro et al. unpublished; as cited in Castro et al. 2004). The northern section was characterized by higher mean densities with 273 conch/ha at Serrana Bank, 46.3 conch/ha at Roncador Bank, and 11.6 conch/ha at Quitasueño (Appeldoorn et al. 2003; as cited in Castro et al. 2004). A population survey conducted in 2007 estimated the biomass of the San Andres archipelago to be 1,674 mt, with adult densities ranging from 1.8 to 151 conch /ha and juvenile densities of 0.6 to 84 conch/ha (Prada et al. 2008). This increase in density was likely assisted by the export ban on Honduras, Haiti and the Dominican Republic, as it eliminated illegal fishing. However, after Canadian and U.S. enforcement agents dismantled illegal import of conch from Honduras into Colombia (Hubbard and Lupert 2009), there was a significant increase in regulation.

During a survey in 2007, the high densities of conch observed at Serrana Bank in 2003 were not found and there was no evidence of substantial juvenile recruitment to rebuild the adult stock (Appeldoorn and Baker, 2013). Subsequently, the fishery in Serrana Bank was closed in 2012 and is projected to reopen by 2013 exclusively for artisanal fisheries, with a share of only 19 mt in semi-clean meat (Prada and Brides 2012). Queen conch populations have been recorded as recovering after a closure, which denotes the importance of the deep stocks in the recovery process (Castro et al. 2011 unpublished). Colombia has informally adopted a control rule for setting the quota based on population density, as developed by Smikle (2010) for Jamaica (see below), which would benefit the stock.

Although conch meat is the most commonly traded conch product in international markets (approximately 90% is exported), queen conch pearls are the most valued conch product (Prada et al. 2008). Between 2000 and 2003 queen conch pearls doubled in value relative to price of conch meat (Figure 10). According to the Colombian Agricultural Institute register, between 2000 and 2003, Colombia queen conch exports totaled more than USD 3.2 million with pearls accounting for 63% of that total, followed by conch meat at 36%, and conch shells at less than 1% (Prada et al. 2008). Each queen conch collected for meat is checked during meat extraction for a pearl. There are 3 legal pearl traders in Colombia, and an unknown number of illegal traders (Prada et al. 2008), with no protocol to monitor. There is a misconception among fishers - that juvenile conch produce pearls more commonly than adults, which may lead to increased harvest of juveniles. The small size of the pearls coupled with their high market value may encourage illegal trade and smuggling (Prada et al. 2008). At this time, no studies on the pearl trade of Columbia have been published.

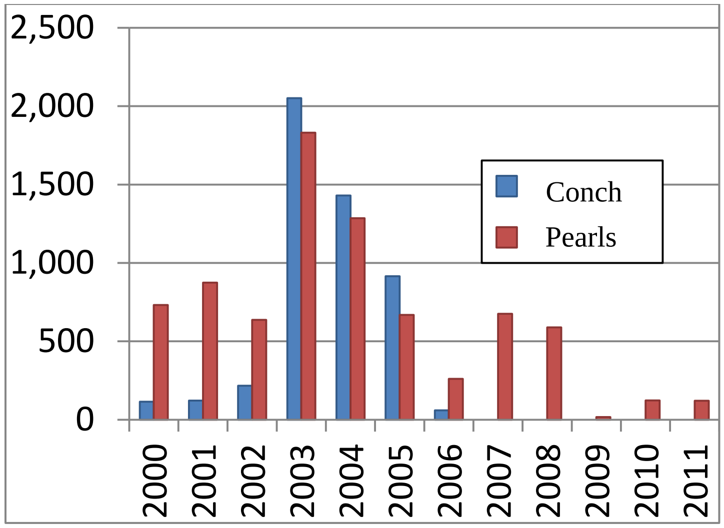

Figure 10: Colombia queen conch peal trade compared to meat trade (Castro et al. 2012).

While there has been a recent change in maritime jurisdiction in Colombia, it is unlikely to affect their queen conch fishery. In November 2012, the International Court of Justice issued a ruling on a jurisdictional dispute between Colombia and Nicaragua regarding territories and maritime jurisdictions. The disputed area was located approximately 400 km north of South America and 200 km east of Nicaragua. The court ruled that Colombia would maintain control over Alburquerque Cays, Bajo Nuevo, East-Southeast Cays, Quitasueño, Roncador, Serrana, and Serranilla islands, and the maritime features that form part of the San Andres Archipelago in the western Caribbean.

6.13 Cuba

The queen conch fishery in Cuba is currently managed under a catch-quota system. Fishery quotas are established by "zones" and set according to population assessments and monitoring. Abundance surveys are conducted, which include research and monitoring cruises in traditional fishing areas (CITES 2012). Quotas are based on abundance surveys (AC19 Doc 8.3 2003). In 1999, there were 9 open fishing zones; annual catch quotas were granted for each zone, and for each business license. Currently, there are only 6 active fishing zones, as 2 zones were closed for not complying with regulatory requirements and 1 was declared a protected area where harvest is prohibited (Lemus and Lorenzo 2012).

Regulations require a lip thickness of greater than 10 mm, but the regulations do not require that animal be landed in shell, so it is difficult to determine whether or not the minimum size requirements are adhered to by the fishery. Compressors (hookah) and SCUBA gears are prohibited. Harvest is closed May 1-September 30 and conducted by free diving operations at depths ranging between 3-10 m (Lemus and Lorenzo 2012).

Historically the commercial harvest of queen conch began in Cuba in the 1960s and the harvest level increased considerably in the mid- to late-1970s. This unregulated and unmanaged harvest caused the collapse and closure of the fishery in 1978 (Lemus and Lorenzo 2012; Munoz et al. 1987). The fishery reopened in 1982 with a 555 mt harvest quota, which increased to 780 mt in 1984 (Munoz et al. 1987). Conch populations continued to decrease at an accelerated rate, despite the then newly established quota system, and the ban on juvenile harvest (Grau and Alcolado, manuscript, as cited in Monoz et al. 1987). Monoz et al. (1997) attributed the continued population declines to harvest quotas being set too high and illegal harvest. In 1991, the conch fishery was considered fully exploited, but stable (CITES 2012). In 1998, the fishery was again closed for a year to conduct an abundance survey (Formoso 2001) and update quotas. Catch estimates (Table 5) for the entire fishery between 2003 and 2011 ranged from 372 mt to 574 mt annually, with recent landings around 500 mt/annually (Lumus and Lorenzo 2012). Queen conch meat is consumed domestically and is exported primarily to Canada and Mexico.

Table 5: Strombus gigas landings in Cuba expressed in metric tons (live weight) (Lumus and Lorenzo 2012).

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total	372.3	552	643.6	326.3	574.4	505.8	529.4	505.5	492.4

Surveys of queen conch in Cuba are scarce, particularly in the southeastern regions of the country. The Jardines de la Reina, an archipelago in the southern part of Cuba, was designated a national park in 1999 and that fishery zone subsequently closed. Queen conch densities within the Jardines de la Reina National Park were estimated to be 1,108 conch/ha (Formoso et al. 2007). Cara De La Hera et al. (2013) observed relatively high queen conch density during surveys in the National Park Desembarco del Granma (a reef lagoon in eastern Cabo Cruz, Cuba). Queen conch densities were evaluated in 2009-2010, at 3 different areas (Farito, Guafe and Laguna within the national park) during rainy, dry, and cold-front periods. The highest densities were observed during the dry season (1395 conch/ha) and the lowest during the rainy season (647 conch/ha). The highest density reported (Cala De La Hera et al. 2011) was at Farito (1723 conch/ha) and the lowest at Guafe (511 conch/ha). Laguna showed a very similar density to Farito (1271 conch/ha). One site with low density (Guafe) was believed to be a result of effluent discharge from the town of Cabo Cruz reaching the lagoon, as conch observed in that area were covered in a thin slime (Cala De La Hera et al. 2011). An analysis of lip thickness showed that 72.93% of conchs had a completely formed lip, but measured less than 200 mm siphonal length. Apparently, the Cabo Cruz conch population consists of small conchs that have increased weight and lip thickness, turning them into "dwarf" or “samba” conchs (Cala De La Hera et al. 2011). Given, the higher conch population density, the National Park Desembarco del Granma is likely an important reserve contributing to the down current larvae supply and recruitment (Cala De La Hera et al. 2011).

6.14 Dominican Republic

The fishery of the Dominican Republic has existed for hundreds of years; a shell 1400 ±70 years old was excavated from a historical catch pile (Torres and Sullivan Sealy 2002b). The Dominican Republic exports conch to Puerto Rico, the U.S. Virgin Islands and the United States. The early commercial fishery (1955-1970) was not sustainable, however new gear allowed a deeper-water fishery that continues today. The Dominican Republic had started to export queen conch to the United States in the early 1990s (CITES 2012). The Dominican Republic had already set minimum shell size of 25 cm for harvest in 1986 (CITES 2012). Following population studies in the mid-1990s, a closed season (July 1-October 31) was established in

1999, and no fishing zones were also established in 2002; although these measures were said to be ineffective due to insufficient enforcement (AC19 Doc 8.3, 2003; CITES 2012). Several surveys in the past 15 years have all come to the similar conclusion: the queen conch fishery is unhealthy. Juvenile and adult densities are declining, only high percentages of juveniles are seen in shallow waters, reproduction is threatened by low densities, and fishing is moving to different areas. In just one year, 1996-1997, juvenile conch abundance decreased significantly. Adult queen conch also decreased in abundance in 1997, but this decrease was not as precipitous as with the juveniles (Delgado 1999). In Jaragua National Park, the age structure in shallow water reflected high fishing pressure with a high percentage of juveniles and low percentage of adults. The density of adults found in deeper waters (53 conch/ha) was at the level needed for successful reproduction (Posada et al. 1999). Low number of juvenile conch were found in the historic fishing areas; however the empty conch shells found in other areas may reflect a change in the fishing areas as the shallow water stocks in historical zones have decreased. In the Parque Nacional del Este, the main fishing area in the south east Dominican Republic, adult mean densities had decreased from 4.5 conch/ha in 1996 to 0.62 conch/ha in 2000 (Torres and Sullivan Sealy 2002a). Juvenile densities also decreased from 283 conch/ha in 1996 to 14.4 conch/ha in 2000 (Torres and Sullivan Sealy 2002a).

The decreases in conch density with fewer adults surveyed is reflective of overfishing and likely a result of a very intensive industrial fishery. The industrial fishery first focused on the offshore Silver and Navidad Banks and reported very large landings from 1981-2002 (Table 6).

Table 6: Landings from the Dominican Republic, recorded as gross weight (Mateo and Tejada 2008).

Year	Landings (mt)	Year	Landings (mt)
1977	133	1993	2600
1978	292	1994	1857
1979	412	1995	2209
1980	706	1996	1957
1981	1291	1997	1573
1982	1169	1998	2668
1983	1240	1999	1242
1984	1504	2000	1777
1985	1798	2001	1432
1986	1583	2002	2684
1987	577	2003	1654
1988	525	2004	1206
1992	3140	2005	1383

Because queen conch populations have significantly declined in the Dominican Republic, many fishers are believed to fish outside the Dominican Republic (Theile 2001). Dominican vessels have frequently been caught poaching in other states fishing grounds. Specifically, when the Jamaican fishery was closed from 2000-2001, landings drastically increased in the Dominican Republic and Honduras (CITES 2012). As a result of high landings and lack of current stock information, in September 2003, CITES suspended exports from the Dominican Republic (CITES 2006). Trade continued to be recorded in 2004, and the CITES moratorium remained in effect (Figueroa and Gonzalez 2012). While the CITES suspension did not affect local consumption, fishing effort and landings volumes for domestic consumption have reportedly declined (FAO report 2012). Today, the queen conch fishery in the Dominican Republic exists mostly for tourist and domestic consumption (Torres and Sullivan Sealy 2002b; FAO report 2012). During the queen conch working group conference, held in Panama City, Panama in October, 2012, the Dominican Republic reported the following queen conch landings: 368 mt in 2009, 19.5 mt in 2010, and 359 mt in 2011 (FAO report 2012).

6.15 United States (Florida)

Within the continental United States, queen conch only occur in Florida where the historical queen conch harvest supported both commercial and recreational fisheries. The population declined to a level that resulted in the closure of the commercial fishery in mid-1970. Later, based on concerns from the citizens of Monroe County, the recreational fishery was closed in 1985 in state waters and in adjacent federal waters in 1986. In 1986, it was estimated that approximately 6,000 queen conch remained in the Florida Keys offshore aggregations (Glazer and Delgado 2003). The decline in queen conch abundance that occurred during the 1980s was attributed to both overfishing and habitat loss resulting from coastal development (Berg and Glazer 1995; Glazar and Quintero 1998; Glazer and Kidney 2004). Since the 1980s, the populations have been slow to recover. Densities ranged from 0.44-4.08/ha from the years 1987-1990 when Berg and Glazer (1990) recommended to the Florida Marine Fisheries Commission that the moratorium continue. Queen conch were listed as a ‘protected species’ by the state of Florida in 1990; although this status does not impart any additional regulatory protection beyond that granted under the rule prohibiting harvest (68B-16, Florida Administrative Code). It is not illegal to take or possess queen conch shells from the land or waters in Florida, so long as such shells do not contain living queen conch at the time of the taking and the queen conch is not killed to obtain its shell. The law also stipulates that “any queen conch shell having an off-center hole larger than 1/16 inch in diameter through its spire shall constitute a violation,” as the this is evidence of illegal collection. The queen conch fishery remains closed and the 25-year prohibition on harvest continues to date.

Queen conch are classified in three sub-populations (nearshore, back-reef, and deepwater) in Florida based upon their spatial distribution (Figure 11). The nearshore subpopulation is located adjacent to the island chain in shallow water and in hard bottom areas and is exhibiting reproductive failure (McCarthy et al. 2002; Delgado et al. 2004; FWC unpublished data; McCawley 2012). The neashore subpopulation receives conch larval recruits from other locations. The geographic barriers that are unique to the Florida Keys (e.g., Hawks Channel) prohibit conch from moving to offshore spawning aggregations. The back-reef population is located in shallow water reef flats in habitats primary consisting of coral rubble, sand and seagrass (Glazer and Kidney 2004; FWC unpublished data; McCawley 2012). Deep water populations are present seaward of the reef on sand plains in water depths ranging from 10 to 25 m. The deepwater population is believed to be reproductively active (FWC unpublished data; McCawley 2012).

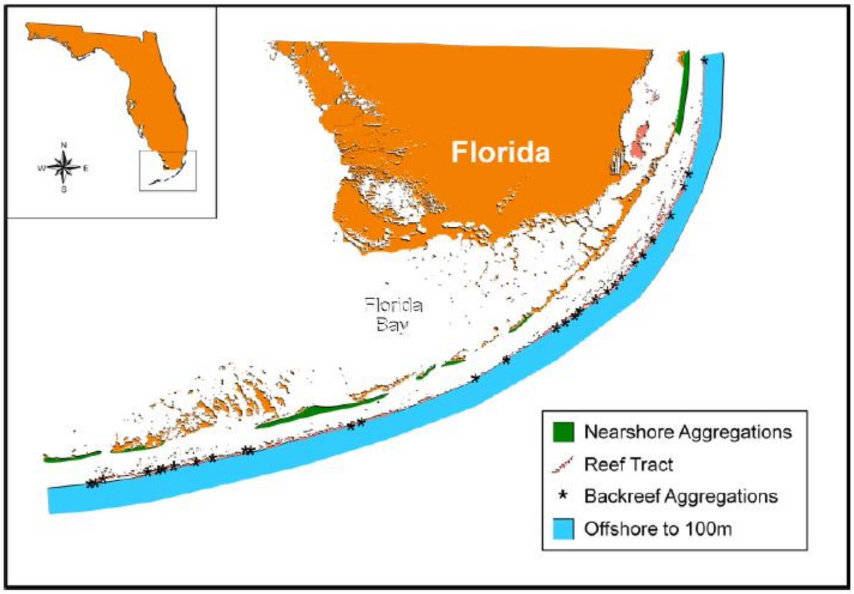

Figure 11: Distribution of queen conch in Florida (McCawley 2012).

In the early 2000s, abundance of queen conch in the back-reef area started to increase and in 2011 the adult abundance peaked at 41,000 (Figure 12). Juvenile abundance in the back-reef aggregations sites in 2011 was estimated to be around 28,000; although these numbers are highly variable due to age classes that have not fully recruited (McCawley 2012). The number of queen conch in the back-reef population (Figure 12) is increasing (McCawley 2012).

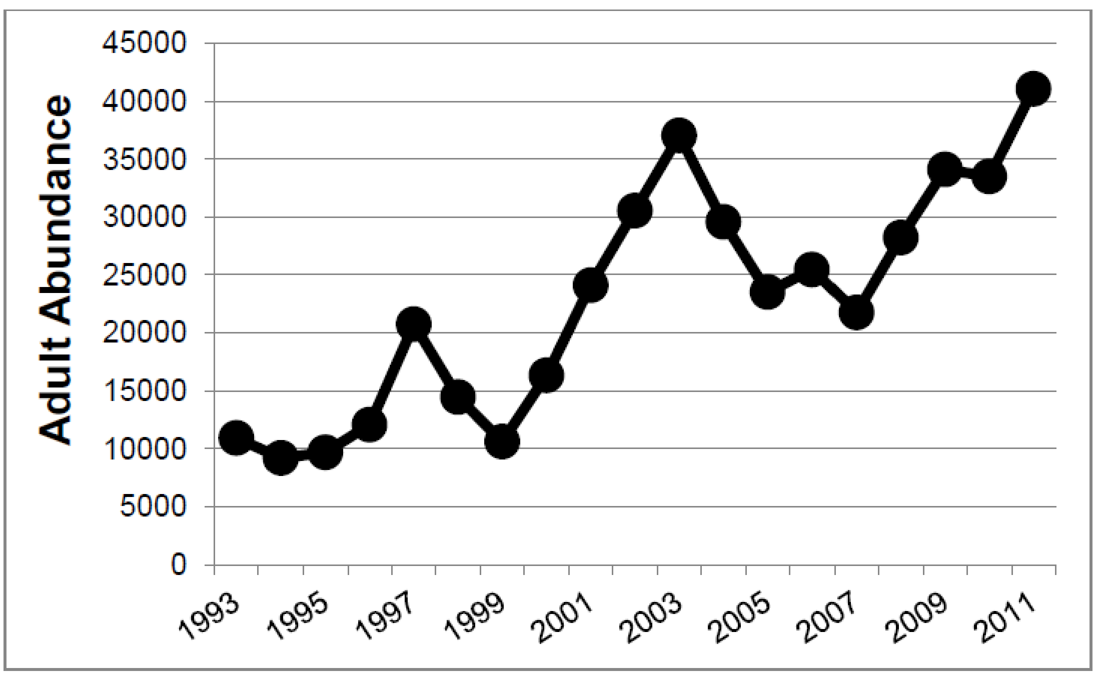

Figure 12: Estimated abundance of adult queen conch within the back-reef spawning aggregations (McCawly 2012).

Unlike the back reef population, queen conch found in the nearshore area are not reproductive, although historical reports indicated that spawning occurred (Glazer et al. 2008). The FWCC does have evidence that suggests that at least 3 nearshore aggregations present in the late 1980s/early 1990s no longer exist (McCawly 2012). Queen conch in nearshore areas have not been observed reproducing, nor do their gonads develop unless the conch are transplanted offshore into breeding aggregations (bypassing Hawk Channel) as discussed further in the Ecotoxicology section.

In the deep-water, adults are successfully reproducing (Glazer et al. 2008). Recent research in the Florida Keys focused on restorative strategies such as transplanting nearshore individuals offshore to both increase the density and abundance within existing spawning aggregations (Glazer and Delgado 2003), and elucidating the cause of the nearshore reproductive failure (Glazer et al. 2008). A recent aggregation off Fort Lauderdale was found to have a high percentage of younger age classes, and nearshore reproduction was observed (Walker and Berry 2012).

Queen conch meat and products are imported into Florida from countries throughout the Caribbean. Based on trade statistics from the U.S. Fish and Wildlife Service, U. S. imports of queen conch meat averaged 1.4 million kilograms annually from 2001 to 2010. The highest levels were reported in 2001 (2,404,131 kg) and the lowest in 2007 (830,008 kg). The most recent data from 2010 indicate 1,309,652 kg was imported (Figure 13). The United States does not directly export conch products, but it does re-export a very small quantity of conch products annually. Overall, there appears to be a general decline in the imports of queen conch (Figure 15) from most major exporting countries, although imports from Honduras and Nicaragua have recently increased (Figure 14). The United States does not allow import of queen conch from Grenada and Haiti in accordance with the current CITES recommendations to suspend trade based on their failure to implement recommendations under the Review of Significant Trade (CITES 2012).

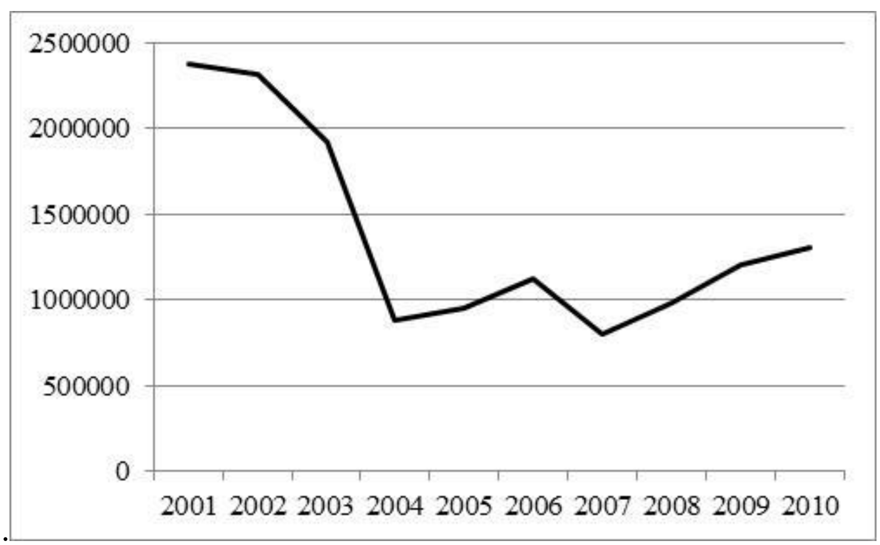

Figure 13: Total annual U.S. imports of queen conch meat (kg). Source: U.S. Trade in Queen Conch (2001-2010), prepared by the USFWS.

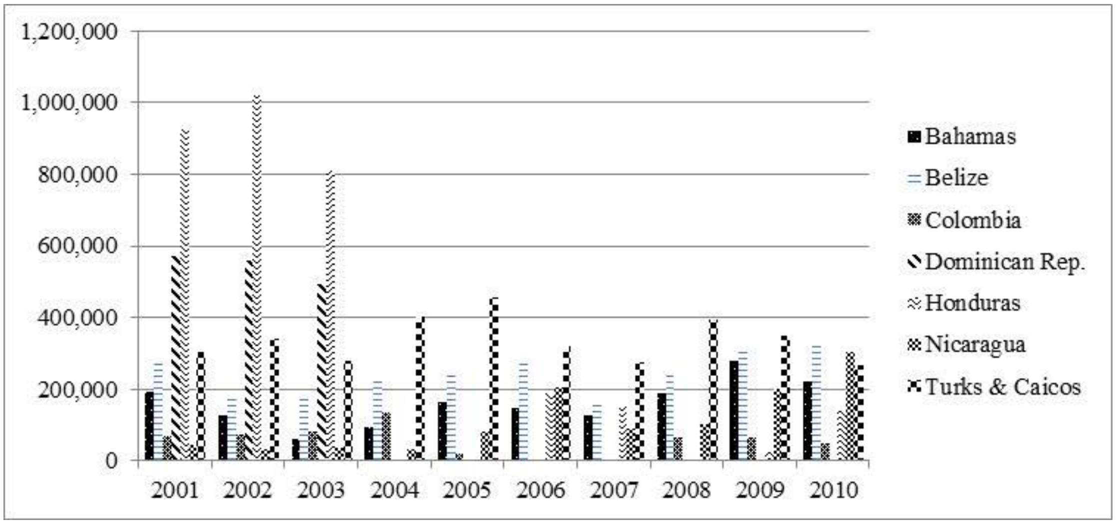

Figure 14: Annual U.S. imports of queen conch meat (kg) from the major exporting countries (i.e., countries from which the U.S. imported a total of 1 million kg or more, from 2001-2010). Source: U.S. Trade in Queen Conch (2001-2010), prepared by USFWS.

6.16 Grenada

Historically the fishery of Grenada supplied Trinidad, Tobago, and Martinique with queen conch. In the late 1970s, conch collected by SCUBA was held in underwater corrals and brought to market when the price was high enough (Brownell and Stevely 1981). Grenada has been under a CITES trade suspension since May 2006. Fisheries Regulations state it is an offence to take, sell, purchase or have in one's possession any immature conch. Immature conch refers to any conch having a shell smaller than 7 inches (18 cm) or which does not have a flared lip. An immature conch can also be classified as one with a total meat weight of less than 8 oz. or 225g after removal of the digestive gland (FAO 2012). Queen conch populations in Grenada are believed to be overfished and composed of mostly juveniles. Grenada imports most of its conch meat from neighboring nations. No estimates of abundance or landings are available.

6.17 Haiti

Queen conch populations in Haiti have been considered overfished since the late 1970s (Brownell and Stevely 1981). In the early 1990s, the conch population in Haiti was considered to be depleted likely due to over-exploitation (CITES 2012). Since 2003, Haiti has been under trade suspension due to their failure to implement recommendations under the Review of Significant Trade (CITES 2012). Haiti established regulations in 2003 that prohibited the harvest of shells without a well-formed lip and the use of SCUBA and hookah gears (AC19 Doc 8.3, 2003). Wood (2009) stated that while controls have existed 'on paper' for decades they had not been implemented due mainly to other government priorities and limited surveillance capacity within the Fisheries Department (CITES 2012).

The first queen conch survey in Haiti was conducted in 1995 (Posada et al. 1997). Based on the need for compressors to harvest in deeper waters and the high harvest of juveniles, the area around La Gonave Island was thought to be overfished (Posada et al. 1997). Low densities and thin lipped individuals showed no potential for harvest at La Gonave Island. Roichelois Bank had an average density of 15 mature conch/ha, while the area to the southwest, facing Jamaica, is a productive area that supports densities of 160 conch/ha and fisherman do not bother harvesting juveniles (Posada et al. 1997). Local consumption in 1997 was estimated to be around 70 mt a year, and no conch meat was exported at that time (Posada et al. 1997). Surveys in 2007 and 2009 show overall low density and populations composed mostly of juveniles (Wood 2010) with queen conch densities appearing to be "seriously depleted" with stocks diminishing rather than increasing. The lowest adult conch densities (0-6 conch/ha) were recorded in the northwest between Le Mole and Petit Goave. The highest densities of adult conch (10 to 35 conch/ha) were recorded in the southwest between Cayenmite and Anse d'Hainault (Wood 2012). Mature adults comprised 12% of the population in the 2007 and 2009 surveys compared to 31% in the 1995 survey. Haiti's queen conch populations are well below the critical level required to ensure successful reproduction and recruitment (Wood 2010).

6.18 Honduras

In response to the primary recommendations resulting from the Significant Trade Review in 1997, Honduras stated that they had a "closed season and minimum size for capture with a limited to number of fishing vessels" (CITES 2012). However, currently there are no management measures in place (Regalado 2012). The commercial conch fishery is closed under a moratorium which allows only for the collection of conch taken during scientific surveys. Since 2006, export quotas have been set at 210 mt annually for meat that is taken during scientific surveys (CITES 2012; Regalado 2012). Vessels that harvest queen conch for scientific surveys are required to be licensed and authorized by the Honduras government (CITES, 2012). Nearshore queen conch populations have been subjected to high exploitation from both commercial fishing and substances fishing (Tewfik et al. 1998). Honduras had an industrial fishery that targeted offshore populations (Ehrhardt and Galo 2005) where conch meat was extracted from the shell, cleaned and packaged at sea. Queen conch is harvested offshore on Roselind, Middle, Oneida and Gorda Banks and either exported or used for bait.

In 1998, 636 mt of queen conch meat was exported, increasing to 1,328 mt in 2001 (CITES 2012), and around 1,000 mt in 2003 (Ehrhardt and Galo 2005). These catches were composed mainly of mature adults (Regalado 2012). In the early 2000s there was evidence that significant portions of queen conch meat landed in and exported from Honduras had been fished illegally in waters under the jurisdiction of neighboring states and territories. In particular, concerns were raised about the increase in queen conch meat exports from Honduras that coincided with the period when the Jamaican fishery at Pedro Bank was closed (2000-2001 and 2002), which led to an increase in poaching at the Bank by foreign vessels (including Honduran vessels) after the commercial moratorium (AC19 Doc 8.3 2003; CITES 2012).

There was a moratorium on conch fishing declared by the Honduran government from 2003 to 2006 in response to CITES' concerns regarding the lack of information, high amount of exports, lack of landings records, illegal activity, and low population densities. Trade resumed in 2006 for meat collected through scientific surveys (CITES 2012). Since 2006, export quotas have been set at 210,000kg/annually for meat that is taken during scientific surveys (CITES 2012; Regalado 2012). Scientific collection was temporarily suspended in 2007, resulting in no trade in 2008; however, trade resumed in 2009 (CITES 2012).

In the Cayos Cochinos, located on the northern coast, density of both adults and juveniles was reported at 7.3 conch/ha in 1996. These low densities were attributed to intensive exploitation that had taken place over the previous decades (CITES 2012). The Cayos Cochinos were declared a Biological Reserve in 1993 and since then, harvest of queen conch has been prohibited (AC19 Doc 8.3 2003). Conch surveys have been conducted in 2009, 2010, and 2011 (Table 7). The average population densities were provided for the entire conch habitat and not just for the area within the bank that is of commercial interest (Regalado, 2012). Population densities increased with depth which is most likely the result of fishing effort focused in shallow areas (Regalado, 2012). No information was provided on age structure of the population. During surveys almost no juvenile conch were observed and managers have found it difficult to identify conch nursery areas (FAO 2012).

Table 7: Average population density over entire back (#/ha) for Honduras.

Fishing Bank	Area (ha)	2009	2010	2011
Roselind	223,866	195	248	134
Oneida	309,810	130	193	196
Gorda	684,829	73	127	93

6.19 Jamaica

The use of SCUBA to harvest queen conch has been prohibited in Jamaica since 1992. Jamaica implemented the Queen Conch Fishery Management Plan in 1994 that established guidelines for management measures including a national total annual catch (NTAC) and individual quota system (Morris 2012). There is a closed season July 31- February 1 (FAO Report, 2012). Harvest of queen conch is prohibited at depths greater than 30 m and industrial fishers are not authorized to harvest conch within 5 miles of the Pedro Cays (Morris 2012). There is not a closed season in the recreational fishery, but harvesting is limited to 3 conch per person, per day (AC19 Doc 8.3 2003). In 2012, the South West Cay Special Fisheries Conservation Area (SWCSFCA) was designated. The SWCSFCA extends a 2-km radius around Bird Key on Pedro Bank and conch harvest is prohibited within the SWCSFCA boundaries.

The intensive fishery for queen conch currently observed in Jamaica started around 1990 (Mahon et al. 1992) at Pedro Bank - one of the most productive Caribbean conch fishing grounds with the largest stock (Appeldoorn 1994a; Aiken et al. 1999; Prada et al. 2008). In 1992, the export market from Jamaica was worth an estimated USD 60 million and the fishery was essentially unmanaged (CFMC 1999; Aiken et al. 2006). Most of the conch caught in Jamaica is exported because the local demand is, and has historically been, small (Aiken et al. 1997). Exports are primarily to Europe, but also Martinique and Guadeloupe (Haughton 2012).

The catch from Pedro Bank was so high that in 1993-1994, the fishery in the U.S. Virgin Islands closed because they couldn't compete with the low prices from Jamaica (Aiken et al. 2006). The first visual abundance survey was completed in 1994. It provided biomass estimates that were used to calculate the TAC. The TAC was chosen as an appropriate way to manage the fishery as most of the catch is exported (Table 8) (Posada et al. 1997).

The conch fishery in Jamaica was closed for the 2000/01 season and part of 2001/02 season because of legal issues associated with awarding commercial conch fishing licenses and respective quotas. During this time, a high amount of poaching was believed to occur based on the concurrent increase in landings reported from Honduras and the Dominican Republic (CITES 2012). High levels of poaching are estimated for most years (CITES 2003), though actual estimates only exist for 2000-2002. These estimates of poaching were greater than the total allowed catch (TAC) for those years. The 2001 TAC was reduced by 22% to account for possible levels of poaching (CITES 2003), a practice that has continued in subsequent years. Despite, the Jamaican Defense Force's attempts to combat poaching (Aiken et al. 1997) it remains an significant issue today.

Table 8: Export quota by year for queen conch from Jamaica (FAO report 2012).

Year	Export Quota (kg)
1994	3000
1995	2000
1996	1900
1997	1800
1998	1700
1999	1366
2000	0
2001	1216
2002	496
2003	950
2004	550
2005	640
2006	690
2007	650
2008	400
2009	400
2010	400
2011	400

Visual surveys are then carried out tri-annually and funded by the conch industry to provide update biomass estimates for the TAC calculations. Results from the 1994 survey included density estimates of 89-227 conch/ha depending on the depth stratification level and a large number of stoned (old adult) conch (Appeldoorn 1995a). Density and abundance of queen conch on Pedro Bank are 10 times that reported in other areas in the region (e.g., 8.7 conch/ha, Wood and Olsen; 24.6 conch/ha, Smith and Neirop 1984; 8.1 conch/ha, Torres Rosando 1987; 2.9 conch/ha, Berg et al. 1992; 12.3 conch/ha, Friedlander et al. 1994; 53.6-96.0 conch/ha, Stoner and Ray 1996; 29 conch/ha, Appeldoorn 1997; 14.6 conch/ha, Tewfik et al. 1997) and are around the same as reported during the first conch survey at Pedro Bank (Tewfik and Appeldoorn 1998). However, a comparison of distribution of conch from the 1997 and the 1994 surveys showed that a change in distribution and density among age classes occurred. These changes showed that adult conch densities decreased by 50% and 82%, respectively, in depth zones between 10-20 m (Tewfik and Appeldoorn 1998). Tewfik and Appeldoorn (1998) reported that the level of exploitation at that time was unsustainable, because of the significant changes that occurred in densities and abundance, as well as population structure.

In 2002, surveys reported densities of 136 conch/ha in the 10-20 m depth range (Smikle and Appeldoorn 2002) and the TAC was reduced to 502 mt (Aiken et al. 2006). In recent years, catch per unit effort has increased with density (Figure 15; Smikle 2010). The most recent survey from November 2011 indicated increased stock size with mean density for exploitable biomass of 243 conch/ha in the 0-10m depth range, 145 conch/ha in the 10-20m range, and 165 conch/ha in the 20-30m depths zones (Murray et al. 2012). The combined average density was 184 conch/ha. However, no information was provided on age structure of the population.

During the Queen Conch Working Group Conference held in Panama City, Panama in October 2012, scientists from Jamaica presented density information and CPUE data (Table 9) for survey years 1994, 1997, 2002 and 2007 (FAO 2012).

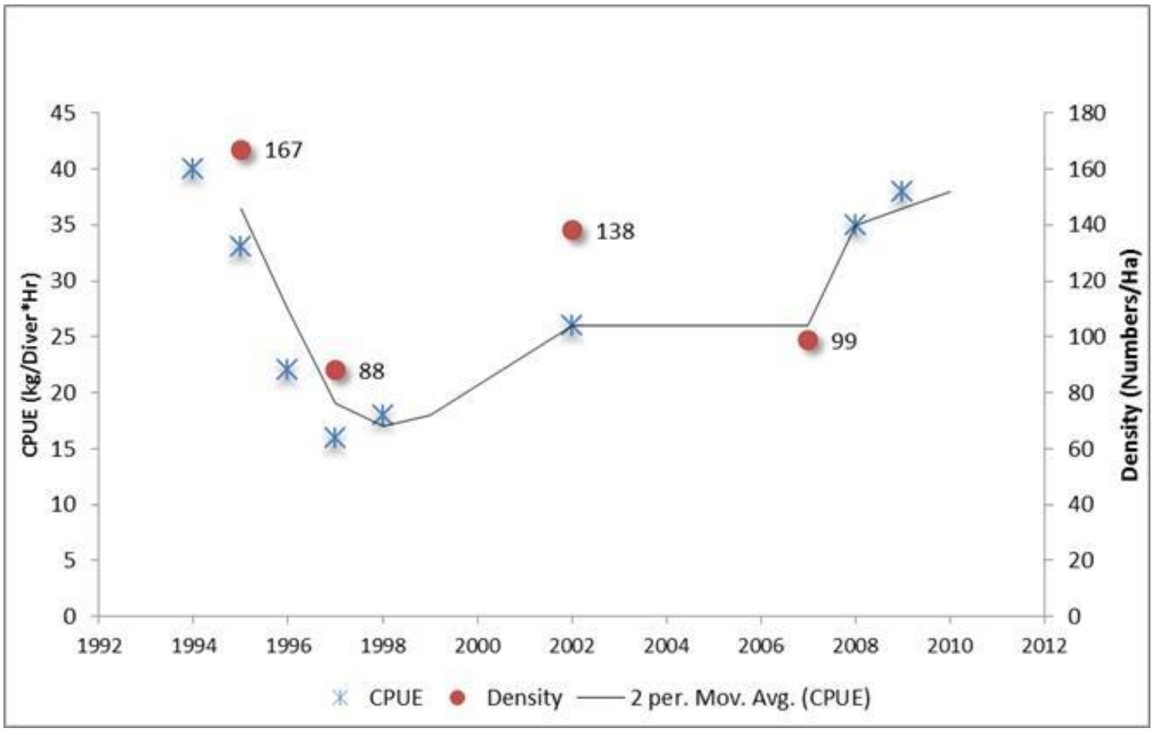

Figure 15: Trend and catch per unit effort and density for the Pedro Bank exploited stock (1993-2009). Maximum sustainable yield is estimated to occur at a density of 100 conch/ha (Smikle 2010).

Table 9: Density estimates per depth strata and biomass from surveys (FAO report 2012).

Survey Year	Depth Strata (Meters)	Density Estimate (Conch/ha)	Biomass estimate (Metric Tons)
1994	0-10	73	13,325.48
	10-20	152	
	20-30	203	
1997	0-10	175	12,203.27
	10-20	88	
	20-30	203	
2002	0-10	175	15,305.85
	10-20	138	

Survey Year	Depth Strata (Meters)	Density Estimate (Conch/ha)	Biomass estimate (Metric Tons)
	20-30	244	
2007	0-10	378	7,421.78
	10-20	49	
	20-30	50	

Annual quotas for Pedro Bank are now determined through a control rule based on harvesting 8% of the estimated exploitable biomass (Figure 16; Smikle 2010). Under this scenario, the maximum catch is fixed when densities are above 100 conch/ha and are progressively reduced if the population density is reduced. The fishery would be closed at 50 conch/ham below the level at which impacts to reproduction can be expected. Additional management measures include: 1) all of the western bank is closed to fishing (due to depth) and represents a very large de facto protected spawning stock with plans to declare a second closed area on the eastern end in shallow areas near the keys utilized by the Jamaica Defense Force; 2) quotas cannot be increased unless supported by the results of an in-water survey, however quotas can be lowered if there is evidence of problems, such as a drop in catch per unit effort or a survey indicating a lack of juveniles for future recruitment; and 3) field surveys are mandated at regular intervals. The adoption of control rules should stabilize the establishment of annual quotas, place them on more standardized set of criteria and facilitate both allocation of quotas and review by in-country CITES authorities (Appeldoorn and Baker, 2013).

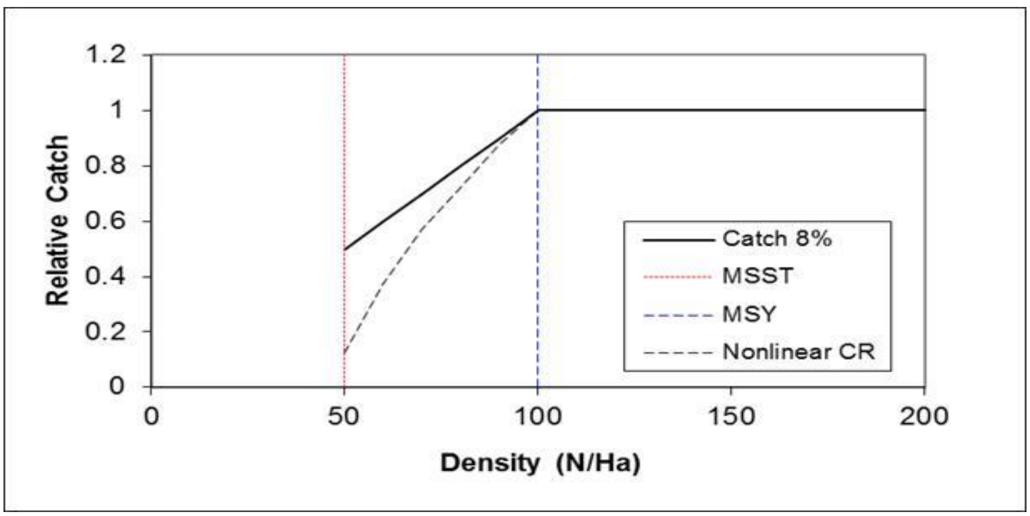

Figure 16: Control rules adopted for conch management in Jamaica based on harvesting 8% of estimated exploitable stock. MSST is the minimum stock threshold; MSY is the maximum sustainable yield. The solid black line represents the control rule; the dashed line is an alternative approach that would progressively drop the percentage of the stock allowed to be exploited. Colombia is considering adopting this alternative approach

Jamaica has also recently initiated a trade in conch opercula with China, where they are used in traditional medicine (Appeldoorn and Baker, 2013). While there are no studies of this trade, opercula are considered a byproduct.

6.20 French West Indies (Martinique and Guadeloupe)

Martinique prohibited the use of SCUBA to harvest queen conch in 1992. Subsequent regulation passed in 1999 prohibited the harvest of queen conch with a shell length of less than 22 cm, shells without a flared lip, and meat weight less than 250 g (without digestive gland) (Regulation No. 994296; CITES 2012). Recent studies on the reproductive cycle of queen conch in waters greater than 40 m around Martinique and Guadeloupe have concluded that the minimal catch size is not an efficient criterion to base sexual maturity on, and only a lip thickness of greater than 6 mm appears to indicate maturity (Frenkiel et al. 2009; Reynal et al. 2009). There is not closed season in the recreational harvest of queen conch, but harvest is restricted to 3 animals per person per day (AC19 Doc 8.3, 2003; CITES, 2012).

Rathier and Battaglya (1994) reported on the state of the conch fishery in Martinique before 1960, when fishing was conducted in shallow water with a conch hook that lifted the conch off the bottom and into the boat. Long nets were also dragged along the bottom, but as catch and density declined, the method was no longer productive. Currently, queen conch in Martinique and Guadeloupe is only harvested by free diving (CITES 2012).

The last reported abundance survey of the conch populations in Martinique occurred in 1986 and 1987. The survey showed populations to be seriously overfished and sustained by juveniles. Deep water populations were considered to be in a better state than inshore populations, which is likely due to the prohibition on SCUBA gear (CITES 2012). The same effort and low yield were realized in Martinique from the early 1980s to the mid-1990s as the fishery declined and juveniles less than 2 years old with median shell lengths of 15 cm were consistently landed. In Martinique, the majority of queen conch meat is imported due to the high levels of local consumption with approximately 300 mt per year believed to be imported, but actual reports of import from Martinique are not always available as they are classified as "France" (CITES 2003). The high demand and low supply for conch meat in Martinique likely results in illegal importing. While the European Union Sanitary Food Regulations restricted the import of queen conch in 1997 (Theile 2001), Martinique continued to import it from the neighboring island of St. Lucia (CITES 2003). Today, queen conch meat can be exported from Martinique if accompanied by a French import permit (Table 10) and a CITES export permit. The price of queen conch meat in Martinique and Guadeloupe has doubled over the past 25 years (FAO report 2012).

Table 10: Martinique and Guadeloupe exports to France (FAO report 2012)

Year	Volume of queen conch meat (kg)
2008	377,747
2009	396,351
2010	382,090
2011	382,797

During the queen conch working group conference held in Panama City, Panama in October 2012, Martinique and Guadeloupe presented density information (FAO report 2012). The most recent surveys in Martinique were conducted by divers and camera tow; divers observed densities within the 0-15 m depths zones at 64 conch/ha, camera tows reported densities within the 0-5 m depth zone at 45 conch/ha, and within the 10-15 m depth zone at 95 conch/ha (FAO report 2012). In Guadeloupe, queen conch densities were taken before and after the fishing seasons during 2011-2012. Before the fishing period of 2011-2012, an average of 106 conch /ha were recorded and after the fishing period, 73 conch/ha were recorded. The range of adult densities varied significantly from 50 conch/ha to 8 conch/ha, and immature conch ranged from 55 to 70 conch/ha (FAO report 2012). Conch density varied with depth: 72 conch/ha within the 0-5 m depth zone, 22 conch/ha within the 5-10 m zone, and 33 conch/ha within the 15-20 m zone (FAO report 2012).

6.21 Mexico

Queen conch were historically fished in the Yucatan Peninsula, from Ciudad del Carmen, Campeche to Chetumal, Quintana Roo, but predominantly in the states of Quintana Roo and Yucatan (Anon 1999). The fishery rapidly grew in the 1970s for export to the United States. (CFMC 1999) with around 150 fishers, but the number soon declined. The decline in fishers was attributed to the unregulated expansion to new fishing areas as well as the transition from free diving to SCUBA and hookah which allowed much greater exploitation at lower effort levels (Appeldoorn 1987b; CFMC 1999). In 1989, the fishery was closed in the Yucatan, and from 1990-1996 the fishery was closed in the state of Quintana Roo with the exception of Chinchorro Bank (CITES 2012). In 1996, size limits, closed seasons, and quotas were established for the Chinchorro Bank and the Cozumel Bank in Quintana Roo (CITES 2012). As of 2003, queen conch were only found in areas with depths greater than 30 m, with the exception of Chinchorro and Cozumel Banks, where some shallow stocks are still encountered (CITES 2012). In November 2012, the entire fishery in Chinchorro Bank was closed and will remain closed until February 2017 (Aldana Aranda GCFInet communication).

Queen conch meat harvested in Mexico is consumed domestically, although shells are exported. Since 2001, Mexico has imported over 184 mt of queen conch meat mainly from Cuba and Honduras (CITES 2012). Temporary and permanent fishery closures have been imposed in various areas throughout Mexico. The establishment of these regulatory mechanisms may have prevented further declines at these locations, but they were unsuccessful in recovering these overexploited populations; illegal fishing of queen conch at both the Chinchorro and the Cozumel Banks and at Alacranes reef were thought to be significant factors preventing these populations' recovery (CITES 2012).

Recent study on the population status of queen conch at Chinchorro Bank showed declines in conch density and its effect on reproductive activities (De Jesus-Navarrete and Valencia-Hernandez 2013). Data obtained from 15 previously surveyed sites (surveyed years: 1990, 1992, 1994, and 1997) considered fished zones, was recently compared to data obtained in a 2009 survey. It showed that adult densities declined overtime, from 10,700 conch/ha in 1990, to 198 conch/ha in 2009. Surveys conducted in July, showed densities in the southern zone at 23 conch/ha while densities in the northern and central zones were 15 and 9 conch/ha (De Jesus-Navarrete and Valencia-Hernandez 2013). Densities were slightly higher during the November surveys: southern zone 96 conch/ha, central zone 39 conch/ha and northern zone had 38 conch/ha (De Jesus-Navarrete and Valencia-Hernandez 2013). During the July survey, no egg masses or spawns where observed and mating was observed only once (De Jesus-Navarrete and Valencia-Hernandez 2013).

Genetic analyses indicate the limited population connectivity between queen conch populations in Mexico and other Caribbean areas may be impeding recovery (see Section 3.3) as larvae emigrate from upstream sources. The southern Chinchorro Bank is believed to be supplied by larvae from locations to the east, such as Jamaica. This is in contrast to the population at northern Chinchorro Bank, which is believed to be reliant on local recruitment as well as supplying larvae to other population in Quintana Roo (de Jesús-Navarrete and Aldana Aranda 2000; Paris et al. 2008; Delgado et al. 2008). Because an Apicomplexa parasite has been documented in queen conch in Alacranes reef, and the Chinchorro and Campeche Banks (see Section 3.6) (Aldana Aranda et al. 2009b), its effect on reproduction in infected individuals (Baqueiro-Cardenas et al. 2007; Castro-Gonzalez et al. 2007) could also be contributing to the slow recovery of these populations.

6.22 Montserrat

In the 1960s, important queen conch nursery habitat was destroyed to construct roads (Posada et al. 1997) and by the mid-1960s, stocks began to show signs of decline due to overexploitation (CITES 2012). The extent of the habitat loss is unknown. The first visual abundance surveys were completed in the 1980s, and the population was considered to be threatened as increased harvesting led to population declines. No surveys or additional information has been published since (CITES 2012). Frequent volcanic eruptions cover seagrass beds with ash, and increase the water temperature to boiling (Posada et al. 1997).

An estimated 1-3 mt of queen conch are harvested per year at depths deeper than 37 m by less than 10 fishers (Luckhurst and Marshalleck 1996; Posada et al. 1997).

Reportedly around 100 kg of queen conch meat originating from Antigua was being imported by local restaurants to Montserrat annually (CITES 2012) with imports from Saint Nevis in recent years. Countries report exports between 2003-2010 to Montserrat at 3,564 kg (CITES 2012), although no exports from Montserrat have been reported.

6.23 Nicaragua

The queen conch fishery was not a major fishery in Nicaragua until the mid-1990s (CITES 2012). Fishing is focused on the offshore Miskito bank to the northeast of Nicaragua, in the Corn Islands or Cayos Perlas. Fishers diving for lobsters currently catch 60% of the queen conch harvest, with the remaining 40% made by divers during the lobster-closed season (Navarro and Castellon 2012) or incidentally (Escoto García 2004).

In 2003, Nicaragua implemented regulations that established a 20 cm minimum size, a minimal lip thickness of 9.5 mm, a minimum weight of 172 g (processed), a seasonal closure between June 1 through September 30, and set the export quota at 45 mt (processed) (AC22 Inf. 4, 2006; Navarro and Castellon 2012).

An industrial fishery currently occurs in Nicaragua with fisherman targeting conch in the same geographic area where lobster are targeted when yields from lobster are low (Navarro and Castellon 2012). Landings, export quotas, and exports have all increased significantly since the 1990s; however landings are often classified and combined with other invertebrate species (Sánchez Baquero 2009). In 2000 the landings were at 32.81 mt of clean meat. The Nicaragua requested that CITES increase the export quota to 45 mt from 2001. The request was granted for that year and figures reached 56.47 and 44.61 mt landed and exported. In 2009, Nicaragua requested an increase in the country's export share, equivalent to 341 mt of clean fillet and 41 mt for use for research purposes. In 2011 export levels reached 340.6 mt and a new quota was set at 345 mt in 2012 (FAO, 2012; Navarro, 2012).

During the Queen Conch Working Group Conference held in Panama City, Panama in October 2012, Nicaragua presented information on its landings (Figure 17) that included exports by weight (100% clean meat) for 2000-2011 (Figure 17) (FAO report 2012; Navarro 2012) with a recent significant increase. Nicaragua exports a significant amount of shells (Georges et al. 2010) and their stocks suffers from poaching by foreign vessels (Theile 2001).

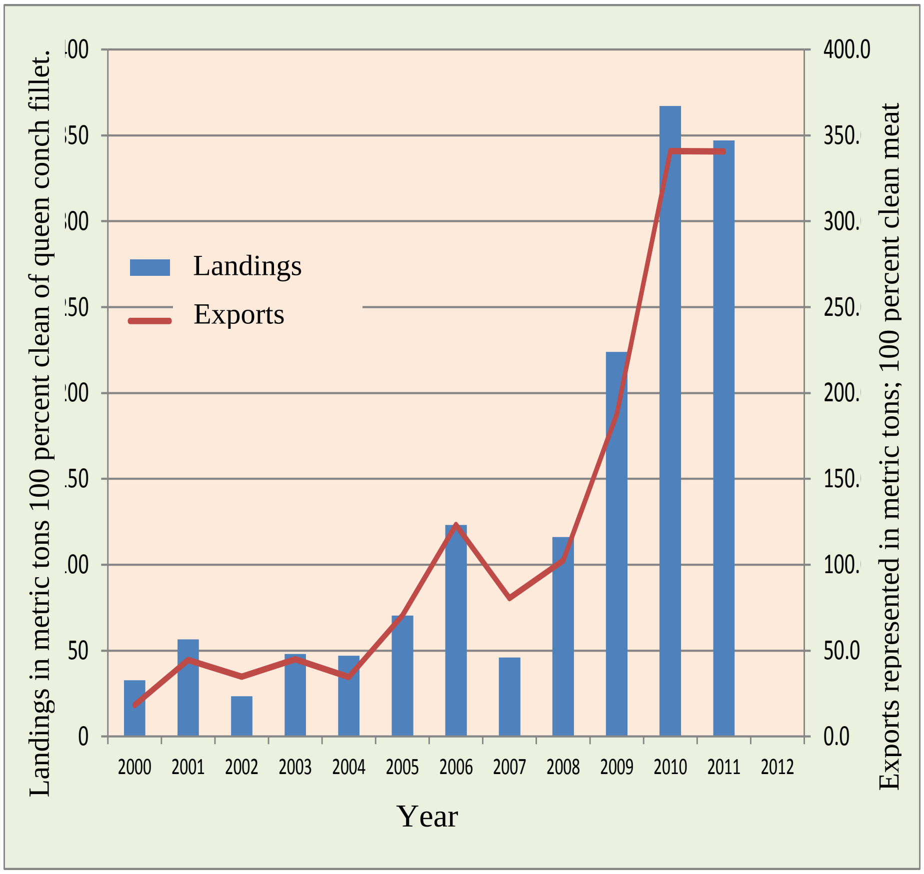

Figure 17: Nicaragua's queen conch landings and exports by weight from 2000-2011 (Navarro 2012).

A survey of queen conch abundance in Nicaragua was conducted in 2002, followed by a 2004 estimate of mean density at 112 conch/ha (CITES 2006). Subsequent surveys were conducted in 2005, 2009, and 2011 (Navarro 2012). Results of the 2009 survey showed adult conch densities ranging from 176-267 individuals/ha depending on the month (April, July, or November), location and depth (10-30 m). Juvenile densities in July were as high as 1,715 conch/ha (Navarro 2012).

6.24 Panama

In the late 1970s, most of the fishing activity for conch in Panama was concentrated in the San Blas Islands, but conch was mainly consumed by the fisherman and was not sold locally or exported (Brownell and Stevely 1981). Landings in 1994 were 372 mt, 5 mt in 1996, and 116 mt in 1998; all assumed to be consumed locally as there are no reports of exports (CITES 2003; Georges et al. 2010). Visual surveys conducted in 2000 in the Boca del Toro archipelago showed very low overall densities of 1.4 conch/ha (adults approximately 0.2 /ha) (CITES AC19 Doc 8.3, 2003). The long-term overexploitation of queen conch in the Bocas de Toro Archipelago is believed to be the primary cause of the extremely low densities observed (CITES AC19 Doc 8.3 2003), which are among the lowest in the Caribbean region. While there are no regulations specific to queen conch, marine resources in general are not allowed to be harvested using SCUBA (Georges et al. 2010). In 2004 the fishery was closed for 5 years (CITES 2012). No new studies have been conducted to assess the current status of the queen conch in Panama.

6.25 Puerto Rico

The value of the commercial conch fishery in Puerto Rico in 1983 was USD 480,000, most likely underreported due to incomplete reports, and not including those caught for personal use (Ballantine and Appeldoorn 1983). The fishery is characterized by the use of SCUBA, down to depths of 30 m, and is primarily based on the west, south, and east coasts.

The Puerto Rican stock of queen conch has suffered from overexploitation, and catch records showed steady declines during the 1980s (Appeldoorn 1991).

Since then, queen conch catch declined from 1983-2011 while effort increased (CITES 2012). Other trends suggesting overfishing have also been observed including catch based primarily on juveniles or maturing adults (Appeldoorn 1991). Fishing mortality is estimated to be 1.14; greater than natural mortality of 1.05 for both juveniles and adults, and 0.52 for just adults (Appeldoorn 1987a), indicating an overfished population. A Yield Per Recruit (YPR) analysis also suggest overfishing as maximum YPR is reached at an age below that of first reproduction (~3.2 years) (Appeldoorn 1991). Analysis of Catch Per Unit Effort (CPUE) data indicates a decline in catch from 160 lbs in the mid-1980s to 72 lbs from 1998-2001 landings (Table 11) show the same trend, much lower catches in the 1990s than the high levels caught for a small time in the 1980s. The high catches after 1980 are most likely the result of the large 1980 year class (Appeldoorn 1991). In the years following, that year's class was then recruited into the fishery, and subsequently reflected as high landings. This type of unusual influx of juveniles into a population can be very misleading and promote overfishing. The long-term average stock biomass is highly overestimated based on 1 year class's data.

Table 11: Queen conch landings in Puerto Rico from 1983-2011. Landings are adjusted to reflect unreported catch (correction factor ranges from 45-59%). Data is reported in metric tons and adapted from Matos-Caraballo et al. (2012).

Year	Landings	Year	Landings
1983	297	1997	138
1984	226	1998	151
1985	211	1999	124
1986	113	2000	223
1987	86	2001	163
1988	186	2002	124
1989	142	2003	157

Year	Landings	Year	Landings
1990	96	2004	171
1991	96	2005	316
1992	68	2006	109
1993	124	2007	117
1994	121	2008	106
1995	136	2010	94
1996	153	2011	120

Torres-Rosado (1987) surveyed queen conch and found a mean density of 8.11/ha on the southwest coast, indicating very low densities. The Southeast Area Monitoring and Assessment Program (SEAMAP), Caribbean has conducted surveys at approximately 5-year intervals since 1996. SEAMAP surveys documented further decline; Mateo (1997) surveyed both the east and west coasts and found average densities of 6.68-7.28 conch/ha and 5.68/ha, respectively, with the majority juveniles. The harvest and possession of queen conch in Federal waters (U.S. EEZ) was consequently prohibited in 1997 (SEDAR 2007), which protected waters primarily along the outer portion of the western platform. Subsequent surveys have shown increases in queen conch densities. In 2001, the west coast population density had increased to 14.42 conch/ha, but was still dominated by juveniles (Appeldoorn 2002; SEDAR 2007).

The most recent survey was conducted in 2006 (Jimenez 2007) and consisted of a total of 99 stations located along the east, south, and west coasts of Puerto Rico. Queen conch were found in 81 of the 99 sampled stations. Densities per habitat type ranged from 5.5 to 73.8 conch/ha. The majority of queen conch were found in seagrass (40%), followed by hard bottom (27%), and algal mats (21%). Density on the west coast increased to 19 conch/ha, and the average density was 31.6 conch/ha. As in other previous surveys, most of the individuals observed were juveniles (Figure 18) (Jimenez 2007). As of 2006, the queen conch population in Puerto Rico appeared to be at a healthier state than what was observed in previous visual surveys (Marshak et al. 2006). Adult distribution was even across newly mature to the very old stage (Figure 18). The overall densities estimates per coast (Figure 19) indicated the east coast had a higher density (12.0) than the south (8.7) and the west (8.8) (Jimenez 2007). Previous studies had found greater densities at shallower depths. However, the 2006 survey (Jimenez 2007) found greater density in deeper depth (Figure 19). While these assessments show improvement, that overall stock is still considered to be overfished (SEDAR 2007) and density is considered to be below the recommended reproductive threshold of 100 adult conch/ha (or higher) to avoid recruitment failure (Report of the Queen conch Expert Workshop 2012).

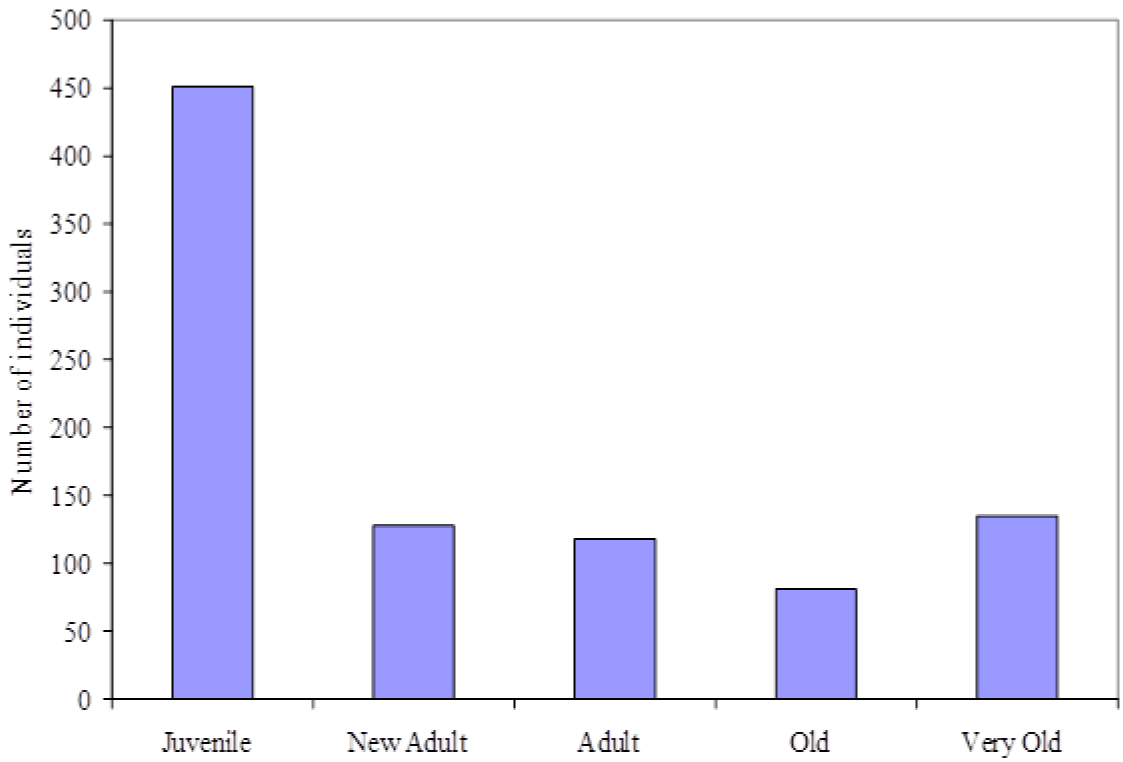

Figure 18: Queen conch age class distribution observed in the 2006 survey (Jimenez 2006).

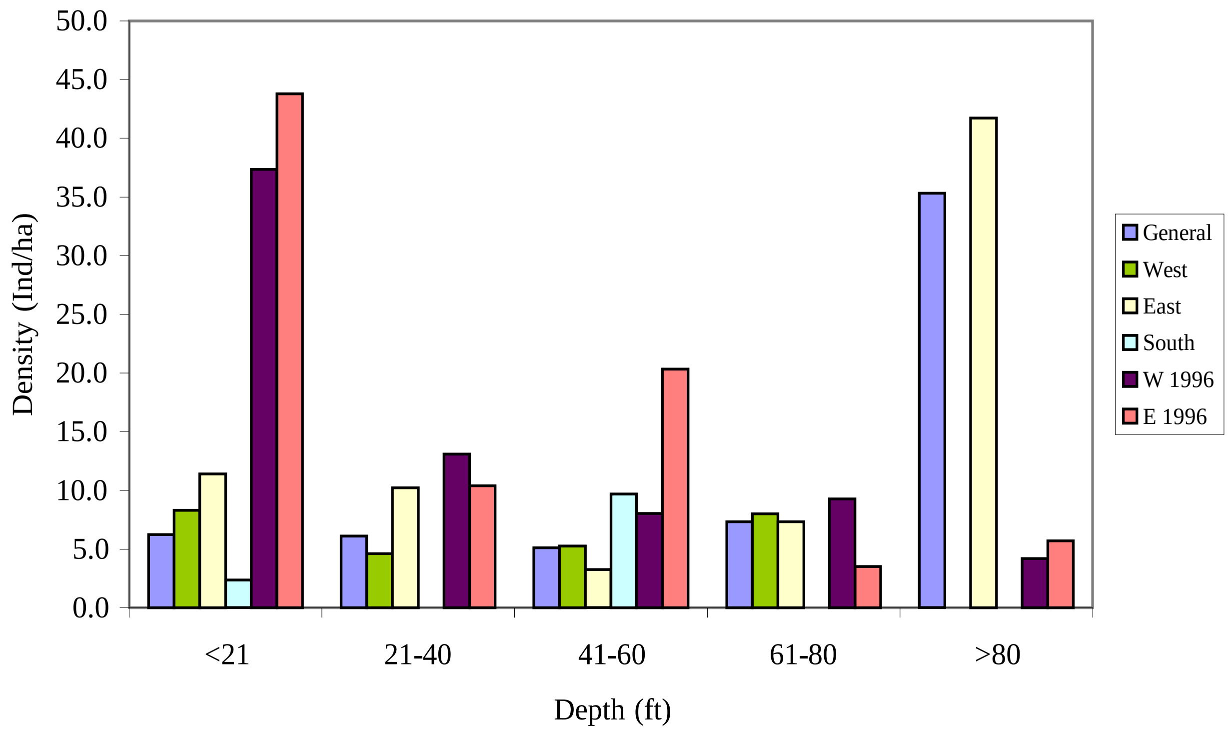

Figure 19: Density of queen conch per depth range 1996 and 2006 surveys (Jimenez 2007).

The Queen Conch Resources Fishery Management Plan of Puerto Rico and the U.S. Virgin Islands (Queen Conch FMP 1997) established a management program that is intended to rebuild conch resources in waters surrounding Puerto Rico. Measures included a minimum size limit of 9 inches (22.9 cm) in length (from the tip of the spire to the distal end of the shell), or a 3/8 inch (9.5 mm) in lip width at its widest point. There is also a closed season (August 1 through October 30). There is no requirement for the conch to be landed in shell; meat can be extracted from the shell while on the boat, but not underwater. However, in February 2013, the Puerto Rico Department of Natural Resource temporarily lifted this prohibition and allowed commercial fishermen to extract conch meat from the shell underwater until July 31, 2013. Harvest continues to be prohibited in the U.S. EEZ off Puerto Rico where the use of hookah is also prohibited. While there are no harvest quotas for territorial waters in Puerto Rico, there are daily bag limits which consist of 3 queen conch/day for recreational fishers, not to exceed 12 per boat and a commercial limit of 150 queen conch/day per fisher, or 450 conchs per vessel per day, whichever is less.

6.26 Saint Kitts/Nevis

Fisheries regulations were first implemented in 1995 in Saint Kitts and current measures include a prohibition on the harvest, sale, and purchase of queen conch with a shell length of less than 18 cm or individuals without a flared lip, or with meat weight less than 225 g (without disgusted gland). Conch meat can be removed from the shell at sea and only the conch meat is landed (Heyliger 2012) and therefore it is not possible to assess adherence to regulation. The use of SCUBA and hookah is authorized by permit only. During the queen conch working group conference held in Panama City, Panama in October 2012, Saint Kitts/Nevis reported daily catch varied between free and SCUBA divers with landings by free diving as high as 300 conch per day, and landings by SCUBA average 250 conch per day. Effort was greater by SCUBA because divers fish an average 4 days a week, while free divers fish an average of 2 days per week (Heyliger 2012). No quotas are in place and no stock assessments have been conducted in Saint Kitts or Nevis.

The fishery in Saint Kitts is small and comprised of less than 15 boats and 30 fishers with conch harvested primarily by SCUBA (Heyliger 2012). The market for queen conch is mainly an export driven market (Table 12) that began in 1995 as Saint Kitts and Nevis consume less than 30% of conch locally and the rest (i.e., approximately 60%) is exported to neighboring countries (e.g., U.S. Virgin Islands, Guadeloupe, and St. Martin) (Heyliger 2012). In Nevis, up to 95% of the conch is exported. High discrepancies, on the order of 100 mt, exist between export data and the resulting country import data (CITES 2012). In 1999, the west sides of the islands were considered overfished (CITES 2012). Although not quantified in abundance surveys, population recovery was believed to be occurring in some locations, possibly as a result of the 1997 European Union Food Sanitary Regulations which banned the imports of queen conch products to Europe, subsequently reducing the demand and allowing for over-exploited populations to recover (CITES 2003).

Table 12: Total number of queen conch landed and exported from Saint Kitts and Nevis 1995-2011. Weight in kilograms (Heyliger 2012)

Year	Total Landing Nevis	Export Nevis	Total Landings St. Kitts	Total landing
1995	9,105.00		13,222.73	

Year	Total Landing Nevis	Export Nevis	Total Landings St. Kitts	Total landing
				22,327.73
1996	19,850.00		28,872.73	48,722.73
1997	8,900.00		20,240.91	29,140.91
1998	59,200.00		21,986.36	81,186.36
1999	46,000.00		20,900.00	66,900.00
2000	41,711.40		30,890.91	72,602.31
2001	23,654.50		46,645.45	70,299.95
2002	43,982.58	32,982.97	35,759.09	79,741.68
2003	24,648.21	40,424.65	43,886.36	68,534.57
2004	30,039.15	26,212.83	62,122.73	92,161.88
2005	25,324.06	22,501.68	119,690.91	145,014.97
2006	49,468.78	68,829.11	54,650.00	104,118.78
2007	58,422.70	74,163.27	59,718.18	118,140.88
2008	58,513.42	56,038.95	69,913.64	128,427.05
2009	35,760.77	66,479.96	49,077.27	84,838.04
2010	27,966.24	83,467.98	66,995.45	94,961.69
2011	102,391.67	131,414.00	73,668.18	176,059.86
Total	**664,938.49**	**602,515.39**	**818,240.91**	**1,483,179.40**

6.27 Saint Lucia

While queen conch are believed to distributed around the island of Saint Lucia, only 2 populations (one in the north and one in the south) have been identified. Although suitable queen conch habitat is available in several bays and back-reef areas, queen conch are seldom found in these shallow water (less than 9 m) areas (Brownell and Stevely 1981; CITES 2012). The population in the south was thought to be undergoing more exploitation that the population in the north in the early 1990s (CITES 2012). The nearshore populations are considered overexploited and consequently fishers now target deeper water (depths ranging between 25-37 m) stocks using SCUBA (CITES 2012). Most of the conch is sold locally, or used for bait (Brownell and Stevely 1981).

Saint Lucia implemented fisheries regulations in 1996 that include prohibitions on harvest of queen conch with weight less than 280g (without digestive gland), or a shell smaller than 18 cm, or a shell that does not have a flared lip (Hubert-Medar and Peter 2012). The Department of

Fisheries requires all queen conch to be landed whole in the shell; however, in 2003, CITES reported that enforcement focused only on the flared lip requirement due to the ease of enforcement and implementation in the field (AC19 Doc 8.3, 2003). There is no closed season and conch are targeted throughout the year (Walker 2003; Hubert-Medar and Peter 2012).

The fishery is comprised of 40 fishers with 20 boats (FAO 2007; Hubert-Medar and Peter 2012) and there were local populations known, but not fished, in the south part of the island (Nichols and Jennings Clark 1994). In 1994, exploitation was believed to be below maximum sustainable yield (undetermined) and sustainable. Evidence for this was curtailing exports to compensate for increased local demand, low percentage of juveniles in catches, unexploited populations, and lack of new entries into the fishery (Nichols and Jennings Clark 1994). Recruitment from deep water stocks was thought to compensate for the high level of fishing pressure observed nearshore (Posada et al. 1997) and queen conch harvested were large and mature. The average size at capture was 391 g in the north (larger than the Caribbean average of 329g) and 285g in the south (Nichols 1984). In 1995, 22 mt were landed with 7 mt exported (Posada et al. 1997). Exports fluctuated from a minimum of 20 mt in 1994 to a maximum of 41 mt in 2001 (CITES 2003). Landings data from 1996-1998 estimated that 99.5% of the catch was composed of mature individuals which suggests that regulations on size limits were being followed, but declining catch per unit effort indicates that stocks have been declining since 1996 (CITES 2012; CRFM 2007). The average harvest estimate was 6.5 mt (using conversion estimate of 1 conch = 329 g) during this period, intentionally lower than it had been in previous years (Nichols and Jennings Clark 1994).

Due to the proximity to Martinique which is one of the major markets for conch in the Caribbean, significant illegal trade from Saint Lucia is thought to be occurring. A 1980 study estimated 6.8 mt of conch was illegally exported to Martinique (Posada et al. 1997). A high amount of illegal trade was also suspected to occur as a result of the 1997 EU Regulations that prohibited the legal import of conch to Martinique. No information is available as of 1996, when a morphometric study reported only weight, lip thickness, and shell length of harvested specimens (CITES 2012).

6.28 Saint Vincent and the Grenadines

There is little information available on queen conch populations in Saint Vincent and Grenadines (CITES 2012). Queen conch is primarily fished when the lobster season is closed (May 1 to August 31) although some fishers target queen conch year round. The Statutory Rules and Orders Act 1986, Part IV section 18, prohibits the possession of queen conch with a shell length of less than 7 inches (18 cm), or without a flared lip, or with a total meat weight of less than 8 oz (225 g) without digestive gland. The 1986 legislation also provides for the Ministry of Agriculture and Fisheries to implement a closed a season for the queen conch fishery (AC19 Doc 8.3, 2003, CITES 2012); although no information is available to suggest the closed season has been implemented.

In the late 1970s, the fishing area around Union Island was already depleted, and the rest of the fishery existed to support exports to Martinique (Brownell and Stevely 1981). Nearshore declines in other areas were observed in the early 1990s (Posada et al. 1997). In 1994, 34 mt of conch was landed with 16 mt exported. An arbitrary export quota was set in 2002 at 70 mt (CITES 2012). In 2003, the CITES reported that SCUBA was being used to target deep water populations along the Grenada Bank (CITES 2012; Isaacs 2012). Landings have fluctuated from 15 mt in 1990 to over 39 mt in 2011 (Isaacs 2012). An average of 30 mt is landed annually with 76% exported to the U.S., England, Trinidad, St Lucia and Barbados. No formal stock assessment has been undertaken. In 2008, a study was conducted that was designed to assess the current status of the queen conch fishery and its sustainability. The study showed that fishers considered queen conch to be smaller in size and less abundant which has led to harvest in deeper waters (CITES 2012). Currently, the average size of conch caught in the fishery is 425 g, and between 45-54 kg of conch can be caught in one fishing trip (Isaacs 2012).

6.29 Trinidad and Tobago

High demand in neighboring Trinidad was causing overfishing in Tobago and forcing fishers into deeper waters areas in the 1970s. Later in the 1990s, both Trinidad and Tobago had depleted populations (CITES 2012). A 2010 technical report Georges et al. (2010) found that the majority (71%) of Tobago fishers interviewed reported observed declines in queen conch abundance. All fishers stated that empty conch shells discarded at sea were responsible for “driving live conch away from near shore areas to further out to sea” (CITES 2012). A 2010 estimate of annual harvest suggested that 4-9 mt of uncleaned meat was harvested in Tobago (Georges et al. 2010; CITES 2012). According to Georges et al. (2010), there is no management of the conch fishery or regulations pertaining specifically to conch harvesting or sale. There are also no fishery landings or sales records for conch meat or shells in Tobago and there is no commercial export, although shells purchased by tourists presumably leave the island as personal effects (CITES 2012). The main island of Trinidad does not have a queen conch fishery likely due to low salinities and high turbidity associated with continental rivers and streams (CITES 2012).

6.30 Turks and Caicos

The queen conch fishery is the second largest fishery in the Turks and Caicos, generating approximately USD $3.8-5 million annually (DEMA 2012). The main market of exports is the United States, although efforts are underway to expand to European markets (DEMA 2012). The fishery has undergone a rapid expansion in recent years. Subsequently the status of queen conch populations have been exacerbated by an increased fishing pressure, combined with habitat degradation, and 2 major hurricanes which have contributed to the depleted status of nearshore populations (DEMA 2012).

The Department of Environment and Maritime Affairs (DEMA) manages the conch fishery with a combination of legislation, quotas, and an export closed season. Regulatory measures include a minimum shell length of no less than 18 cm, or a meat weight of no less than 225 g, and all conch landed must have a flared lip. The uses of SCUBA and hookah gears are also prohibited. In 2000, a closed season to exports (July 15 through October 15) was established, although queen conch can still be consumed locally during the closed season (DEMA 2012). Accurate figures pertaining to local consumption are difficult to determine; however, the rate of local consumption has increased with tourism (DEMA 2012). Queen conch harvest is prohibited in the Admiral Cockburn Land and Sea National Park and in the East Harbor Conch and Lobster Reserve. Both protected areas are located in south Caicos (CITES 2012). Data used to manage the fishery included a TAC based on calculated maximum sustainable yield (MSY), CPUE, and landings data (Clerveaux and Vaughn 2003). The TAC is currently set at 50% of MSY until population surveys can be conducted (DEMA ,2012). During the queen conch working group conference held in Panama City, Panama, in October 2012, the Turks and Caicos (DERM 2012 ppt) presented information on their yearly quotas from 2004 to 2011 (Table 13).

Table 13: Queen conch quotas and landings from 2005 to 2011 (DEMA 2012 ppt).

Year	MSY	Assessment Include local consumption	Suggested Quota SAC by % MSY	Quota	Landings (uncleaned)	Export (Clean Filet)
2004	1,674,990	No	1,423,741 (85%)	1,507,491(90%)	1,500,008	601,476
2005	1,678,315	No	1,426,567 (85%)	1,510,399 (90%)	1,488,171	590,559
2006	1,717,970	No	1,528,993 (89%)	1,528,993 (89%)	1,501,831	611,548
2007	2,057,586	Yes	1,444,874 (70%)	1,606,743 (79%)	1,606,911	643,164
2008	1,758,587	No	1,442,041 (82%)	1,606,743 (92%)	1,604,967	606,626
2009	2,032,969	Yes	1,5557,660 (77%)	1,600,000 (79%)	1,666,413	613,732
2010	1,685,895	No	No Recommendation	1,600,000 (95%)	636,875	125,550
2011	1,628,963	No	943,000 (58 %)	1,300,000 (80%)	823,239	200,096

Queen conch harvest has been recorded in Tucks and Caicos since the 1800s. Until the 1960s, conch were taken in waters less than 7 m using a conch rake. The conch rake was replaced by free diving in the 1970s and 1980s as vessels changed from wood to fiberglass, engines improved and people and product could travel farther. Prices rose from $.06 per conch in 1960 to $.18 per conch in 1978 and in 1973 frozen exports to the United States began. Queen conch for export are removed from shell at sea, and delivered to 1 of 5 processing plants in either Providenciales or South Caicos (Tewfik and Béné 2000).

Data include catch data from 1887, landings data from 1901, and effort data from 1974. This long term data set includes declines where fishers have had to travel farther in the last few decades to maintain catches (Medley and Ninnes 1999). It is important to consider effective versus nominal effort in the queen conch fishery in Turks and Caicos. For example, effective effort was increasing in 2003 while nominal effort remained the same as lobster stocks were declining. Declining lobster stocks mean that more fisherman are targeting conch, and increase in effective effort means that more effort is being exerted, but computer models are not able to reflect this using the constant nominal effort data (Olsen 1985; Berg and Olsen 1989; Clerveaux and Vaughn 2003).

From 1975 to 1984, 40% of conch imports into Miami, FL were from the Turks and Caicos (Berg and Olsen 1989). Catches in 1990-1994 were quite high, and showed a recovery from the low catches recorded in 1989 (Posada et al. 1997). In 2007, the conch stocks in the Turks and Caicos were considered by the CITES to be of least concern and one of the last healthy populations of conch in the Caribbean (Lockhart et al. 2007). However, the last visual survey, completed in 2001 is dated (DEMA 2012). Increased market demand, habitat degradation, and 2 hurricanes (Ike and Hannah) are believed to be the cause if declining catches from 2008 to the present (Figure 20) (Wood 2012; Haughton 2012; DEMA 2012).

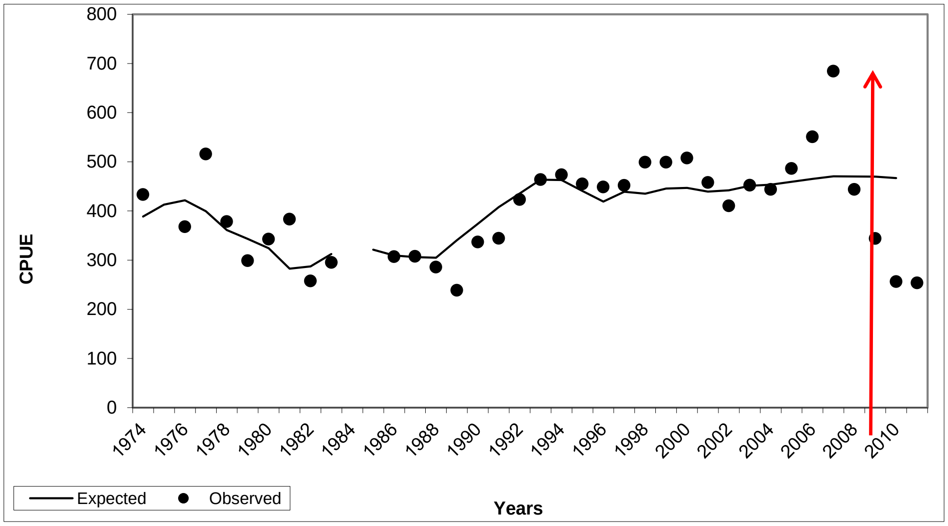

Figure 20: Observed decline queen conch catch post 2008 hurricanes (DEMA 2012 ppt)

The market for conch shell has been developing over the past few years, primarily with an export market to China. The conch shell quota has been set at one million pieces, which is consistent with the current quota for landed meat (362 mt).

Queen conch in the Turk and Caicos Islands are exposed to large-scale poaching operations from neighboring Hispaniola. These poaching enterprises usually involve a "mother ship," with several smaller dingy-type vessels that branch out along the edge of the Turks and Caicos banks. These ships can carry several tons of poached seafood products back to their country of origin. As of August 2012, steps have been made to control poaching by introducing a new satellite monitoring program to detect foreign vessels which is functioning (Wood 2012; DEMA 2012).

6.31 U.S. Virgin Islands

With the exception of Lang Bank, St. Croix, conch fishing in federal waters of the U.S. Caribbean was prohibited in 2005. The possession of queen conch in the U.S. EEZ is prohibited, except in the area east of 64°34' W longitude which includes Lang Bank east of St. Croix, U.S. Virgin Islands, during November 1 through May 31 (50 CFR 622.33). In territorial waters, the U.S. Virgin Islands (U.S.V.I.) set a 50,000 lbs (22 mt) annual quota for St. Croix in 2008. There is also an annual quota limit of 50,000 lbs (22 mt) for St. Thomas/St. John territorial waters. When the U.S.V.I. closes territorial waters off St. Croix to the harvest and possession of queen conch, the queen conch harvest in Lang Bank is also closed (see 50 CFR 622.33).

The commercial trip limit for the harvest of queen conch in U.S. Caribbean federal waters was modified in 2013 to be compatible with the trip limit in territorial waters. The new commercial trip limit for the harvest of queen conch in federal waters off St. Croix is 200 queen conch per vessel per day, instead of the previous 150 queen conch per fisher per day. The purpose for establishing the new trip limit is to facilitate enforcement efforts. Recreational harvest was not changed and remains at 3 conchs per person per day, or if more than 4 persons are aboard, 12 per vessel per day. In territorial waters, the recreational bag limit is 6 conchs per person per day and no more than 24 per vessel per day.

Regulatory measures include a size limit of 9 inches (22.9 cm) in length, and the shell lip must be at least a 3/8 inch (9.5 mm) thick. Conch is required to be landed alive and whole in the shell; the removal of meat out of shell in at sea is prohibited. Harvest of queen conch in both Federal and territorial waters is prohibited between June 1 and October 31. Possession of queen conch meat during the closed season is illegal. SCUBA and hookah gears are not prohibited in territorial waters and SCUBA gear is not prohibited in Lang Bank.

The queen conch fishery in the U.S.V.I. is composed of different populations around the 3 islands; St Thomas, St John, and St Croix. SCUBA has been used to harvest queen conch since the 1970s, which indicates that shallow waters stocks were reduced even then (CFMC 1999). The fishery targeted the 15-30 m depth range, as only a limited number of juveniles were available in the shallow areas. In 1983, the overall density of conch for the entire U.S.V.I. ranged between 2-10 conch/ha (Wood and Olsen 1983). The St. Thomas and St. John stocks were considered seriously depleted since the 1970s (Wood and Olsen 1983). The fishery in St. Thomas and St. Johns was closed from 1987-1992 because of depleted stocks, but when reopened in 1992, no changes were made to the management protocol and the fishery was again depleted very quickly (Posada et al. 1997). Subsequently, the fishery was closed again from 1992-1995 (García-Moliner 2012). The overall density in St. Croix was 24.79 conch/ha in 1998, and a significant portion of the catch is juveniles below the legal size limit (Table 15).

Table 14: Proportion of conch harvest that was below the U.S.V.I. legal size (CFMC 1999).

%	1986	1994	1995	1998
Shell Length*	48.0	59.0	80.0	74.3
Lip Thickness**	89.3	-	78.8	94.0

* Minimum size = 228.6 mm

** Minimum size = 9.5 mm

Gordon (2010) conducted the most recent survey of queen conch in the U.S.V.I. Results from this survey found higher densities of queen conch for all the island groups, estimated densities for common transects from previous studies were lower than those observed in 2008 and 2010. Queen conch were found at 80% of the sites surveyed. The population was composed of mainly juveniles (greater than 50%) with the other part of the population spread evenly among the older age classes; this age class structure represents successful recruitment. The overall density among the 3 islands was 234.1/ha with an island specific density of 583.4 conch/ha (St. Thomas), 158.5 conch/ha (St. Croix), and 73.7conch/ha (St. Johns). These higher densities are partly due to the inclusion of new survey sites on St. Thomas and St. Croix. Overall average density without the new sites included was 124 conch/ha. St. Croix and St. Thomas had 135 conch/ha and 159 conch/ha, respectively (Gordon 2010). Overall queen conch density by depth for survey transects suggested high density values at all depth strata, except the 19-24 m range (Gordon 2010). Conch densities by depth indicate that juvenile conch density declined with depth, while adult densities increased by depth (Gordon 2010). The results of the most recent surveys show that queen conch densities at all the island groups were higher in 2008-2010 than in previous survey years (Wood and Olsen 1983; Boulon 1987; Friedlander et al. 1994; Friedlander 1997; and Gordon 2002).

Despite these high densities, commercial catch in St. Croix has been recorded at twice the estimated sustainable level since 2000 (Table 16). According to monthly commercial landing reports, St. Croix consistently harvests more queen conch than St. Thomas and St. Johns (Table 15). Exceeding the maximum sustainable yield in St. Croix for so long with no apparent negative consequences indicates that MSY is potentially underestimated (García-Moliner 2012). Gordon (2010) indicates that, “the regulations in place in the U.S. Virgin Islands appear to be effective and a good precautionary measure.”

Table 15: Total queen conch landings (lbs) from Division of Fish and Wildlife commercial catch reports. St Thomas (STT), St. Johns (STJ), and St. Croix (STX)

Fishing Year	STT/STJ	STX	U.S.V.I.
1995-96	2,899	25,773	28,672
1996-97	1,527	40,405	41,932
1997-98	1,300	68,898	70,198
1998-99	1,422	55,016	56,438
1999-00	941	57,294	58,235
2000-01	1,669	101,720	103,389
2001-02	2,654	127,367	130,021
2002-03	3,037	105,327	108,364
2003-04	2,150	126,096	128,246
2004-05	444	136,265	136,709
2005-06	3,325	244,226	247,551
2006-07	1,869	196,628	198,497
2007-08	888	83,033	83,921
2008-09	1,195	97,849	99,044

6.32 Venezuela

The commercial conch fishery in Venezuela is conducted almost exclusively in the insular region, with the archipelagos of La Orchila, Los Roques, Los Testigos, and Las Aves all had significant conch densities (Schweizer and Posada 2006). Until the mid-1980s, queen conch were predominantly harvested in Los Roques Archipelago. Studies of the conch population around Los Roques in the 1980s (Laughlin et al. 1985) showed the population to be severely overfished, and subsequently the Los Roques Archipelago conch fishery was closed in 1985. However, despite this closure high landings continued (e.g., 360 mt in 1988) and in 1991, the entire fishery in Venezuela was closed (CITES 2003). Despite the closure, 4 mt was exported in 1998 (Schweizer and Posada 2006). In 1999, high pressure from fisherman caused the fishery to be re-opened, and survey of abundance was conducted (CITES 2012). Information on the status of queen conch populations from that survey indicated 60% of the population were adults, but overall mean density were very low (18.8 conch/ha) (Schweizer and Posada 2006). The fishery was closed again in 2000 and remains closed (CITES 2012). Illegal fishing from Venezuelans and other nations is reported, and this is hypothesized to be the cause of the lack of population recovery (CITES 2003).

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8. Appendix 1

Summary of current queen conch fisheries regulations as summarized from CITES (2012) and updated with most current information from individual countries presentations at the Queen Conch Working Group meeting in October 2012 in Panama (www.strombusgigas.com). If there are no regulatory measures "none" was filled in. Size and weight columns are minimum size and minimum weight regulations. MC = market clean weight, D = without digestive gland, P = processed weight. An asterisk "*" that accompanies text means that prohibition is only implemented within a protected area or marine reserve.

Country	Relevant Legislation	Size (Shell Length)	Weight (g)	Closed Season	SCUBA	Hookah	Lip (thickness)
Antigua and Barbuda	Fisheries Act, No.14 of 1983 and the Fisheries Regulations, No.10 of 1990,	18 (cm)	225 (D)	1 July-31Augest	none	none	Flared lip (5 mm)
Aruba	Closed fishery (since 1987)	Fishery closed	Fishery closed	Fishery closed	Fishery closed	Fishery closed	Fishery closed
Bahamas	Fisheries Regulations of 1986	none	none	1 April – 31 July	Prohibited	*Permit only	none
Barbados	No regulation	none	none	year round harvest	none	none	none
Belize	Fishery Regulations of 2005	7 inch	85 (MC)	1 July-30 Sept	Prohibited	none	none
Brazil	No information	unknown	unknown	unknown	unknown	unknown	unknown
Bermuda	Closed fishery (since 1978)	Fishery closed	Fishery closed	Fishery closed	Fishery closed	Fishery closed	Fishery closed
British Virgin Islands	Fisheries Regulations of 2003	7 (inch)	226	1 June- 30 Sept	*Prohibited	none	Must have flared lip
Caribbean Netherlands (Bonaire)	Island Resolution Containing General Provision. Fishing by permit only. In 2012 moratorium on issuing permits,	18 (cm)	225	none	none	none	none
Caribbean Netherlands (Saba)	Commercial fishery closed. Opened to domestic consumption only.	19 (cm)	none	none	Prohibited	Prohibited	Must have flared lip
Caribbean Netherlands (St. Eustatius)	Marine Environment Ordinance St. Eustatius	19.5 (cm)	none	none	none	none	Must have flared lip
Cayman Islands	Marine Conservation Law and Regulation of 1978 Amended in 2002; 2007	none	none	1 May-31 Oct	Prohibited	Prohibited	none
Costa Rica	Closed Fishery (Since 1989)	Fishery closed	Fishery closed	Fishery closed	Fishery closed	Fishery closed	Fishery closed

Country	Relevant Legislation	Size (Shell Length)	Weight (g)	Closed Season	SCUBA	Hookah	Lip (thickness)
Colombia	General Fisheries Statute, Act 13 of 1990 and its Regulatory Decree 2256 of 1991	none	100 (MC)	1 June-31 Oct	Prohibited	Prohibited	none
Cuba	Decree-Law 164 (Fishing Regulations) 1996; Resolution 87 of 1996 (CITES Regulations); Decree-Law 200 of 2000 for environmental breaches; Resolution 220 of 2008; Resolution 160 of 2011 (Declared species of special significance in Cuba)	none	Meat allowed to be extracted at sea	1 May-30 Sept	Prohibited	Prohibited	Flared lip 10 (mm)
Dominican Republic	Law 64-00, Decree 833-03 of 2003, Law 307 of 2004. CITES moratorium was imposed since2003, lifted in 2012.	25 cm	none	1 July-31 Oct	none	none	none
Florida	Fishery closed (since 1986)	closed	closed	closed	closed	closed	closed
Grenada	CITES Trade Suspension (since 2006)	18 (cm)	225	none	none	none	Must have flared lip
Haiti	CITES Trade Suspension (since 2003)	none	none	none	none	none	none
Honduras	Commercial fishery closed since 2003; Domestic consumption prohibited since 2005. Harvest for scientific surveys 210 mt annually.	none	none	none	none	none	none
Jamaica	Fishing Industry Act of 1975; 1976	None	None	31 July -1 Feb (Commercial only)	Prohibited	none	None
Martinique	Regulation 994296	22 (cm)	250 (D)	none	Prohibited	none	none
Mexico	Unknown	Yes (size unknown)	none	Yes (season unknown)	none	none	none
Montserrat	Unknown						
Nicaragua	Decree DGRN-PA-No 407-05 of 2005	20 (cm)	172 (P)	1 June-30 Sept	none	none	Flared lip (9.5 mm)
Panama	Unknown	none	none	none	none	none	none
Puerto Rico	Reglamento de Pesca de Puerto Rico 2010 No 7949	22.9 (cm): not required to be	none	1 Aug-31 Oct	Prohibited in Federal waters	Prohibited in Federal waters	Flared lip (9.5 mm)

Country	Relevant Legislation	Size (Shell Length)	Weight (g)	Closed Season	SCUBA	Hookah	Lip (thickness)
		landed in shell			only	only	
St Kitts/Nevis	Fisheries Regulation No 11 of 1995	18 (cm): not required to be landed in shell	225 (D)	None	Authorized permit only	Authorized permit only	Must have flared lip
St Lucia	Fisheries Regulation No 67 of 1987; No 9 of 1994	18 (cm)	280 (D)	None	None	None	Must have flared lip
St Vincent/Grenadines	Statutory Rules and Orders Act Part 4 Sec 18 of 1986	18 (cm)	225 (D)	Year round harvest	none	unknown	Must have flared lip
Trinidad and Tobago	No regulations	none	none	none	none	none	none
Turks and Caicos	The Fisheries Protection Ordinance	18(cm)	225 (D)	15 July-15 Oct (closed export only)	Prohibited	Prohibited	
US Virgin Islands	78 FR 5617; 50 CFR 622.33	22.9 (cm)	none	Federal (1 Nov-May 31); Territorial (June 1 - October 31)	Authorized in territorial waters; Prohibited in Federal waters	Authorized in territorial waters; Prohibited in Federal waters	Flared lip (9.5 mm)
Venezuela	Fishery closed (since 2000)	closed	closed	closed	closed	closed	closed