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United States Virgin Islands Queen Conch Stock Assessment

Executive Summary

Conch stocks have been periodically surveyed in the U.S. Virgin Islands. Previous conch scooter transect surveys were completed in 1981, 1985, 1990, and 1996. In 2001, a follow-up queen conch scooter transect survey study was completed. The objective of this study was to determine the status of conch stocks, assess the effectiveness of management regulations, and make management suggestions.

During this study, conch densities, particularly adults, were higher on scooter transects around St. Thomas compared to St. John. Overall conch densities around St. Croix were higher than St. Thomas and St. John. Mean juvenile conch densities for all transects common to all sampling years ranged from 1.0 juvenile conch/ha on St. Thomas to 72.3 juvenile conch/ha on St. Croix. St. John had 7.5 juvenile conch/ha. Mean adult conch density for all common transects was similar on St. Thomas (24.2 adult conch/ha) and St. Croix (27.4 adult conch/ha), but much lower on St. John (7.2 adult conch/ha).

Both adult and juvenile conchs were more abundant on algal plains and seagrass beds than other benthic habitats. Maximum adult conch densities were found in the 13 to 18 m depth range for common transects around St. Thomas and St. John. In St. Croix, the highest mean adult densities were found in the 19 to 24 m depth range. In general, there was a decrease in juvenile conch with increasing water depth.

Results of this study were compared with previous studies. Between 1996 and 2001, there was a substantial decrease in overall queen conch densities for common transects in St. Thomas. Between 1981 and 2001, there was also a substantial decrease in overall queen conch densities for the 9 common transects common to all survey years for St. John. This decline occurred despite current bag limits, minimum size limits, and seasonal closure. Over the past two decades, St. Croix had higher overall queen conch densities than either St. Thomas or St. John. Compared to previous years, juvenile conch densities in 2001 were much lower on St. John and St. Thomas. Low juvenile conch densities may reflect the lack of successful recruitment, patchy distribution of the species, and/or more importantly intensive fishing pressure.

It is recommended that surveys in deeper water (>24m) be conducted in the future. These depths have not previously been surveyed. In order to obtain a more complete picture of the status of conch stocks, these depths need to be surveyed. Other management recommendations include more public education, additional resource surveys and restoration efforts, and stricter enforcement.

INTRODUCTION

The queen conch, *Strombus gigas*, is a large gastropod that has great economic significance throughout the Caribbean and adjacent regions (Appeldoorn 1994a). According to Appeldoorn (1994a), from 1988 to 1991 (four years) landings of queen conch throughout the Caribbean region were on the order of 4,000 metric tons (mt) of conch meat with a potential value of US $ 40,000,000. The high market value for conch makes the resource an important source of foreign exchange, either through domestic sale within the tourist industry or through export. Accessibility, ease of harvest, and high demand has resulted in generally overfished stocks around the Caribbean.

The populations of queen conch around St. Thomas, St. John, and St. Croix, U.S. Virgin Islands were recognized as seriously depleted by the late 1970's (Wood and Olsen 1983). By the early 1980's queen conch harvest had exceeded sustainable yield around St. Thomas, St. John, and St. Croix, U.S. Virgin Islands (USVI) (Wood and Olsen 1983). Declines in landings were also reported by the CFMC (1988).

In response to severe overfishing of conch in St. Thomas/St. John District, the USVI government established a 5-year moratorium on the harvest of queen conch on St. Thomas/St. John beginning February 1988 (Friedlander 1997). Based on the results of 5 year closures conducted in Cuba and Bonaire (Munoz et al 1987), a 5-year closure was considered an appropriate time period to enhance stock size in the Virgin Islands. Unfortunately, there were no comprehensive surveys of queen conch populations at the end of the moratorium to determine if the closure was successful in enhancing the population size of queen conch. Also, after the USVI moratorium was lifted in 1992, there were no restrictions on conch harvest for two years. During the period of no restrictions, heavy fishing pressure was reported on conch stocks throughout the northern USVI (Friedlander 1997).

On 12 July 1994 USVI regulations on conch were approved establishing a closed season from July 1 to September 30 each year, a limit on the number of conch landed, a size limit, and a requirement to land conch whole and in the shell (VIRR 1994, see also CFMC 2001). The requirement to land conch in the shell created extensive controversy on St. Croix as conch shells piled up at landing sites and on beaches. However, this was considered the only way of effectively enforcing size regulations. Because of the controversy and lack of enforcement, regulations are often ignored, particularly on St. Croix where there is a fairly substantial conch fishery in comparison with St. Thomas/St. John.

The U.S. Virgin Islands landed approximately 15 mt (30,000 kg) of conch in the year 1990 (Appeldoorn 1994a). USVI commercial catch reports indicate that there is only a small commercial fishery for queen conch in St. Thomas and St. John ranging from 225.5 to 3,138 kg between the July 1993 to June 1994 and July 2000 to June 2001 fishing years (DFW data files). In St. Croix, reports indicate that conch landings doubled from 35,572 lb in July 1993 to June 1994 to 72,902 lb in July 1997 to June 1998 (Table 1).

The United States Virgin Islands encompasses three major islands: St. Thomas, St. John, and St. Croix, as well as several offshore keys (see Figure 1). The territory as a whole consists of a variety of habitats including fringing and patch reefs, mangrove lagoons, seagrass beds, carbonated pavement, sand plains, and algal plains (Dammann and Nellis 1992). Available conch habitat in the USVI is mainly limited to waters of the surrounding shallow insular shelf platform (Appeldoorn 1987). The approximate size of this habitat was established to be 34,300 ha for St. Croix and 162,925 ha for St. Thomas and St. John (CFMC 1999). Within many of the surrounding bays, seagrass beds and algal plains provide habitat to both adult and juvenile queen conch.

Over the last 20 years, the Division of Fish and Wildlife conducted visual surveys in order to monitor the status of the U.S. Virgin Islands conch stock. Repeated sampling at selected sites can indicate trends in stock condition over time. Estimates of conch abundance around St. Thomas, St. John, and St. Croix were previously conducted in 1981 (Wood and Olsen 1983), 1985 (St. John only; Boulon 1987), 1990 (Friedlander et al 1994), and 1996 (Friedlander 1997).

OBJECTIVES

The objective of this project is: (1) to provide baseline information on the population status of queen conch in a variety of critical marine habitats in USVI; (2) to provide time series information on changes in the USVI queen conch population; (3) to monitor queen conch populations in marine reserve areas and other protected habitats, and (4) to collect, analyze, manage and disseminate fisheries independent data on the queen conch resources in the USVI.

METHODS

Study Sites

In 1981, an initial 22 transects located around the islands of St. Thomas and St. John were surveyed to determine the density and size distribution of queen conch (St. Thomas=10 transects, St. John=12 transects) (Wood and Olsen 1983). An additional site (Saba Island) was added to the St. Thomas transect list in 2001 because juvenile conch appeared to be abundant at this site (based on DFW staff observations). For 2001, a total of 11 sites were surveyed in St. Thomas, and 12 sites were surveyed in St. John (Figure 1 and Table 2).

There were also 22 original sites around the island of St. Croix in 1981 (Wood and Olsen 1983). In 2001, only the first 16 of the original 22 transects were resurveyed because of limited study time (Figure 1 and Table 2).

Scooter transects

Queen conch abundance and density estimates were derived from visual surveys conducted along transects by two scuba divers using SCUBAPRO (Seaglider & Sea Shuttle) and DACOR underwater scooters. Global position satellite (GPS) coordinates from previous studies conducted in 1990 (see Friedlander et al 1994) and in 1996 (see Friedlander 1997) were used to locate the beginning point of each survey line (Appendix 1). At the start of each site a diver was deployed with a line attached to a buoy. The buoy was used for tracking the divers, and indicating the starting and ending point of each transect so that GPS coordinates could be recorded (from the boat). A Wide Area Augmentation System (WAAS) Garmin GPS (GPSMAP 76) was used to increase accuracy from ±30 m with a standard GPS unit to ±3 m (GARMIN Corporation 2001).

Two divers performed each transect. One diver drove an underwater scooter and followed a fixed compass heading recorded in previous USVI transect studies (Friedlander 1997) for a period of at least 30 minutes depending on scooter battery life, underwater conditions, and conch abundance (time needed to measure each conch). This diver also towed a buoy on a line so that the support vessel could track the movement of both divers. A second diver on another scooter was responsible for recording data (see data recording on scooter transect section below).

At the completion of a transect, the diver carrying the marker buoy weighed it down with a dive weight and both divers surfaced. At this point the support vessel recorded the GPS coordinates at the location of the marker buoy indicating the end of the transect line. Transects were conducted during the same time of year (summer months) as those performed in previous surveys (Friedlander 1997, Friedlander et al 1994, Boulon 1987, and Wood and Olsen 1983) to reduce seasonal variability between surveys. Dives did not exceed the no-decompression limits.

Data recording on scooter transects

Transect time was typically about 30 minutes. During each survey, the scooter was kept approximately one meter above the substrate. Divers focused on a width of 2 meters to either side of the scooter path (4 meters). The total distance covered by scooters ranged from 0.1 to 1.5 km. The differences in distances are attributed to the time required to stop and measure conch, as well as suitability of the dive conditions. Underwater visibility, current, and scooter battery life were factors that limited survey time. In areas with no conch, divers did not stop and scooters were operated continuously. In areas with abundant conch, divers stopped while each conch was measured.

As stated above, the first diver maintained compass bearings with the lead scooter. The second diver recorded the transect start and stop times and depths, depth and time of each habitat change, habitat type, and length and lip thickness of each conch were measured and recorded. The first diver also assisted in spotting and gathering the conch for measurements.

Conch length measurements were taken from the apex of the spire to the end of the siphonal notch. Measuring procedures are based on Appeldoorn (1994b). The length of the individual conch was measured to the nearest cm (Friedlander 1997) with an underwater ruler. Lip thickness of adult conchs was measured in the mid-lateral region of the shell with a caliper to the nearest mm. Based on these lip measurements, conch maturity could be determined (see below).

The habitats observed were categorized into six major habitats: (1) unconsolidated sediment (sand or mud with <10% submerged vegetation); (2) coral reef; (3) colonized pavement; (4)

rubble; (5) seagrass (continuous seagrass: 90% to 100% cover; patchy seagrass: 10% to <90% cover); (6) algal plain (continuous macroalgae: 90%-100% cover; patchy macroalgae 10% to <90% cover). This benthic habitat classification is based on NOAA's National Ocean Service (NOS) habitat classification (NOS 2000, Appendix 2).

Conch maturity categories

Conchs were separated into five maturity categories based on Appeldoorn (1992, see also Appendix 3):

- Stage 0 (juveniles) – any conch without flared lip;
- Stage 1 (newly mature adult) – lip thickness 4 to 7 mm, shell clean;
- Stage 2 (sexually mature adult) – flared lip fully formed, little to no erosion on Shell, periostracum tan, lip thickness 8 to 15 mm;
- Stage 3 (old adult) – outer lip starting to erode, periostracum starting to erode, lip thickness 16 to 33 mm;
- Stage 4 (very old adult = roller) – lip very thick and square, heavy erosion present, lip dark rose to platinum gray in color, lip thickness 34 to 59 mm.

2001 Data analysis

The length of each transect was obtained by calculating the distance between the WAAS GPS coordinates of the beginning and end points of each transect. By using the length of transect and time taken to perform each transect, the average speed was calculated in meters/minute. Total area for each transect was calculated by multiplying the length of each transect by the transect width (4 meters). Total areas surveyed are presented in Appendix 4.

Five depth ranges were selected: (a) 0 to 6 m, (b) 7 to 12 m, (c) 13 to 18 m, (d) 19 to 24 m, and (e) 25 to 30 m. Depths were rounded to the nearest whole number. For example, if a depth was recorded at 6.4, then it would be in depth range (a).

If the entire transect depth was within a single depth range (as specified above), then the entire transect length was assigned to that single depth range. However, when the depth in a single transect line changed between different depth ranges (as specified above), then the time duration between recording events (for habitat change or conch occurrence) was divided by the number of different depth ranges that had been encountered (for two depth ranges, time duration was divided by two (=number of depth ranges encountered)). The quotient is then multiplied by speed to estimate the length of the depth range. The area of a depth range is then calculated by multiplying the length of the depth range by the width (4 m).

Calculating areas for each habitat type were simpler than those for the five depth ranges (see above paragraph). When the habitat in a transect line changed, time was recorded. For each transect habitat, the total time in a habitat was calculated (end time minus start time in a single habitat). Total time in a habitat was then multiplied by the estimated scooter speed to get the total transect length within a single habitat. Once lengths of each habitat were calculated, then area for habitat could be calculated by multiplying the length times width (4 m).

Overall conch densities were calculated by summing the number of conch observed per transect divided by the total area of each transect. Size class densities (adult and juvenile conch) were also determined. Conch densities for each habitat were derived by dividing the number of conch per habitat type by the total area of habitat type per transect. Densities based on depth were calculated by determining the number of conch in each depth range divided by the total area for each depth range in square meters.

Length (juvenile and adult) and age (adult) frequencies were determined. Differences in density or abundance by habitat, depth, or location were analyzed.

RESULTS

2001 Conch densities on scooter transects (including Saba Island, St. Thomas)

A total of 244 queen conch were observed on scooter transects around the USVI conducted in 2001 (Table 3)**.** Nearly 63% of all conch encountered were found around the island of St. Croix although more area was sampled around St. Thomas and St. John combined.

Average densities of adult conch off St. Thomas (24.0 adult conch/ha) were noticeably higher than from St. John (7.2 adult conch/ha). Densities of adult conch varied from 115.9 adult conchs/ha around Water Island, St. Thomas to 0.0 adult conchs/ha found on 14 transects around both St. Thomas and St. John (Figures 2 and 3). Two Brothers, St. John (73.3 adult conch/ha) along with Lindquist Beach, St. Thomas (51.6 adult conch/ha) and West End (57.9 adult conch/ha) had high numbers of adult conch relative to the other survey sites. Saba Island, St. Thomas (a new site added in 2001) had both the highest juvenile conch per hectare and total conch per hectare (284.1 conch/ha) among all survey sites for St. Thomas and St. John in 2001 (Figures 2 and 3).

The densities of adult and juvenile conch in St. Croix differed greatly from St. Thomas and St. John (Table 4). Densities of adult conch in St. Croix varied from 127.7 adult conchs/ha at site 9 to 0.0 adult conch/ha found on 7 of the 16 transects (Figure 4). In St. Croix, the average density of juvenile conch (72.3 juvenile conch/ha) was much greater than that of adult conch (27.4 adult conch/ha). Juvenile densities ranged from 487.0 juvenile conchs/ha to 0.0 juvenile conchs/ha found on 8 of the 16 sites surveyed.

St. Thomas' average conch densities for all transects including those transects common among years and the Saba Island transect were 24.0 adult conch/ha and 27.5 juvenile conch/ha. St. Johns' average conch densities were 7.2 adult conch/ha and 7.5 juvenile conch/ha. On St. Croix, juvenile conch density (72.3 juvenile conch/ha) was nearly three times the density of adults (27.4 adult conch/ha, Figure 5).

2001 Comparisons of densities inside and outside VINP

Of the 12 scooter transects conducted around the island of St. John, six transects (Figure 1 and Table 2) were within the Virgin Islands National Park (VINP). The mean density of adult conch on these transects was 0.0 adult conch/ha (VINP) compared to 14.5 adult conch/ha for the remaining transects around St. John (outside VINP). The mean density of juvenile conch respectively was 10.5 juvenile conch/ha (VINP) and 4.5 juvenile conch/ha (outside VINP). Both sets of transects had high variances due to many transects with zero conchs. The coefficient of variation (CV=SD/mean) for VINP transects was 1.99 while the other locations around St. John had a slightly lower CV of 1.64. Of the 10 juvenile conch observed in VINP, 9 of them (90%) were found on the single transect in Lameshur Bay. No adult conchs were found in VINP. Two Brothers (6 adults) followed by Turner Bay (1 adult) had the only adults observed on all transects.

Comparison of densities for common transects around St. Thomas and St. John between 1996 & 2001 surveys (not including Saba Island, St. Thomas)

In 1996, for common transects around St. Thomas, mean density of adult conch (32.2 adult conch/ha) and juvenile conch (31.5 juvenile conch/ha) was greater (Friedlander 1997) than 2001 (24.2 adult conch/ha; 1.9 juvenile conch/ha). This difference in density between 1996 and 2001 is due almost exclusively to the increased number of transects with zero conchs in 2001 compared with 1996. In 1996 around St. John, density of adult conch was greater (14.7 adult conch/ha) than 2001 (7.2 adult conch/ha), while density of juvenile conch in 1996 (4.1 juvenile conch/ha) was less than that of 2001 (7.5 juvenile conch/ha) (Tables 3 and 4, see Friedlander 1997).

The average density of conch for St. Thomas and St. John was lower in 2001 (2001=19.9 conch/ha; 1996=39.2 conch/ha (Friedlander 1997). Again, the difference in density is due to the absence of conchs observed on most transects in 2001. In 1996 there were fewer transects with 0.0 conch/ha (Tables 3).

Comparison of densities for St. Thomas and St. John among all survey years

In St. Thomas, USVI, data on adult conch densities were only available for 1990 (Friedlander et al 1994) 1996 (Friedlander 1997), and 2001. In St. John, adult conch densities were compared for the nine transects common to all the survey years: 1981, 1985, 1990, 1996 and 2001. Juvenile data was not recorded for St. John in 1981 (Wood and Olsen 1983) and 1985 (Boulon 1987). Mean densities of adult queen conch in St. John were lower in 2001 compared to all other survey years: 1996 (Friedlander 1997), 1990 (Friedlander et al 1994), 1985 (Boulon 1987), and 1981 (Wood and Olsen 1983) (using only the nine transects common to all survey years, see Figure 6). These results are different from the previous comparisons among survey years because the Lameshur Bay, Two Brothers, and Mingo/Lovango transects are excluded from the analysis since they were not surveyed in 1985.

In a previous study, the high variance associated with conch surveys resulted in no statistical difference between surveys conducted in 1981, 1985, 1990, and 1996 using standard statistical techniques (Friedlander et al 1994). However, a Jonckheere test showed a continuous decline in abundance was significant (Friedlander 1997). Although not statistically tested here, there was a decrease in conch density from 82.7 conch/ha in 1996 to 40.7 conch/ha in 2001 for St. Thomas and St. John. However, density of conch in 2001 was one and a half times higher than conch density in 1990 (27.4 conch/ha). This fluctuation reveals the irregularity in conch stocks over time and the need for continued conch stock monitoring.

Conch density among the nine transects common to all survey years on St. John is still in decline or has not increased (Figure 6). Three additional transects were surveyed only in 1990 (Friedlander et al 1994), 1996 (Friedlander 1997), and 2001 (this study). Among these years, 1996 (Friedlander 1997) had the highest adult conch density with 14.7 adult conch/ha, followed by 1990 (Friedlander et al 1994) with 12.6 adult conch/ha, and 2001 with 7.2 adult conch/ha. However, in 2001 juvenile conch density in St. John was greatest (7.5 juvenile conch/ha), followed by 1996 (Friedlander 1997) with 4.1 juvenile conch/ha, and 1990 (Friedlander et al 1994) with 1.4 juvenile conch/ha (Figure 7).

Mean densities among survey years (1990, 1996, and 2001) around St. Thomas varied. In 1990 (Friedlander et al 1994), there were 11.8 adult conch/ha and 1.6 juvenile conch/ha. In 1996 (Friedlander 1997), the mean densities of adult conch were approximately three times higher (32.2 adult conch/ha) and juveniles were approximately 20 times higher (31.5 juvenile conch/ha). In 2001, there was a decline in mean adult density from 1996 to 24.2 adult conch/ha. In 2001 juvenile density in St. Thomas declined to nearly the 1990 level with a density of 1.9 juvenile conch/ha (Figure 8).

1981 vs. 2001 surveys for St. Croix

Surveys of conch abundance around St. Croix, USVI were only done in 1981 and 2001. In 1981 (Wood and Olsen 1983), conch data for all transects were lumped (only densities by habitat type were given). Therefore, there was no data specific to any of the 22 transects. Also, densities of only adult queen conch were provided. Furthermore, only transects 1 to 16 of the original 22 transects were resurveyed in 2001. Transects 17-22 were not surveyed. Average weighted density of adult conch in St. Croix in 1981 (Wood and Olsen 1983) was 7.6 adult/ha. This was dramatically lower than the average adult density in 2001 with 27.4 adult/ha (Figure 9).

In 2001, however, overall density (adults and juveniles) in St. Croix was 99.6 conch/ha (Figure 10). This high density is primarily due to a number of transects having very high densities of conch. For example 4 of the 16 transects had overall densities ranging from 195.5 to 502.7 conch/ha: sites 13 (502.7 conch/ha), 2 (296.6 conch/ha), 4 (224.4 conch/ha), 9 (212.9 conch/ha), and 16 (195.5 conch/ha). Site 13 had the highest juvenile density (487.0 juvenile conch/ha) among all transects (Figure 11).

Habitat types and preferences for St. Thomas and St. John

Algal plain and sand were the most abundant habitat types encountered around St. Thomas and St. John on scooter surveys in 1990 (Friedlander et al 1994), 1996 (Friedlander 1997), and 2001. In 2001, for 21 common transects around St. Thomas and St. John, algae constituted 36% of the total habitat and sand constituted 25% (Figure 12, see also Appendix 5). This was followed by seagrass (18%), coral reef (11%), rubble (9%), and pavement (1%). Hurricane Marilyn in 1995 did not appear to alter the habitat areas surveyed between 1990 and 1996 (Friedlander 1997).

There were noticeable differences in conch densities among habitat types. In 2001 for St. Thomas, seagrass had the highest density of queen conch, followed be algae and rubble (Figure 13). A similar pattern occurred in 1996 (Friedlander 1997). In 1990 (Friedlander et al. 1994), however, rubble had the highest density of queen conch, followed by seagrass, algae, sand, coral reef, and pavement In 2001, pavement was only recorded at one site on St. Thomas and nine sites on St. Croix (Appendix 5). In 2001 for St. John, queen conch was only recorded in seagrass, algae, and sand habitats (Figure 14, and Appendices 6 and 7). Queen conch densities at each site and each island are presented in Appendix 8.

Habitat types and preferences for St. Croix

Pavement and algae were the most abundant habitat types encountered around St. Croix on scooter transects in 2001, constituting 48% and 27%, respectively. All other major habitat types were similar in area surveyed (Figure 15). In 1981, the percentages of habitat surveyed were: algae (41%), followed by coral reef/pavement (26%), sand (18%), and seagrass (15%) (Figure 15, see Wood and Olsen 1983).

In 2001, algal habitats in St. Croix had the highest mean density of conch (113.5 conch/ha), followed by seagrass (94.0 conch/ha) then pavement (25.3 conch/ha) (Figures 16 and 17). When taking the error bars into consideration, there was only a small difference in conch density by habitat type for St. Croix (Wood and Olsen 1983, see also Figure 17).

Depth distribution for St. Thomas and St. John

In 2001, adult conch densities for the original 22 transects around St. Thomas and St. John were highest in the 13 to 18 m depth range (59.0 adult conch/ha, Figure 18). The lowest adult densities were found in the 7 to 12 m depth range (7.8 adult conch/ha) and in the 19 to 24 m depth range (16.7 adult conch/ha). This density distribution was very different for the depth distribution found on transects during the 1996 and 1990 surveys (Figures 19 and 20).

In 2001, juvenile conch showed a decrease in density with increasing depth, while juvenile densities increased with increasing depth for 1996 (Friedlander 1997, Figures 18 and 19). The highest juvenile densities in 2001 were found in the 7 to 12 m depth range (11.1 juvenile conch/ha) while the lowest densities were observed in the 13 to 18 m depth range (5.0 juvenile conch/ha). In 2001, no juvenile conchs were found in the 0 to 6 m, 19 to 24 m, and 25 to 30 m depth range (Figure 18). Contrary to these results, in 1996 the highest densities of juveniles were found at the deepest depth range (31.5 juvenile conch/ha, Figure 19, see Friedlander 1997). Average adult and juvenile queen conch densities by depth for St. Thomas and St. John in 2001 (only) can be seen in Figures 21 and 22 and Table 5. The total area surveyed at each depth range for St. Thomas and St. John is shown in Tables 6.

In 1990 (Friedlander et al 1994), total conch densities were lower at shallow depths (0 to 12 m) and higher at deeper depths (13 to 30 m, Figure 20). Total conch density by depth for common transects around St. Thomas and St. John in 1990, 1996, and 2001 is shown in Table 5.

Depth distribution for St. Croix

No depth data were available for St. Croix in 1981 (Wood and Olsen 1983). However, 2001 data shows that the highest mean adult densities were found in the 19 to 24 m depth range (28.9 mean adult conch/ha), while the lowest were found 7 to 12 m depth (12.5 mean adult conch/ha, Figure 23). There were no queen conch observed in the 0 to 6 m and 25 to 30 m depth range mainly because there were few transects that were completed at these depth ranges. Total area surveyed in each depth range for St. Croix is shown in Table 6.

Size and maturity categories for St. Thomas and St. John

The size distribution of queen conch on 2001 transects showed a bimodal distribution with one peak at 8 cm and a second at 20 to 23 cm (Figure 24). The 8 cm peak consists exclusively of juveniles. The 20 to 23 cm peak consists primarily of conch with a shell lip that is flared. The shell lip typically flares at 3 ½ years of age (Stoner and Ray 1996) and is a sign of the onset of sexual maturity. Typically conchs that are 3 ½ years of age have a shell length of 20 cm (Creswell and Davis 1991). There were at least 31 mature queen conchs of the 72 observed around St. Thomas (Figure 24) and 7 mature queen conchs of the 19 observed around St. John (Figure 25).

Individual conchs were placed into maturity categories based on shell characteristics (Appendix 3). In 2001, approximately 42% of all conch observed on scooter transects around St. John were juveniles (stage 0). The majority of the adults (40%) were stage 3 individuals that were older adults with the outer lip starting to erode, the periostracum starting to erode, and fouling of the shell occurring. A small percentage (11%) of very old (stage 4) adults were observed in St. Thomas. An even smaller percentage (7%) of newly mature adults (stage 1) was observed. Studies suggest the conch soon grow out of this category (Friedlander 1997).

In St. John, approximately 63% of all conch observed on scooter transects were juvenile (Figure 26). Most adult conchs were stage two (sexually mature) individuals. A small percentage (5%) of conchs was newly mature adults (stage 1). Also, there were no old (stage 3), nor very old (stage 4) adults observed (Figure 26). Shell length frequencies for St. Thomas/St. John in 1996 and 2001 are shown in Figure 27.

2001 size and maturity categories for St. Croix

Queen conch in St. Croix revealed a fairly uniform size distribution (see Figure 28). There were similar proportions of conch at all sizes. Forty-nine conchs of 153 observed around St. Croix were sexually mature (32%). Approximately 68% of all conchs observed on scooter transects were juveniles (stage 0). Among the adult conch, 25% were in stage one, 50% were stage two, 25% were stage 3, and 0% were stage four (Figure 29). Shell length frequencies for St. Croix in 1981 and 2001 are shown in Figure 30.

Shell length frequencies for the territory (St. Thomas, St. John and St. Croix) in 2001 are shown in Figure 31.

<u>DISCUSSION</u>

Comparison of queen conch densities among islands in the US Virgin Islands

During 2001, queen conch densities were higher on scooter transects around St. Thomas compared to St. John. The densities of queen conch observed at each survey site in St. Thomas and St. John in 1990, 1996 and 2001 are shown in Figures 32 to 50. Conch densities, particularly juvenile densities, were higher on scooter transects around St. Croix compared to St. Thomas and St. John (Figure 5). For St. Croix, mean density of adult queen conch increased from 7.6 adult conch/ha in 1981 (Wood and Olsen 1983) to 27.4 adult conch/ha in 2001 (juvenile conch were not sampled in 1981). Around St. Thomas, only two sites had relatively high densities of conch in 2001, Inner Water Island and Saba Island (the new site). Overall, St. Thomas had an average of 24.0 adult conch/ha and 27.5 juvenile conch/ha in 2001. In St. John in 2001, all sites had low conch abundances, and an overall mean density of 7.2 adult conch/ha and 7.5 juvenile conch/ha. Around St. Croix in 2001, several sites had high conch densities, particularly for juveniles. For example, site 2 had 247.0 juvenile conch/ha, site 4 had 138.1 juvenile conch/ha, site 13 had 487.0 juvenile conch/ha, and site 16 had 138.0 juvenile conch/ha. In 2001 overall, St. Croix had 27.4 adult conch/ha and 72.3 juvenile conch/ha. In 1998, 50% of all conchs harvested in St. Croix were juveniles (CFMC 2001). This not only suggests that juveniles in St. Croix are common, but recruitment is strong. However, it also indicates that fishing pressure is high and that stocks may decline because of reduction in sexually mature adults owing to over harvest of juveniles.

The higher conch densities on St. Croix compared to St. Thomas/St. John are likely due to the shallower water depths of the St. Croix shelf and perhaps exploitation patterns. In St. Croix, the shelf area does not extend far from the shoreline (<3 nm), and the shelf depth ranges from 6 to 12 m. This depth range is primarily where juvenile and subadult size/age categories for conchs are found (Schweizer and Posada, draft).

The shelf around St. Thomas and St. John extends much further (8 nm to the south, and 20 nm to the north), and is primarily between 25 to 45 m deep. Many of the surveys around St. Thomas and St. John were not conducted in deep waters (>24 m) as the survey sites' locations were based on previous studies and dive limitations. Therefore, adult breeding stocks typically found at deeper depths (Appeldoorn 1994a) were not surveyed or encountered. Further resource studies at water depths >24m are needed.

There are restrictions and regulations in effect for the harvest of conch in the USVI. A bag limit of 2 conchs per person per day (recreational fishers) has been in effect in the VINP in St. John since 1962. No commercial take of conch is permitted in the VINP. Despite this regulation, no difference in conch densities were detected between transects conducted in the VINP and other sites outside VINP, St. John.

In St. Thomas and St. John, there was a moratorium on the harvest of queen conch from 1988 to 1992 (see Friedlander 1997). The density of queen conch increased from 13.4 conch/ha in 1990 to 63.7 conch/ha in 1996 on St. Thomas (Table 4). This suggests that the moratorium was effective. However, this does not account for the decline in the density of queen conch on St. John. This decline on St. John may be because about half of the sites were in the National Park which has its own regulations that do not appear to be effectively enforced, and because the moratorium was primarily done at the request of St. Thomas fishers who were therefore more likely to adhere to the moratorium. Few St. John fishers are licensed or participate in the St. John/St. Thomas Fisheries Advisory Committee (FAC).

Current queen conch regulations require fishers to harvest only queen conch that are at least 9” in length or have a shell thickness of 3/8”. Conch must be brought to shore whole in the shell. Recreational harvesters can harvest only 6 conch per person or 24 per boat in territorial waters. Commercial fishers can harvest 150 queen conch per commercial fisher per day. These regulations are not effectively enforced because of the lack of enforcement officers dedicated to enforcing marine fisheries laws.

Queen conch recruitment

During the 2001 survey, only 4 juvenile conchs were observed on the scooter transects previously surveyed in 1990 and 1996 around St. Thomas. At the new St. Thomas site, Saba Island, an additional 26 juvenile conch were observed in a shallow water seagrass bed (6 to 10 m). Juvenile and adult conch abundances varied between sites. Given the high degree of variability and reports of high densities of juvenile queen conch in some un-sampled bays (e.g. Brewers Bay, St. Thomas and an unsampled portion of Fish Bay, St. John), it is recommended that funding for this project be increased to allow more adequate sampling of habitats in the Virgin Islands. However the objective of this survey was to detect historic trends at established stations over time, not to identify and survey new areas for conch.

The low numbers of juvenile queen conch found at most sites on St. Thomas and St. John may be owing to lack of successful recruitment. According to Stoner and Ray (1996), at least 53.0 adult conch/ha are needed for optimal reproduction to take place. Therefore many of the sites in St. Croix clearly have sustainable densities. However, most sites around St. Thomas and St. John do not have conch densities high enough for optimal reproduction.

Conch larvae live in the upper water column for 16-28 days, feeding on phytoplankton (Stoner and Ray 1996). Given the range of time for planktonic development before settlement, it is likely that a portion of queen conch larvae returns to their natal habitat and a portion disperse long distances. Genetic studies and analysis of queen conch larvae life history and ocean currents in the Caribbean region suggest that larvae can travel long distances with the currents before settling out of the plankton and metamorphosing (Stoner and Ray 1996). The prevailing water current is from east to west in St. Thomas and St. John. This suggests that recruitment in St. Thomas and St. John may be linked to the reproductive success of queen conch of British Virgin Islands' (B.V.I located east of St. Thomas/St. John) conch stocks. Recruitment in the USVI may be a function of how well the queen conch fishery in the B.V.I is managed and protected.

The low numbers of juveniles in St. Thomas/St. John may also be a function of the illegal harvest of juveniles in the easily accessible shallow coastal waters around the islands. The Division of Fish and Wildlife's knowledge of large populations of juveniles in Brewer's Bay and Fish Bay is a function of telephone calls from members of the public who reported the illegal harvest of juvenile queen conch from these bays. It was estimated that several hundred juvenile queen conch were removed from Fish Bay and the Division of Environmental Enforcement reported over 500 juveniles conchs removed and killed from Brewer's Bay in one incident.

Queen conch abundance related to habitat

Queen conchs were most abundant on algal plains and seagrass beds (Table 7 and Appendix 7). Around St. John, much of the habitat surveyed was shallower than St. Thomas (Appendix 1). Overall in St. John, conchs were found almost exclusively in seagrass beds (63% of all conchs on scooter transects). Such was the case for 1996 surveys (Friedlander 1997) as well. Conchs were found primarily in manatee grass (*Syringodium filiforme*) and turtle grass (*Thalassia testudinum*).

From 1990 (Friedlander et al 1994) to 2001, the percentage of surveyed habitat covered by seagrass has increased, or remained relatively stable among the 22 common transects around St. Thomas and St. John (Figure 12). In fact, the percentage of each of the major habitat types surveyed on St. Thomas and St. John has remained rather uniform from 1990 (Friedlander et al 1994) to 2001 (Figure 12).

In St. Croix habitat was much more patchy in 2001 compared to 1981. Also, new habitats were surveyed in 2001 compared with 1981 (Wood and Olsen 1983, see Figure 15). The habitat patchiness and new habitats may be primarily due to hurricanes and storms within this 20-year period (especially hurricanes Hugo in 1989, Marilyn in 1995 and Lenny in 1999). Other possible contributing factors include anchor damage, water pollution, increased runoff and sedimentation, and global warming. Data on conch density and size/age distribution by habitat are useful for establishing refuges for various life stages of these organisms and estimating densities over the entire shelf area.

The effect of hurricanes on queen conch density

In September 1989, Hurricane Hugo struck the Virgin Islands with wind speeds up to 150 per hour (Quinn 1991). It has been suggested that the effects of the hurricane retarded the conch population recovery. For example, in Lameshur Bay, St. John, the population of conch after the hurricane were 10% of what they were 3 years prior (Quinn 1991). In August 16 1995, Hurricane Marilyn also struck the Virgin Islands with sustained winds of 104 mph with maximum gust to 129 mph (NOAA 2000). Despite Marilyn's devastation, density of conch was greater in 1996 than 1990 for St. Thomas (Table 3). The density increase was possibly a function of the moratorium that was in effect for 5 years.

Age structure of queen conch

Many of the adult conchs observed around St. Thomas were old individuals. Juvenile abundance was extremely low in most locations around St. Thomas (not including Saba Island) and much lower than adult abundance.

Conclusion

In summary, abundance declined between 1996 (Friedlander 1997) and 2001 for common transects in St. Thomas (Figure 8), and between 1981 (Wood and Olsen 1983) and 2001 for the 9 transects common to all survey years for St. John (Figure 6). If management regulations are not enforced, continued decreases in conch abundance are expected in St. Thomas and St. John. St. Croix, on the other hand, has abundant populations of conch at many sites. If laws are enforced and the conch fishery properly managed, continued increases in conch abundance may be achieved.

Any effective management strategy should include prohibition of recreational conch harvest within park boundaries. Reserves have the benefit of providing migrants to surrounding areas, enhancing reproduction, exporting larvae, and providing biological reference areas (Bohnsack 1996). Reserve areas for queen conch in the Bahamas have shown to have 31 times more adult conch than fished areas (Stoner and Ray 1996). Protected sites within St. John's National Park did not demonstrate increased conch abundance. This may indicate that they do not have much protection. This is particularly confounding, because most of the sites included coral sand and seagrass beds, which are used during summer spawning periods (Brownell and Stevely 1981). Additionally, there are large rhodolith/rubble communities surrounding the island of St. John, which provides deeper rubble habitats that are the primary winter feeding habitats for many older conchs (Stoner and Sandt 1992).

Long term restocking of small conch into the natural environment probably is not an economic way to replenish and support the fishery (Appeldoorn 1994a). Restocking the ocean with hatchery-reared conch is a very costly project, considering the high mortality rate within the first 6-9 months of release (Appeldoorn 1994a). The cause of the initial decline in the conch populations is not from natural recruitment failure, but from overfishing and/or destruction of habitat, which result in recruitment failure (Appeldoorn 1994a). Conch populations can ultimately be restored by effective resource management and heightened enforcement.

All management measures are only as good as the level of compliance. Generally, there are insufficient resources and/or personnel for enforcement purposes (Uwate et al 2001). Enforcement of conch regulations is often viewed in isolation. Allocation of resources toward enforcement should be viewed in terms of maintaining the viability of all marine resources. The worth of all resources is sufficient to warrant an investment in effective enforcement.

Finally, public education is probably one of the most important and long-lasting strategies for managing fishery resources. Community awareness and public support for management strategies can encourage restoration efforts. Cooperative management by everyone that uses conch resources will ultimately benefit all involved groups.

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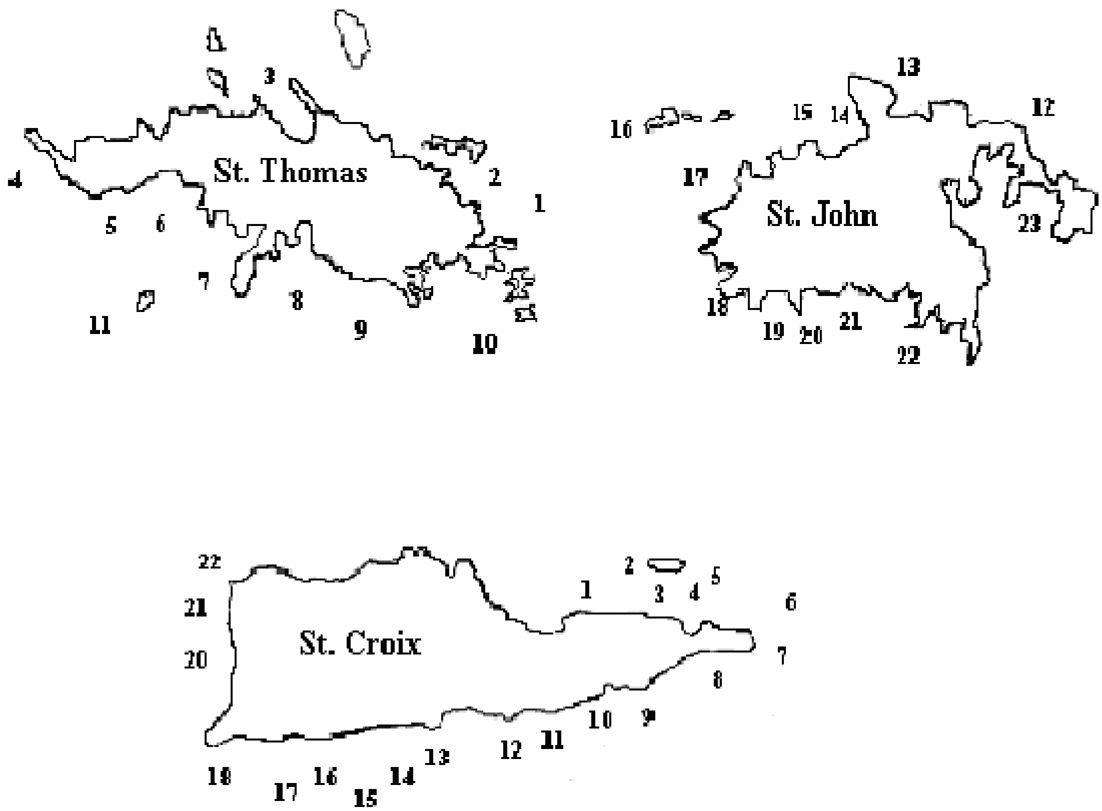
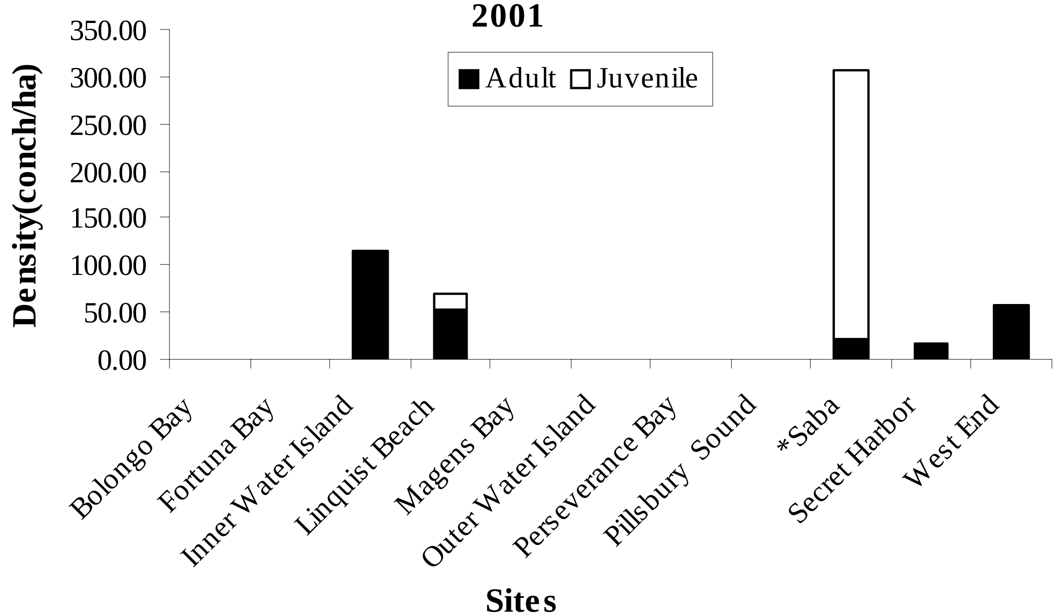
Figure 1. Conch Transect Sites in the U.S. Virgin Islands*[1]
(St. Thomas, St. John, and St. Croix*[2]) for
All Survey Years



*notes:

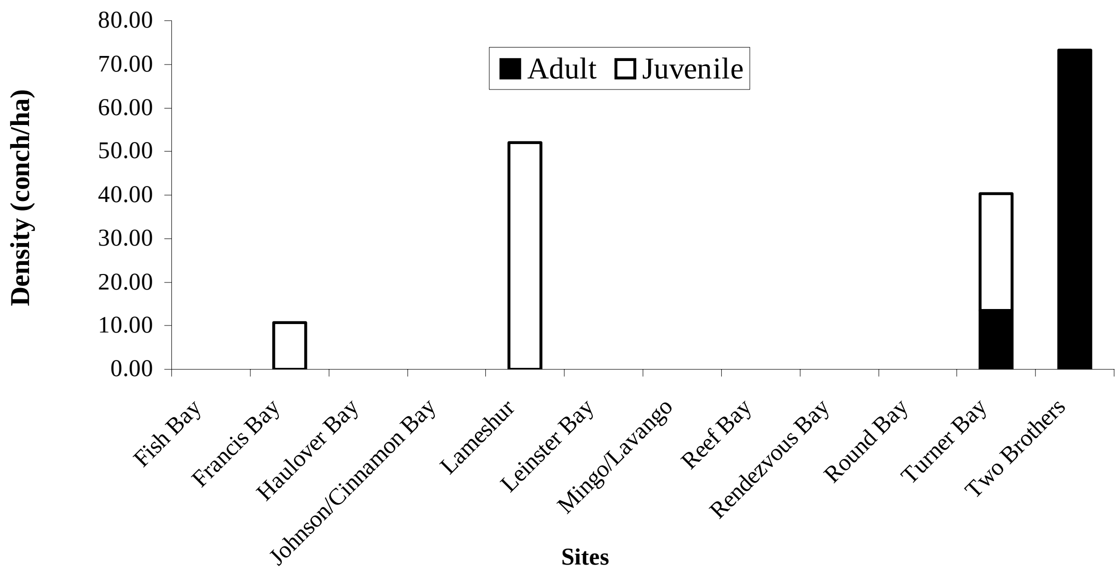
1. These maps are not to scale.
2. For St. Croix, only transects 1 to 16 were surveyed in 2001.

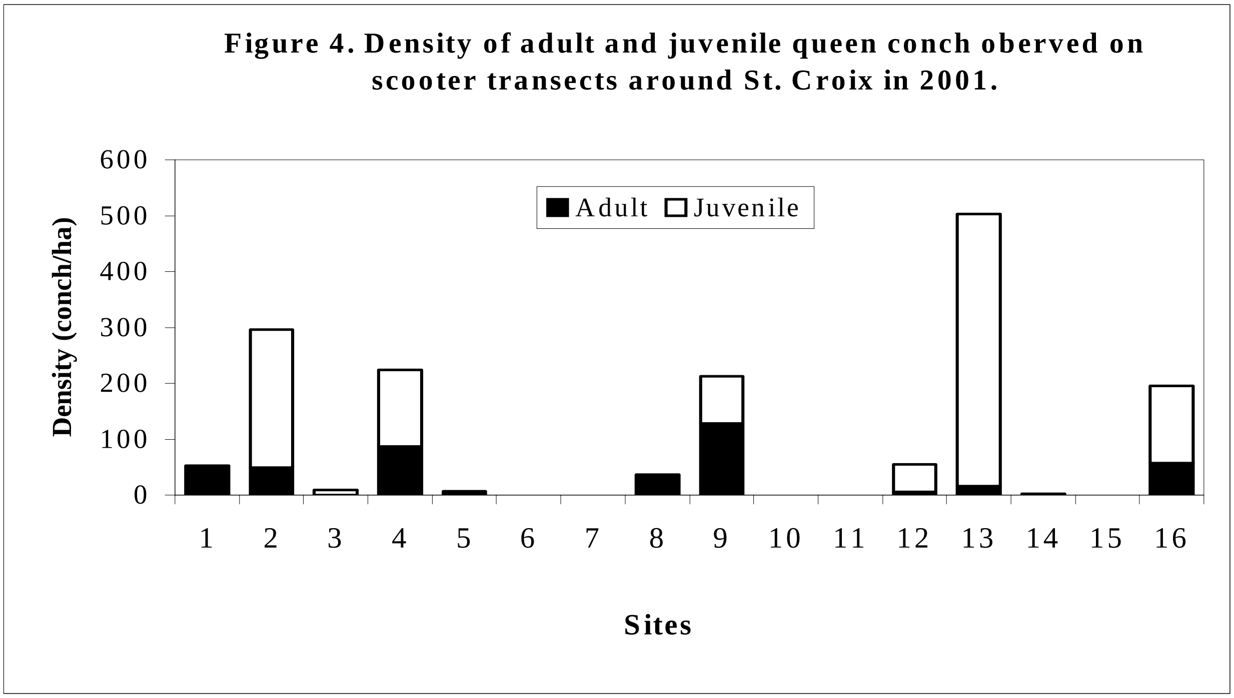
Figure 2. Density of adult and juvenile queen conch observed on scooter transects around St. Thomas, USVI in 2001



Note: Saba Islands is a new site added to the St. Thomas transect list in 2001

Figure 3. Density of adult and juvenile queen conch observed on scotter transects around St. John, USVI in 2001





*Note: Only the first 16 of the original 22 transects were surveyed in 2001

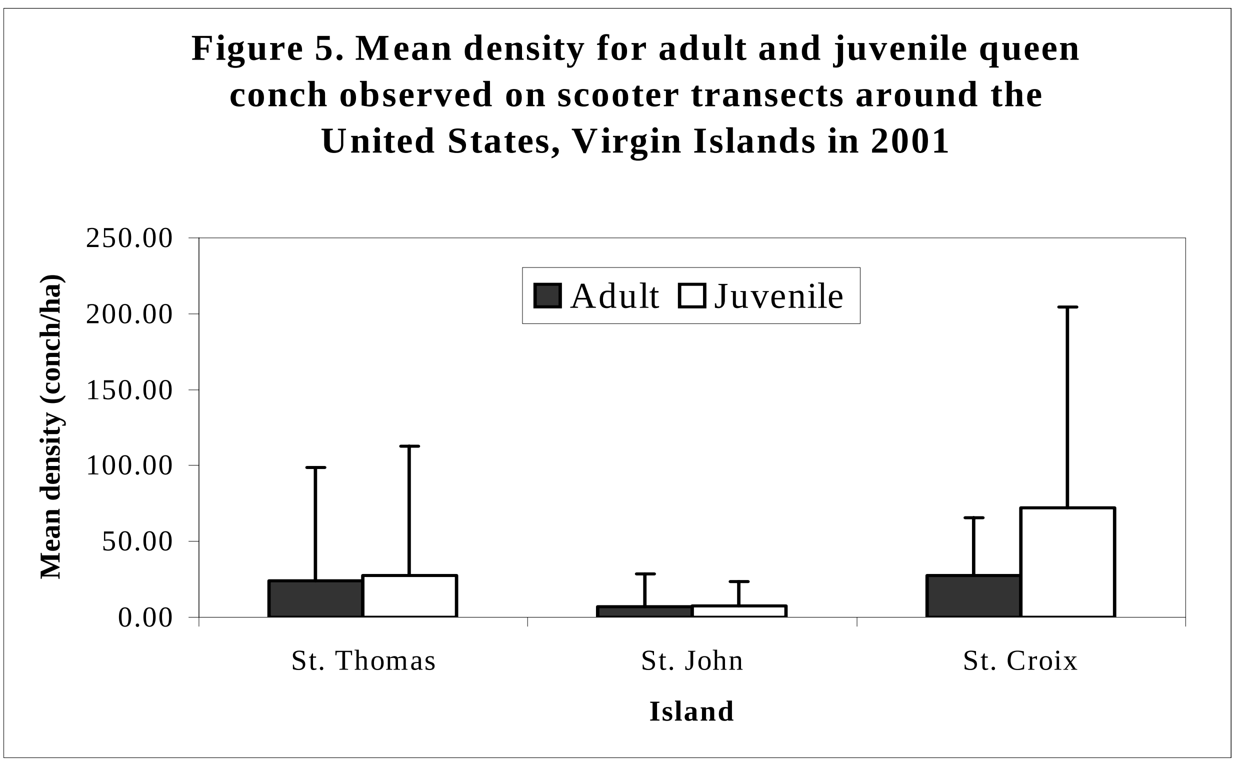
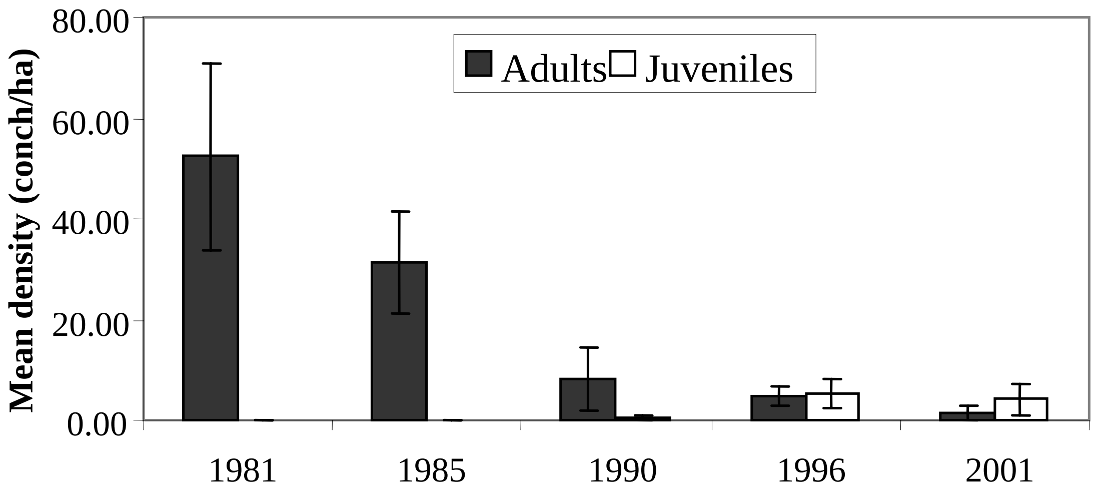
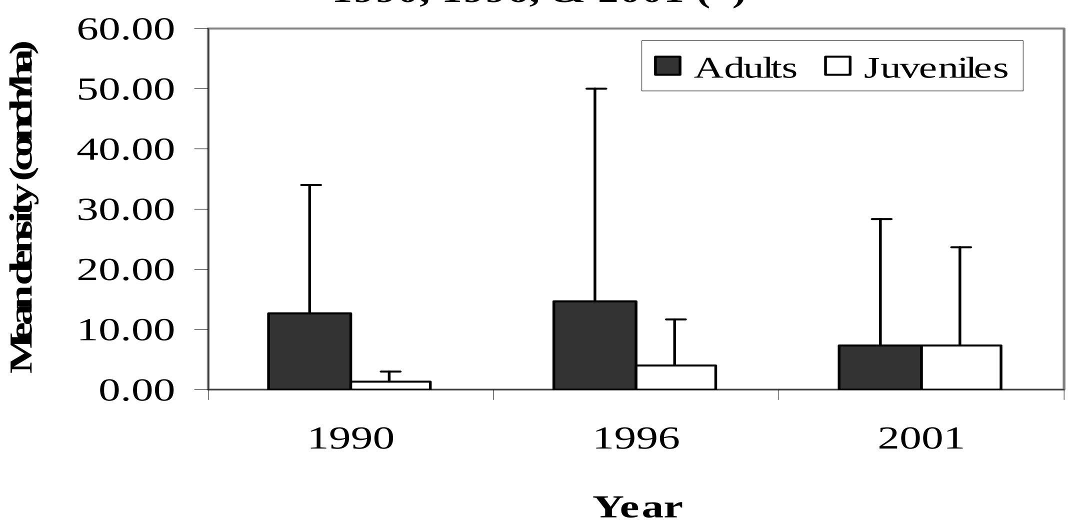


Figure 6. Mean density of adult and juvenile queen conch observed transects around St. John, 1981 to 2001. Only the 9 transects common to all survey years are used. Error bars are standard error of the mean (*)

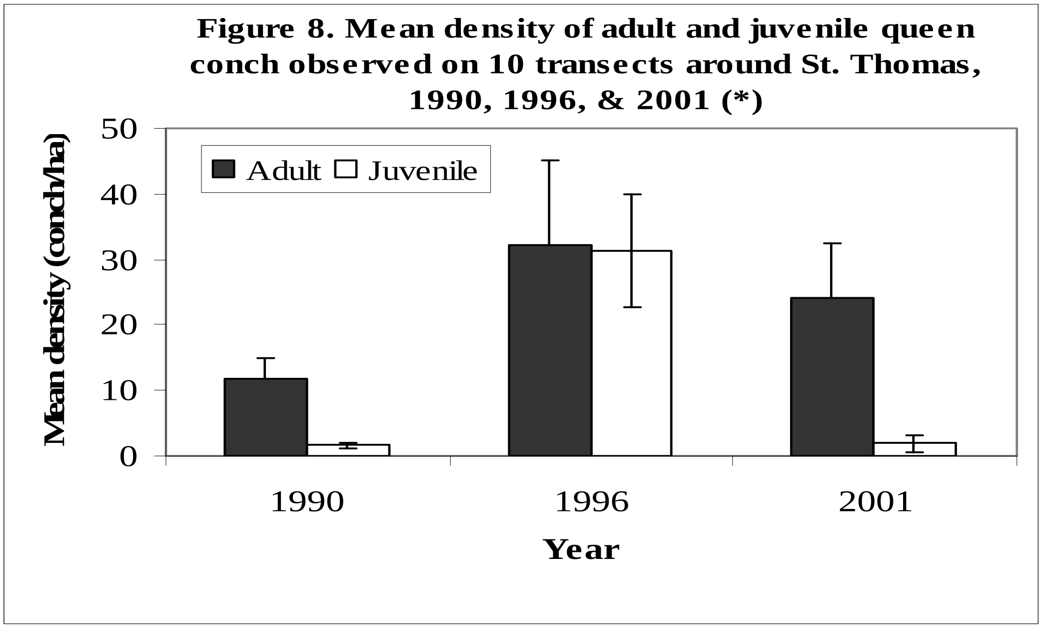


*Note: No juvenile data available for St. John in 1981 and 1985. Source data from Friedlander (1997)

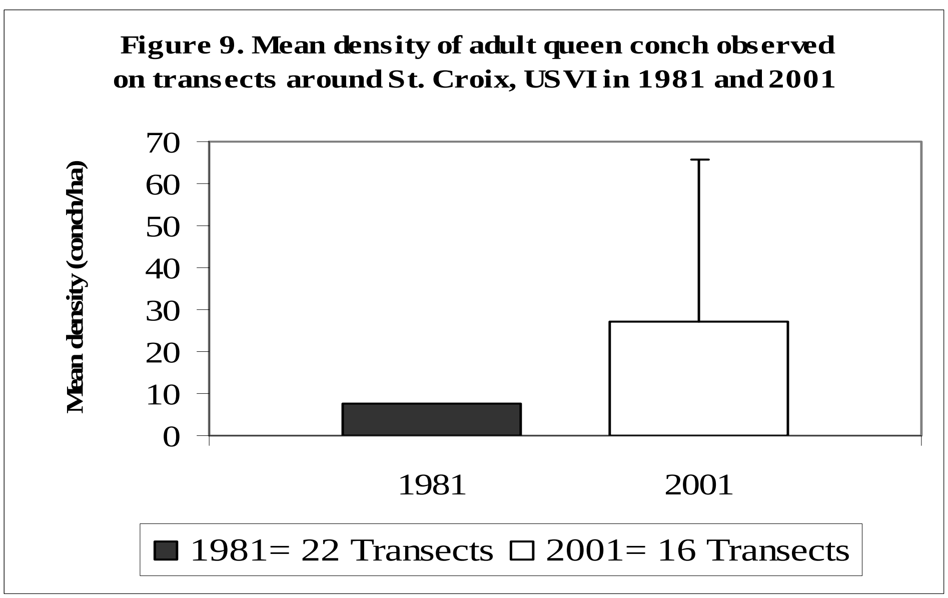
Figure 7. Mean density of adult and juvenile queen conch observed on 12 transects around St. John, 1990, 1996, & 2001 (*)



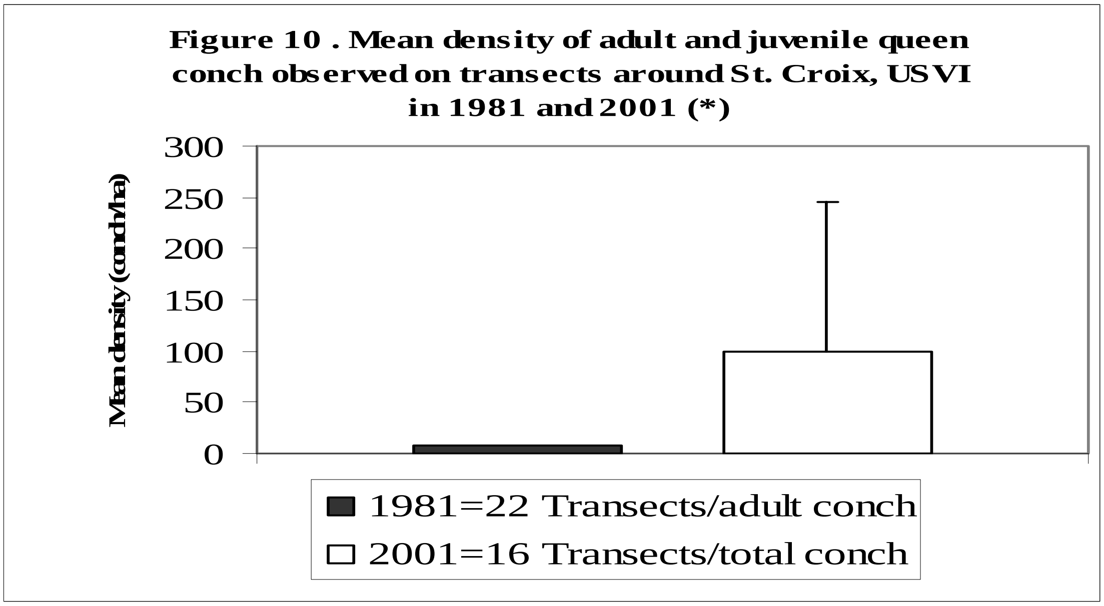
*Note: 1990 and 1996 data from Friedlander (1997)



*Notes: 1) 1990 and 1996 data from Friedlander (1997)
2) No available data for St. Thomas in 1981 and 1985
3) Error bars are standard error of the mean



*Notes: 1) 1981 data from Wood and Olsen (1983)
2) 1981 data provide an average weighted density
3) No standard deviation provided for 1981



*Notes: 1) 1981 data from Wood and Olsen (1983)
2) Error bars are standard deviation of the mean
3) 1981 data provide an average weighted density
4) No standard deviation provided for 1981

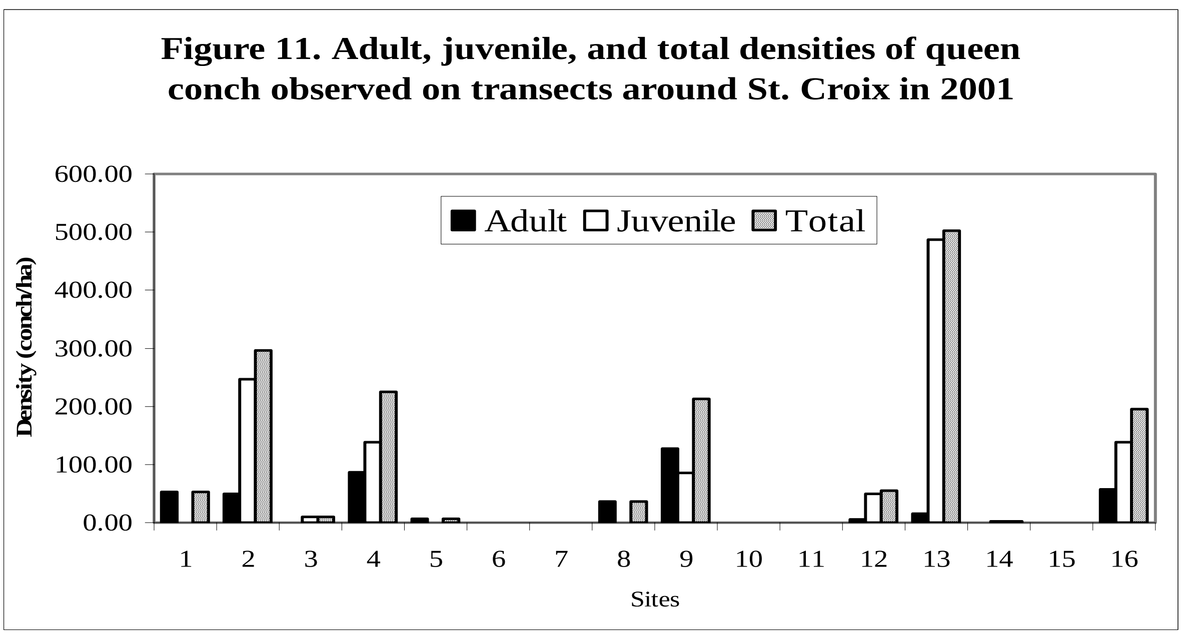
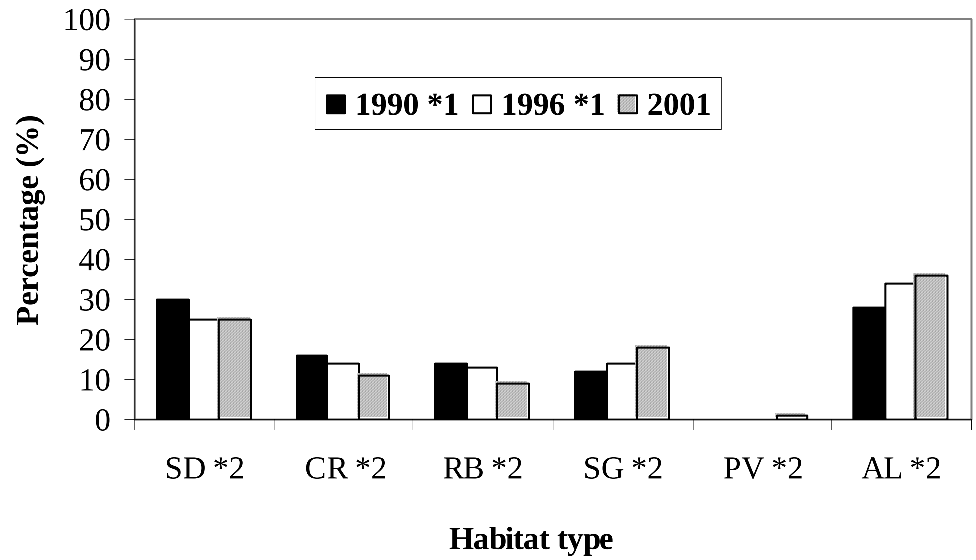
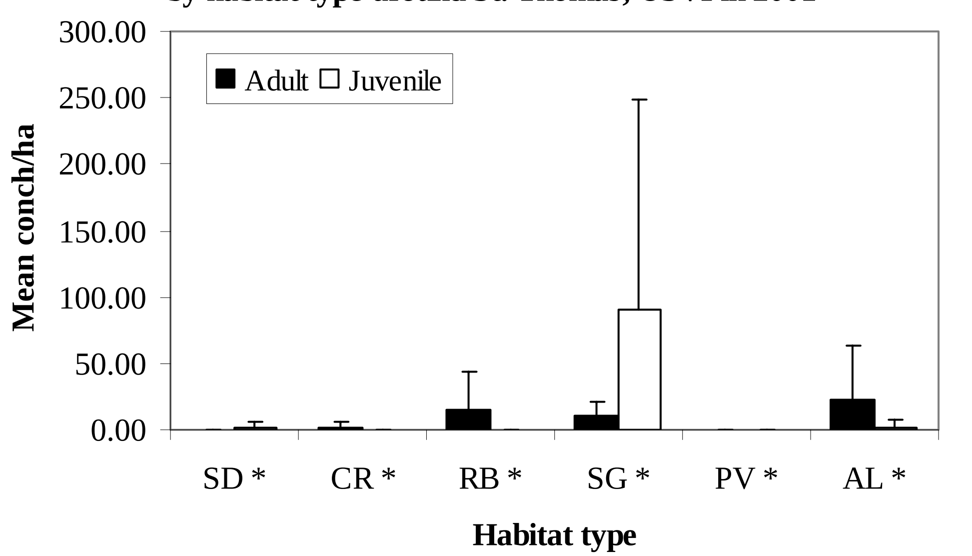


Figure 12. Percentage of habitat types encountered during 22 common transects around St. Thomas and St. John, USVI in 1990, 1996, & 2001



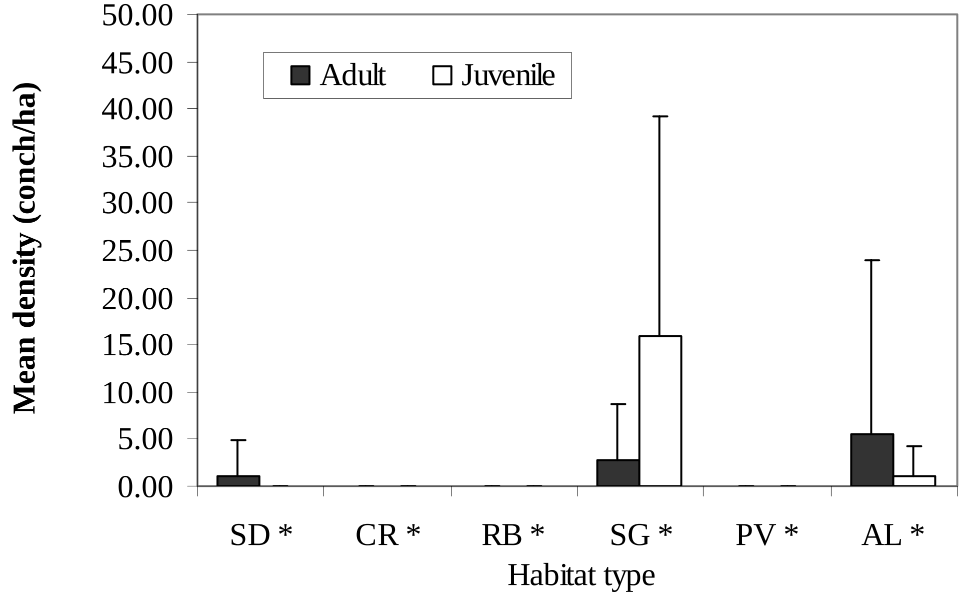
*Notes: 1) 1990 and 1996 data from Friedlander (1997) and Friedlander et al (1994)
2) Sand (SD), Coral Reef (CR), Rubble (RB), Seagrass (SG), Pavement (PV), Algae (AL)

Figure 13. Mean density for adult and juvenile queen conch by habitat type around St. Thomas, USVI in 2001



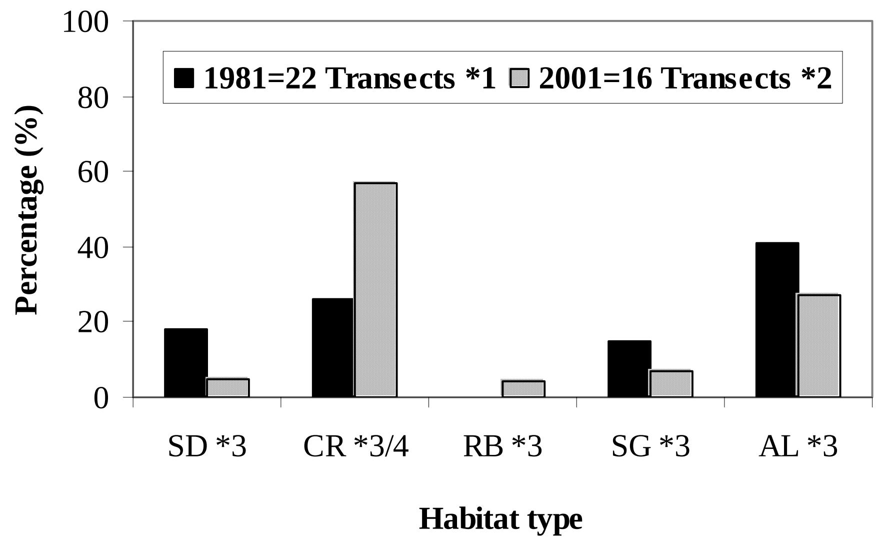
*Note: Sand (SD), Coral Reef (CR), Rubble (RB), Seagrass (SG), Pavement (PV), Algae (AL)

Figure 14. Mean density for adult and juvenile queen conch by habitat type around St. John, USVI in 2001



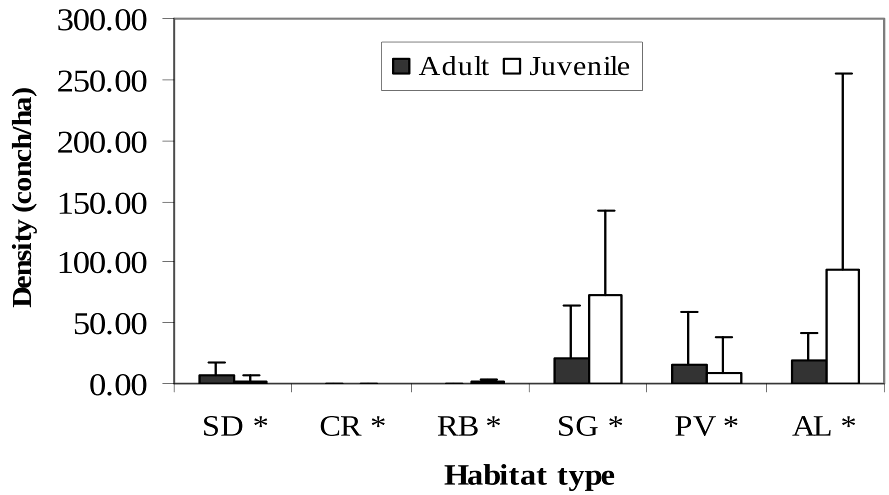
*Note: Sand (SD), Coral Reef (CR), Rubble (RB), Seagrass (SG),
Pavement (PV), Algae (AL)

Figure 15. Percentage of habitat types encountered around St. Croix, USVI in 1981 and 2001.



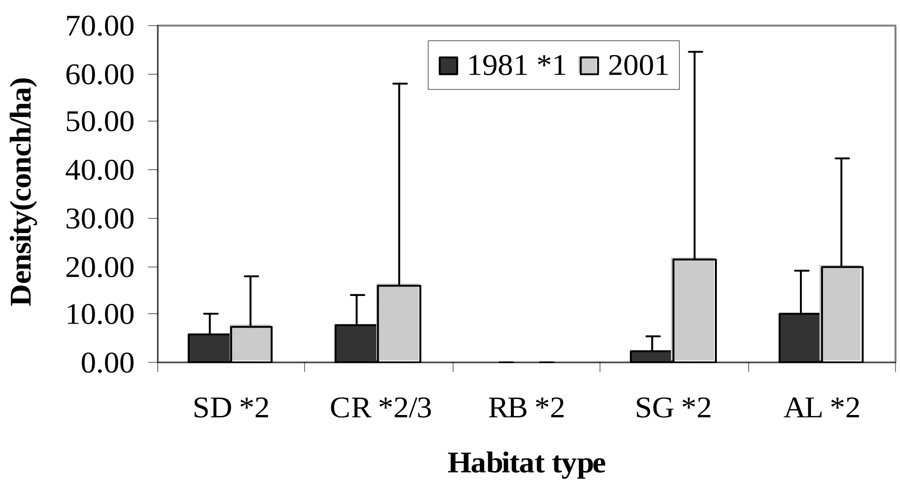
*Notes: 1) 1981 data from Wood and Olsen (1983)
2) In 2001 only 16 of the original 22 transects were surveyed
3) Sand (SD), Coral Reef (CR), Rubble (RB), Seagrass (SG), Algae (AL)
4) Coral Reef habitat includes Pavement (PV)

Figure 16. Mean density of adult and juvenile queen conch by habitat type around St. Croix, USVI in 2001



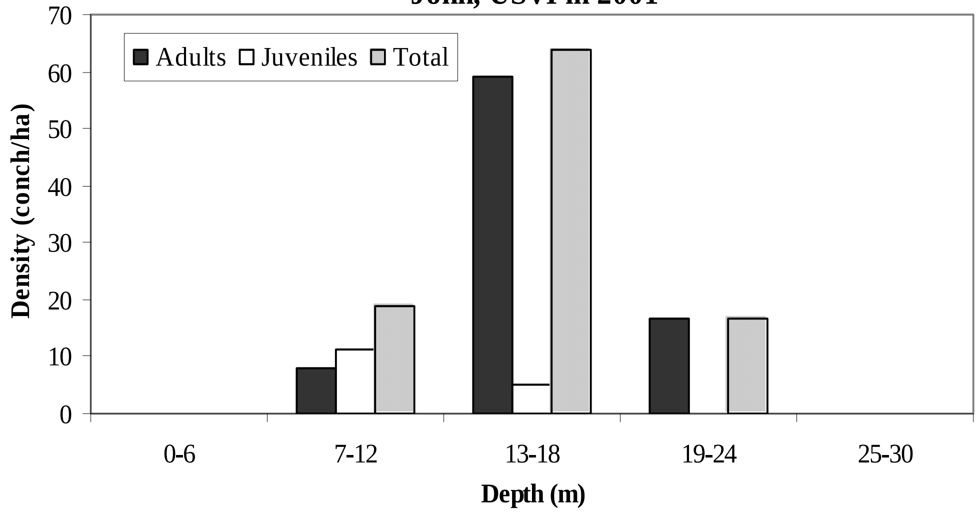
*Note: Sand (SD), Coral Reef (CR), Rubble (RB), Seagrass (SG), Pavement (PV), Algae (AL)

Figure 17. Mean density of adult queen conch by habitat type around St. Croix, USVI in 1981 & 2001



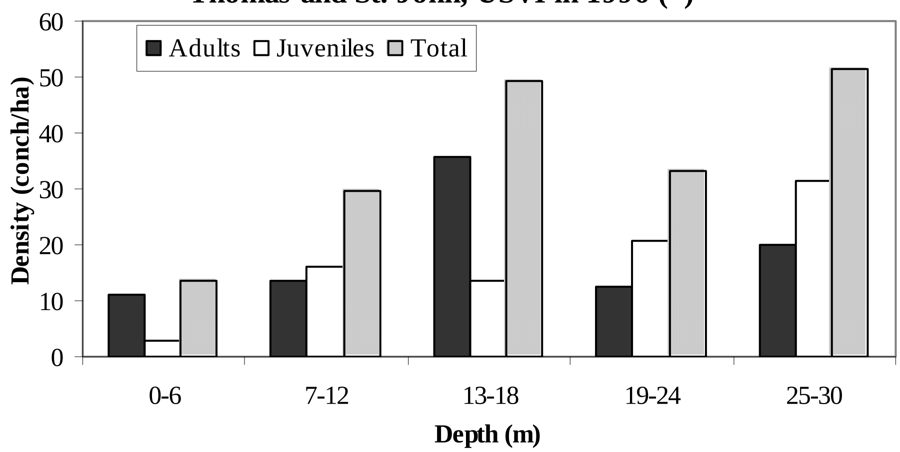
*Notes: 1) 1981 data from Wood and Olsen (1983)
2) Sand (SD), Coral Reef (CR), Rubble (RB), Seagrass (SG), Algae (AL)
3) Coral Reef habitat includes Pavement (PV)

Figure 18. Adult, juvenile, and total queen conch densities by depth for 22 common transects around St. Thomas and St. John, USVI in 2001



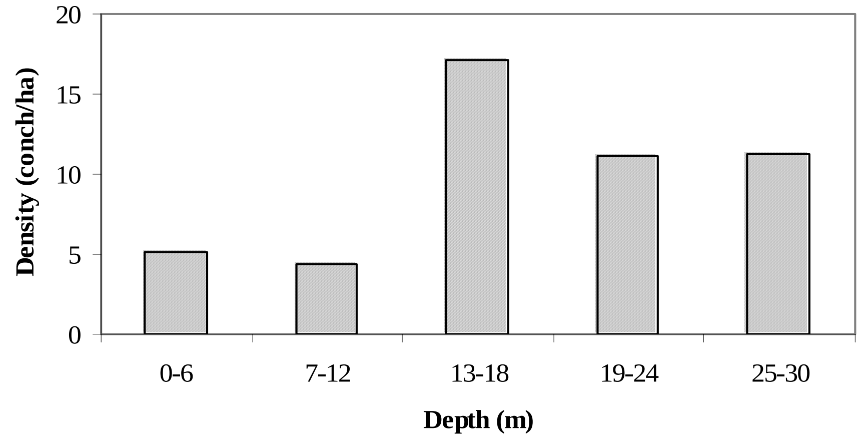
*Note: No depth data available for 1981 and 1985

Figure 19. Adult, juvenile, and total queen conch densities by depth for 22 common transects around St. Thomas and St. John, USVI in 1996 (*)



*Notes: 1) 1996 data from Friedlander (1997)
2) No depth data available for 1981 and 1985

Figure 20. Total queen conch density by depth for 22 common transects around St. Thomas and St. John, USVI in 1990 (*)



*Notes: 1) 1990 data from Friedlander et al. (1994)
2) No depth data available for 1981 and 1985

Figure 21. Adult and juvenile mean queen conch densities by depth for St. Thomas, USVI in 2001

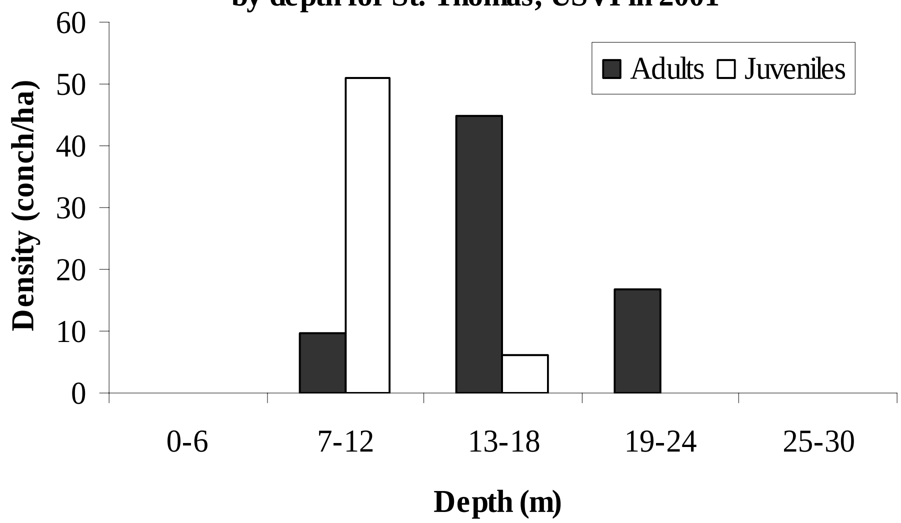


Figure 22. Adult and juvenile mean queen conch densities by depth for St. John, USVI in 2001

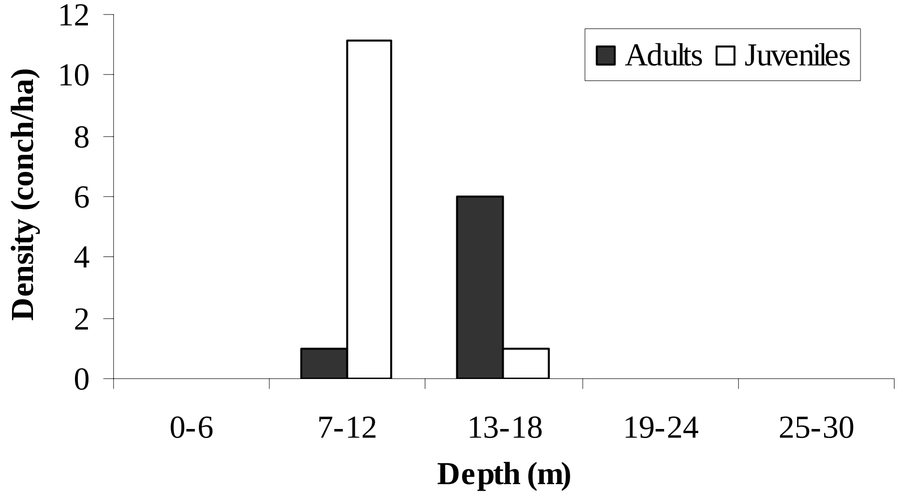


Figure 23. Adult and juvenile mean queen conch densities by depth for St. Croix, USVI in 2001

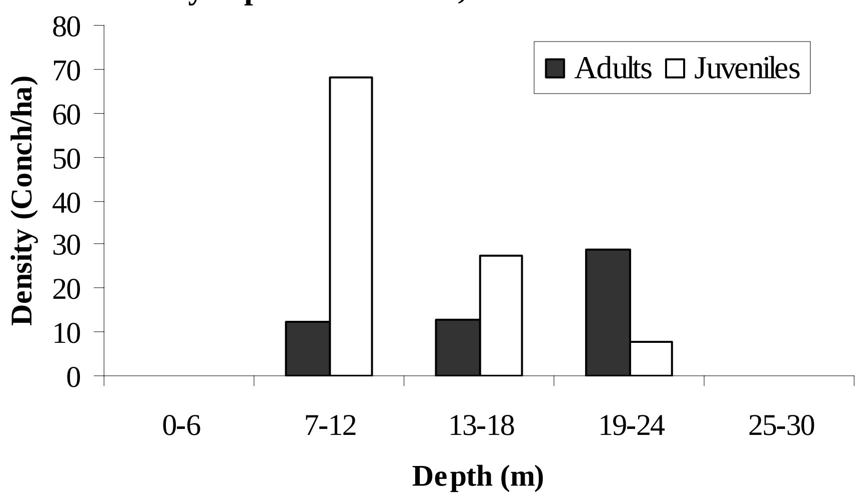
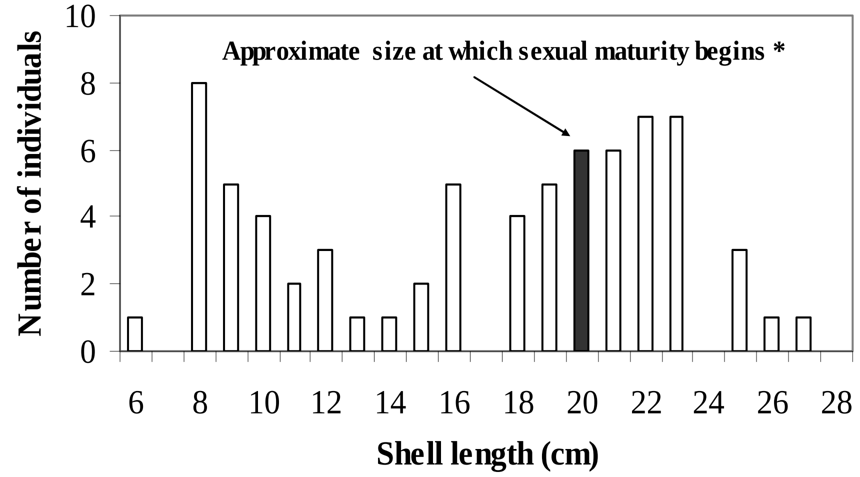
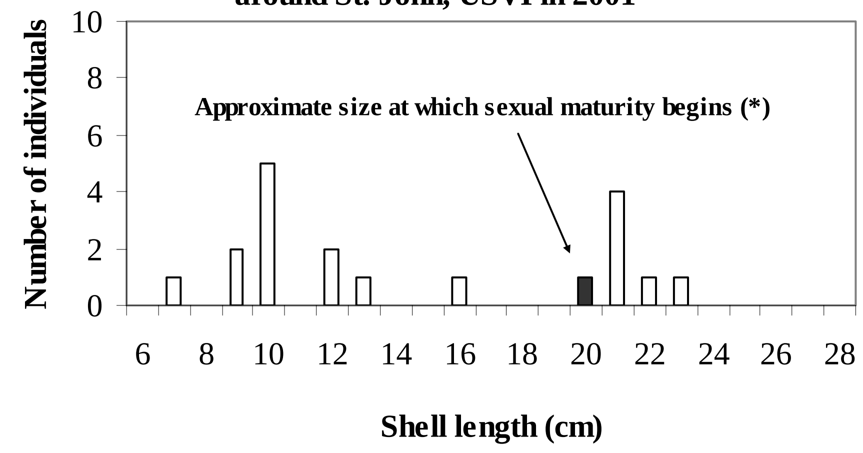


Figure 24. Measured shell lengths for queen conch around St. Thomas, USVI in 2001



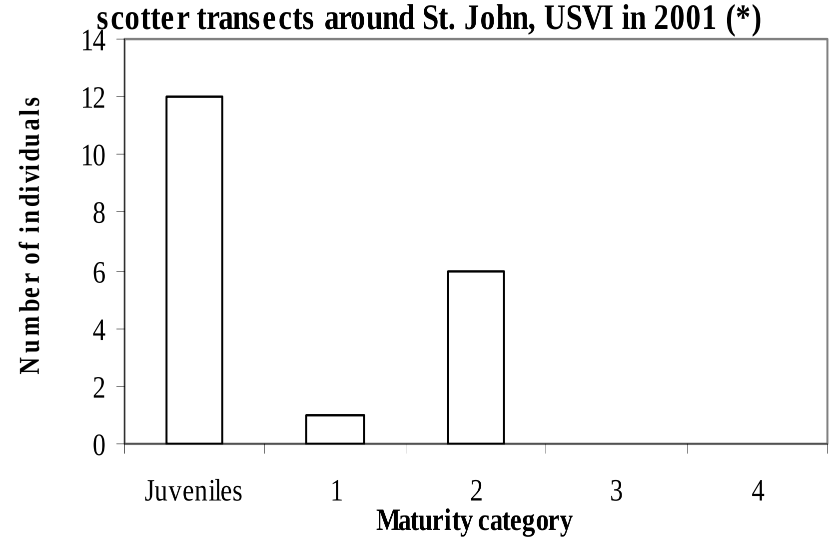
*Note: Sexual maturity reference from Stoner and Ray (1996)

Figure 25. Measured shell lengths for queen conch around St. John, USVI in 2001



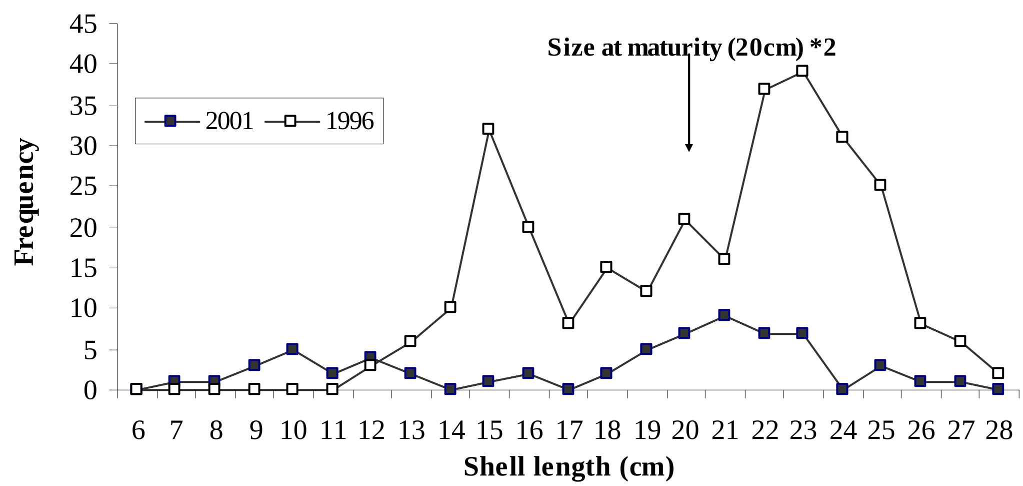
*Note: Sexual maturity reference from Stoner and Ray (1996)

Figure 26. Maturity categories for queen conch from scotter transects around St. John, USVI in 2001 (*)



*Note: Maturity categories based on Friedlander (1997)

Figure 27. Shell length (cm) for queen conch observed on 22 scooter transects around St. Thomas and St. John, USVI in 1996 and 2001 (*1)



*Notes: 1) 1996 data from Friedlander (1997)
2) Sexual maturity reference from Stoner and Ray (1996)

Figure 28. Measured shell lengths for queen conch around St. Croix, USVI in 2001

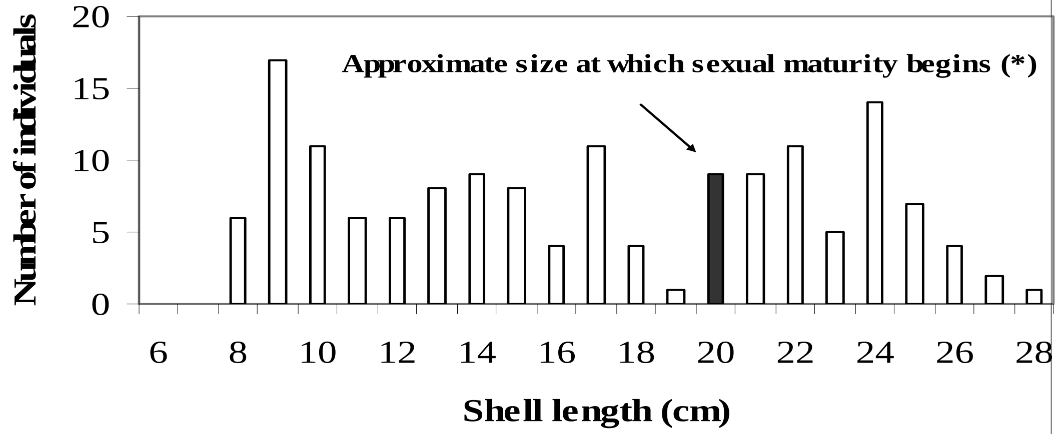
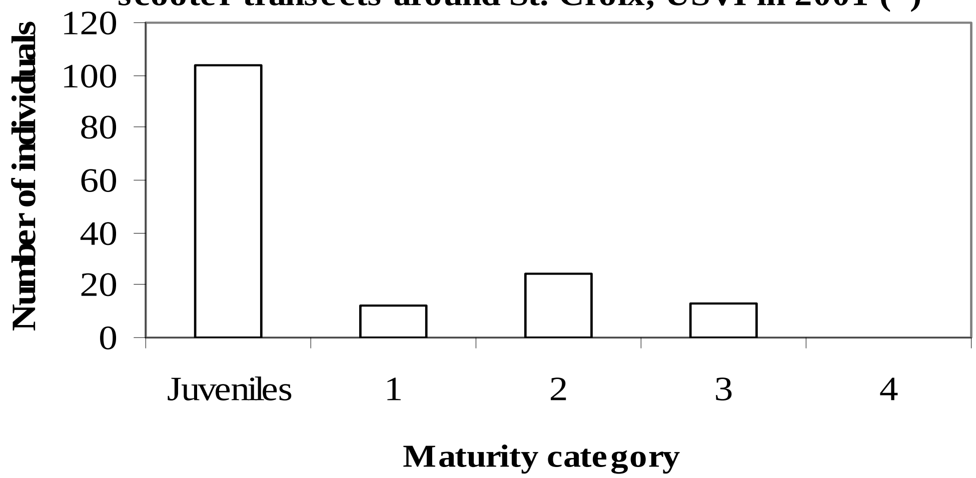
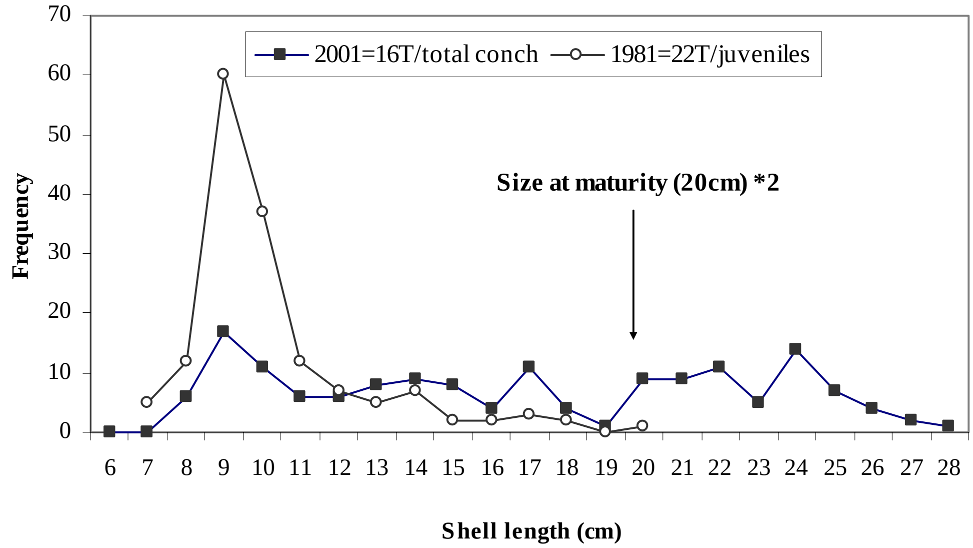


Figure 29. Maturity categories for queen conch from scooter transects around St. Croix, USVI in 2001 (*)



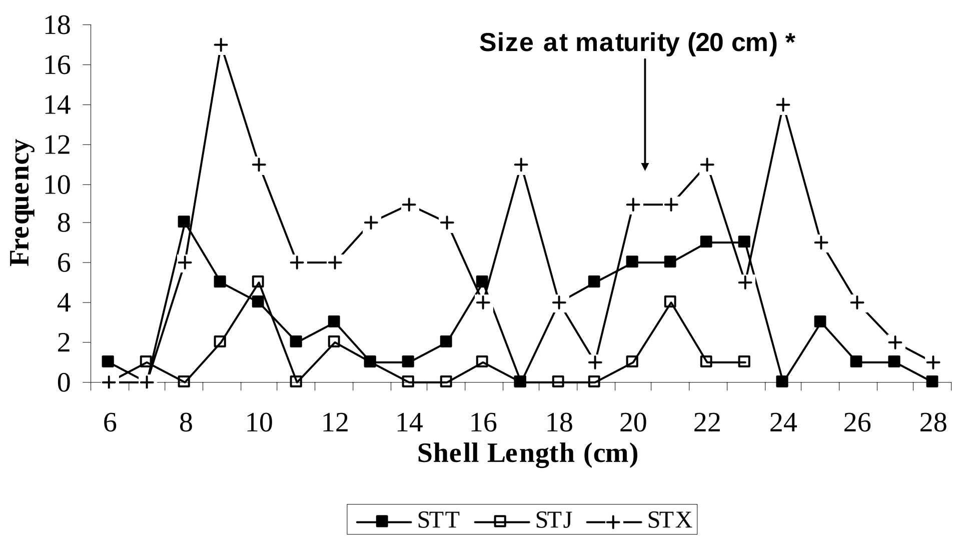
*Note: Maturity categories based on Friedlander (1997)

Figure 30. Shell length (cm) for queen conch observed on scooter transects around St. Croix, USVI in 1981 & 2001 (*1).



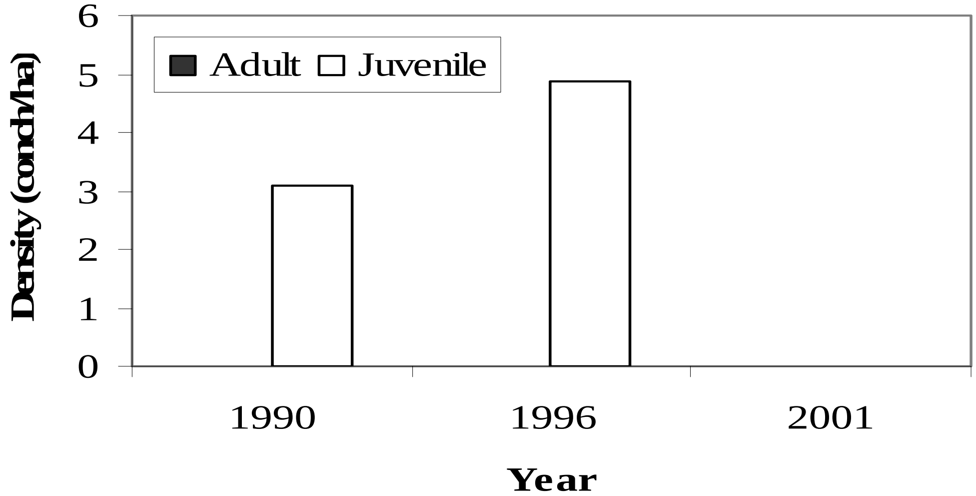
*Notes: 1) Sexual maturity reference from Stoner and Ray (1996)
2) 1981 data from Wood and Olsen (1983)
3) 1981 shell length size-frequency distributions were provided for juvenile conch only

Figure 31. Shell length (cm) for queen conch observed around St. Thomas, St. John, and St. Croix, USVI in 2001



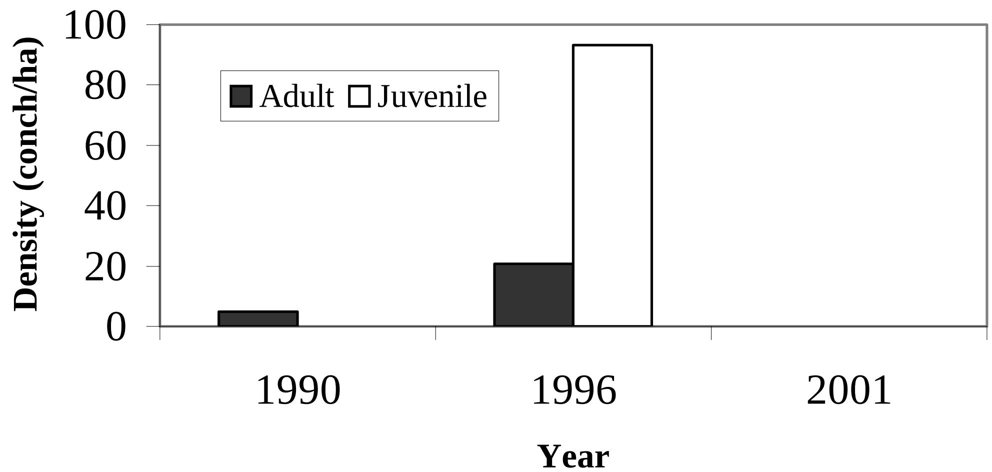
*Note: Sexual maturity reference from Stoner and Ray (1996)

Figure 32. Density of queen conch observed at Bolongo Bay, St. Thomas by sample year 1990, 1996, & 2001 (*)



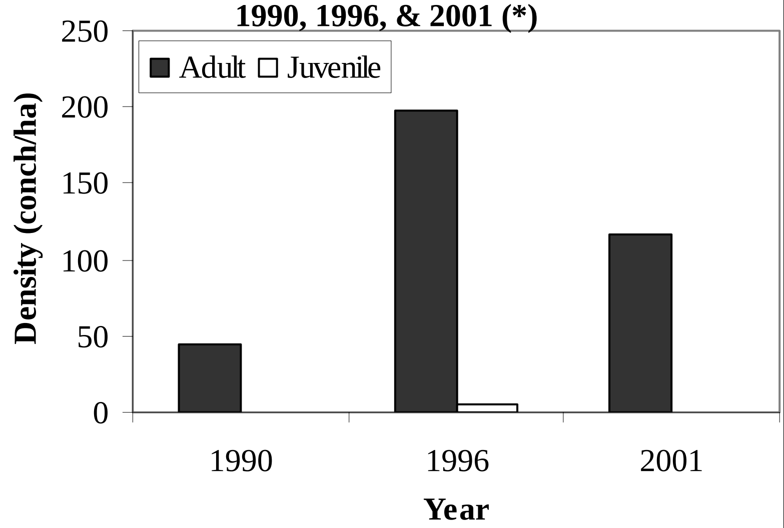
*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)

Figure 33. Density of queen conch observed at Fortuna Bay, St. Thomas by sample year 1990, 1996, & 2001 (*)



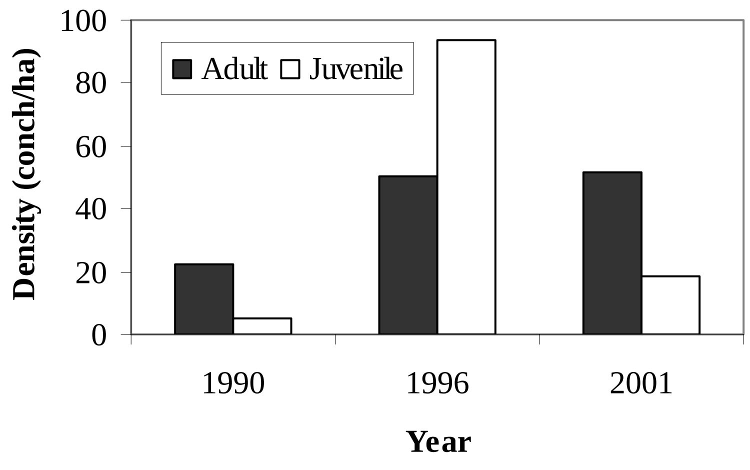
*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)

Figure 34. Density of queen conch observed at Inner Water Island, St. Thomas by sample year 1990, 1996, & 2001 (*)

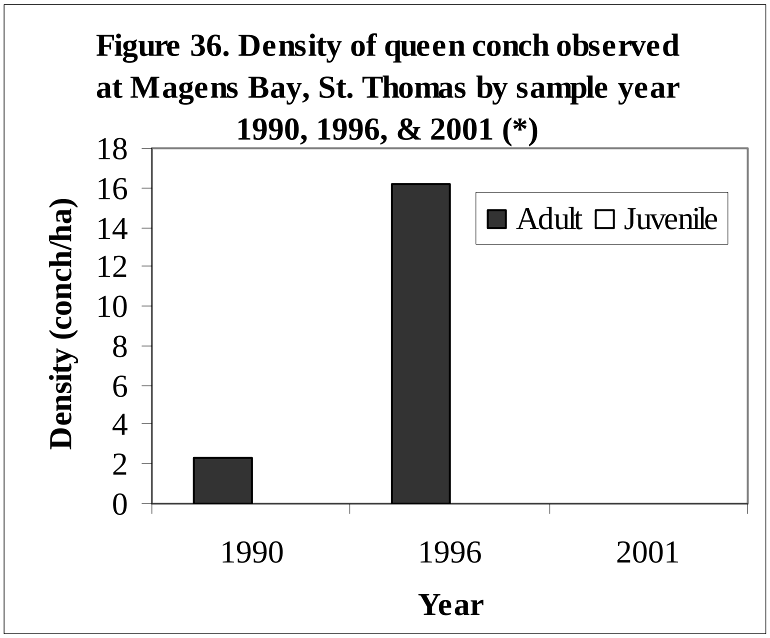


*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)

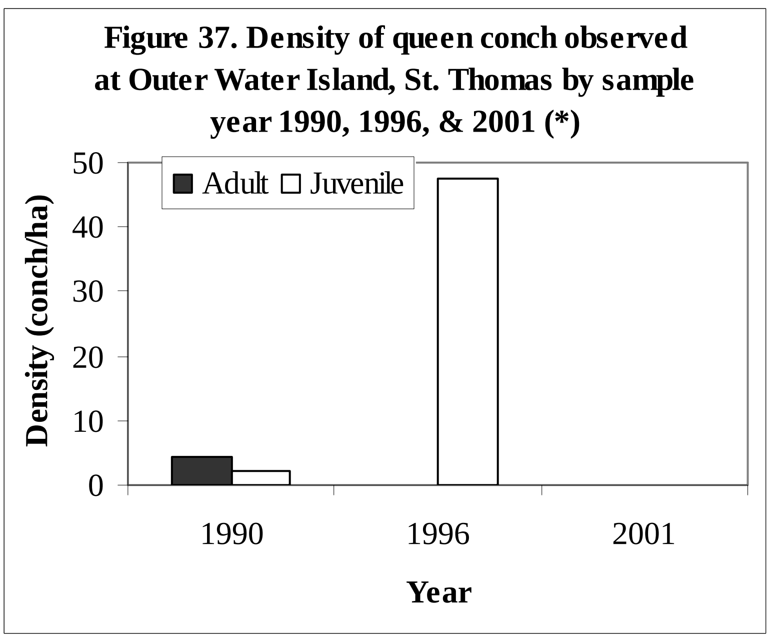
Figure 35. Density of queen conch observed at Linquist Bay, St. Thomas by sample year 1990, 1996, & 2001 (*)



*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)

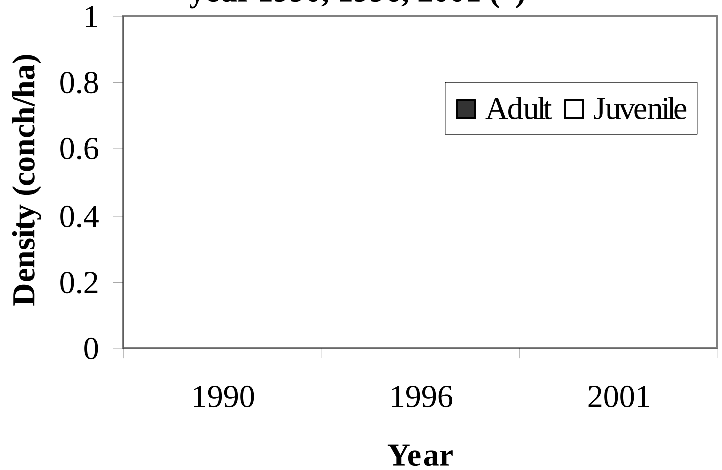


*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)



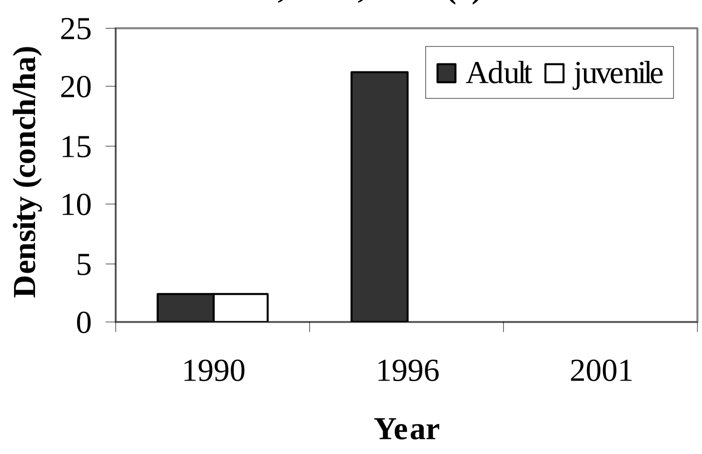
*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)

Figure 38. Density of queen conch observed at Perserverance, St. Thomas by sample year 1990, 1996, 2001 (*)

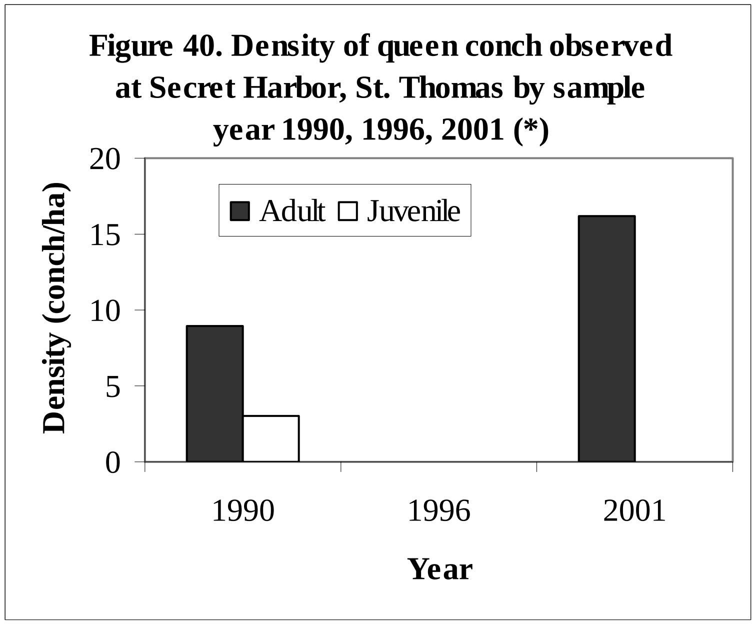


*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)

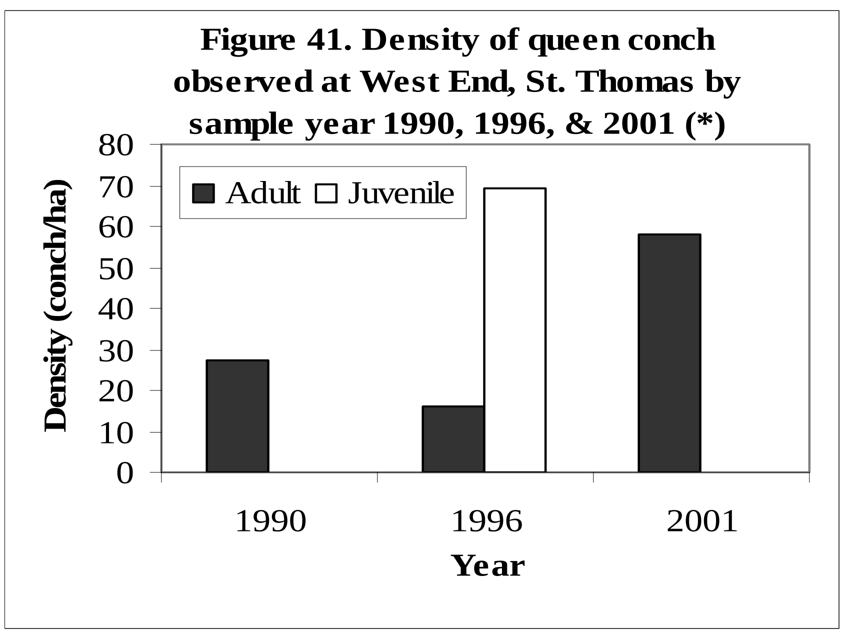
Figure 39. Density of queen conch observed at Pillsbury, St. Thomas by sample year 1990, 1996, 2001 (*)



*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)



*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)



*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)

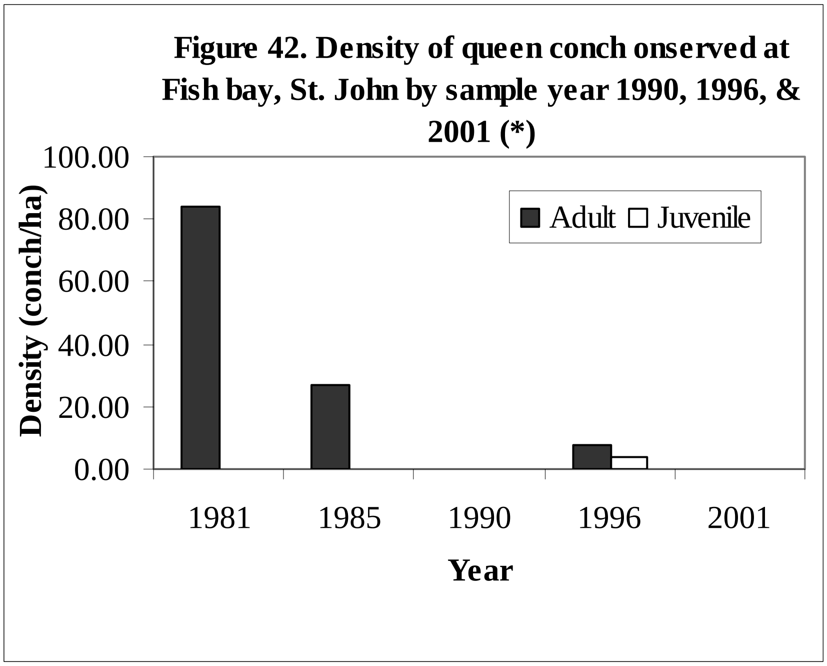


Figure 42. Density of queen conch onserved at Fish bay, St. John by sample year 1990, 1996, & 2001 (*)

*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)
3) No juvenile data available for 1981 and 1985

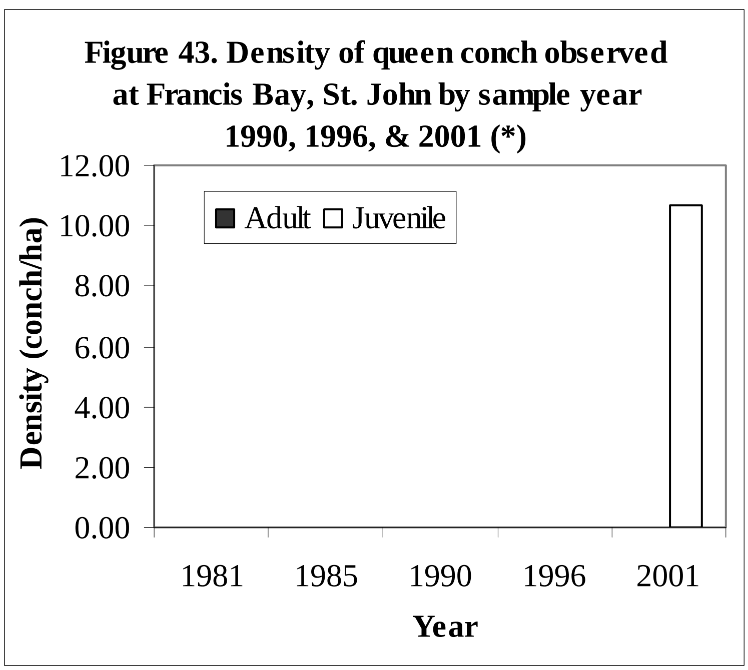
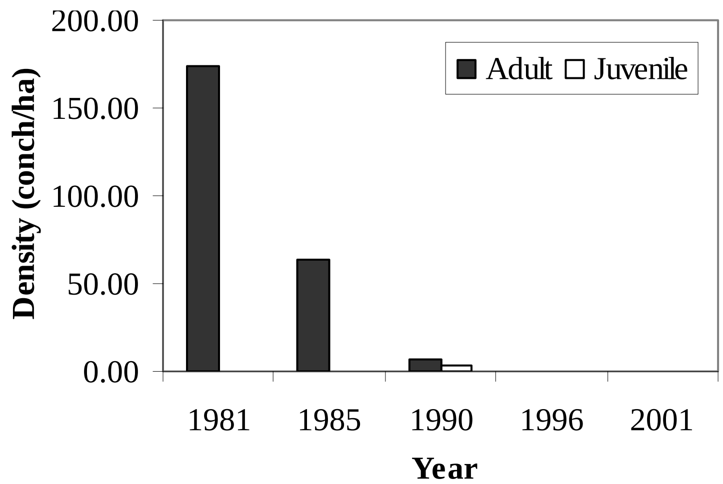


Figure 43. Density of queen conch observed at Francis Bay, St. John by sample year 1990, 1996, & 2001 (*)

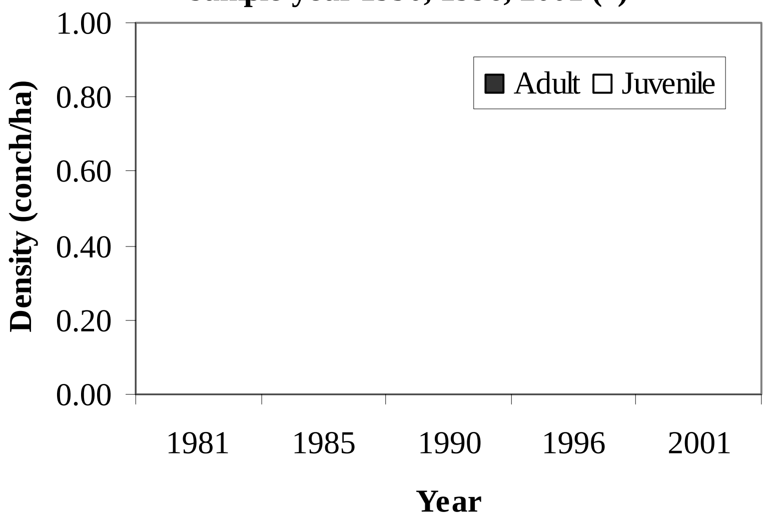
*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)

Figure 44. Density of queen conch observed at Haulover Bay, St. John by sample year 1990, 1996, & 2001(*)

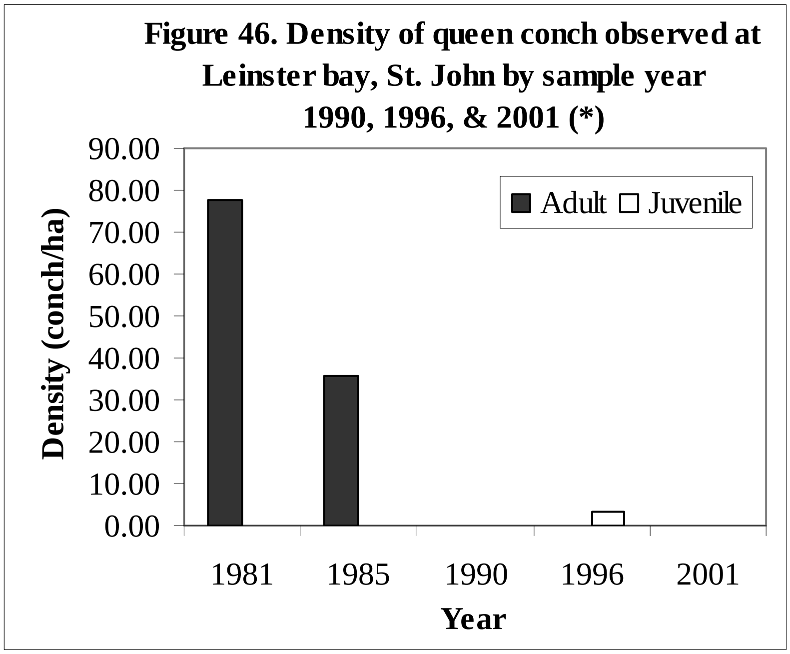


*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)
3) No juvenile data available for 1981 and 1985

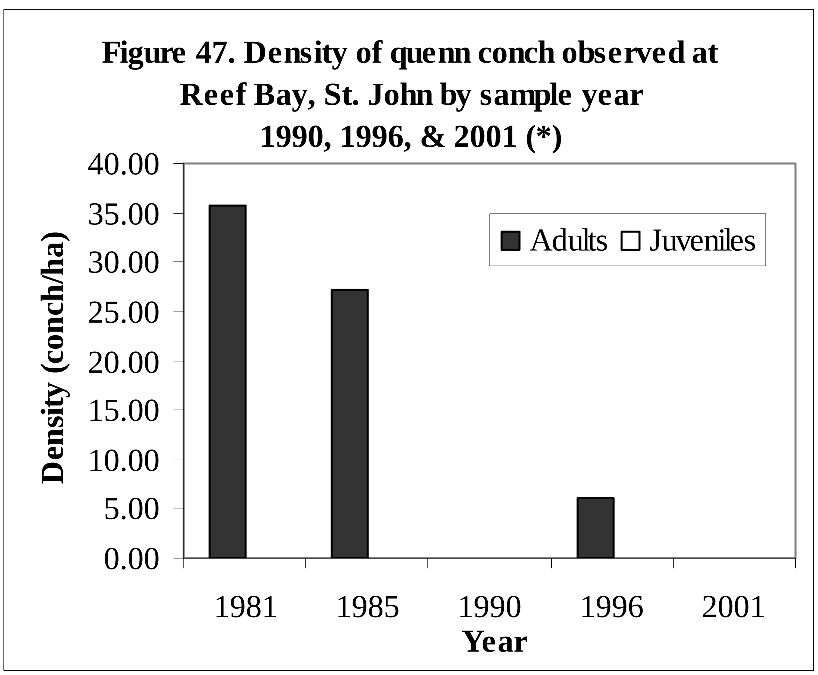
Figure 45. Density of queen conch onserved at Johnson's Reef/Cinnamon Bay, St. John by sample year 1990, 1996, 2001 (*)



*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)
3) No juvenile data available for 1981 and 1985

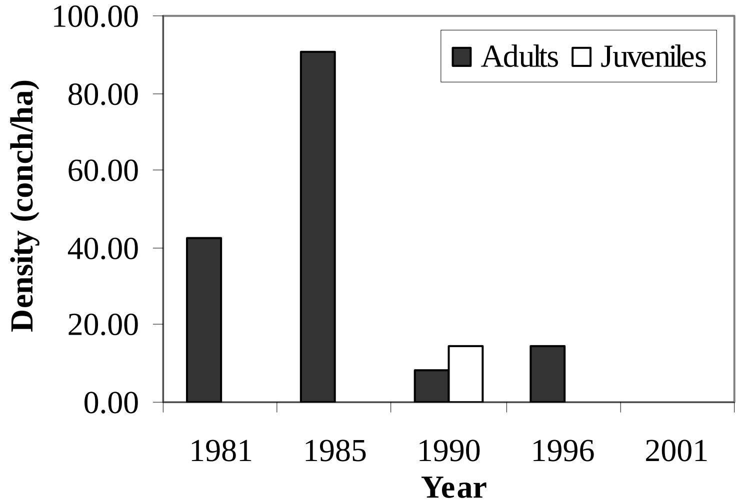


*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)
3) No juvenile data available for 1981 and 1985



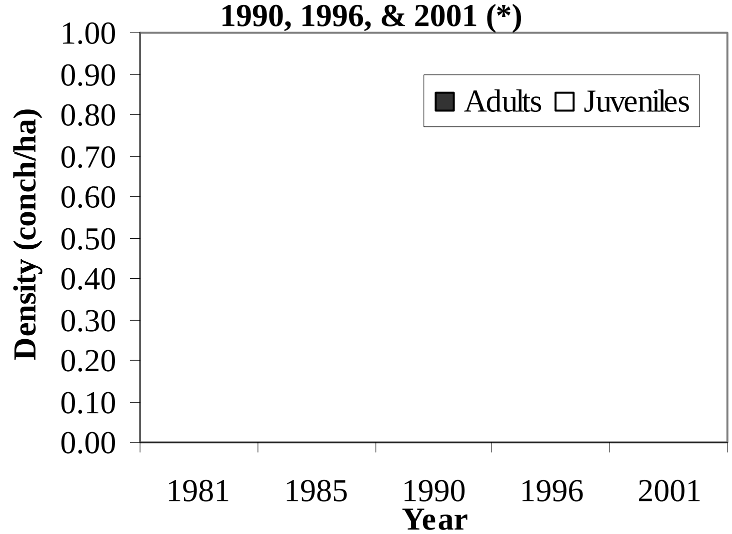
*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)
3) No juvenile data available for 1981 and 1985

Figure 48. Density of queen conch observed at Rendezvous Bay, St. John by sample year 1990, 1996, & 2001 (*)



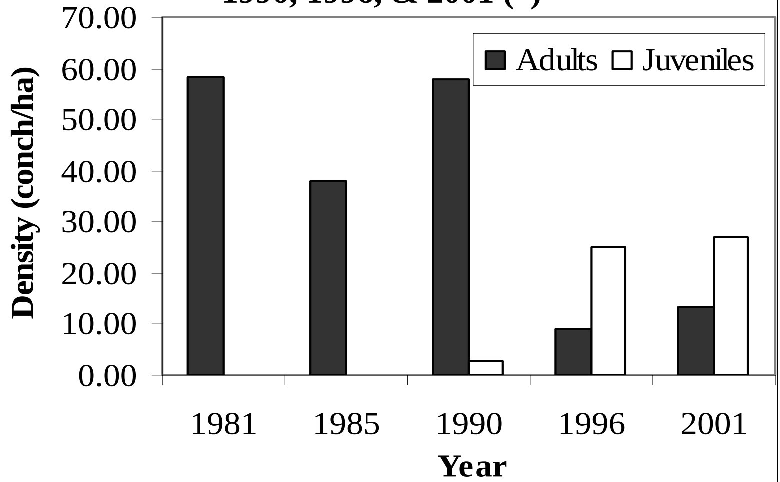
*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)
3) No juvenile data available for 1981 and 1985

Figure 49. Density of queen conch observed at Round Bay, St. John by sample year 1990, 1996, & 2001 (*)



*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)
3) No juvenile data available for 1981 and 1985

Figure 50. Density of queen conch observed at Turner Bay, St. John by sample year 1990, 1996, & 2001 (*)



*Notes: 1) 1990 data from Friedlander et al (1994)
2) 1996 data from Friedlander (1997)
3) No juvenile data available for 1981 and 1985

Table 1. Estimated conch landings (in pounds) for the U.S.V.I., 1993-2001 (*).

Area	Year							
	1993 - 1994	1994 - 1995	1995 - 1996	1996 - 1997	1997 - 1998	1998 - 1999	1999-2000	2000-2001
St. Thomas/ St.John	6,919	551	2,899	1,507	4,773	2,960	2,522	1,423
St. Croix	35,572	37,593	21,763	24,887	72,902	44,317	N/a	102,000
USVI	42,491	38,144	24,662	26,394	77,675	47,277	2,522	1,423

*Note: All data from State/Federal catch reports submitted to the Division of Fish & Wildlife, DPNR and NMFS. Weights are in pounds of meat.

Table 2. Study Sites around St. Thomas, St. John, and St. Croix, USVI (Transect numbers correspond to Figure 1*)

St. Thomas		**St. John**	
No.	**Site Name**	**No.**	**Site Name**
1	Pillsbury Sound	12*	Haulover
2	Linquist Bay	13*	Leinster
3	Magens Bay	14*	Francis
4	West End	15*	Johnson's Reef/Cinnamon Bay
5	Fortuna Bay	16	Lovango
6	Perseverance Bay	17	Two Brothers
7	Water Island / Inside	18	Turner Bay
8	Water Island / Outside	19	Rendezvous Bay
9	Bolongo Bay	20	Fish Bay
10	Secret Harbor	21*	Reef Bay
11	Saba Island (new site for 2001)	22*	Lameshur Bay
		23	Round Bay
St. Croix			
1	Site 1	9	Site 9
2	Site 2	10	Site 10
3	Site 3	11	Site 11
4	Site 4	12	Site 12
5	Site 5	13	Site 13
6	Site 6	14	Site 14
7	Site 7	15	Site 15
8	Site 8	16	Site 16

*Note: Asterisks (*) denote location within Virgin Islands National Park.

Table 3. Number and densities (conch/ha) of juvenile and adult queen conch observed on sites around the US Virgin Islands

ST. THOMAS SITES*	1990				1996				2001			
	Juvenile		Adult		Juvenile		Adult		Juvenile		Adult	
	No.	Density	No.	Density	No.	Density	No.	Density	No.	Density	No.	Density
Bolongo Bay	1	3.08	0	0.00	1	4.89	0	0.00	0	0.00	0	0.00
Fortuna Bay	0	0.00	2	4.88	36	93.29	8	20.73	0	0.00	0	0.00
Inner Water Island	0	0.00	21	45.05	2	5.89	67	197.36	0	0.00	22	115.91
Linquist Beach	3	5.20	13	22.55	28	93.92	15	50.31	4	18.75	11	51.57
Magens Bay	0	0.00	1	2.33	0	0.00	4	16.16	0	0.00	0	0.00
Outer Water Island	1	2.23	2	4.47	12	47.42	0	0.00	0	0.00	0	0.00
Perseverance Bay	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Pillsbury Sound	1	2.35	1	2.35	0	0.00	11	21.20	0	0.00	0	0.00
Saba Island									26	284.14	2	21.86
Secret Harbor	1	3.00	3	9.00	0	0.00	0	0.00	0	0.00	2	16.17
West End	0	0.00	11	27.30	30	69.19	7	16.14	0	0.00	5	57.90
Mean	**0.70**	**1.59**	**5.4**	**11.79**	**10. 9**	**31.46**	**11.2**	**32.19**	**2.73**	**27.54**	**3.82**	**23.95**

*Notes:1) 1996 data from Friedlander (1997), 1990 data from Friedlander et al. (1994).
2) No site data available for St.Thomas in 1981 and 1985, only St. John was surveyed.
3) Saba Island is a new site added in 2001.

Table 3 (continued). Number and densities (conch/ha) of juvenile and adult queen conch observed on sites around US Virgin Islands

ST. JOHN SITES*	1981		1985		1990				1996				2001			
	Adult		Adult		Juvenile		Adult		Juvenile		Adult		Juvenile		Adult	
	No.	**Density**	**No.**	**Density**	**No.**	**Density**	**No.**	**Density**	**No.**	**Density**	**No.**	**Density**	**No.**	**Density**	**No.**	**Density**
Fish Bay	26	83.95	8	26.67	0	0.00	0	0.00	1	3.79	2	7.58	0	0.00	0	0.00
Francis Bay	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	10.70	0	0.00
Haulover Bay	167	173.82	61	63.54	1	3.30	2	6.60	0	0.00	0	0.00	0	0.00	0	0.00
Johnson/ Cinnamon Bay	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Lameshur	9	10.61			1	3.50	16	56.00	0	0.00	30	125.87	9	52.07	0	0.00
Leinster Bay	128	77.42	59	35.76	0	0.00	0	0.00	0	0.00	1	4.59	0	0.00	0	0.00
Mingo/ Lavango	4	2.80			1	2.41	1	2.41	2	3.53	0	0.00	0	0.00	0	0.00
Reef Bay	45	35.77	34	27.20	0	0.00	0	0.00	0	0.00	4	6.10	0	0.00	0	0.00
Rendezvous Bay	32	42.41	68	90.67	0	0.00	4	8.35	5	14.34	5	14.34	0	0.00	0	0.00
Round Bay	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Turner Bay	58	58.29	34	37.78	1	2.63	22	57.75	11	24.89	4	9.05	2	26.87	1	13.43
Two Brothers	7	5.38			2	4.57	9	20.54	1	2.26	4	9.05	0	0.00	6	73.30
Mean	**39.67**	**40.87**	**29.33**	**31.29**	**0.50**	**1.37**	**4.50**	**12.64**	**1.67**	**4.07**	**4.17**	**14.72**	**1.00**	**7.47**	**0.58**	**7.23**

*Notes: 1) 1981 data from Wood and Olsen (1983), 1985 data from Boulon (1987), 1990 and 1996 data from Friedlander (1997).
2) No juvenile data was available for queen conch in 1981 and 1985.

Table 3 (continued). Number and density (conch/ha) of juvenile and adult queen conch observed on sites around the US Virgin Islands

St. Croix Sites*	**2001**			
	Juveniles		**Adults**	
	No.	Density	No.	Density
Site 1	0	0.00	7	52.37
Site 2	25	247.13	5	49.43
Site 3	1	9.59	0	0.00
Site 4	16	138.10	10	86.31
Site 5	0	0.00	1	7.01
Site 6	0	0.00	0	0.00
Site 7	0	0.00	0	0.00
Site 8	0	0.00	13	36.17
Site 9	6	85.14	9	127.71
Site 10	0	0.00	0	0.00
Site 11	0	0.00	0	0.00
Site 12	9	48.88	1	5.43
Site 13	31	487.00	1	15.71
Site 14	1	2.67	0	0.00
Site 15	0	0.00	0	0.00
Site 16	12	137.98	5	57.49
Mean	**6.31**	**72.28**	**3.25**	**27.35**

*Notes: 1) No density data available for individual sites in 1981 (total mean density = 7.6 conch/ha).
2) No surveys were conducted in 1985, 1990, and 1996.
3) No surveys were conducted in 1985, 1990, and 1996.
4) Totals for density columns are mean values.

Table 4. Abundance and mean densities (conch/ha) of adult and juvenile queen conch observed on common transects around the US Virgin Islands between 1981, 1985, 1990, 1996, and 2001 (*).

	1981		1985		1990				1996				2001			
	Adults		Adults		Juvenile		Adult		Juvenile		Adult		Juvenile		Adult	
	No.	Density	No.	Density	No	Density	No.	Density	No.	Density	No.	Density	No.	Density	No.	Density
St. Thomas					7	1.59	54	11.79	109	31.46	112	32.19	4	1.88	40	24.16
St. John	476	40.87	264	31.29	6	1.37	54	12.64	20	4.07	50	14.72	12	7.47	7	7.23
St. Croix		7.61											101	72.28	52	27.31
Total	476	24.24	264	31.29	13	2.96	108	24.43	129	35.53	162	47.17	117	98.50	99	58.70

*Notes: 1) 1981 data from Wood and Olsen (1983), 1985 data from Boulon (1987), 1990 data from Friedlander et al. (1994), Friedlander (1997).
2) Wood and Olsen (1983) indicate that the average weighted adult density for St. Thomas and St. John is 9.7 adult/ha
3) Friedlander et al. (1994) was the only report that provided raw densities from St. John transects performed in 1981
4) There is no raw data available for St. Thomas in 1981 and 1985.
5) In 1985 only St. John was surveyed.

Table 5. Total conch density by depth for common transects around St. Thomas and St. John in 1990, 1996, and 2001 (*)

Depth (m)	Total density (no./ha)		
	1990 (*)	**1996 (*)**	**2001**
0-6	5.10	13.60	0.00
7-12	4.32	29.70	18.96
13-18	17.17	49.30	58.95
19-24	11.18	33.20	16.65
25-30	11.21	51.40	0.00

*Note: 1990 data from Friedlander et al. (1994), 1996 data from Friedlander (1997).

Table 6. Area surveyed by depth range in the US Virgin Islands, 2001

St. Thomas	Area surveyed (m^2) at each depth range					Total area surveyed (m^2)
	0-6	**7-12**	**13-18**	**19-24**	**25-30**	
Bolongo Bay	0	312	1562	0	0	1874
Fortuna Bay	0	0	0	968	0	968
Inner Water Island	63	1833	0	0	0	1896
Linquist Bay	0	144	1991	0	0	2135
Magens Bay	420	1832	1551	0	0	3803
Outer Water Island	0	0	0	1557	0	1557
Perseverance Bay	0	0	0	356	152	508
Pillsbury Sound	0	72	130	520	0	722
Secret Harbor	0	0	1237	0	0	1237
West End	0	0	0	804	20	824
*Saba Island	0	916	0	0	0	916
Total	**483**	**5,109**	**6,471**	**4,205**	**172**	**16,440**

Table 6 (continued). Area surveyed by depth range in the U.S. Virgin Islands, 2001

St. John	Area surveyed (m^2) at each depth range					Total area surveyed (m^2)
	0-6	7-12	13-18	19-24	25-30	
Fish Bay	122	790	0	0	0	912
Francis Bay	0	0	935	0	0	935
Haulover Bay	0	0	1953	772	0	2675
Johnson Reef / Cinnamon Bay	215	536	375	0	0	1126
Lameshur	0	1728	0	0	0	1728
Leinster Bay	0	0	1278	0	0	1278
Mingo/Lovango	0	0	4631	0	0	4631
Reef Bay	268	4385	0	0	0	4653
Rendezvous Bay	0	1696	0	0	0	1696
Round Bay	0	0	0	515	0	515
Turner Bay	0	745	0	0	0	745
Two Brothers	0	0	818	0	0	818
Total	**605**	**9,880**	**9,990**	**1,287**	**0**	**21,713**
St. Croix						
Site 1	0	1337	0	0	0	1337
Site 2	0	1012	0	0	0	1012
Site 3	0	1042	0	0	0	1042
Site 4	0	0	1158	0	0	1158
Site 5	0	1426	0	0	0	1426
Site 6	0	0	0	3773	0	3773
Site 7	0	0	1567	0	0	1567
Site 8	0	225	225	3145	0	3595
Site 9	0	0	0	704	0	704
Site 10	0	0	4041	0	0	4041
Site 11	0	1552	0	0	0	1552
Site 12	0	0	1840	0	0	1840
Site 13	0	636	0	0	0	636
Site 14	0	0	3748	0	0	3748
Site 15	0	1607	0	0	0	1607
Site 16	0	0	870	0	0	870
Total	**0**	**8,837**	**13,449**	**7,622**	**0**	**29,908**

Table 7. Percentages and mean densities (conch/ha) for predominant community types in the U.S. Virgin Islands

Habitat	Percentage (%)	Adult Mean Density
1981 (STT/STJ)*1		
SD	16	9.31
CR	18	10.58
RB*2		
SG	20	6.47
PV*2		
AL	46	9.31
1985 (STT/STJ)*3		
1990 (STT/STJ)*1		
SD	30	10.48
CR	16	1.68
RB	14	24.10
SG	12	17.54
PV	0	0.00
AL	28	17.29
1996 (STT/STJ)*1		
SD	25	20.2
CR	14	0.00
RB	13	12.12
SG	14	27.09
PV	0	0.00
AL	34	55.5
2001(STT/STJ)		
SD	25	16.30
CR	11	1.75
RB	9	15.39
SG	18	23.14
PV	1	0.00
AL	36	34.74

*Notes:

1. 1981 data from Wood and Olsen (1983), 1990 data from Friedlander et al (1994), 1996 data from Friedlander (1997);
2. Rubble (RB) and Pavement (PV) were categorized as Coral Reef (CR) by Wood and Olsen (1983);
3. There is no habitat data available for 1985.

Table 7 (continued). Percentages and mean densities for predominant community types in the U.S. Virgin Islands		
Habitat	**Percentage (%)**	**Adult Mean Density**
1981 (STX)*		
SD	18	5.76
CR	26	7.79
RB	0	0.00
SG	15	2.40
PV	0	0.00
AL	41	10.15
2001(STX)		
SD	5	7.36
CR	9	0.00
RB	4	0.00
SG	7	21.58
PV	48	15.86
AL	27	19.91

*Note: 1981 data from Wood and Olsen (1983).

Appendix 1.
2001 U.S. Virgin Islands Transects GPS Coordinates, Compass Heading and Depths

	Beginning locale		Ending locale		Compass heading
	GPS	**Depth (m)**	**GPS**	**Depth (m)**	
St. Thomas					
Bolongo Bay	18º18.493' N 64º53.848' W	12.1	18º18.426' N 64º54.092' W	9.7	120º
Fortuna Bay	18º20.477' N 65º00.759' W	19.7	18º20.437' N 65º00.883' W	21. 5	280º
Inner Water Island leg A	18º18.636' N 64º57.698' W	15. 5	18º18.504' N 64º57.658' W	17. 3	0º
Inner Water Island leg B	18º18.636' N 64º57.701' W	16.7	18º18.748' N 64º57.695' W	10	10º
Linquist Bay	18º20.584' N 64º51.141' W	12.4	18º20.544' N 64º51.426' W	8.8	300º
Magens Bay	18º21.690' N 64º55.626' W	3.9	18º21.996' N 64º55.151' W	17.0	330º
Outer Water Island	18º18.438' N 64º56.840' W	16.7	18º18.417' N 64º56.631' W	22.4	50º
Perseverance Bay	18º20.710' N 64º59.994' W	21. 2	18º20.642' N 64º00.003' W	25.8	95º
Pillsbury Sound	18º19.307' N 64º49.260' W	11. 5	18º19.246' N 64º49.184' W	23.6	90º
*Saba Island	18º18.452' N 65º00.135' W	6.4	18º18.381' N 65º00.236' W	6.4	270º
Secret Harbor	18º18.298' N 64º51.440' W	18. 2	18º18.377' N 64º51.295' W	16.7	80º
West End	18º21.094' N 65º02.648' W	22.7	18º21.020' N 65º02.738' W	23. 3	220º

Appendix 1 (continued).

2001 U.S. Virgin Islands Transects GPS Coordinates, Compass Heading and Depths

	Beginning locale		**Ending locale**		
	GPS	**Depth (m)**	**GPS**	**Depth (m)**	**Compass heading**
St. John					
Fish Bay	18º19.240' N 64º45.845' W	1.8	18º19.126' N 64º45.880' W	3.0	200º
Francis Bay	18º21.905' N 64º45.015' W	16.7	18º21.781' N 64º44.992' W	17. 3	185º
Haulover Bay	18º21.082' N 64º40.724' W	20	18º21.248' N 64º41.052' W	16.7	330º
Johnson'sReef/ Cinnamon Bay	18º21.523' N 64º45.860' W	5.2	18º21.520' N 64º46.012' W	15. 5	275º
Lameshur Bay	18º19.100' N 64º43.397' W	2.4	18º18.871' N 64º43.441' W	11. 2	200º
Leinster Bay	18º20.584' N 64º51.141' W	15. 2	18º20.544' N 64º51.426' W	17.6	305º
Mingo/Lovango	18º20.992' N 64º49.005' W	16.7	18º21.209' N 64º48.419' W	18. 2	100º
Reef Bay Leg A	18º19.212' N 64º44.881' W	9.7	18º19.290' N 64º44.922' W	7.6	330º
Reef Bay Leg B	18º19.290' N 64º44.922' W	7.6	18º18.790' N 64º45.126' W	2.4	225º
Rendezvous Bay Leg A	18º19.016' N 64º46.291' W	12.7	18º19.030' N 64º46.294' W	8.8	0º
Rendezvous Bay Leg B	18º19.030' N 64º46.294' W	8.8	18º18.950' N 64º46.374' W	11.2	240º
Round Bay	18º20.222' N 64º40.756' W	18. 2	18º20.254' N 64º40.810' W	21. 5	340º
Turner Bay	18º19.351' N 64º47.862' W	10.6	18º19.269' N 64º47.804' W	12.1	150º
Two Brothers	18º20.509' N 64º48.944' W	13.6	18º20.478' N 64º48.383' W	15. 2	100º

Appendix 1(continued)

2001 U.S. Virgin Islands Transects GPS Coordinates, Compass Heading and Depths

	Beginning locale		**Ending locale**		
Conch Transects	***GPS***	**Depth (m)**	**GPS**	**Depth (m)**	**Compass heading**
St. Croix					
Site 1	17º46.573’ N 64º39.975’ W	6.1	17º46.498’ N 64º39.811’ W	7.6	118º
Site 2	17º46.892’ N 64º38.538’ W	11.2	17º46.942’ N 64º38.411’ W	12.1	95º
Site 3	17º46.441’ N 64º37.536’ W	12.1	17º46.385’ N 64º37.407’ W	13.0	105º
Site 4	17º46.682’ N 64º36.990’ W	15.2	17º46.692’ N 64º36.834’ W	15.2	104º
Site 5	17º46.977’ N 64º35.239’ W	10	17º46.965’ N 64º35.047’ W	12.4	161º
Site 6	17º45.522’ N 64º33.157’ W	21.2	17º45.519’ N 64º32.648’ W	24.2	115º
Site 7	17º44.592’ N 64º33.226’ W	18.2	17º44.465’ N 64º33.057’ W	18.2	116º
Site 8	17º44.495’ N 64º34.693’ W	11.2	17º44.082’ N 64º34.947’ W	19.4	243º
Site 9	17º42.670’ N 64º36.386’ W	21.0	17º42.646’ N 64º36.478’ W	21.5	264º
Site 10	17º41.675’ N 64º39.524’ W	13.6	17º41.294’ N 64º39.914’ W	14.2	268º
Site 11	17º41.770’ N 64º41.003’ W	9.4	17º41.923’ N 64º41.146’ W	9.4	269º
Site 12	17º40.975’ N 64º42.005’ W	17.6	17º40.777’ N 64º42.155’ W	17.9	267º
Site 13	17º40.379’ N 64º46.567’ W	6.7	17º40.303’ N 64º46.527’ W	12.1	142º
Site 14	17º39.385’ N 64º47.744’ W	14.5	17º39.089’ N 64º48.154’ W	12.7	250º
Site 15	17º39.381’ N 64º49.381’ W	10.6	17º39.218’ N 64º49.238’ W	12.4	142º
Site 16	17º38.957’ N 64º49.363’ W	15.5	17º39.059’ N 64º49.305’ W	16.1	330º

Appendix 2. Benthic habitat classification scheme* for 2001 transects	
Major habitat types encountered	**Habitat type description**
(1) Unconsolidated Sediments	Mud or sand with <10% cover of submerged vegetation
(2) Coral Reef	Hardened substrate of unspecified relief formed by the deposition of calcium carbonate by reef building corals and other organisms
(3) Colonized Pavement	Flat, low-relief, solid carbonate rock with coverage of macroalgae, hard coral, gorgonians, and other sessile invertebrates that are dense enough to begin to obscure the underlying carbonate rock
(4) Rubble	Scattered rocks or dead, unstable coral rubble often colonized with algae
(5) Seagrass	Habitat with 10% or more cover of *Thalassia testudinum*, *Syringodium filiforme*, *Halodule wrightii*, *Halophila ballonis*, or some combination thereof
(6) Algal Plain	An area with 10% or greater coverage of any combination of numerous species of red, green, or brown macroalgae

Note: Habitat classification based on NOAA's National Ocean Service (NOS) habitat classification (see NOS 2000).

Appendix 3. Conch maturity categories*			
Stage	Category	Lip thickness (mm)	Description
0	Juvenile	No lip	Any conch without flared lip
1	Newly mature adult	1 -7 mm	Newly mature, shell clean. Short time period for this stage.
2	Sexually mature adult	8 - 15 mm	Sexually mature. Flared lip fully formed. Little to no erosion on shell. Shell color of periostracum is tan.
3	Old adult	16 - 33 mm	Old adult, outer lip starting to erode. Fouling starting to occur.
4	Very old adult (roller)	34 - 59 mm	Lip is very thick and square. Heavy erosion is present. Short total length.

*Note: Maturity categories from Friedlander (1997).

Appendix 4. Total area (m^2) surveyed for conch transects by year					
	1981 (*)	**1985 (*)**	**1990 (*)**	**1996 (*)**	**2001**
STT/STJ	212,000	71,900 (STJ only)	82,978	74,226	38,155
STX	178,000				29,910

*Notes: 1) 1981 data from Wood and Olsen (1983), 1985 data from Boulon (1987), 1990 data from Friedlander et al. (1994), 1996 data from Friedlander (1997).
2) In 1981 surveys were completed using towed-diver transects. Scooter transects were used for all other survey years.

Appendix 5. Area surveyed for predominant community types in the U.S. Virgin Islands, 2001							
Site	**Area surveyed (m^2) of each habitat type**						
St. Thomas	**Sand**	**Coral Reef**	**Rubble**	**Seagrass**	**Pavement**	**Algae**	**Total area surveyed (m^2)**
Bolongo Bay	312	562	0	125	0	875	1,874
Fortuna Bay	644	0	0	0	0	322	966
Inner Water Island	284	537	0	0	0	1,074	1,895
Linquist Bay	0	0	0	356	0	1,778	2,134
Magens Bay	1,961	1,680	560	0	0	0	4,201
Outer Water Island	27	30	0	0	0	1,500	1,557
Perseverance Bay	0	279	0	0	0	229	508
Pillsbury Sound	0	144	58	0	520	0	722
Secret Harbor	315	0	0	613	0	309	1,237
West End	0	0	432	0	0	0	432
*Saba Island	153	0	0	763	0	0	916
Total	**3,696**	**3,232**	**1,050**	**1,857**	**520**	**6,087**	**16,442**
St. John							
Fish Bay	548	0	0	365	0	0	913
Francis Bay	127	0	0	0	0	807	934
Haulover Bay	454	636	0	0	0	1635	2725
Johnson Reef / Cinnamon Bay	268	0	268	0	0	590	1126
Lameshur	207	0	0	1175	0	346	1728
Leinster Bay	447	0	0	0	0	830	1277
Mingo/Lovango	0	0	2084	0	0	2547	4631
Reef Bay	2326	0	0	2148	0	179	4653
Rendezvous Bay	594	0	0	721	0	382	1697
Round Bay	78	271	0	0	0	116	465
Turner Bay	27	0	0	718	0	0	745
Two Brothers	655	0	0	0	0	164	819
Total	**5,731**	**907**	**2,352**	**5,127**	**0**	**7,596**	**21,713**

Appendix 5 (continued).
Area surveyed for predominant community types in the U.S. Virgin Islands, 2001

Site	**Area surveyed (m^2) of each habitat type**						
St. Croix	**Sand**	**Coral Reef**	**Rubble**	**Seagrass**	**Pavement**	**Algae**	**Total area Surveyed (m^2)**
Site 1	45	0	0	0	1248	45	1338
Site 2	0	0	0	221	0	791	1012
Site 3	245	0	0	797	0	0	1042
Site 4	0	0	0	1158	0	0	1158
Site 5	509	0	662	0	255	0	1426
Site 6	0	0	0	0	3773	0	3773
Site 7	0	0	0	0	1567	0	1567
Site 8	824	599	0	0	0	2171	3594
Site 9	0	0	0	0	705	0	705
Site 10	0	0	0	0	4040	0	4040
Site 11	0	0	0	0	0	1552	1552
Site 12	0	0	0	0	491	1350	1841
Site 13	0	0	0	0	0	637	637
Site 14	0	1999	375	0	1374	0	3748
Site 15	0	0	0	0	771	836	1607
Site 16	0	0	0	0	0	870	470
Total	**1,623**	**2,598**	**1,037**	**2,176**	**14,224**	**8,252**	**29,910**

Appendix 6.
Number of adult and juvenile queen conch observed at each community type in The U.S. Virgin Islands, 2001*

Site	**Habitat Type**											
St. Thomas	Sand		Coral Reef		Rubble		Seagrass		Pavement		Algae	
	Adt	Juv	Adt	Juv	Adt	Juv	Adt	Juv	Adt	Juv	Adt	Juv
Bolongo Bay	0	0	0	0			0	0			0	0
Fortuna Bay	0	0									0	0
Inner Water Island	0	0	2	0							20	0
Linquist Bay							1	1			10	3
Magens Bay	0	0	0	0	0	0						
Outer Water Island	0	0	0	0							0	0
Perseverance Bay			0	0							0	0
Pillsbury Sound			0	0	0	0			0	0		
Secret Harbor	0	0					1	0			1	0
West End					5	0						
Saba Island	0	1					2	25				
Total	**0**	**1**	**2**	**0**	**5**	**0**	**4**	**26**	**0**	**0**	**31**	**3**

*Note: Blank cells represent the absence of habitat for transect.

Appendix 6 (continued).
Number of adult and juvenile queen conch observed at each community type in The U.S. Virgin Islands, 2001*

Site	**Habitat Type**											
St. John	**Sand**		**Coral Reef**		**Rubble**		**Seagrass**		**Pavement**		**Algae**	
	Adt	Juv	Adt	Juv	Adt	Juv	Adt	Juv	Adt	Juv	Adt	Juv
Fish Bay	0	0					0	0				
Francis Bay	0	0									0	1
Haulover Bay	0	0	0	0							0	0
Johnson Reef / Cinnamon Bay	0	0			0	0					0	0
Lameshur	0	0					0	9			0	0
Leinster Bay	0	0									0	0
Mingo/ Lovango					0	0					0	0
Reef Bay	0	0					0	0			0	0
Rendezvous Bay	0	0					0	0			0	0
Round Bay	0	0	0	0							0	0
Turner Bay	0	0					1	2				
Two Brothers	1	0									5	0
Total	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**11**			**5**	**1**
St. Croix												
Site 1	3	0							2	0	2	0
Site 2							0	8			5	17
Site 3	0	1					0	0			0	0
Site 4							10	16				
Site 5	1	0	0	0	0	0	0	0	0	0	0	0
Site 6									0	0		
Site 7									0	0		
Site 8	0	0	0	0							13	0
Site 9									9	6		
Site 10									0	0		
Site 11											0	0
Site 12									0	0	1	9
Site 13											1	31
Site 14			0	0	0	1			0	0		
Site 15									0	0	0	0
Site 16											5	12
Total	**4**	**1**	**0**	**0**	**0**	**1**	**10**	**24**	**11**	**6**	**27**	**69**

*Note: Blank cells represent the absence of habitat for transect.

Appendix 7

Density (conch/ha) of adult and juvenile queen conch at each community type in the U.S. Virgin Islands, 2001.

Site	**Habitat Type**											
St. Thomas	Sand		Coral Reef		Rubble		Seagrass		Pavement		Algae	
	Adt	Juv	Adt	Juv	Adt	Juv	Adt	Juv	Adt	Juv	Adt	Juv
Bolongo Bay	0.0	0.0	0.0	0.0			0.0	0.0			0.0	0.0
Fortuna Bay	0.0	0.0									0.0	0.0
Inner Water Island	0.0	0.0	10.5	0.0							105.4	0.0
Linquist Bay							4.7	4.7			46.9	14.1
Magens Bay	0.0	0.0	0.0	0.0	0.0	0.0						
Outer Water Island	0.0	0.0	0.0	0.0							0.0	0.0
Perseverance Bay			0.0	0.0							0.0	0.0
Pillsbury Sound			0.0	0.0	0.0	0.0			0.0	0.0		
Secret Harbor	0.0	0.0					8.1	0.0			8.1	0.0
West End					57.9	0.0						
Saba Island	0.0	10.9					21.9	273.2				
Total	**0.0**	**10.9**	**10.5**	**0.0**	**57.9**	**0.0**	**34.6**	**277.9**	**0.0**	**0.0**	**160.3**	**14.1**
St. John												
Fish Bay	0.0	0.0					0.0	0.0			0.0	0.0
Francis Bay	0.0	0.0									0.0	10.7
Haulover Bay	0.0	0.0	0.0	0.0							0.0	0.0
Johnson Reef Cinnamon Bay	0.0	0.0			0.0	0.0					0.0	0.0
Lameshur	0.0	0.0					0.0	52.0			0.0	0.0
Leinster Bay	0.0	0.0									0.0	0.0
Mingo/ Lovango					0.0	0.0					0.0	0.0
Reef Bay	0.0	0.0					0.0	0.0			0.0	0.0
Rendezvous Bay	0.0	0.0					0.0	0.0			0.0	0.0
Round Bay	0.0	0.0	0.0	0.0							0.0	0.0
Turner Bay	0.0	0.0					13.4	26.9				
Two Brothers	73.3	0.0									61.1	0.0
Total	**73.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**13.4**	**78.9**			**61.1**	**10.7**

*Note: Blank cells represent the absence of habitat for transect.

Appendix 7 (continued). Density (conch/ha) of adult and juvenile queen conch at each community type in U.S. Virgin Islands, 2001*												
Site	**Habitat Type**											
St. Croix	Sand		Coral Reef		Rubble		Seagrass		Pavement		Algae	
	Adt	Juv	Adt	Juv	Adt	Juv	Adt	Juv	Adt	Juv	Adt	Juv
Site 1	22.4	0.0							15.00	0.0	15.0	0.0
Site 2							0.0	79.1			49.4	168.1
Site 3	0.0	9.6					0.0	0.0			0.0	0.0
Site 4							86.3	138.1				
Site 5	7.0	0.0			0.0	0.0			0.0	0.0		
Site 6									0.0	0.0		
Site 7									0.0	0.0		
Site 8	0.0	0.0	0.0	0.0							36.	0.0
Site 9									127.7	85.1		
Site 10									0.0	0.0		
Site 11											0.0	0.0
Site 12									0.0	0.0	5.4	48.9
Site 13											15.7	487.0
Site 14			0.0	0.0	0.0	2.7			0.0	0.0		
Site 15									0.0	0.0	0.0	0.0
Site 16											57.5	138.0
Total	**29.5**	**9.6**	**0.0**	**0.0**	**0.0**	**2.7**	**86.3**	**217.2**	**142.7**	**85.1**	**179.2**	**841.9**

*Note: Blank cells represent the absence of habitat for transect.

Appendix 8. Total queen conch density (conch/ha) at each community type in The U.S. Virgin Islands, 2001*						
Site	**Habitat Type**					
St. Thomas	Sand	Coral Reef	Rubble	Seagrass	Pavement	Algae
Bolongo Bay	0.00	0.00		0.00		0.00
Fortuna Bay	0.00					0.00
Inner Water Island	0.00	10.52				105.40
Linquist Bay				9.40		60.90
Magens Bay	0.00	0.00	0.00			
Outer Water Island	0.00	0.00	0.00			0.00
Perserverance Bay	0.00	0.00				0.00
Pillsbury Sound		0.00	0.00		0.00	
Secret Harbor	0.00			8.10		8.10
West End			57.90			
Saba Island	10.91			295.10		
Total	**10.91**	**10.52**	**57.90**	**312.50**	**0.00**	**174.40**
St. John						
Fish Bay	0.00			0.00		
Francis Bay	0.00					10.70
Haulover Bay	0.00	0.00				0.00
Johnson Reef / Cinnamon Bay	0.00		0.00			0.00
Lameshur	0.00			52.07		0.00
Leinster Bay	0.00					0.00
Mingo/Lovango			0.00			0.00
Reef Bay	0.00			0.00		0.00
Rendezvous Bay	0.00			0.00		0.00
Round Bay	0.00	0.00				0.00
Turner Bay	0.00			40.30		
Two Brothers	12.22					61.08
Total	**12.22**	**0.00**	**0.00**	**92.37**		**71.78**

*Note: Blank cells represent the absence of habitat for transect.

Appendix 8 (continued).
Total queen conch density (conch/ha) at each community type in the U.S. Virgin Islands, 2001.

St. Croix	Sand	Coral Reef	Rubble	Seagrass	Pavement	Algae
Site 1	22.44				15.00	15.00
Site 2				79.08		217.50
Site 3	9.59			0.00		
Site 4				224.41		
Site 5	7.01		0.00		0.00	
Site 6					0.00	
Site 7					0.00	
Site 8	0.00	0.00				36.17
Site 9					212.85	
Site 10					0.00	
Site 11						0.00
Site 12					0.00	54.31
Site 13						502.71
Site 14		0.00	2.67		0.00	
Site 15					0.00	0.00
Site 16						195.47
Total	**39.04**	**0.00**	**2.67**	**303.49**	**227.85**	**1021.16**

*Note: Blank cells represent the absence of habitat for transect.