Queen Conch Stock Assessment

Proposed MPA and Fishing Grounds

Berry Islands, Bahamas

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By

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Project Sponsors, Contributors and Volunteers

Project Sponsors

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Table of Contents

Tables

Figures

PROJECT SUMMARY

This field study was designed for two primary objectives – to provide baseline data on the distribution and abundance of queen conch in a proposed marine protected area (MPA) in the southeast Berry Islands, and for a stock assessment of queen conch in the historically important fishing grounds on the Berry Islands bank. The study was conducted during June and July 2009, with a combination of SCUBA and towed diver surveys at more than 300 locations. On average, an area of more than 5,000 m^2 (0.5 hectare) was surveyed for conch at each location.

Adult queen conch on the Berry Islands bank were most abundant in a depth zone 5–10 m deep in an area west of Rum Cay on the southern edge of the bank. Subadult conch (i.e., 3 yr old "rollers") were most abundant in the same general location but in depths less than 2.5 m. Average densities in this south sector were 118 adults per hectare and 70 subadults per hectare. North and west sectors of the fishing ground had extremely low conch densities, typically less than 4 adults per hectare, and 8 subadults per hectare. Total numbers of conch for the survey area were approximately 2.54 million adults and 1.61 million subadults. The southern sector of the bank contained more than 98% of the adults in the total surveyed area and 96% of the subadults.

In the MPA, queen conch were surveyed on the shallow bank north and west of the islands. In this area, densities averaged just 4.4 adults per hectare and 13 subadults per hectare. On the deeper island shelf south and east of the islands average densities for adults ranged 3.7 to 27.4 per hectare, with highest density in a depth range of 5-10 m. Subadult densites were less than 3 per hectare at all depth intervals. A total of just 9,200 adults and 39,400 subadults were estimated for the shallow bank area encompassed by the proposed MPA.

Juvenile aggregations (>50 individuals/ha) were observed at just 10 locations, five in the proposed MPA and one just outside the northwest corner of the MPA. The other four sites occurred west of Chub Cay, along the southern edge of the bank. Two nursery grounds near Cat and Vigilant Cays studied by Iversen in the 1980s now have very few conch.

The surveys were conducted during peak mating season for queen conch and offered insight into the status of the reproductive population on the Berry Islands bank. Mating behavior was observed at only 15 of 308 survey locations, with just one mating pair observed in the MPA. The number of mating pairs was directly proportional to conch density, with highest numbers found in an area along the southern bank edge characterized by small phenotype adults (average shell length = 15 cm). These small adults probably have low fecundity. Outside the area of highest adult density, the adults on the Berry Islands bank had thin shell lip thickness and were probably not yet reproductively mature. Even in the high density areas, mating frequencies were far below those predicted by earlier studies of density-dependent mating in the Exuma Cays Land and Sea Park. Logistic regression showed that a 50% probability of mating occurred at 335 adults per hectare and 90% probability at 500 adults per hectare. Very few locations had these densities.

Given the low density of queen conch adults over most of the Berry Islands bank fishing grounds, relative youth of the adult population except in the area west of Rum Cay where adults were very small, low mating frequency, and apparent loss of

historically significant juvenile populations, it seems likely that recruitment overfishing is occurring. Management actions need to be taken to preserve the reproductive potential, protect juvenile aggregations, and control fishing mortality. Suggested possible actions include developing and implementing a conch management plan specific to the Berry Islands, expanding or moving the MPA boundaries, prohibiting collecting conch with hookah gear, requiring that conch be landed in the shell to reduce illegal harvest of underage conch, and instituting a closed season for conch fishing during the reproductive season. Informal interviews with Berry Islanders suggest that they recognize the declining fishery for queen conch and favor management actions such as those listed. The success of a fisheries management plan will likely depend upon community involvement in management decisions, and fisheries monitoring and enforcement.

1.0 INTRODUCTION

1.1 Status of International Conch Fisheries

Queen conch (*Strombus gigas*) have been heavily exploited throughout the Greater Caribbean region for decades. In 1992, concern for the future of the species led the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) to list queen conch in their Appendix II that includes species not necessarily threatened with extinction, but for which trade must be controlled to avoid utilization incompatible with their survival. Since 1995, CITES has been reviewing the biological and trade status of queen conch and has recommended that the importation of conch be prohibited from 8 countries. Queen conch continues to be a commercially viable fishery in a few Caribbean countries, including Jamaica and the Turks and Caicos Islands (British West Indies) which CITES considers to be well-managed and, Belize and the Bahamas where more management has been requested and the end of export suggested.

1.2 Status of Bahamian Conch Fisheries

Locally, it has long been assumed that the large physical extent of the Bahamas (343,450 sq. km., CRFM, 2006) and the relatively small population (331,000, 2007 est.) has protected its marine resources from overfishing. However, evidence for the impact of fishing on conch populations in the Bahamas was provided 15 years ago by Stoner & Ray (1996) who showed that densities of adults on the shallow bank in the Exuma Cays Land & Sea Park were 31 times higher than densities in comparable habitats with moderate fishing pressure near Lee Stocking Island. Differences diminished with water depth on the offshore island shelf as availability of conch to free-diving fishers decreased with depth, but differences remained as high as 15 times. As might be expected, ages of conch in fished areas of the bank were substantially less than ages in the protected area. Since that early comparative study, fishing pressure on queen conch has grown with increasing demand for seafood in the Bahamas and abroad, and with increased use of surface-supplied air in diving operations. As a result, juveniles are being harvested illegally, and the previously inaccessible deep-water stocks are being exploited, leaving no refuge for reproduction.

Conch populations near New Providence Island have diminished below economically useful levels and conch for Nassau restaurants are now gathered from nearby Andros Island, the Berry Islands and the more distant Abacos. The Department of Marine Resources (DOMR) has been considering various fishery management options including minimum size and age limits, a closed season for conch reproduction, ending exports and a network of marine protection areas (MPA) including one in the southeast corner of the Berry Islands that is anticipated to be established in late 2009. Unfortunately, funding for stock density data in the Bahamas has not been available and the DOMR is without data to make informed management decisions.

1.3 Focus of Study

This study was developed subsequent to meetings in March 2009 between marine scientists of Community Conch and the DOMR. Officials at DOMR requested conch density data in the proposed MPA and for the primary fishing grounds on the Berry Islands bank that they had identified through discussions with fishermen (Fig. 1). Supplemental meetings with other interested persons at the Bahamas National Trust (BNT), the Bahamas Reef Environment Educational Foundation (BREEF), and the Bahamas office of The Nature Conservancy (TNC) supported this focus for current conch research in the Bahamas.

Specific objectives:

1) Provide baseline stock density and distribution data for queen conch inside the new MPA and for comparison, in surrounding areas
2) Collect density data for the important fishing grounds that occur on the south, west and north sectors of the Berry Islands bank.

Both density surveys were designed to yield the baseline density data needed by the DOMR for comparison with subsequent surveys and for consideration in terms of depensatory observations relevant to conch. For example, Appeldoorn (1988) theorized that conch reproduction requires a minimum density of adults, and this was verified by Stoner and Ray-Culp (2000) in the Exuma Cays Land & Sea Park.

Additional objective:

3) Conduct interviews with local community members to gain a better understanding of their views regarding the state of the conch fishery in the Berry Islands and the proposed marine reserve.

The interviews conducted by Community Conch volunteers served as an opportunity for local community members to participate in the work of this organization at a preliminary level. It is widely recognized that community involvement in the process of development and management of marine protected areas (Mascia, 2003) and fisheries (Berkes et al., 2001) can improve policy effectiveness. A more thorough explanation of this aspect of the study and the results are described in Appendix A.

1.4 Site Description

The Berry Islands are located approximately 35 miles northwest of Nassau. They consist of 30 small islands that when combined form a landmass of 12 sq. mi. The total human population is approximately 650, the majority living on the largest island of Great Harbour Cay in the north. The other major population centers are Chub Cay and Frazer's Hog Cay on the south. These two cays along with Bird Cay and Whale Cay are within the boundaries of the proposed MPA on the southeast corner of the Berry Islands.

Geographically, the Berry Islands are located at the northeast corner of the Great Bahama Bank. This corner of the Great Bahama Bank is referred to as the Berry Islands bank in this report. The islands or cays form a semicircle that extends eastward. Offshore are deep banks ranging from 5 to 22 meters that transition into deep channels; Northwest Providence Channel on the north, Northeast Providence Channel on the east and the

Northwest Channel on the south. The drop off from the *deep banks* to the channels is gradual to the east occurring up to 8 miles out and steep to the north and south at 1-2 miles out. The sides of the channels are steep and drop quickly from 1,000 m to as much as 3,000 m in some locations. Inshore of the curve of the islands is a *shallow bank* interrupted by sand bores with depths ranging from 0-2 m at low tide. To the west of this shallow interior are the north and west fishing grounds which include depths of 1-4 m.

2.0. METHODOLOGY

2.1 Fishing Grounds and MPA Surveys

2.1.1. Timing of Surveys

The surveys were conducted from June 6 through July 10, 2009. This survey period was selected to maximize overlap with the most active mating season of *Stombus gigas* which is June, July and August (Stoner et al., 1992) and minimize overlap with the hurricane season which begins June 1. Future comparison surveys would best be completed during a similar period.

2.1.2 Berry Islands Fishing Grounds

DOMR has developed maps of important conch fishing grounds in the Bahamas. Those in the vicinity of the Berry Islands run in a wide band on the shallow banks west from Chub Cay to the vicinity of Northwest Channel light, and from there northeast to Great Stirrup Cay and south to the Joulter Cays. There were also a few smaller areas west of Bonds Cay and Great Harbour Cay (Fig. 1). Due to logistical constraints, the area south of Northwest Channel light to the Joulter Cays was not included in this assessment. To facilitate sampling for a stock assessment, a grid of 1^0 blocks of latitude and longitude was overlaid on the fishing grounds. At the latitude of the Berry Islands, each block measures 1855 m north to south and 1673 m east to west and was designated by its latitude/longitude coordinates in the southeast corner. Towed surveys were conducted in each block, typically starting just inside the southeast corner and towed to the northwest with the prevailing winds. Occasionally the direction was reversed if winds were from the west.

In each block, a snorkeler was towed 1000 m (determined by GPS) and observed a transect 6 m wide for a total of 6000 m^2. Snorkelers identified:

- # of adults, identified by a flared lip; 3-4 years and older
- # of sub-adults (rollers), identified by lack of a flared lip; 3 years old
- # of juveniles smaller than 15 cm shell length; 1-2 year olds (numbers were estimated when too many to count)

The results were standardized to number of conch per hectare.

Where conch were most abundant, they were opportunistically measured for:

- Shell length (± 0.1 cm) with large vernier calipers
- Shell lip thickness (± 1 mm) with small vernier calipers – to provide index of relative age (Appeldoorn 1998, Stoner and Sandt 1992)

Reproductive behavior was also noted by counting the:

- Number of pairs - contact between 2 or more adults

Though Stoner & Culp-Ray (2000) distinguished between pairing (contact) and mating (copulation), copulation could not be confirmed while towing, therefore pairs counted in this survey may or may not have been involved in copulation.

2.1.3 Proposed Marine Protected Area

The boundary of the proposed MPA on the southeast corner of the Berry Islands encompasses approximately 60% deep water (>20 m) and 40 % and shallow water (<20 m). Deep banks rim the islands on the offshore sides to the south and east. Shallow banks occur inshore, on the west and north sides of the islands. The islands of Crab Cay, Chub Cay, Frazer's Hog Cay, Bird Cay and Whale Cay are included. Little Whale, Cockroach and the Fish Cays are excluded.

Depth stratified surveys were conducted offshore on the south and east sides of the islands. Five depth intervals were sampled along 6 survey lines that were located perpendicular to the islands and the bathymetry in the MPA (M1-M6, Fig. 1). For comparison, 3 transects were located east and west of the MPA (W1-W3, E1-E3). The depth intervals chosen (A:0-2.5, B: 2.5-5, C:5-10, D:10-15, E:15-20 m) are identical to those used by Stoner and Ray (1996) for direct comparison with that earlier study in the Exumas Cays. The two shallowest interval locations (A & B) were towed in a direction parallel to the isobaths. The three deeper depth intervals, C, D and E were sampled by divers. Two divers descended at the depth location on the survey line and swam four transects parallel to the isobaths. The length and direction of each transect was determined using a calibrated flow meter and compass carried by one diver while the other diver recorded flow meter readings, numbers and types of conch (as described above). Four, 7 minute swims were conducted from the anchor set. Each transect was 8 m wide as determined by a measured cord carried between the two divers. In strong current conditions, sometimes drift dives were required, their length being determined by GPS on descent and ascent.

Shallow water tows were conducted on the north and west sides of the islands within the MPA boundaries. As described in the fishing grounds section, tows were run in grids usually from the southeast corner of each grid cell. However, the shallow bank of the MPA and the shallow area south of Great Stirrup Cay were divided into four cells per degree of latitude and longitude for higher resolution of mapping. Tides determined boat entry into many of these areas. Occasionally, walking transects were performed at low tide. In very calm conditions, surveys could be made from the bow of the boat. This occurred only for 3 days in the lee of Bird and Whale Cays.

The data collected on the depth stratified surveys and the shallow water tows were the same as that collected in the fishing grounds as described in the previous section.

2.1.4 Previously Surveyed Nursery Sites

Two nursery sites identified and studied by Iversen et al. (1987) in the early 1980's now lie within the proposed MPA. These included the shallow waters surrounding Vigilant and Cat Cays which were revisited during June 2009 (Fig. 6). Each site was visited near high water, first attempting to determine the presence of queen conch, followed by systematic belt transects when centers of the populations were located. Shell length and lip thickness data were collected for representative adults when present.

2.1.5 Sites Identified by Local Fishermen

Interviews with local fishermen from Bullock's Harbor on Great Harbour Cay identified several locations that were not included in the fishing grounds mapped by DOMR.

2.1.5.1 Great Harbour Transects

Based on information from a local fisherman, three long depth stratified transects were set up west of Great Harbour Cay (N1-N3, Fig. 1). Depths being deeper than any other location in the study, the five intervals started at B and ended with F:20-25 m and G; 25-30 m. Due to current, most dives were drift dives and data was collected as described for the E, W and M transects in and adjacent to the MPA.

2.1.5.2 Ambergris and Other Shallow Sites

Additional information from local fishermen suggested surveying shallow sites near Ambergris Cay and Great Stirrup Cay (Fig. 1). Conch data were collected at these sites using tows.

2.1.6 Survey Boats

Two 17-18 foot motorboats dispatched from two larger support vessels were used to conduct the towing and diving surveys whether deep or shallow. Garmin GPS 440S units were installed on each boat. The position of grid corners for the fishing grounds and shallow MPA work were uploaded into the GPS units for easy location in the field. Coordinates from each day's sampling were downloaded from the GPS to computers at the end of each day.

3.0 RESULTS

3.1 Depth-Stratified Surveys in and around the Proposed MPA

Densities of adult conch within the boundaries of the proposed MPA varied substantially with depth (Fig. 2a). Mean density was highest in depth interval C (5-10 m) (27.4 adults/ha), and ranged 3.7 to 7.2 adults/ha in the surrounding depth strata (Table 1). The highest value in the survey of 110 adults/ha occurred at the east edge of the proposed MPA on survey line M-6 in 9 m of depth. Another high value (93.6 adults/ha) occurred in 12 m depth on the E-3 survey line east of Adler and Frozen Cays north of the MPA. These values contributed to high average densities shown in Table 1, while most of the other values throughout this part of the survey were substantially lower (0-15 adults/ha). Overall averages were 4.7 to 13.7 adults/ha for the depth strata surveyed however the density values were highly variable resulting in large standard deviations (Table 1).

Subadult conch in this area of the survey were concentrated in depths < 5m (depth intervals A and B) (Fig. 2b, Table 2), and density values were generally lower than those of adults. Highest average values (6.1 to 7.2 subadults/ha) occurred in the shallow depth intervals on the survey lines west of the proposed MPA. However, substantially higher subadult densities shown just west of the MPA boundaries (Fig. 4) were found well north of the survey lines represented in Table 2 and Fig. 2. While sub-adults occurred in low densities at intervals A through D in the proposed MPA, none were observed in intervals deeper than 5 m in survey lines east or west of the MPA. Age-1 and 2 juveniles were very rare at the stations located offshore from the islands. Only five individuals were observed within offshore MPA boundaries (intervals A, B, and D), and none were observed in offshore waters east of the MPA. Juveniles were more abundant in the western sector (interval A only) and on the shallow bank north and west of the islands (see below).

3.2 Shallow Bank Survey in the Proposed MPA

Adult queen conch were relatively rare on the inshore, shallow bank within the proposed MPA, occurring at fewer than half of the survey sites (Table 3). Several sites had densities between 0.1 and 10 adults/ha, and 10 to 25 adults/ha, but the majority of 42 transect sites had densities equal to zero (Fig.5). Highest densities (33.3 adults/ha) occurred north of Bird Cay. Adults in substantial densities were also found in a small well-studied nursery area east of Vigilant Cay (see below).

Subadult conch were somewhat more abundant in the shallow bank habitat within the MPA boundaries than adults (Table 4). Like adults, subadults were observed on fewer than half of the survey sites (Fig. 6). Three locations yielded estimates of 50-100 per ha, and three had more than 100 subadults/ha. No particular pattern was evident, except that the most consistent presence of subadult conch occurred on the bank between Frazer's Hog Cay and Bird Cay.

Juvenile conch (age-1 and age-2) were observed at 5 locations on the shallow bank inside the proposed MPA, all in < 2 m depth, and at one location just outside the northwest corner of the MPA north of Crab Cay (Fig. 6). These observations included those at Vigilant and Cat Cays (see below). Highest densities (213-317 juveniles/ha) occurred on the shallow bank between Frazer's Hog Cay and Bird Cay. However,

juveniles were often highly aggregated and they will need to be surveyed with higher precision in the future.

3.3 Previously Surveyed Nursery Sites

The Vigilant Cay nursery was visited on 10 June 2009, near high water. Relatively few conch were found on the west side of the island, and one 1,000 m transect line (0.6 ha) through the sparse western population revealed just one subadult and two juveniles. A more substantial population was obvious on the very shallow east side of the Cay where conch were concentrated in a north-south band approximately 400 m long. Four transects through this band yielded average density estimates of 16.7 (SD = 14.0) adults/ha, 14.0 (SD = 12.8) subadults/ha, and 23.8 (SD = 34.4) juveniles/ha. A sample of the adults averaged 19 cm shell length (SD = 1 cm) and all had very thin shell lips (mean = 2 mm, SD = 1 mm) (n = 15) (see below). The entire population was comprised of not more than 60 adults, 50 subadults, and a few hundred age-1 and age-2 juveniles.

The Cat Cay nursery was visited on 11 June 2009. At high tide it was possible to circumnavigate the small cay in a small boat, except for a short section at the southwest corner which is nearly attached to Bird Cay by a very shallow sand bar. A systematic search of the shallow bank in bare sand and seagrass habitats from the shoreline to 200 m offshore in depths ranging 0 to 2.5 m revealed very few conch. In approximately 3.0 ha searched, only 1 adult, 2 subadult, and 21 juvenile conch were observed, and it was clear that the site did not serve as a significant nursery habitat for queen conch at the time of the survey.

3.4 Broad-Scale Survey on the Fishing Grounds

Adult conch were widely dispersed over the area defined as the fishing ground, but densities were generally very low except along the southern edge of the Berry Islands bank, west of Rum Cay and running west along the bank edge to the Northwest Channel Light (Fig. 7; Table 3). The highest density estimates were 1,717 adults/ha (depth interval B) and 1,180 adults/ha (depth interval C) located 2 km and 6 km northwest of Rum Cay, respectively (Table 3). All other values >500 adults/ha were in blocks surrounding the latter survey transect. Highest average density of adult conch (333 adults/ha) occurred in depth interval C of the fishing ground south sector. On the north edge of the southern bank, surveys were conducted at high tide to navigate the sand bores. Adult conch were found there in very low densities, and it was deemed unproductive to survey the further into the bank interior. Zero densities characterized the western sector of the survey where the average density was just 0.7 adults/ha. Again, most of the interior of the western bank was comprised of very shallow sand bores which were not accessible during the low tide, were low yielding and considered inefficient to survey. Zero to low adult densities occurred on the north bank sector south of Great Stirrup Cay and west of Great Harbour Cay (Fig. 8; Table 3). Also, four 1-km survey lines were sampled through the fishing site located west of Bonds Cay, but only one adult conch was observed in that area (Fig. 7).

Distribution of subadult conch (Fig. 10) was somewhat different from adult distribution. They were most abundant on the southern edge of the Berry Islands bank, like adults, but their distribution was shifted to the north, away from the edge of the deep bank. Subadult density was substantially higher in depth interval A (132 per hectare)

than in the deeper intervals (Table 4). Densities were mostly zeros within 1 km of the bank edge and in depths > 5 m, reflecting the observations discussed earlier for surveys within the MPA boundaries (see Fig. 2b). Highest densities occurred west of Rum Cay (621 subadults/ha) and at the northwest corner of the MPA north of Crab Cay (523 subadults/ha) both in depths < 1.5 m. Very few subadults were found along the entire western periphery of the shallow bank or west of Great Harbour Cay (Fig. 9), and none were observed at the Bonds Cay fishing ground (Fig. 10).

Juvenile conch (age-1 and age-2) were relatively rare throughout most of the broad-scale survey area with only 10 sites (inc. 5 in the MPA) yielding densities over 50 juveniles/ha (Fig. 10). Juveniles occurred at 41 of the 73 survey stations in the south sector of the Berry Islands bank, mostly in counts of < 10 individuals. Twenty four of these occurrences were in depths < 2.5 m, 15 were in 2.5 – 5 m, and only 3 individuals were observed in depth zone C (5 – 10 m). The west sector yielded only 4 individuals at 3 sites, and the north sector yielded only 8 at 3 sites, all in < 2.0 m depth and near to the islands.

3.5 Sites Outside the Fishing Ground

During the fieldwork period, local fishers suggested that surveys for queen conch should include an area to the south of Ambergris Cay and a deeper bank area west of Great Stirrup Cay. The Ambergris Cay area was surveyed with 6 transects, but adult densities ranged from just 0 - 20/ha (Fig. 7; Table 3). Subadults were more abundant, with one estimate of 120/ha in the shallowest depth interval (Table 4), and 3 others in the range of 25-50/ha (Fig. 10).

To explore the second site recommended, depth-stratified surveys analogous to those conducted in the southeast region were made along three survey lines at the northwest periphery of the Berry Islands bank that extended well outside the fishing grounds (Fig. 7). The southern most line yielded highest densities of adult conch, with 46 and 157 adults/ha in depths of 10 - 15 m (Table 5). All other density estimates made over these survey lines were < 21 adults/ha. Densities of subadult conch (Fig. 10) were < 6/ha at every other dive location on the three survey lines, except for one value of 111 subadults/ha in 26 m depth on the middle survey line (Table 5). This one occurrence of subadults in deep water was unlike the distribution of subadults over the rest of the survey, where they were most abundant in relatively shallow water.

3.6 Adult Size and Shell Lip Thickness

Data on shell length and lip thickness were collected for adult conch at sites where adults were found in substantial numbers (Tables 6 & 7). Shell lengths at individual sites or within depth zones where samples were pooled (e.g., MPA, East of MPA, West of MPA, NW bank edge) were remarkably uniform as shown by very small standard deviations. Largest conch (mean = 26 cm SL) were found at depths > 10 m within the MPA boundaries, and the smallest (mean = 15 cm SL) were found in the depth range 2.5 to 10 m in the area west of Rum Cay (Table 6). Average lengths of adult conch in most other areas were between 19 and 22 cm.

Shell lip thickness in adult conch generally increased with increasing water depth (Table 7). Nearly all adults in depths < 2.5 m (zone A), both in open bank areas and at protected locations such as Vigilant and Water Cays, had very thin lips, almost always

< 5 mm. The exception was east of the MPA boundaries, where lip thicknesses ranged from 1 to 19 mm in zone A. A population of conch with uniformly thick shell lips (mean = 29 mm) was found at one site east of Bonds Cay on 15 June. Average lip thicknesses were 12 to 17 mm in most other locations > 5 m depth. Most importantly, the small phenotype adults, which made up the bulk of the high density population in 2.5 to 10 m depth west of Rum Cay, were characterized almost entirely by thick lipped individuals (15-19 mm).

3.7 Reproductive Behavior

Reproductive behavior was rarely observed in the survey area; just 15 of more than 300 sites surveyed contained mating pairs (Table 8). The only reproduction observed in the proposed MPA was one mating pair on the shallow flats north of Bird Cay, and three egg masses were observed at 19 m depth on survey line M6 at the eastern end of the MPA. Most mating was found in water depths between 4 and 7 m and where adult densities were high, especially in the high-density area west of Rum Cay on the southern edge of the Berry Islands bank. Two mating pairs were observed at one site east of the MPA boundaries, where adult density was just 13.3 adults/ha. Densities at all other reproductive sites were higher, between 30 and 1,716 adults/ha, and it is apparent that mating was directly associated with adult density.

Logistic regression was used to determine how the presence or absence of mating behavior might be associated with adult density, water depth and water temperature. The latter two variables had no significant association with mating ($p = 0.486$ and 0.501, respectively), but adult density had a highly significant effect, and a logistic model with only adult density as an independent variable correctly predicted 95.1% of mating behavior. A probability curve based upon the logistic model (Fig. 11) showed that mating probability rose quickly above about 250 adults/ha and that 50% probability of mating occurred at 335 adults/ha. A 90% probability of mating occurred at about 500 adults/ha.

3.8 Overall Stock Assessment

More than 300 counts for conch density were made on the Berry Islands bank including the proposed MPA area, and the majority of these counts resulted in zero values for adults (51.9%), subadults (64.0%), and especially juveniles (77.3%) (Fig. 12). Only 24 counts (7.8%) yielded densities >50 adults/ha, and only 16 (5.2%) were >100/ha. Based upon the survey results, total numbers of conch can be estimated for specific regions of the Berry Islands bank by simple extrapolation. Arbitrary boundaries for the southern sector of the fishing ground were survey blocks south of 25° 31′ N and west of the proposed MPA (77° 55′ W) and comprised about 21,000 ha of bank area (Table 9). A western sector of approximately equal area was bounded by latitudes 25° 31′ N to 25° 43′ N, and a northern sector included all bank areas north of 25° 43′ N and west of Great Harbour Cay. The latter two sectors did not include the deep water lines surveyed outside the fishing ground boundaries because these surveys did not yield spatially comprehensive data. These stock assessments reveal that 98.7% of adult conch on the fishing grounds (total = 2.54 million adults total) occurred in the southern section of the bank (Table 9), on just over 40% of the surface area. Similar observations were made for subadults, with 96.1% of 1.61 million individuals located in the southern section. The

west sector did not have a substantial number of conch, and highest potential for conch fishing on the north and west sections of the bank currently occurs west of the fishing grounds in deeper water (Fig. 7).

Total numbers of adult conch on the shallow bank within the proposed MPA boundaries were relatively low, estimated to be approximately 9,200 adults and 39,400 subadults or just 0.36% and 2.38% respectively, in the overall stock assessment area. Queen conch in the deep bank regions of the MPA undoubtedly contribute additional numbers; however, most of that area is narrow, particularly in the depth zones where adults were common, and most densities in that area were well less than 10 adults/ha (Fig. 2a).

4.0 DISCUSSION

4.1 Distribution, Age, and Size Frequency by Depth

The depth distribution of queen conch on the Berry Islands bank was typical of that observed elsewhere in the Bahamas and greater Caribbean region. Virtually all age-1 and age-2 juveniles were observed in depths < 5 m (intervals A & B) on the bank, and most high densities occurred either close to the islands or immediately adjacent to sand bores in very shallow water. While subadults (age-3) were found across a greater range of depth, highest densities for this age class also consistently occurred in depths < 5 m. Adult queen conch were distributed over a wide range of depth from 0 to 25 m or more, with highest average values occurring in depths between 5 and 10 m on the southern edge of the fishing ground, and diminishing with increasing depth. This is shallower than observations made by Stoner and Ray (1996) in the Exuma Cays, where adult densities were highest in 10 to 15 m in the unfished Exuma Cays Land and Sea Park (ECLSP), and in 15 to 20 m in a fished area near Lee Stocking Island (LSI). Peak adult densities in the US Virgin Islands occurred at 12-18 m depth in 1990 (Friedlander et al., 1994). As is true elsewhere, adult conch were not abundant in water deeper than 15 or 20 m and virtually the entire population is vulnerable to diving with hookah equipment.

As observed near LSI (Stoner & Schwarte, 1994), adults found in shallow water on the Berry Islands bank tended to have very thin shell lips. Two explanations are possible: a) the adult conch have their origin in the shallow nursery grounds and move offshore with age, and b) fishing is easiest in shallow water and adult conch are removed before the shells grow to thicker condition with age. Evidence for the latter explanation is provided by data on shell lip thickness and conch age structure from ECLSP, where old, thick-shelled individuals (to 25 mm) are present even in shallowest depth zones. At LSI, modal shell thickness was just 5 mm in shallow water, then increased substantially with depth. Thin shell lips in all of the shallow water locations on the Berry Islands bank are typical for heavily fished populations. Exceptions occurred at the extreme eastern edge of the deep bank off Alder Cay where an old population of conch with a mean lip thickness of 29 mm was found in 3 m depth and in the southern sector of the bank where very small conch had lip thickness averaging 19 mm (Fig. 3). We believe that the first exception represents a population experiencing relatively low fishing pressure associated with highly exposed sea conditions. The latter population was associated with small phenotype adults (mean = 15 cm SL). Otherwise, adult conch lengths had distributions

similar to those observed in the Exuma Cays (Stoner & Schwarte, 1994; Stoner & Ray, 1996).

The occurrence of very small adults south and west of Rum Cay warrants some discussion. Queen conch 15 cm in shell length are not unknown in the Bahamas and probably represent a habitat-related phenotype (or "ecotype"). Natural populations in the Exuma Cays show that different habitats (e.g., depth and vegetation type, etc.) have conch with different shell forms including patterns of length, spine length and spire shape; and Martín et al. (1995) have shown that conch juveniles take on the shell form associated with a habitat when transplanted. Queen conch remaining on the shallow banks near LSI tend to be smaller than those that migrate offshore to deeper water (Stoner & Schwarte, 1994). This 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. All of these variables might affect the growth rates and the resulting adult lengths of adult conch on the Berry Islands bank. Given the phenotypic plasticity of queen conch, we have no reason to believe that the small adults are a different species but genetic testing might assist in the interpretation of this phenotype. Another untested mechanism would be a long-term decline in conch size based upon selective removal of large individuals through fishing. The general 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 occur. There is some evidence for this phenomenon occurring over many generations in marine fishes that are subject to heavy fishing pressure. It would be difficult to confirm or refute this mechanism in queen conch without long-term research.

4.2 Conch Populations in the Proposed MPA

Surveys within the boundaries of the proposed Berry Islands MPA showed that only about 9,200 adults and 38,000 subadults live within the boundaries on the shallow bank inside the island chain. Additional numbers of subadults and adults would be contributed by the offshore bank region extending south and east of the islands; however, densities there were relatively low and the habitat is small in surface area except at the eastern most end of the MPA. It is very unlikely, therefore, that this outer deep bank habitat would add more than about 50% more conch. On the other hand, five of the 10 sites with substantial densities of age-1 and age-2 queen conch occurred within the proposed boundaries for the new MPA and another was located just outside the boundary north of Crab Cay. This suggests that the choice of location for the MPA could be good as a nursery location.

Re-visits to the two nursery grounds studied by Iversen et al. (1987) showed that Vigilant Cay and Cat Cay no longer support large populations of queen conch. Though the methodologies differ, densities at that time were approximately 1000x higher than those found in 2009 at the east Vigilant Cay site. While juveniles, subadults, and very young adults were all present at the Vigilant Cay site, less than two dozen individuals were found at the Cat Cay site. At the time of this survey, aggregations of juvenile conch were more prominent in slightly deeper water on the open flats between Frazer's Hog Cay and Bird Cay and to the west of Whale Cay. All of the sites were less than 2 km

from deep water environment of the Northwest Providence Channel. This is similar to Stoner's (2003) conclusion that nursery grounds are usually situated in locations receiving oligotrophic water from deep open water on every tidal cycle.

4.3 Broad-Scale Distribution over the Berry Islands Bank

The most obvious feature of queen conch distribution over the Berry Islands bank was that both adults and subadults were only present in substantial numbers along the southern edge of the bank. Despite the report of fishing grounds along the western edge, densities of adults and subadults there both averaged < 1.0 individual/ha and there was no evidence of historical populations. Densities in the north sector were little better, averaging < 2.0 adults/ha and < 3.0 subadults/ha. Local densities were higher in a few specific locations, but it is clear that neither of these regions can support a viable commercial fishery for queen conch.

Survey results from the smaller grounds outlined by the DOMR west of Great Harbour Cay and west of Bonds Cay suggest that these locations also no longer have economically valuable conch resources. Recommendations by local fishers to explore areas south of Ambergris Cays and north of Chub Cay revealed substantial densities of subadults, but adult densities were low and total numbers can probably sustain only a small fishery for local consumption. Higher numbers of adult conch along line N3 at 10-15 m west of Great Stirrup may represent a deeper fishing ground, but the population appears to cover a relatively small area. This area could be surveyed more extensively.

Juvenile conch occurred in substantial densities only on the southern edge of the Berry Islands bank. Age-1 and age-2 juveniles were found at relatively few sites, but some locations such as the two sites identified in very shallow locations between Crab Cay and Rum Cay probably each held thousands of juveniles. As observed in the Exuma Cays (Sandt & Stoner, 1993; Stoner, 2003), nursery grounds for queen conch on the Berry Islands shallow bank appear to be associated with tidal channels where very shallow sand bores meet shallow seagrass flats in locations bathed with clear water from the adjacent deep water environment, in this case the Northwest Providence Channel. All of the nursery sites were located within 4 km of the bank edge, as has been observed in the Exuma Cays (Stoner et al., 1996).

Outside of these dense nursery areas, juveniles occurred in small numbers in the shallow waters of the southern sector, were extremely rare in the west and found in only a few near shore locations in the north sector. This may reflect the pattern of larval recruitment to the benthos over the bank, or the fact that juveniles are frequently collected for bait. For example, piles of broken juvenile conch were observed on Vigilant Cay. However, the surveys reported here were not designed to quantify juveniles, and future research on nursery distribution is warranted. This will require a survey approach that accommodates the highly aggregated distribution of juveniles (see Stoner & Ray, 1993).

The survey did not cover the very shallow interior section of the Berry Islands bank. However, we do not believe this represents a limitation to the study. First, the bank areas identified as important fishing grounds were covered in their entirety except for the sector reaching south to Joulters Cay. Second, much of the back interior is very shallow even at high water and, while adult conch can live in shallow water even briefly exposed to air during low tide, large populations are rarely found in these conditions. Third,

almost no conch were found to the east of the identified fishing ground in the west sector despite a very large effort there. In fact, queen conch populations tend to be located close to shelf edges in other well-studied areas, where the shoals are flushed with cool, oligotrophic water from the surrounding deep water basins as discussed earlier. Further evidence for that mechanism is provided by distributional data along the southern edge of the Berry Islands bank. Adult densities decreased substantially from the high values near the southern bank edge to near zero just 5-7 km north.

4.4 Density Comparisons with Other Locations

Broad-scale surveys for adult queen conch have been conducted at several locations in the Caribbean region over the last 35 years, offering some comparisons with the new research on the Berry Islands bank (Table 10). Highest average densities have been recorded for areas closed to fishing in Los Roques, Venezuela (1886 adults/ha) in the early 1980's before the archipelago became heavily fished, and in Cuba (1582 adults/ha). More recently, protected areas at Glovers Reef, Belize, and in the Exuma Cays Land and Sea Park (ECLSP), Bahamas have yielded more modest density values of 173 and 53.6 adults/ha, respectively, while closure of the conch fishery in Cozumel resulted in a nearly 10-fold increase in adult density. In all cases, densities in the protected areas were 7 to 32 times higher than in adjacent fished areas, and it is clear that eliminating fishing effort can quickly result in increased densities of conch (Acosta, 2006).

A broad-scale queen conch survey conducted over depths 0-18 m on the Great Bahama Bank in 1983 to 1984 produced an average density of 20.8 adults/ha (Smith & van Nierop, 1984), which is substantially higher than the average for the new surveys on the Berry Islands bank except in the south sector (Table 9); however, the earlier report provides no details on survey methods, and direct comparisons are difficult to make. The high average value (50 adults/ha) for shallow water on the southern bank is close to the value for the shallow bank near Warderick Wells in the ECLSP, while other values on the fishing grounds and in the proposed MPA are more similar to those in the fished and overfished areas near Lee Stocking Island and elsewhere. However, the average density was driven by a relatively small number of very high density samples (i.e., 4 samples > 500 adults/ha) on the shallow bank, and this may represent summer mating aggregation as has been observed near Lee Stocking Island (Stoner & Sandt, 1992).

4.5 Reproductive Potential on the Berry Islands Bank

Reproductive behavior was very rare in the surveys conducted during the summer of 2009, despite a few locations with high adult densities. Mating was observed at only 15 of the more than 300 sites surveyed for adult conch, and the total number of reproductive pairs observed in 5 weeks was only about 115 of > 5700 adults counted. Eliminating just the top two locations, only 64 pairs were observed mating. The new survey was conducted during peak reproductive season for Bahamian queen conch (Stoner et al., 1992), and it is clear that mating on the Berry Islands bank was extremely low.

We know from earlier research in the Exuma Cays that mating is density dependent (Stoner & Ray-Culp, 2000). The percentage of adult conch mating (mating frequency) increased substantially with conch densities above 50 adults/ha and reached

an apparent plateau at about 100 adults/ha. Direct comparisons show that mating frequency on the Berry Islands bank was lower than in the Exumas. For example, among the 27 locations in the Berry Islands where densities were > 50 adults/ha, average mating frequency was just 3.5% versus 12.1% in comparable Exuma sites. Above 100 adults/ha, average mating frequency was 4.8% in the Berry Islands and 13.1% in the Exumas. Also, only 2 of 41 sites (4.8%) with densities higher than 50 adults/ha in the Exuma Cays had zero mating, while the proportion was 10 times higher (48.1%) in the Berry Islands. This difference is completely unexplained; however, all but one of the high density areas were dominated by small phenotype adults, and it is possible that these conch have a lower reproductive capacity than more typical large phenotype adults (i.e., > 20 cm shell length). It is also very likely that the small phenotype females produce fewer eggs than large individuals, exacerbating low reproductive potential on the Berry Islands bank.

Curiously, the adults observed outside the high density sector of the Berry Islands bank had more typical size. However, with few exceptions, they had thin shell lips, which is problematic with respect to reproductive potential. While queen conch are often considered to be adults when the lip is flared, Appeldoorn (1988) 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.

In sum, reproduction on the Berry Islands bank appears to be hindered by a combination of at least three important factors: a) low adult density over vast areas where most of the conch are young and may not be reproductively mature, b) low mating frequency in areas with high adult densities, and c) likely low fecundity among the primary spawning population. Low density of conch observed in 2009, and reported declining densities over time, is very likely due to overfishing on the Berry Islands bank. The consequence of low density, created by high fishing pressure, is the observed low reproductive potential on bank.

4.6 Stock Assessment for the Berry Islands Fishing Ground

The total number of adult queen conch on the Berry Islands bank fishing ground during the summer season in 2009 was estimated to be 2.54 million individuals, 99% of which were located on the southern periphery of the bank. Numbers of conch in the proposed MPA were miniscule compared with those on the southern bank. Subadults were also concentrated on the southern fishing ground, but the total number (1.61 million) was substantially less than the number of adults. While, theoretically, an adult conch population is comprised of individuals from many year classes, virtually all of the conch observed in depths <2.5 m depth were very young. Given that the average lip thickness was 3 mm or less, except east of the MPA (8 mm), it is likely that these individuals are less than 4 years old and they were probably not reproductively mature (see above). In absolute terms, most of the population was centered in slightly deeper water at the south edge of the bank in the fishing ground. That segment of the population was comprised of small phenotype adults that were observed mating. However, given

natural mortality of subadults before recruiting to the adult cohort, very low mating frequency (even in the high density areas), and the apparent decline of juvenile numbers throughout the bank, it seems very likely that adult numbers are destined to decline.

5.0 CONCLUSIONS

1. The south sector of the Berry Islands bank has a substantial population of adult and subadult conch queen conch. This appears to be the most productive fishing ground on the bank, holding 99% of the bank's adult conch stock and the only location where densities are generally high enough for reproduction.

2. Densities of queen conch outside the southern sector of the Berry Islands bank were very low, well below densities where reproduction can occur.

3. The total number of conch on the Berry Islands bank fishing ground during June/July 2009 was approximately 2.54 million adults and 1.61 million subadults. The age structure of the adult cohort indicates that future fishery populations will be smaller than that in 2009 without a change in fishery management.

4. Adult queen conch on the Berry Islands bank were most abundant in shallow water and easily accessible to free diving fishers. While some were found as deep as 25 m, virtually all conch are accessible to diving with hookah equipment. The vast majority of subadult and juvenile conch were associated with very shallow bank waters (0 to 2.5 m depth), consequently these early stages are highly subject to human influence.

5. Most of the Berry Islands bank was occupied by adult conch with shell lip thicknesses below 8 mm. These thin-lipped individuals represent adults that are in their first months after the lip flare, and are not likely to reproduce before being removed by fishing. Most of the observed mating occurred at the bank edge where small phenotype adults predominate.

6. Conch mating was observed in only 15 of more than 300 locations surveyed. Logistic regression confirmed density dependence in reproduction, and it is clear that densities of queen conch adults are too low for reproductive behavior to occur over most of the area identified as fishing ground on the Berry Islands bank as well as in the proposed MPA. The source of larvae for the bank may be the deep water refugia surrounding the bank or some other upstream sources.

7. Observed mating frequencies on the Berry Islands bank were only about one-third those predicted from earlier studies of density-dependent reproduction in the Exuma Cays. This appears to be a function of relatively low reproductive activity in the small phenotype adults that dominate the high density areas, and the relative youth of adults on other parts of the bank (i.e., the population of queen conch with flared shell lips is comprised primarily of sexually immature conch).

8. Given the low density of queen conch adults over most of the Berry Islands fishing grounds, low mating frequency, relative youth of the adult population, and apparent loss of historically significant juvenile populations it seems likely that overfishing is occurring. Changes in fishery management practice appear to be warranted.

9. Although densities of adult and subadult conch are low in the proposed MPA, the 5 nursery areas support the protection of this area and its ability to recover conch populations over time.

10. There is concern within the local communities of the Berry Islands that queen conch stocks are declining and that something should be done to prevent further depletion. Local fishermen in particular, are in favor of additional regulation of the conch fishery that would curtail the impact of commercial fishing. The need for enforcement locally was widely recognized (see Appendix A).

6.0 RESEARCH RECOMMENDTIONS

6.1 Overview

Scientific research is inherently open ended, and more questions are always generated as new information emerges. Here, however, we attempt to point out the kinds of quantitative science that need to be accomplished to provide the best scientific advice for wise management of the queen conch resource on the Berry Islands bank:

6.2 Specific Research Recommendations

1. Assess the most important nursery grounds identified on the Berry Islands bank to consider their role in supplying recruits to the fishery. During the 2009 survey, juvenile conch were encountered in substantial densities just 10 times and only on the southern edge of the bank. However, time did not permit evaluation of the numbers of juvenile conch and the extent of the nursery grounds. Such information would be important in establishing protection for conch populations on the bank. Emphasis should be placed on the southern sector of the fishing ground, on the proposed MPA, and immediately south of Great Stirrup Cay where local knowledge suggests that juvenile populations were once abundant.

2. Evaluate the potential impacts of discarding knocked conch on the fishing grounds with a field experiment. A concern identified by Berry Islands' fishers was that such a practice results in reductions of conch in the immediate vicinity. Discarded conch are now particularly abundant in the south sector of the fishing ground from Mamma Rhoda Rock westward to at least Rum Cay. The mechanisms of declining numbers are unknown, but the idea of negative impact from discarded shells is commonplace in the Caribbean region, and should be investigated, perhaps engaging local fishers in a rigorous experiment.

3. Conduct field observations to determine minimum shell lip thickness associated with sexual maturity. The adult population on the Berry Islands bank is comprised of young conch with thin shell lips. Field observations should be made during a summer spawning

season to determine the shell lip thickness at which fishery managers can be confident that the adults can have at least one spawning season before being removed by the fishery. Observations should also be made on reproductive behavior and fecundity of the small phenotype adults.

4. Monitor conch populations inside the MPA after the fishing closure is established. This would most likely include surveys of adult, subadult, and juvenile populations at intervals no greater than 3 years. As mentioned above, juvenile aggregations in the MPA should be evaluated at the soonest possible time for a pre-closure baseline. Subsequent to closure, it would be useful to evaluate "spillover" of conch into the surrounding fishing areas to determine how the MPA might supply conch directly to the fishery.

5. Explore mechanisms of larval transport and retention as they relate to the Berry Islands bank. Larval transport mechanisms in this area are completely unknown and should be explored as possible. It will be important to determine whether the conch population or sub-populations on the bank are self recruiting and whether they exist as sources or sinks for the greater Bahamian population.

7.0 MANAGEMENT RECOMMENDATIONS

7.1. Overview

Results of this 2009 survey indicate that the queen conch fishery on the Berry Islands bank is not functioning at a sustainable level and that management practices are needed that will allow a return to sustainable fishing. The goals that would lead to this management objective include:

A) Protection of the queen conch population for sustainable reproductive potential.
B) Protection the nursery grounds.
C) Reduction/control of the total fishing effort (or mortality) on the Berry Islands bank.

The following action recommendations support these goals and come from a synthesis of the survey findings and review of queen conch management issues and plans in the Bahamas and throughout the Caribbean. We suggest that the recommendations be used to develop, implement and monitor a Conch Management Plan for the Berry Islands. The queen conch resource in the Berry Islands is probably an independent fishery with unique growth, size, distributional, mortality and use characteristics and should be managed as such. A generalized management scheme for the Bahamas will not be appropriate to the unique Berry Islands resource. This recommendation is supported by the findings of Ehrhard and Deleveaux (1999) who state that "each fishery will have to be independently and specifically assessed and the drawing of conclusions independently and specifically applied to management measures in each of the fisheries." Though some management options may be applicable to all conch fisheries in the Bahamas, each primary fishery area will need a plan. The Berry Islands Management Plan could serve as a pilot project for other conch fisheries in the Bahamas.

7.2. Specific Management Recommendations

1. Collect catch and landing data on the queen conch population of the Berry Islands bank to develop a landings quota. While the results of conch surveys conducted during the summer of 2009 represent the best spatially-comprehensive data available for the status of adult and subadult conch stocks on the Berry Islands bank, the stock assessment now needs to be considered in light of more detailed information on fishing effort and annual landings. More specifically, information is needed on the numbers of boats and divers fishing the banks, the numbers of days spent on the water, and the numbers, weight and age classes of conch landed. Statistics would be most accurate if conch caught in the Berry Islands were measured in the Berry Islands; at either Chub Cay and/or Gt. Harbour Cay. Landing and catch data could be required as a condition of the fishing permit.

These statistics could then be used to set a landings quota or a total allowable catch for the Berry Islands bank. In this scenario, a total allowable catch would be set and allocated among fishermen of record. This system is being implemented for overfished populations around the world with substantial success in bringing fishing mortality in line with sustainability and increasing income for fishers of record.

2. Move or enlarge the proposed MPA and consider protecting additional conch nursery habitat. MPAs have many roles but are most often implemented to sustain recovery of depleted stocks and promote habitat and ecosystem processes. The key to any successful MPA is initial location and enforcement. The FAO manual for the monitoring and management of queen conch states "putting marine reserves where fishers do not fish will have no positive effect (although it may reduce problems later)(FAO, 2006)." The proposed Berry Islands MPA contains at least 5 nursery areas and could be a future source for conch replenishment but will not have any immediate effect because the densities there are low and the area is not commercially fished. Based on these findings, three recommendations are made on the location of the MPA boundaries and the creation of conch nursery protected areas. The first two suggestions are alternative options for expanding the Berry Islands Marine Protected Area currently in planning (Fig. 1).

2a. Move the boundaries of the MPA to the west to include the high density, reproductive stocks west of Rum Cay. This would place the MPA where the fishers fish and protect those stocks with the highest densities and reproductive rates and thus lead to a faster recovery of depleted stocks. In this scenario, in addition to moving the MPA west, the boundaries of the currently proposed MPA could be reduced to include only the shallow bank as a conch nursery protected area.

2b. Extend the boundaries of the proposed MPA to encompass nursery and subadult grounds to the west of Chub Cay. Ten nursery areas were found during the 2009 survey, five of which are within the current boundaries of the proposed MPA. Three of the outside nursery areas lie west and north of the MPA between Chub Cay and Rum Cay surrounded by high densities of subadults (Fig. 10). This area has historically been heavily fished as evidenced by low adult densities and many "knocked" shells. Including a protected area between Chub Cay and Rum Cay would substantially enhance the juvenile and subadult stocks of the MPA with minimal impact on conch fisherman.

2c. Establish a conch nursery protected area in the shallow waters south of Gt. Stirrup Cay. In the interviews, it was often reported that the area south of Gt. Stirrup Cay and west of Gt. Harbour Cay had been a conch nursery but had been fished out. Although these statements could not be verified by the 2009 survey, they are supported by the findings of subadult and adult conch due west of this area in deeper water. Also, there appears to be local support for a protected nursery in that area since it is not fish or lobster habitat and is close to a populated area where it can be monitored.

3. Enact a regulation that prohibits the use of hookah equipment to catch queen conch. Currently, the use of hookah equipment is legal during lobster season from August 1 to March 31 at depths from 30 to 60 ft (10-20m). However, local fishers admitted using this equipment in the restricted season from April 1 to July 31 when 60-70% of the conch are caught (Gittens, 2009) and deeper than 60 feet. The cessation of the use of hookah equipment would provide a deep water refuge for reproductive age conch. This restriction would facilitate enforcement since no compressed air should be on fishing boats outside the lobster season.

4. Institute a season closed to conch fishing during some portion of the spawning season. Spawning season for queen conch is considered to range from May through September in the Bahamas; a shorter season in the northern islands and a longer season in the south corresponding to the water temperatures. The Bahamas has not established a closed season in order to accommodate fisherman who would have nothing to fish if conch and lobster fisheries are closed at the same time. Interestingly, in all other countries where CITES lists the queen conch as a species of least concern or of possible concern (USVI, Turks & Caicos, Jamaica, and Belize), there is a three month closed season with start dates ranging from July1 to August 1. A closed season should be implemented in the Bahamas from July 1- September 30 thus protecting some of the conch spawning season (July and August) and allowing fishermen to continue to catch conch during the highest yielding months of April, May and June. Continued monitoring would determine if the start date needed to begin earlier in the year.

5. Require that queen conch be landed in the shell to eliminate illegal conch from the fishery. DOMR fishing regulations state that it is illegal to harvest conch without a flared lip. However, much of the conch officially landed in the Bahamas is cleaned at sea and there is no statistical correlation between the size of the conch shell and the weight of the meat making it impossible to know the size (or maturity) of the conch landed without its shell. Fishermen have resisted this rule arguing that landing conch in the shell takes up too much deck space, and the weight can make the boat unseaworthy. In the interviews, Berry Islands residents stated that commercial fishermen include the meat of illegal sized conch in bags of cleaned conch meat which are sold directly to restaurants. Ehrhardt and Deleveaux (1999) found that 34 to 60% of conch piles outside of conch salad vendors and near Paradise Island consisted of juveniles. Clearly, anecdotal and scientific evidence indicate that the law to prevent the harvest of juvenile conch is regularly broken. A requirement that conch be landed in the shell would minimize the catch of immature conch and eliminate loss of data when boats sell directly to restaurants.

6. Institute a minimum shell lip thickness for harvested conch to insure that adults have had at least one summer season to spawn. The survey found that the lip thickness of conch in all of the shallow water locations on the Berry Islands bank were < 5mm and indicative of a very young adult population and heavy fishing pressure. While these young adults have a flared shell lip, they probably do not mate or spawn in the first reproductive season after the flare forms. A shell thickness of 8 to 10 mm is a better indicator of actual reproductive maturity than the simple presence of lip flare.

7. Develop the capacity to enforce the management actions. DOMR currently lacks the funds for management enforcement rendering many of its current regulations ineffective. New funding for enforcement is required for any of the management recommendations above to be effective. Additional government funds will need to be allocated to DOMR for these purposes. At minimum, one fisheries officer would be required to patrol the MPA and supervise collection of catch data in Chub Cay. The efficiency of these funds could be increased by partnering with community residents to form an auxiliary group to perform many of these duties on a volunteer basis.

8.0 COMMUNITY INVOLVEMENT

1. Organize meetings to discuss management alternatives and to enlist community help with enforcement. One huge advantage in managing the conch resource in the Berry Islands is that the local population appears to be concerned about overfishing of the conch resource, supportive of the proposed MPA and anxious for the enforcement of regulations to stem violations. Building on the relationships developed during the survey, it is recommended that community meetings be organized to formally discuss options that would lead to a Conch Management Plan for the Berry Islands. Meetings would also need to be held where significant numbers of other stakeholders, especially fishers and vendors, live. Topics addressed might include:

- Enlarging or adjusting the boundaries of the MPA
- Enforcement areas and local participation with enforcement (paid and volunteer)
- Location for weighing and recording landings data
- Boundaries of nursery protected areas
- Dates for a closed season
- Impact of conch enforcement on other marine resources including the lobster, grouper and pelagic fisheries
- Participation in a knocked conch experiment and future surveys
- Potential for starting a conch fishery cooperative in the Berry Islands

Community Conch has appreciated the support of DOMR, Bahamian NGOs and local residents in conducting this conch assessment. It is our hope that the conclusions and recommendations of this report lead to improvements in regulating the conch fishery in the Berry Islands and throughout the Bahamas.

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Table 1. Density data for adult queen conch in surveys conducted near the bank edge in the proposed Berry Islands MPA and in adjacent areas east and west of the MPA. Density values are reported in numbers of conch per hectare. *n* is the number of samples at each depth interval. Depth zones: A = 0-2.5 m, B = 2.5-5 m, C = 5-10 m, D = 10-15 m, E = 15-20 m.

Geographic area & depth interval	n	Range of density values	Mean ± SD
Inside MPA			
A	4	3.5 – 13.3	7.2 ± 6.0
B	6	0 – 15.0	3.7 ± 7.1
C	6	0 – 110	27.4 ± 45.8
D	6	0 – 26.3	5.0 ± 10.5
E	6	0 – 23.5	5.7 ± 8.8
West of MPA			
A	3	3.3 – 13.3	8.6 ± 5.0
B	3	5.0 – 11.7	7.2 ± 3.8
C	3	0	0 ± 0
D	3	0	0 ± 0
E	3	0 – 17.2	5.7 ± 9.7
East of MPA			
A	1	13.3	13.3 ± 0
B	2	3.3 – 13.3	10.8 ± 3.5
C	3	0	0 ± 0
D	3	0 – 93.6	33.0 ± 52.5
E	3	0 – 4.6	1.5 ± 2.4
Overall			
A	8	0 – 13.3	8.6 ± 5.2
B	11	0 – 15.0	5.8 ± 5.5
C	12	0 – 110	13.7 ± 34.1
D	12	0 – 93.6	10.8 ± 27.1
E	12	0 – 23.5	4.7 ± 7.7

Table 2. Density data for subadult queen conch in surveys conducted near the bank edge in the proposed Berry Islands MPA and in adjacent areas east and west of the MPA. Density values are reported in numbers of conch per hectare. n is the number of samples at each depth interval. Depth zones: A = 0-2.5 m, B = 2.5-5 m, C = 5-10 m, D = 10-15 m, E = 15-20 m.

Geographic area & depth interval	n	Range of density values	Mean ± SD
Inside of MPA			
A	4	0 – 4.7	2.7 ± 2.4
B	6	0 – 5.0	1.0 ± 2.4
C	6	0 – 6.2	1.0 ± 2.2
D	6	0 – 3.8	0.6 ± 1.2
E	6	0	0 ± 0
West of MPA			
A	3	0 – 15.0	6.1 ± 7.8
B	3	0 – 5.0	7.2 ± 3.8
C	3	0	0 ± 0
D	3	0	0 ± 0
E	3	0	5.7 ± 9.7
East of MPA			
A	1	3.3	3.3 ± 0
B	2	0 – 1.7	0.8 ± 1.0
C	3	0	0 ± 0
D	3	0	0 ± 0
E	3	0	0 ± 0
Overall			
A	8	0 – 15.0	4.0 ± 4.8
B	11	0 – 5.0	1.2 ± 2.0
C	12	0 – 6.2	0.5 ± 1.8
D	12	0 – 3.8	0.3 ± 1.1
E	12	0	0 ± 0

Table 3. Density data for adult queen conch in surveys conducted on the shallow bank area of the Berry Islands bank including the proposed MPA in the southeast sector. Density values are reported in numbers of conch per hectare. *n* is the number of samples at each depth interval. Depth zones: A = 0-2.5 m, B = 2.5-5 m, C = 5-10 m.

Geographic area & depth interval	n	Range of density values	Mean ± SD
MPA			
A	39	0 – 33.3	4.4 ± 8.1
B	3	0 – 10.8	4.0 ± 5.8
Ambergris Cays			
A	4	0 – 16.7	7.5 ± 8.8
B	2	10.0 – 20.0	15.0 ± 7.1
Bonds Cay			
A	4	0 – 1.7	0.4 ± 0.9
Fishing Grounds			
South sector			
A	35	0 – 255.0	30.7 ± 53.4
B	30	0 – 1716.7	163.6 ± 359.8
C	8	3.3 – 1180.0	332.9 ± 407.5
Overall	73	0 – 1716.7	118.4 ± 281.6
West sector			
A	8	0 – 8.3	1.7 ± 3.0
B	53	0 – 8.3	0.7 ± 1.7
C	9	0	0 ± 0
Overall	70	0 – 8.3	0.7 ± 1.8
North sector			
A	12	0 – 13.3	3.5 ± 4.8
B	20	0 – 23.8	1.5 ± 5.3
C	5	0	0 ± 0
Overall	37	0 – 23.8	1.9 ± 4.8

Table 4. Density data for subadult queen conch in surveys conducted on the shallow bank area of the Berry Islands bank including the proposed MPA in the southeast sector. Density values are reported in numbers of conch per hectare. *n* is the number of samples at each depth interval. Depth zones: A = 0-2.5 m, B = 2.5-5 m, C = 5-10 m.

Geographic area & depth interval	n	Range of density values	Mean ± SD
MPA			
A	39	0 – 142.0	13.3 ± 30.2
B	3	0 – 2.2	0.7 ± 1.2
Ambergris Cays			
A	4	6.7 – 120.0	39.6 ± 54.5
B	2	8.3 – 33.3	20.8 ± 17.7
Bonds Cay			
A	4	0	0 ± 0
Fishing Grounds			
South sector			
A	35	0 – 621.7	131.9 ± 181.8
B	30	0 – 133.3	16.8 ± 36.5
C	8	0 – 1.7	0.2 ± 0.6
Overall	73	0 – 621.7	70.2 ± 140.5
West sector			
A	8	0 – 5.0	0.6 ± 1.8
B	53	0 – 11.7	0.7 ± 2.1
C	9	0	0 ± 0
Overall	70	0 – 11.7	0.6 ± 1.9
North sector			
A	12	0 – 28.3	8.3 ± 10.6
B	20	0 – 2.1	0.2 ± 0.6
C	5	0 – 5.6	1.1 ± 2.5
Overall	37	0 – 28.3	2.9 ± 7.0

Table 5. Density data for adult and subadult queen conch in surveys conducted in deepwater transects west of Great Stirrup Cay in the northern Berry Islands. Density values are reported in numbers of conch per hectare. *n* is the number of samples at each depth interval. Depth zones: A = 0-2.5 m, B = 2.5-5 m, C = 5-10 m, D = 10-15 m, E = 15-20 m, F = 20-30 m

Age group & depth interval	n	Range of density values	Mean ± SD
Adults			
C	3	1.7 – 6.7	4.6 ± 2.6
D	4	0 – 156.7	51.3 ± 73.5
E	3	0 – 7.4	3.5 ± 3.7
F	3	0 – 20.5	11.7 ± 10.6
Subadults			
C	3	0 – 5.4	1.3 ± 3.1
D	4	0 – 3.7	1.4 ± 1.8
E	3	0	0 ± 0
F	3	0 – 111.2	37.1 ± 64.2

Table 6. Total shell length for adult conch sampled in selected regions of the Berry Islands bank, June and July 2009. Data are reported for five depth zones. Zones A and B occupy most of the bank interior, while zones C, D, and E occur only along the outer periphery of the bank. Values are mean ± standard deviation, and number of conch measured (n).

	Depth zones				
Location	**A** 0 - 2.5 m	**B** 2.5 - 5.0 m	**C** 5.0 - 10 m	**D** 10 – 15 m	**E** 15 – 20 m
MPA shelf region	19 ± 3 (15)	---	22 ± 2 (14)	26 ± 1 (5)	24 ± 2 (11)
East of the MPA	22 ± 4 (7)	21 ± 2 (17)	---	22 ± 2 (6)	---
West of the MPA	18 ± 2 (6)	15 ± 1 (14)	15 ± 2 (25)	---	23 ± 0 (1)
Bank N of Chub Cay	20 ± 1 (15)	---	---	---	---
Vigilant Cay	19 ± 1 (15)	---	---	---	---
Northwest Channel Light	---	20 ± 3 (7)	---	---	---
NW bank edge	---	---	---	22 ± 3 (5)	23 ± 2 (13)
Water Cay	21 ± 2 (5)	---	---	---	---

Table 7. Shell lip thickness for adult conch sampled in selected regions of the Berry Islands bank, June and July 2009. Data are reported for five depth zones. Zones A and B occupy most of the bank interior, while zones C, D, and E occur only along the outer periphery of the bank. Values are mean ± standard deviation, and number of conch measured (n).

	Depth zones				
Location	**A** 0 - 2.5 m	**B** 2.5 - 5.0 m	**C** 5.0 - 10 m	**D** 10 – 15 m	**E** 15 – 20 m
MPA shelf region	3 ± 2 (15)	---	12 ± 5 (14)	17 ± 7 (5)	17 ± 7 (11)
East of the MPA	8 ± 7 (7)	29 ± 4 (17)	---	6 ± 1 (6)	---
West of the MPA	2 ± 1 (6)	19 ± 3 (14)	15 ± 3 (25)	---	14 ± 0 (1)
Bank N of Chub Cay	3 ± 2 (15)	---	---	---	---
Vigilant Cay	2 ± 1 (15)	---	---	---	---
Northwest Channel Light	---	6± 8 (7)	---	---	---
NW bank edge	---	---	---	14 ± 10 (5)	16 ± 7 (13)
Water Cay	3 ± 2 (5)	---	---	---	---

Table 8. Reproductive behavior observed in the surveys for queen conch on the Berry Islands bank, June and July 2009. Regions include the shelf east of the proposed MPA area (East shelf), within the proposed MPA, in the high-density area on the South bank west of Rum Cay, and at the northwest edge of the bank outside the traditional fishing ground.

Geographic region	Date	Depth (m)	Adult density (no./ha)	Number of mating pairs	% of adults mating
East shelf	15 Jun	4.1	13.3	2	50.0
MPA bank	16 Jun	1.9	30.0	1	11.1
South bank	20 Jun	4.6	275.0	5	6.1
South bank	20 Jun	5.0	180.0	3	5.6
South bank	26 Jun	4.2	256.0	15	19.6
South bank	26 Jun	5.5	317.0	16	16.8
South bank	27 Jun	4.6	1716.0	>30	5.8
South bank	27 Jun	6.9	333.0	4	4.0
South bank	27 Jun	3.6	525.0	8	5.1
South bank	27 Jun	5.4	1180.0	22	10.8
South bank	27 Jun	4.3	577.0	4	2.3
South bank	27 Jun	6.2	658.0	4	2.0
South bank	27 Jun	1.7	57.0	1	5.7
South bank	28 Jun	7.2	87.0	2	7.7
Northwest bank	5 Jul	13.7	157.0	2	4.3

Table 9. Estimated total abundance of adult and subadult queen conch on the Berry Islands bank in June/July 2009, summarized by major geographic region. See text for geographic boundaries. Calculations do not include the bank and shelf areas south and east of the southeast islands (e.g., Chub, Whale, Bonds) where the surveys were spatially limited. n is the number of survey points considered for the estimates, which are rounded to the nearest 100. Percentages of grand totals are shown.

Region	n	Area (ha)	No. of Adults	% of Adults	No. of Subadults	% of Subadults
MPA shallow bank	40	3,100	9,200	0.36	39,400	2.38
Fishing grounds						
South sector	73	21,565	2,517,800	98.71	1,588,800	96.05
West sector	70	21,720	15,000	0.59	12,900	
North sector	37	9,463	8,600	0.34	13,000	0.79
Totals for Fishing ground	180	52,748	2,541,400	99.64	1,614,700	97.62
Grand totals	220	55,848	2,550,600	100	1,654,100	100

Table 10. Comparison of adult densities in shallow water conch fishing grounds where broad-scale surveys were made. Three areas in the Bahamas are represented – the Exuma Cay Land and Sea Park (ECLSP) in the central Exuma Cays, near Lee Stocking Island (LSI) in the southern Exuma Cays, and on the Berry Islands bank (this study). For the Berry Islands bank, the mean density is reported is for survey depths ranging 0 to 5 m. This represents depths easily worked by free-diving fishers and allows direct comparisons with several of the studies list below.

Region	Survey date	Status	Depths surveyed (m)	Reference	Adult density (no./ha)
Cuba, Diego Perez	1972-74	unfished	3 - 4	Alcolado, 1976	1582
Cuba, Cabo Cruz	1972-74	fished	0 - 5	Alcolado, 1976	130
Turks & Caicos	1974-75	fished	0 - 4	Hesse, 1979	2.6
Venezuela, Los Roques	1981-83	protected	1- 18	Weil & Laughlin, 1984	1886
Venezuela, Los Roques	1981-83	fished	1 - 4	Weil & Laughlin, 1984	160
Puerto Rico	1985-86	overfished	0 - 5	Torres Rosado, 1987	0
Florida Keys	1987-88	overfished	0 - 20	Berg et al., 1992a	0.50
Bermuda	1988	overfished	0 - 25	Berg et al., 1992b	0.52
US Virgin Islands	1990	overfished	0 - 6	Friedlander et al., 1994	5.2
Mexico, Cozumel	1989	overfished	?	Martinez-Vasquez, 1995	89
Mexico, Cozumel	1995	protected	?	Martinez-Vasquez, 1995	830
Belize, Glovers Reef	2003-04	fished	1 - 5	Acosta, 2006	25
Belize, Glovers Reef	2003-04	protected	1 - 5	Acosta, 2006	173
Bahamas					
LSI	1991	fished	0 - 5	Stoner & Schwarte, 1994	1.7
ECLSP	1994	protected	0 - 5	Stoner & Ray, 1996	53.6
Berry Islands bank					
MPA	2009	fished	0 - 5	This study	4.4
Fishing ground - south	2009	fished	0 - 5	This study	50.0
Fishing ground - west	2009	fished	0 - 5	This study	1.2
Fishing ground - north	2009	fished	0 - 5	This study	2.2

Fig. 1. Berry Islands bank showing the proposed MPA, fishing grounds, survey lines locations and reporting areas. A line of survey points was run perpendicular to the isobaths through each of the letter-coded survey lines.

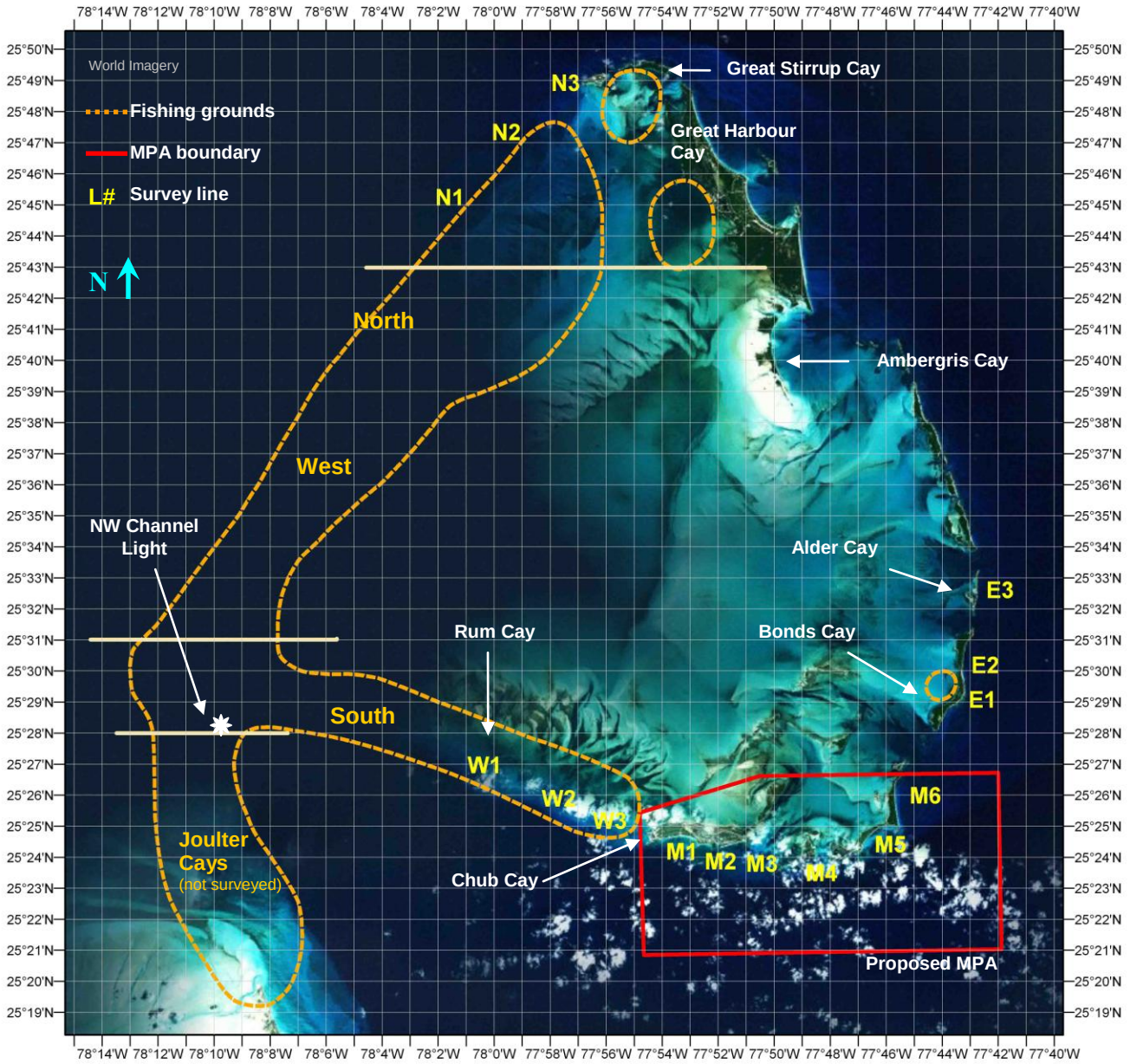


Fig. 2. Densities of adult and subadult queen conch at the bank edge shown as a function of five depth strata. Results are shown for a series of six survey lines within the proposed marine protected area (MPA) and for three survey lines each in regions east and west of the MPA. Values are means ± SD, and shown for West, MPA, and East regions from left to right.

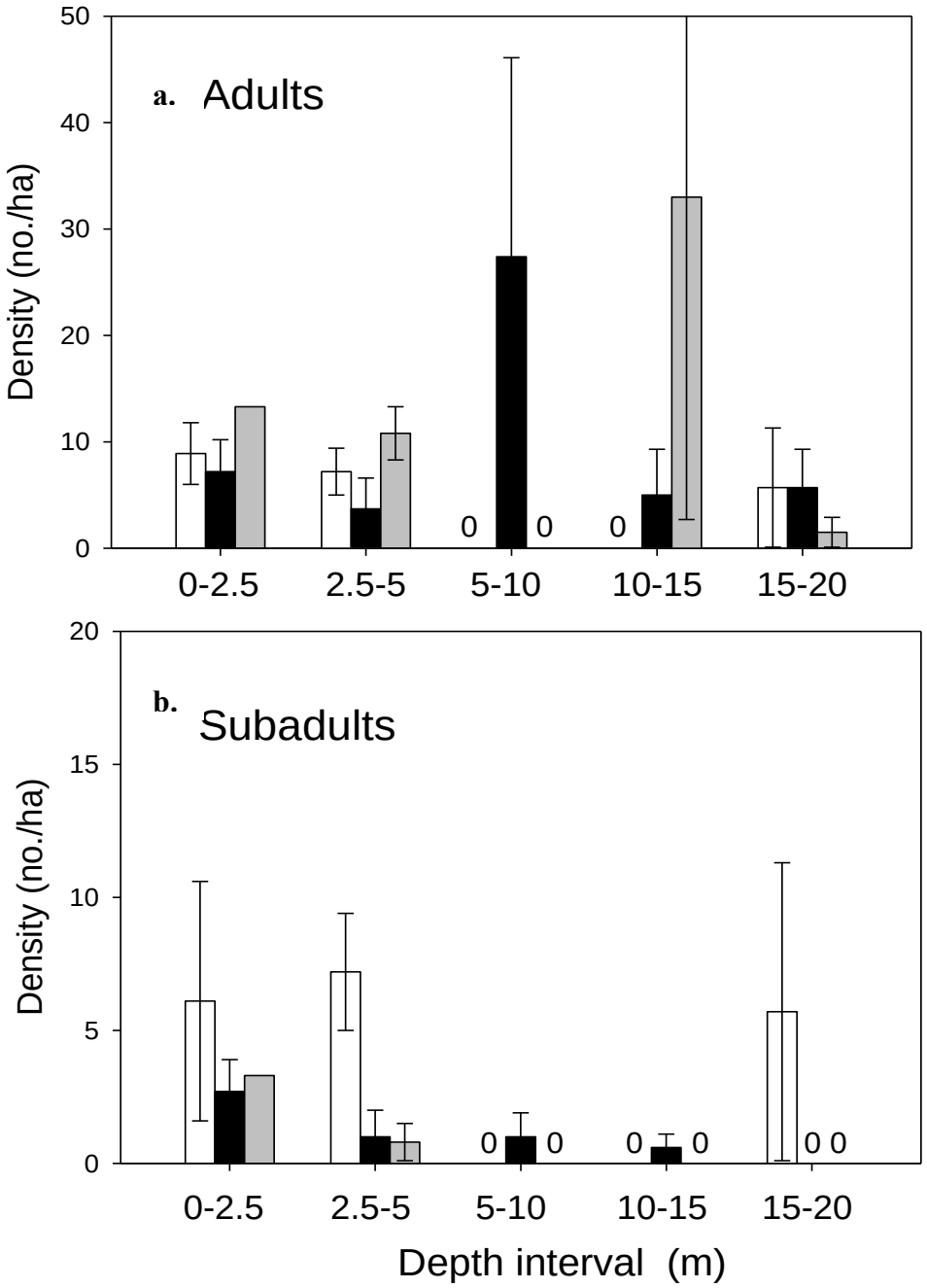


Fig. 3. Density distribution of adult queen conch in the proposed MPA and in the surrounding region of the southeast Berry Islands.

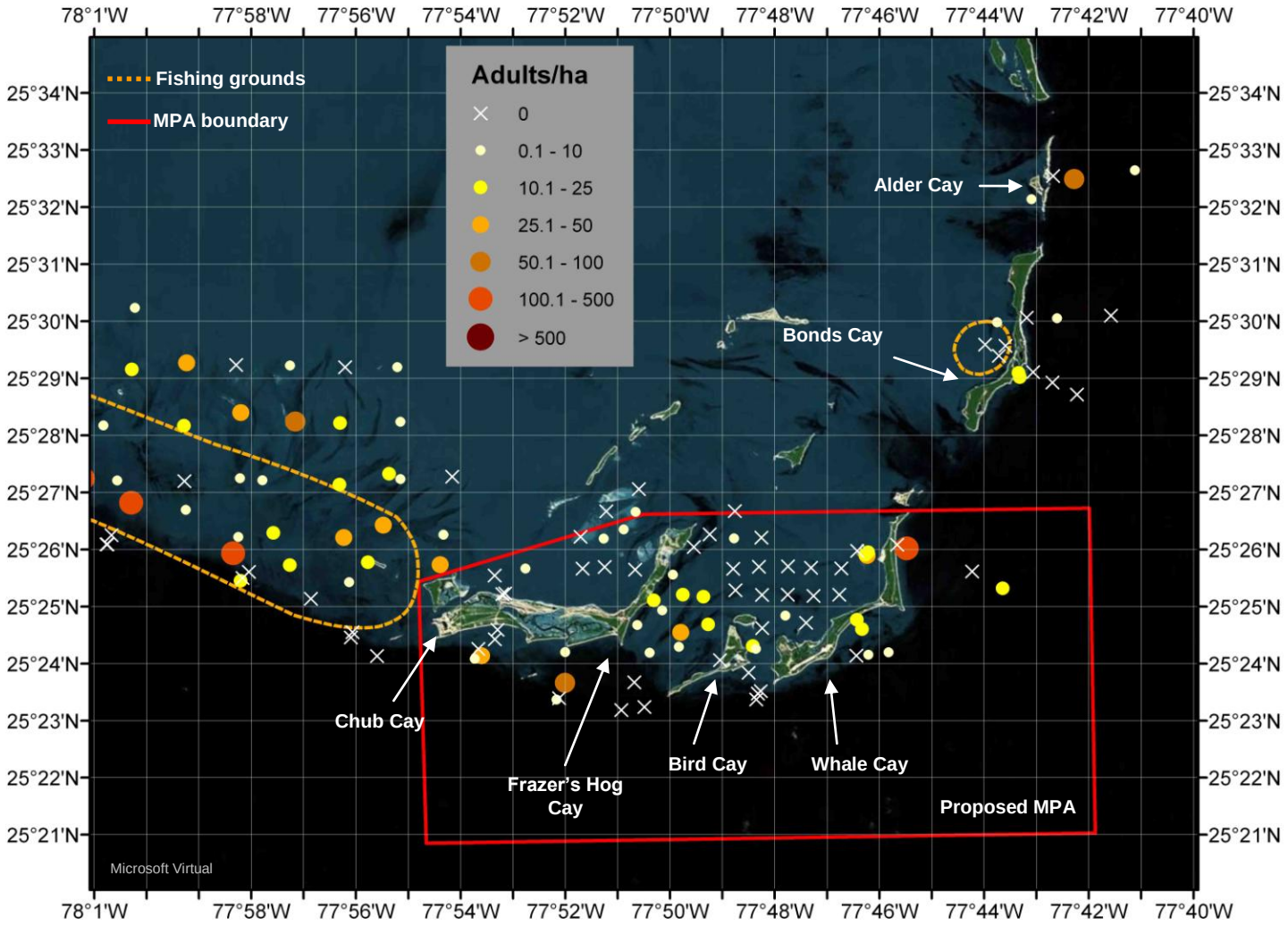


Fig. 4. Density distribution of subadult queen conch in the proposed MPA and in the surrounding region of the southeast Berry Islands.

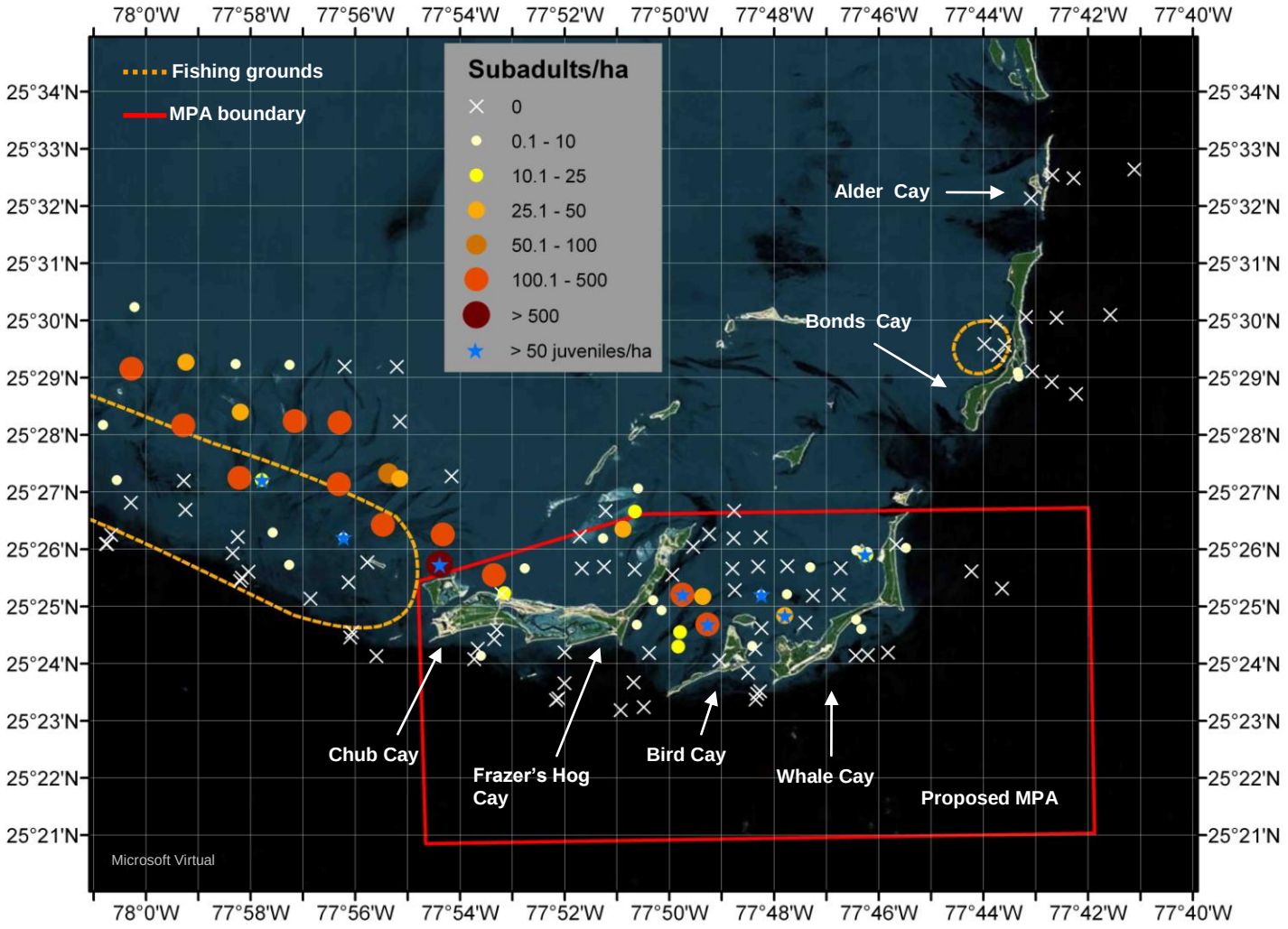


Fig. 5. Density distribution of adult queen conch in the MPA proposed for the southeast Berry Islands.

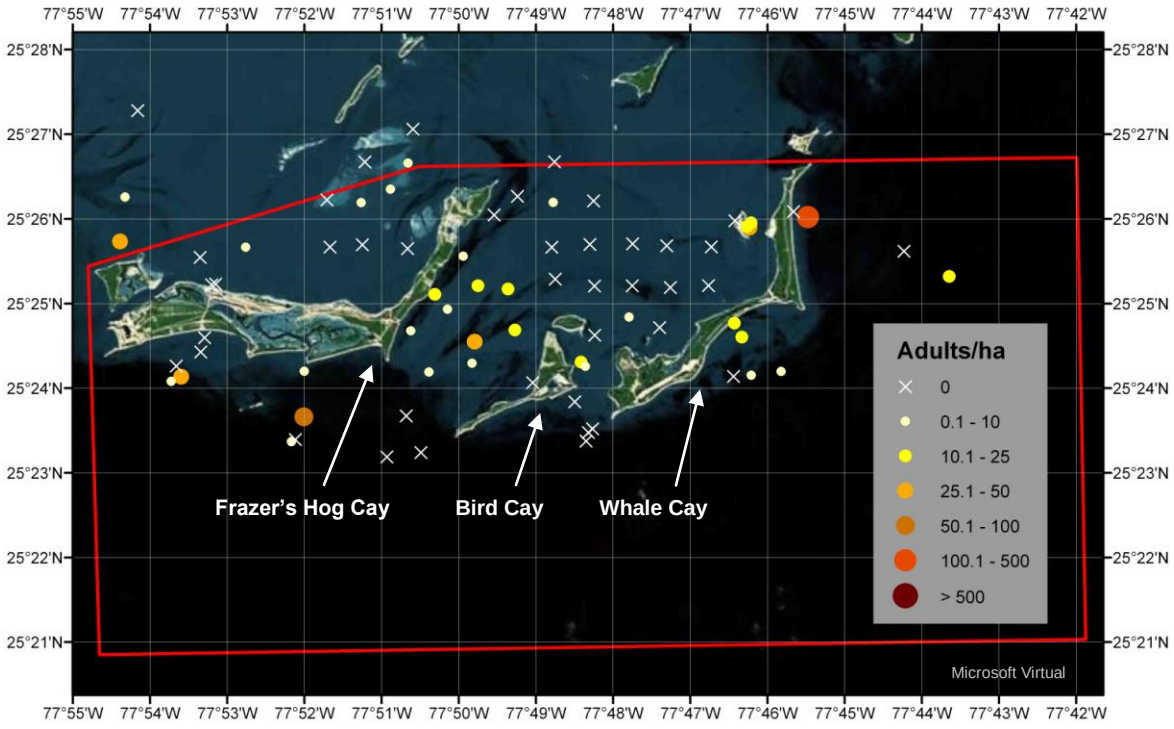


Fig. 6. Density distribution of subadult queen conch and nurseries in the MPA proposed for the southeast Berry Islands.

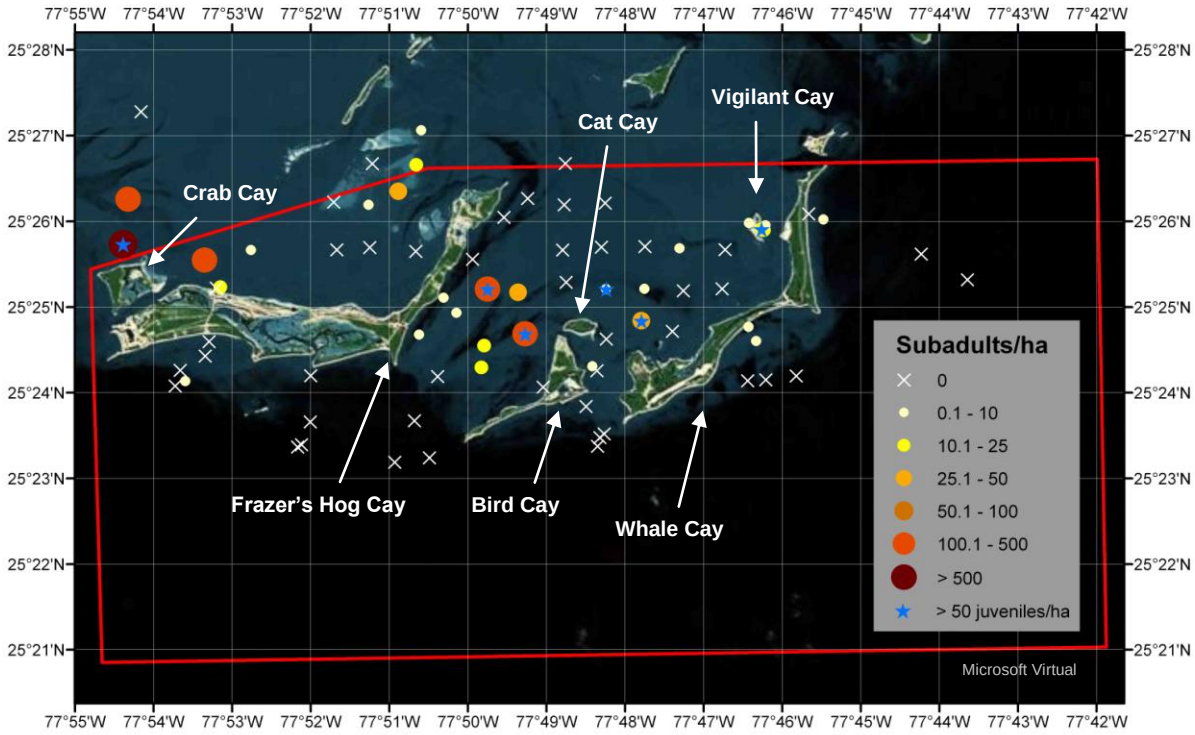


Fig. 7. Density distribution of adult queen conch over the fishing grounds and surrounding areas on the Berry Islands bank.

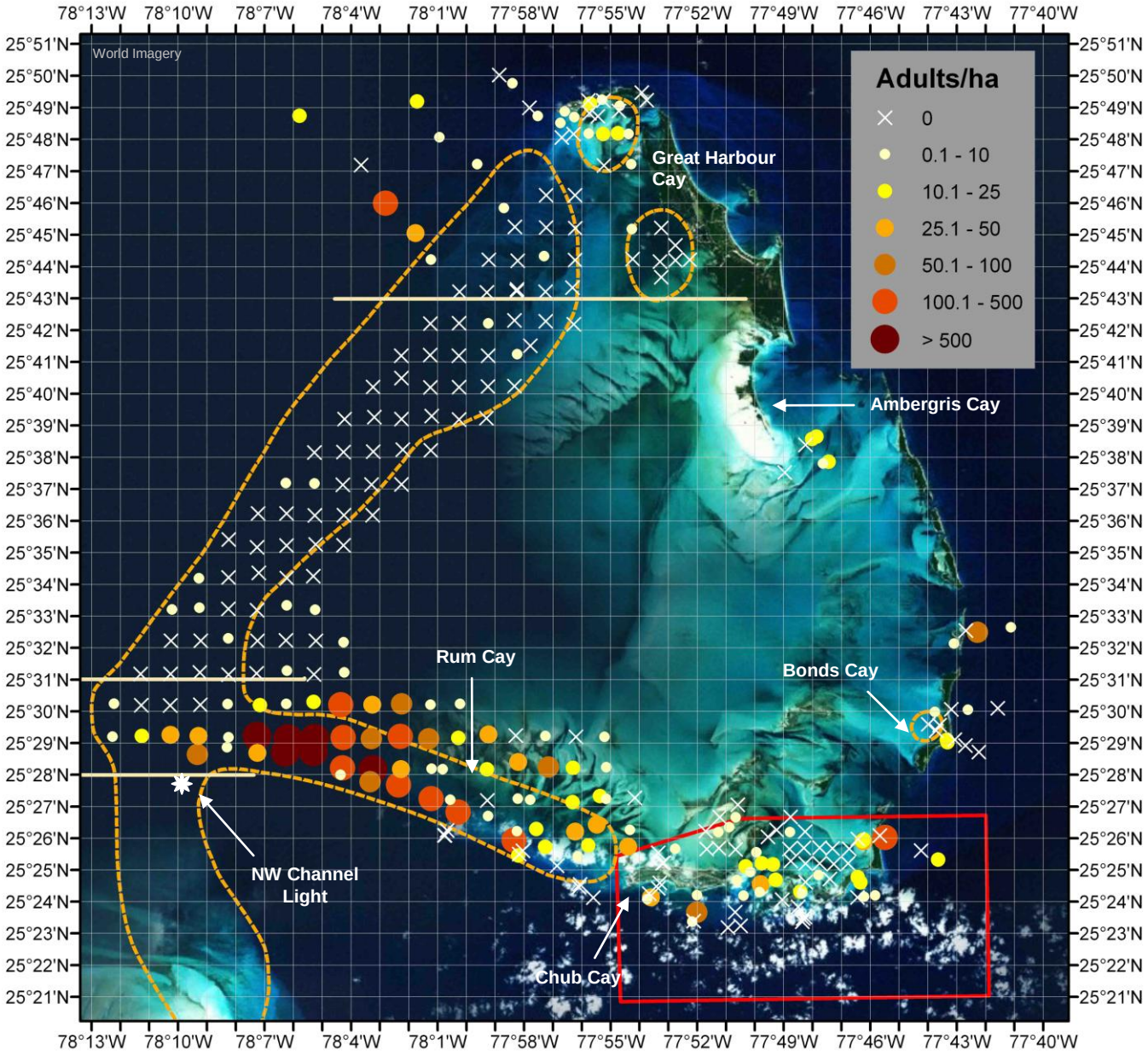


Fig. 8. Density distribution of adult queen conch on the northern Berry Islands bank near Great Harbour Cay.

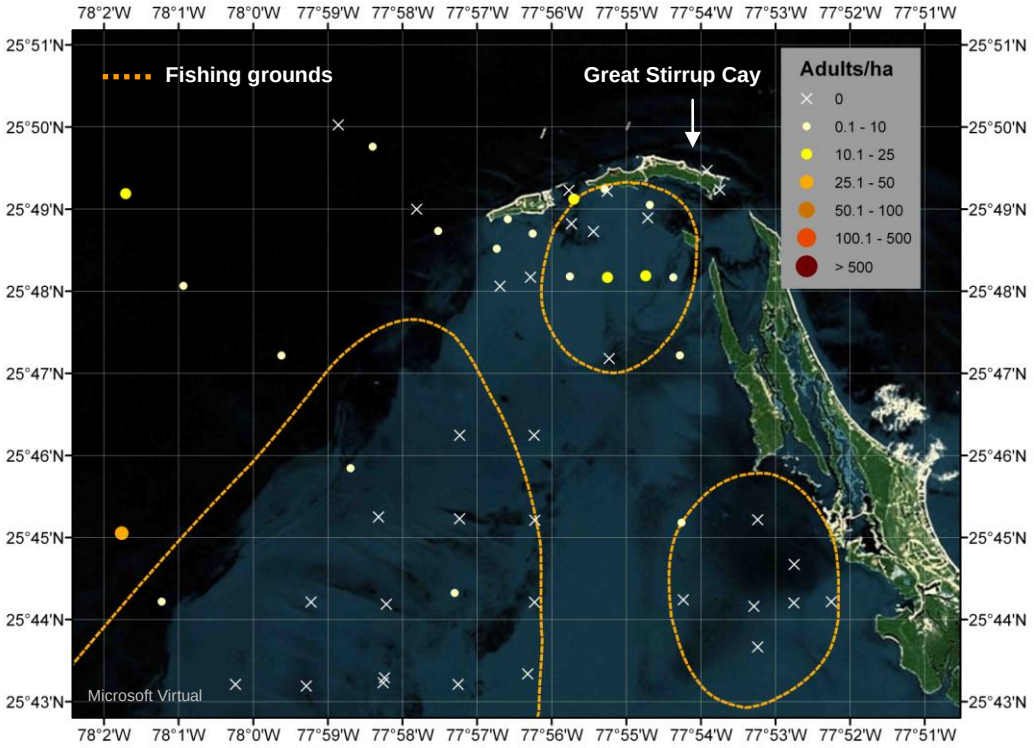


Fig. 9. Density distribution of subadult queen conch on the northern Berry Islands bank near Great Harbour Cay.

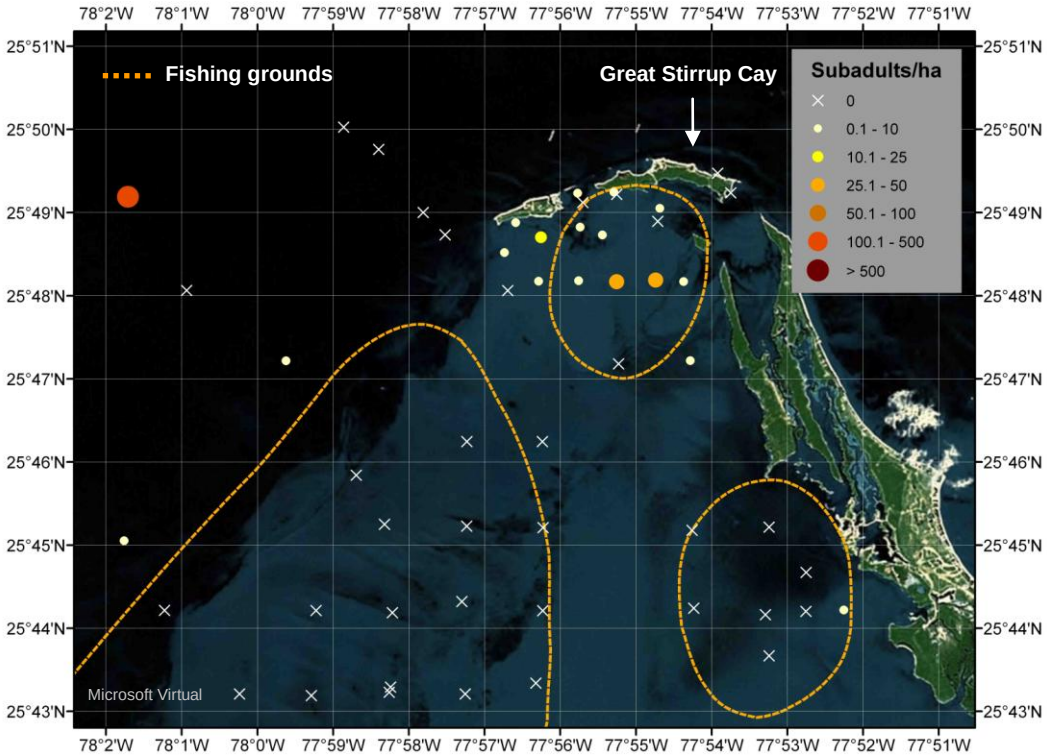


Fig. 10. Density distribution of subadult queen conch over the fishing grounds and surrounding areas on the Berry Islands bank.

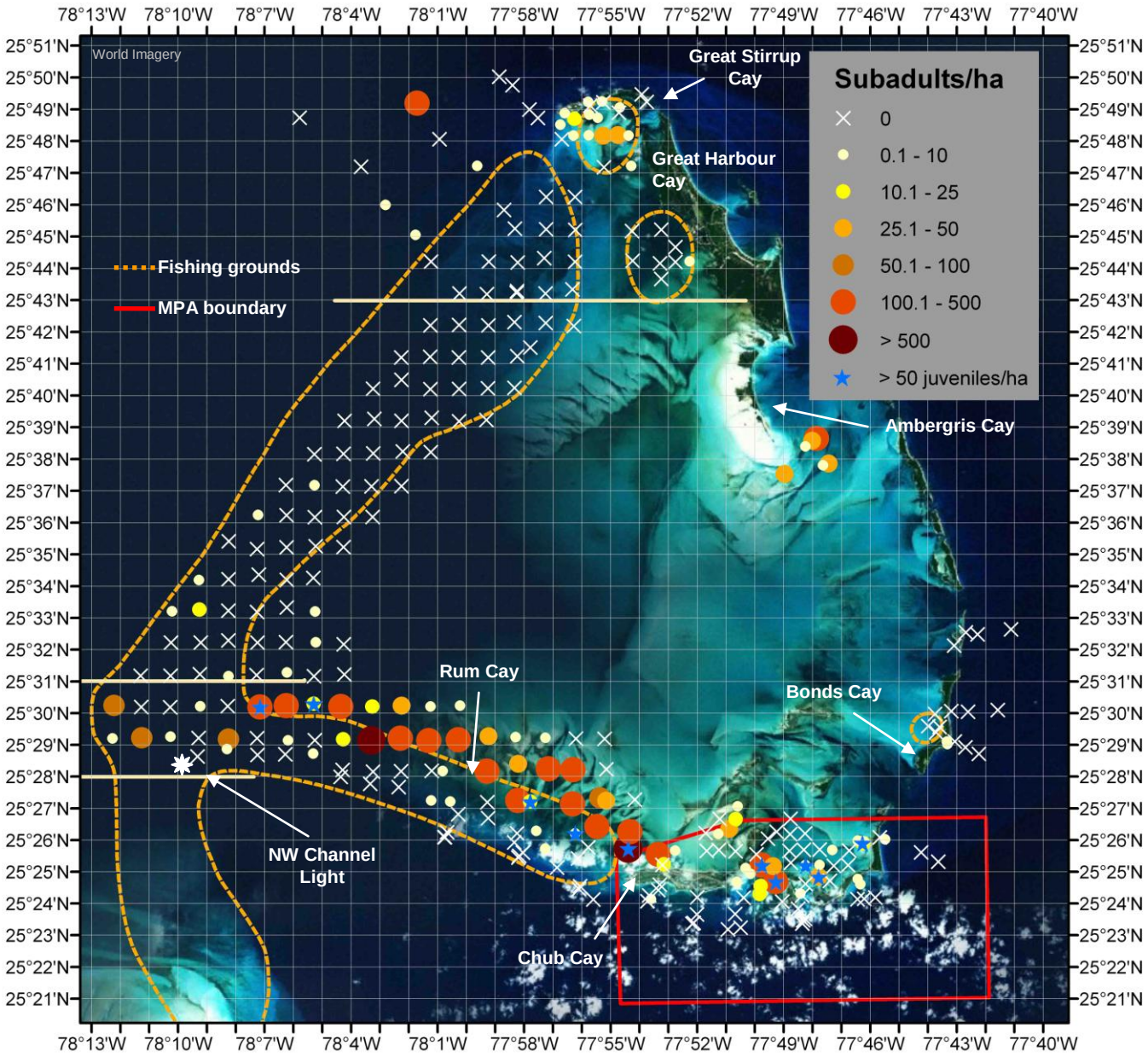


Fig. 11. Logistic model showing the probability of queen conch mating as a function of adult density.

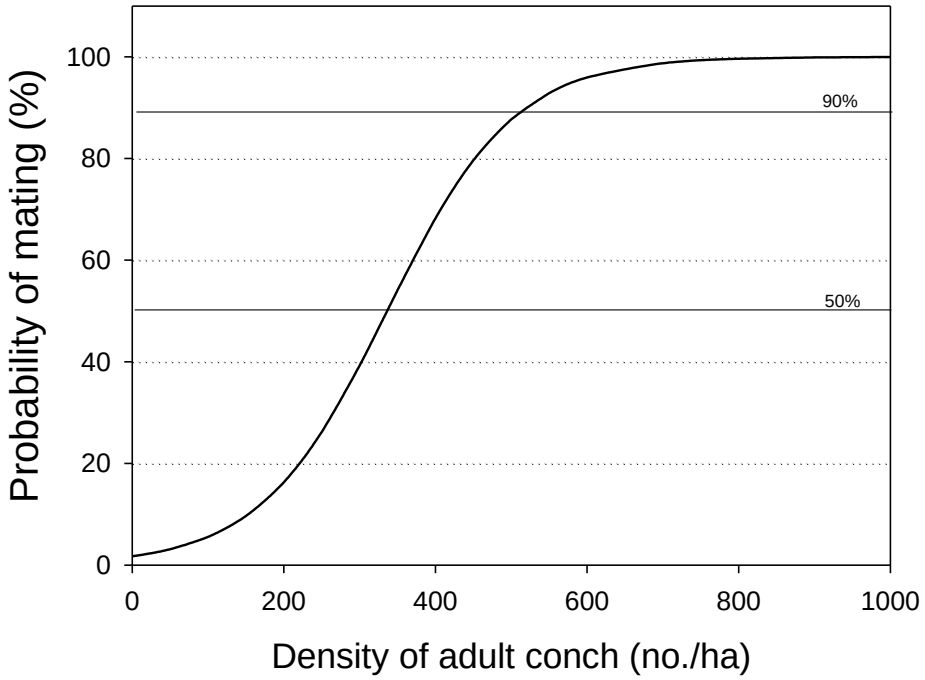
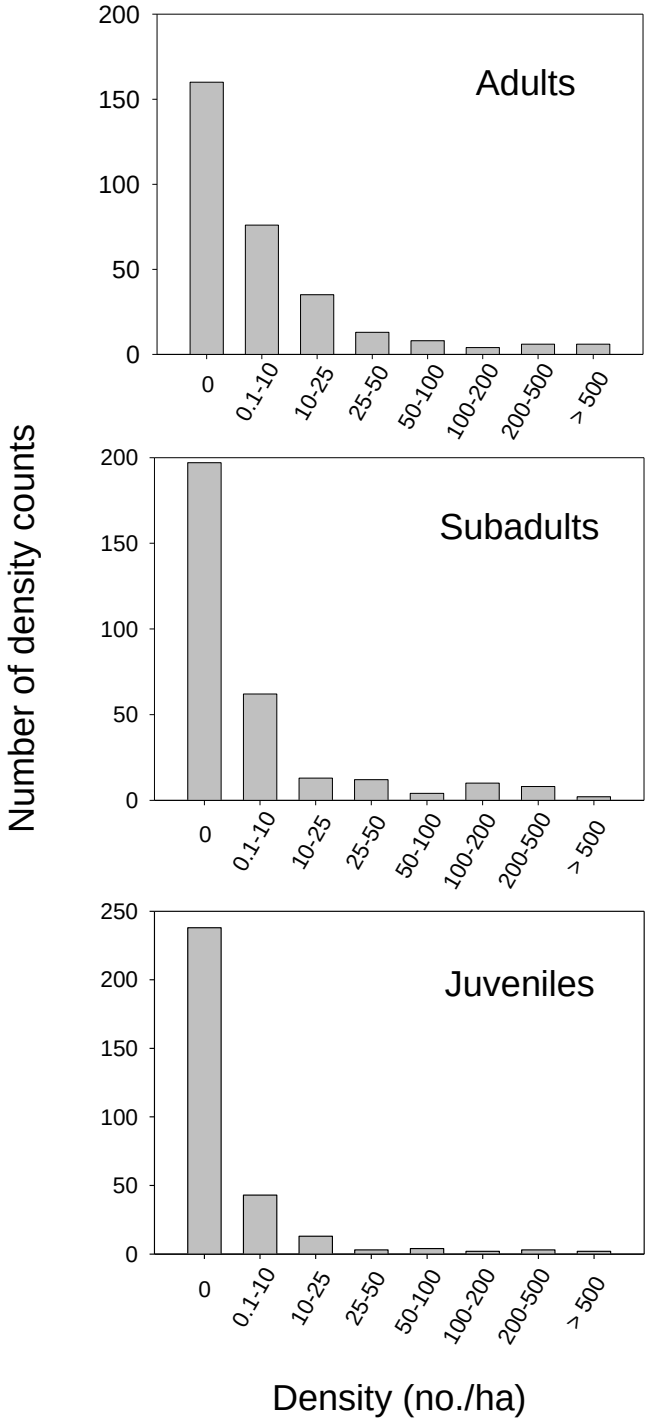


Fig. 12. Frequency distribution of adult, subadult, and juvenile queen conch densities over the entire survey region. n = 308 for each.



APPENDIX A

Community Interviews

A 1.0 Introduction

In addition to the original scope of work, interviews were conducted by volunteers within the communities of Great Harbour Cay and Chub Cay/Frazer's Hog Cay. Although the effort was considered preliminary in nature, the results of the interviews were immediately useful in identifying alternative survey sites, and will be helpful in developing community participation programs in the future. The purpose of the community interviews was to gain a better understanding of the attitudes and perceptions held by local people regarding the state of the conch fishery and the new marine reserve in the Chub Cay/Frazer's Hog Cay area, and to enhance the project's ties to the community.

A 2.0 Methods

A total of 12 informal semi-structured interviews were conducted by volunteers of the Community Conch organization during the 6 week field period in the two major communities of the Berry Islands, Chub Cay/Frazer's Hog Cay and Great Harbour Cay. The general goals of the interviews were 1) to determine the level of concern about the state of the conch fishery in the Berry Islands, 2) to gauge the level of acceptance of a new marine reserve in the area, and 3) to identify what other conch fishery management approaches the community would support. Interview participants were selected using non-random respondent-driven "snowball" and convenience sampling. Interviewers used framework, open-ended questions to guide participants (see below) and took notes or used video to record the data.

- How long have you lived in this area?
- What do you think about state of conch fishery?
- What do you think about MPAs?
- Do you think an MPA would be appropriate for the Berry Islands?
- If you think there should be restrictions on the conch fishery, what would you propose?

A 3.0 Results

A 3.1 Time lived in the Berry Islands

It was important to determine the length of time participants had lived in the area because this could influence their historic knowledge of conch fishing in the Berry Islands and therefore, their perception of the state of the conch fishery. Two participants stated they have lived in the Berry Islands for 3 years. One participant only visited the fishing grounds seasonally. Most of the interviewees had lived in the area for at least 30 years.

A 3.2 The state of the conch fishery

In response to the general question, "what do you think about the state of the conch fishery?" 10 of the 12 interview participants were concerned about the state of the conch fishery and indicated they believed conch populations were declining in the area. Interviewees often elaborated in their responses to include specific concerns. The amount of conch being taken from the fishery by commercial interests, the illegal harvest of under-sized or juvenile conch by commercial fishermen and local people, the practice of throwing "broken" shells back into the water where the conch were caught, and the pressure on the conch fishery from foreign recreational and commercial fishermen were all concerns expressed by at least 2 interviewees. Those that were not concerned about the conch fishery in the Berry Islands indicated they believed there are still plenty of conch left and that the area is able to support a lot of fishing, particularly by non-local commercial fishing interests. The following quotes represent general response themes.

> *I've seen a big change (in the conch fishery). We gotta do something soon. (local bonefishing guide)*

> *About 50 odd years ago, we used to go around here, you could go out in the nighttime and get conch. You could go in the grass and pick up conch. But now, you know, you gotta go so far for conch right now. Right now we got too much conch boats out there. And what are they doing out there, cleaning it out you know. And what they're doing is picking up all the round shells and babies and all that stuff. Kind of ridiculous.*
> *(local bonefishing guide)*

> *I think if people would stop breaking the shells and leaving them right on the bank…things would be a whole lot better as far as the conch are concerned. (recreational fisherman)*

A 3.3 Marine reserves

All of the interview participants expressed support for the marine protected area/marine reserve management strategy. When specifically asked what they thought about a marine reserve in the Berry Islands, 11 out of 12 were in favor. The reasons given for being in favor of this approach included concern for the welfare of future generations, that a marine reserve would be helpful in protection juvenile conchs and help prevent over-fishing generally, and that it may allow populations to recover.

> *Everyone basically are not going to live according to the law. You know, someone is going to take an undersized conch or lobster or something like that. But the thing we need to be, more or less, is reminded of our future. Where are we going to go? If you keep on taking the small ones, there will be no reproduction. (recreational fisherman)*

If we start killing out all the baby ones, what we gonna have for tomorrow? What are we going to have for our children?...Either we protect or we gonna lose them. (charter boat guide)

The single participant who was not in favor of the proposed reserve expressed his concern that a reserve may directly conflict with recreational and local fishing activities of nearby communities, and suggested that the reserve be repositioned to avoid this conflict.

In the (reserve) area that we know about today, it will be a hindrance in the market of the Chub deep sea fishing area and the native fishing people who are fishing out of Chub, and there's people who work in Chub, on their time off also fish to help...they can send them to Nassau to some family member on a flight to pick up a box or two or a cooler or two, and sell it and make some money, so they have to look out for their interest also. So we think if it was more east than it is, it would be in a better position. (recreational fisherman, local political leader)

A 3.4 Conch fishery management

Generally, there was strong support for more regulation of the conch fishery. The following suggestions for managing the fishery were made: More enforcement, take limits, closed season, designate specific fishing area which can be closed and opened, empower local people to aid in enforcement, make boundaries more visible by using buoys, exclusion of foreign fishing. The majority of participants (9/12) specifically stated that enforcement was necessary, though several participants also suggested that education and awareness efforts directed toward the local community, law enforcement, and fishermen would be beneficial. Local participation in the management process was specifically suggested by at least two participants.

They need to close the season around here for at least 3 years…at least around Chub..cause right now conch getting scarce. (local bonefishing guide)

The more you do in the kind of situations, the more you go to that community in which you are nearin' and get information or get suggestions, the best way they see it…if you keep an open mind, and keep things open where you involve everybody, they're on a good road. (local recreational fisherman, political leader)

We really need to police the area more. The community need to be conscious of what's going on. Every island needs to be more conscious of what's going on. The fishermens need to know that if it goes, we have no more grouper, no more conchs, no more lobster, at the end of the day we have nothing. (local recreational fisherman)

A 3.5 “Local knowledge”

According to interviewees, commercial conch fishing is done primarily using hookah, though fishermen free-dive in shallow water when hookah is illegal (Apr-July, closed crawfish season). At any time, 6-8 commercial boats fishing are observed in the area around Chub Cay. It was believed that the commercial fishing boats in the area may stay for up to 2 weeks and leave with 10,000 lbs or more of conch on board. It was repeatedly stated that commercial fishermen will take both legal and illegal sized conch. Under-sized conch are taken from the shell, skinned and frozen in 10 lb poly ice bags for sale locally and in Nassau. Although, commercial fishing appears to have the greatest impact on the conch fishery, there was recognition by several interviewees that it was not only commercial fishermen who have contributed to the decline of conch populations in the area, but also community members who occasionally fish who choose to ignore current regulations (i.e. taking juveniles).

A 3.6 Limitations of the interviews

The semi-structured interview approach was very useful in gathering more in-depth, thoughtful information; however, the method was followed somewhat loosely, and thus allowed room for inconsistency in how and when the guiding questions were asked. Other sources of bias did exist and are acknowledged here.

All interviews were conducted by volunteers who were not formally trained. There were multiple interviewers and two different methods of data recording, note-taking and video. In several interviews it was noted that the interviewer tended toward asking more leading-style questions. Also, the inherent reason for the interview and the association of the interviewers with a conservation organization may have biased participant responses. Participants may have been inclined to answer questions in a way they thought would be most acceptable to a conservation organization, but there was really no way to avoid this tendency and it is uncertain that this factor was a significant source of bias.

The type of sampling used to select interview participants, non-random “snowball” and convenience sampling, introduced a fundamental level of bias to the overall representational legitimacy of the data. However, there was an effort made to interview a variety of people, not just those directly involved in fishing. In a future study, a larger sample or random quantitative survey would help control this bias. It would be particularly useful to interview more commercial fishermen, as the trends in commercial fishing were supported by a single interview with a commercial fisherman and primarily comments by local fishermen.

A 4.0 Discussion

Overall, the interviews conducted within communities of the Berry Islands added depth to Community Conch’s understanding of the issues related to the conch fishery in this area, and possibly in other regions of the Bahamas. Practically, the interviews were extremely helpful in obtaining “local knowledge” in identification of other potential fishing grounds in the northern Berry Islands. Volunteer participation and community

involvement in the project were enhanced as the organization became more familiar with the communities affected by decline and management of the conch fishery.

Despite a relatively small sample size, there were definite trends that emerged in the interviews including the almost unanimous belief that the conch fishery in the Berry Islands is declining. Community support for the marine reserve in the southern Berry Islands was generally high, which indicates a higher probability of the success of this management approach. The results also suggest that there is strong support for some measure of stricter local regulation of the fishery, at least among the local fishing community, which might be considered by the DOMR.