Distribution and Abundance of Queen Conch, *Strombus gigas*, (Gastropoda: Strombidae) on the Shallow Waters of the Jaragua National Park, Dominican Republic

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ABSTRACT

The distribution of juvenile queen conch has been associated with certain ecologically unique characteristics within seagrass beds, such as strong tidal circulation patterns, depth between 2 to 3.5 m, and seagrass beds with intermediate biomass. Knowledge of the location of nurseries grounds is important to guarantee their protection for fisheries management or stock enhancement programs. The Jaragua National Park is located in the Southwest portion of the Dominican Republic and supports an important artisanal fishery for lobsters, queen conch and fishes. Its general management plan is in the way of being reviewed.

In order of provide precise information on juvenile queen conch distribution in the shallow waters of the Jaragua National Park, a total of 34 transects were conducted during the months of March and June - July of 1997. Data were collected on conch abundance, length, age, habitat type, and depth (to a maximum of 20 m). For conch density and abundance estimations, the area was divided into five regions (Canal de Beata, Bucan de Tui, El Cuevon, Bahia de Las Aguilas, Cabo Rojo). Most of the conch found were juveniles (88.9%). Canal de Beata had the highest density of juveniles (114.17 conchs/ha) and abundance (658,707 conchs), while Bucan de Tuy had the lowest density (4.03 conchs/ha) and Cabo Rojo had the lowest abundance (14,343 conchs). The overall estimates of juvenile density and abundance was 52.98 conchs/ha and 1,076,169 conchs, respectively. Juvenile density was highest on mixed seagrass beds (73.9 conchs/ha) and below 7 m depth (73.7 conchs/ha). Adult density at these depths was 4.6 conchs/ha. Canal de Beata appears to be the most suitable area to be considered as an important nursery ground and measures should be taken for its protection.

KEY WORDS: Queen conch, density, Dominican Republic.

INTRODUCTION

The queen conch, *Strombus gigas*, is an important commercial marine species. It is second only to the spiny lobster, *Panulirus argus*, as the most valuable demersal resource in the Caribbean region (Brownell and Stevely 1981, Appeldoorn 1994). However, intensive fishing for queen conch has led to stock collapse and fishery closure in a number of areas (e.g., Bermuda, Cuba, Florida, Mexico, US Virgin Islands) (Appeldoorn 1994). As a consequence of the queen conch overfishing, there has been increased research on the biology and ecology of conch. Some of these studies have shown the importance of understanding juvenile distribution and habitat requirements. The most productive nursery areas for the species tend to occur in shallow (<5 - 6 m deep) seagrass meadows. However, despite the presence of extensive seagrass meadows in certain productive areas such as Florida, Puerto Rico, Belize, and Bahamas, only few sectors of the meadows actually have show potential as nurseries areas.

Recent studies in Bahamas (Stoner et al. 1996, Jones 1996) mention some biotic and abiotic factors such as major characteristics for potential nursery grounds in Bahamas: intermediate density of seagrass (usually 30 - 80 g dry wt/m^2), depths of 2 - 4 m, strong tidal currents, and clear oceanic water flushing. Nursery habitats appear to be determined by complex interactions of physical features, seagrass and algae communities and larval recruitment. Because nursery areas appear to be unique and limited spatially, their extent, location, and definition have important implications for both fisheries management and stock enhancement. These critical habitats need to be identified and protected if production is wish to be maintained.

The Jaragua National Park is the largest of all marine parks in Dominican Republic (792 km^2). It is located in the Southwest portion of the Dominican Republic and has a vast diversity of marine ecosystems such as mangroves, seagrass beds, coral reefs, coastal lagoon and rocky shores. Its insular shelf supports an important artisanal fishery for lobsters, queen conch and fishes. The vast majority of conch landed in Dominican Republic come from this area. The purpose of this study is estimate conch abundance and distribution around the shallow waters of Jaragua National Park in order to identify potential conch nurseries sites.

MATERIALS AND METHODS

A preliminary survey was conducted (November 24 to 29, 1996) to obtain an idea of the distribution of queen conch in the shallow waters of the Park (Figure 1). The survey was conducted by a towed diver (J. Posada) who tried to cover representatives portions of the area. Results were complemented with information related directly from others and from a previous study in the area (Appeldoorn 1993).

As a consequence of the preliminary survey, the formal study area was limited to the 20m depth contour and extended from Cabo Beata to Cabo Rojo. The total area was calculated with a planimeter and estimated in 188.01 km^2. Stations were randomly chosen within each of these five zones by placing a grid drawn at 0.1 minute of latitude and longitude, over a nautical chart of the study area. Intersections on grid were chosen by taking numbers from a random number table (Sokal and Rohlf 1981). Additional surveys were conducted in the Islands of Los Frailes and Alto Velo.

At each station, estimates of abundance and density of queen conch were made from visual surveys, conducted by divers, along parallel strip transects. Transect width was four (4) meters, while transect length was variable according on depth. Buoys were dropped at the starting and ending points of each transect and the coordinates of these points were obtained, by using a Global Positioning System (GPS). Then, transect length was estimated by calculating the distance between these points.

While conducting a transect, divers followed a fixed compass reading for a set period of time and kept approximately one meter above bottom.. All living and dead conchs were counted. For each transect, records were kept on start and ending time, habitat type, time over each habitat type and depth, and time of appearance of each conch observed. Habitat types were based on sediment characteristics or dominant biota as follows: sand, algae, gorgonian, *Thalassia, Halimeda, Halophila*, mud, coral and hard bottom. Analysis were made by zones and habitat type. The surveyed area was arbitrarily divided into five (5) zones (Figure 2): the zone 1 corresponded to the Canal de Beata, including the north portion of Isla Beata; zone 2 extended from Playa Costinilla to Trudille; zone 3 included the eastern part of Trudille to Cabo Falso, while zone 4 extended from L'ansaso to the South of Cabo Rojo and zone 5 covered an small portion in he north of Cabo Rojo. The area of each zone was calculated with a planimeter.

The area within each transect was calculated by multiplying the distance of each transect by the transect width. Area for each habitat was calculated by multiplying the total area by the percentage of time spent over each habitat. Abundance for each zone was estimated multiplying the average conch density in the zone by the total area of the zone. Ninety five percentage (95%) confident limits were estimated for each zone. Densities for each habitat were derived by dividing the number of conch per habitat type by the total area of that habitat type per transect. Densities based on depth were calculated by determining the number of conch in each depth range divided by the area of depth range. Kruskall-Wallis rank sum tests (Sokal and Rohlf 1981) were used to compare densities (adult and juvenile) among zones and habitat types. Dunn multiple comparison tests were used to test the significance of pair-wise comparisons from the Kruskall-Wallis rank sum tests performed on the density data to determine which habitats and zones had significantly different abundance of conchs.

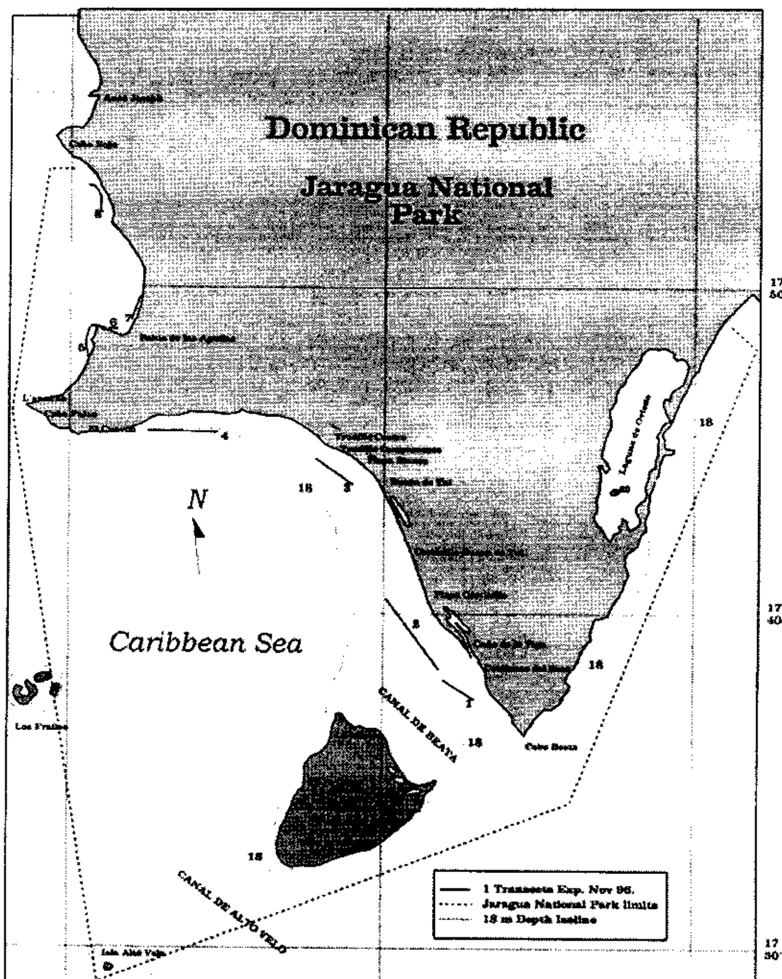

Figure 1. Map of the Jaragua National Park showing the limits of the park and the areas covered in the preliminary survey.

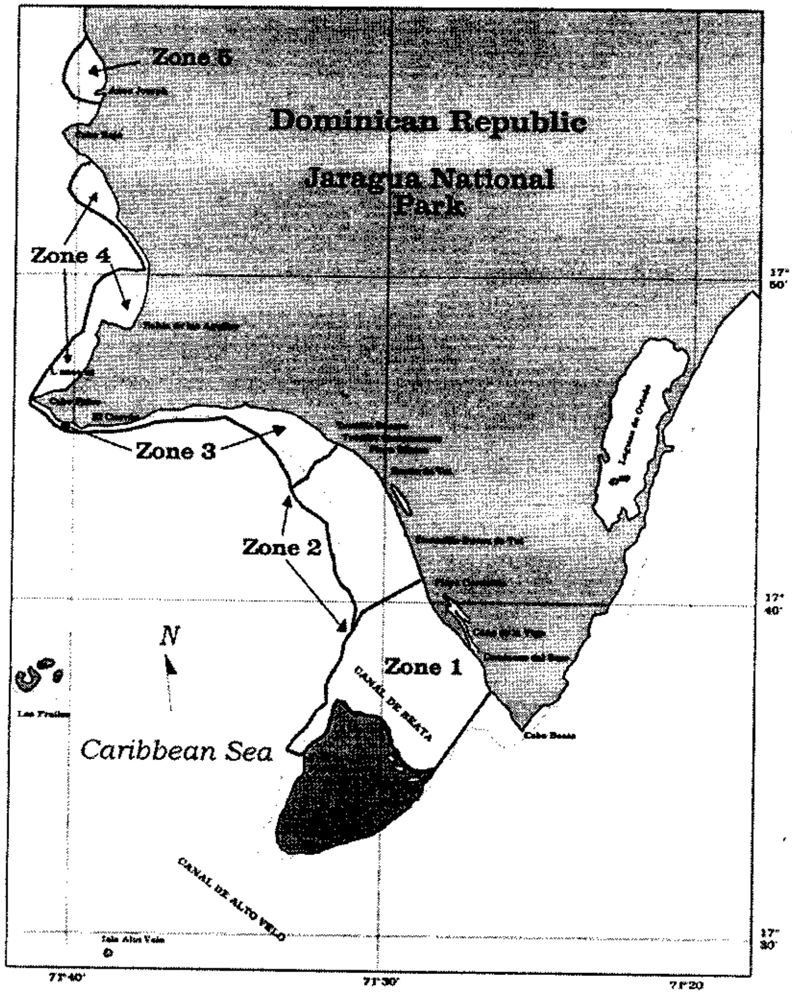

Figure 2. Map showing the zones in which the shallow waters of the park were arbitrarily divided.

RESULTS

Conch were found at 29 of 34 stations. A total of 165,043m^2 was surveyed and 948 conchs were observed. Conch densities within individual transects with conch ranged from 6.87 to 508.98 conchs/ha. Most of the conch observed were juveniles (88.9%). Adults were equitably distributed among newly mature and mature. No old conch were found.

Estimates of density and abundance for the five zones are presented on Table 1. Significant differences were found in juvenile densities among zones (Kruskal-Wallis, H = 27.2, DF = 4, p = < 0.0001).

Zone 1 had the highest density of juveniles (114.17 conch/ha) and abundance (658,707 conchs) [95% confidence interval (CI): 383,442 to 933,973] while Zone 2 had the lowest density (4.03 conch/ha) and Zone 5 had the lowest abundance (14,343 conch) (95% CI: 5,587 to 23,098). Zone 3 had the highest adult density (7.08 conchs/ha) while Zone 1 had the highest adult abundance (38,503 conchs). Dunn's pairwise multiple comparisons showed Zone 1 vs. Zone 3 to have similar densities of juveniles and that these densities were significantly higher (p < 0.05) compared to other areas. Densities of juveniles in other zones were not significantly different from each other. Average juvenile density overall stations was 52.98 conchs/ha, while adult average density over all stations was 4.26 conchs/ha.

Density estimates of dead juvenile and adult conch are presented on Table 2. Most of the stations with highest densities of dead juvenile and adult conch were in Zone 1 and Zone 5. *Thalassia-Syringodium* mixed was the most abundant habitat type encountered overall stations, constituting 39% of the total, followed by *Thalassia*, and algal plain (Table 3). There were no significant differences in densities among habitats in juveniles (Kruskal-Wallis, H = 8.44, DF 6, p = 0.2075) and adults (Kruskal-Wallis, H = 8.04, DF 6, p = 0.2351). *Thalassia-Syringodium* mixed had the highest juvenile number and density with 476 conch and 73.9 conchs/ha, respectively. Adult conch percentage was highest in *Thalassia* (43.24%), while adult conch density was highest in *Syringodium* (8.26 conchs/ha), followed by *Thalassia* (7.64 conch/ha).

Depths sampled ranged from 1.84 to 18 meters (mean: 7 m) (Table 4). The highest juvenile number and density occurred in water shallower than 7 meters (531 conch and 73.71 conch/ha). Percentage of juveniles decreased with depth (Table 4). Adult density (2.89 conchs/ha) was lower within the 7 to 12 meters stratum and higher (8.37 conchs/ha) within the 13 to 18 meters stratum.

Table 1. Estimates of densities and abundance among zones on the Jaragua National Park, Dominican Republic

	Conch/ha	Abundance	95% Confidence Limit	
Zone 1			Lower	Upper
Juveniles	114.17	65,8707	38,3442	93,3973
Mature	6.67	38,503		
Total	120.84	697,210	419,868	974,553
Area (km^2)	57.69			
Zone 2				
Juveniles	4.03	24,453	8,919	71,156
Mature	3.07	18l622	3,033	55,990
Total	7.10	43,075	17,475	124,390
Area (km^2)	60.68			
Zone 3				
Juveniles	58.54	221,293	111,823	39,987
Mature	7.08	26,799	11,923	34,223
Total	65.63	248,084	131,193	68,689
Area (km^2)	37.8			
Zone4				
Juveniles	21.02	46,001	111,823	330,763
Mature	2.43	5,307	11,923	41,634
Total	23.45	51,308	131,193	3649,51
Area (km^2)	21.88			
Zone 5				
Juveniles	16.02	14,343	5,587	330,763
Mature	1.08	966		41,634
Total	17.10	15,309	6,553	364,951
Area (km^2)	8.95			
Total density and abundance in Jaragua National Park				
	Density/ha	Abundance		
Juvenile	52.98	996,076		
Adults	4.26	80,092		
Total	57.24	1,076,169		
Total area	188.01			

Table 2. Density estimates of juvenile and adult dead conchs in Jaragua National Park, Dominican Republic

Station	No. of juveniles	No. of adults	Total No. of conchs	Area (meters)	Density Juv/ha	Density Mat/ha	Total Conchs/ha
1	37	9	46	3,097.7	119.4	39.05	148.50
2	1	5	6	6,018.2	1.66	8.31	9.97
3	6	7	13	3,961.8	15.14	17.67	32.81
4	2	2	4	4,358.6	4.59	4.59	9.18
5	2	12	14	2,970.1	6.73	40.40	47.13
6	15	0	3	2,912.7	51.50	0	51.50
7	3	0	3	2,063.0	14.54	0	14.54
8	5	1	6	2,887.5	17.32	3.46	20.78
9	21	3	24	3,606.2	58.23	8.32	66.55
10	12	6	18	1,157.0	103.72	51.86	155.57
11	13	9	13	5,145.7	25.26	0	25.26
12	26	6	32	2512,8	103.47	23.88	127.35
13	18	5	23	3,491.5	51.55	14.32	65.87
14	8	8	16	2,822.3	28.35	28.35	56.69
15	30	12	42	2,465.4	121.68	48.67	170.36
16	14	1	15	2,352.8	59.50	4.25	63.75
17	7	1	8	1,227.0	57.05	4.25	63.75
18	-	-	-	1,193.7	0	0	0
19	-	-	-	1,129.4	0	0	0
20	2	2	-	1,381.1	14.48	14.48	0
21	-	4	4	2,364.7	0	16.92	16.92
22	-	-	-	573.2	0	0	0
23	2	-	2	2,759.8	7.25	0	7.25
24	1	2	3	1,829.3	5.47	10.93	16.40
25	-	-	-	1,520.7	0	0	0

Table 2 (cont.). Density estimates of juvenile and adult dead conchs in Jaragua National Park, Dominican Republic

Station	No. of juveniles	No. of adults	Total No. of conchs	Area (meters)	Density Juv/ha	Density Mat/ha	Total Conchs/ha
26	2	1	3	2,215.1	9.03	4.51	13.54
27	8	-	8	1,369.1	58.82	0	58.03
28	4	-	4	689.4	58.03	0	88.38
29	16	-	16	1,810.3	88.38	0	88.38
30	-	-	-	597.71	0	0	0
31	-	-	-	1,481.1	0	0	0
32	6	-	6	4,554.1	13.17	0	13.17
33	3	-	3	2,577.1	11.64	0	11.64
34	17	2	19	1,434.2	118.5	13.94	132.48

CONCLUSIONS

The surveys covered representative areas of the shallow waters at the Jaragua National Park. As expected for shallow waters, most of the observed queen conch were juveniles and no old conch were observed. Similar results have been observed in the shallowest regions of many Caribbean banks (Stoner, 1997). Previous researchers have suggested that this is a consequence of both a gradual offshore migration with increasing age and intense fishing activities in the shallow waters (Weil and Laughlin 1984, Appeldoorn 1993, Stoner and Schwarte 1994, Stoner 1997).

The lowest total density of juvenile conch was observed at Zone 2. This region, including the deeper waters, was the area reported by Colom et al. (1991) and Infante and Silva (1992) as the most important landing district of the Jaragua National Park. Its nearest town, Trudille, supports a very active fishing community. Five of the eight main queen conch fishing grounds reported by Tejeda (in press) were located in this area . High numbers and densities of empty queen conch shells (dead conchs) were found in zone 1 and zone 5. This may indicate a recent increase in fishing activities in those regions, as previous shallow water supplies, especially for free divers, have been diminished.

Juveniles and adults were predominant on seagrasses, although there were no significant differences in mean densities among habitats. Sand was the habitat with the second highest juvenile density (67.84 conch/ha). However this may be an artifact influenced by the low area covered over this habitat type. In general, juvenile queen conch are most numerous on shallow banks and reef flats, characterized by macroalgae and *Thalassia testudinum* (Stoner et al., 1996).

Juvenile conch densities were significantly higher for Zone 1 and Zone 3 ($p < 0.05$). This basically coincides with the preliminary observations made by Appeldoorn (1993) and indicates that there are areas at Jaragua National Park where juvenile queen conch prevalence, both in abundance and year to year. Stoner et al. (1996) and Jones (1996) have described some of the features needed as a potential nursery ground (i.e. intermediate density of seagrass, depth of 2-4m, strong tidal current and clear oceanic water flushing). It appears that some areas of Zone 1 (specially) and Zone 3 combine all or some of the appropriate biotic and abiotic factors needed for a habitat to function as a nursery ground.

Continued research is needed, specially to determine the habitat characteristics (such as depth, macrophyte biomass and circulatory patterns) that affect the existence and distribution of juvenile queen conch in the entire area. This information may help in understanding the ecological factors that mediate recruitment of juvenile queen conch and to improve predictive models of spatial analyses such as Jones (1996) that may aid in locating the existence of nursery grounds, determine critical habitats and establish reserve areas, given their important implications for both fisheries management and stock enhancement (Jones 1996, Stoner 1997).

Although juvenile conch densities are rarely reported and sampling methods vary among studies, conch juveniles densities (52.98 conch/ha) in the Jaragua National Park are higher than areas such as Belize, Jamaica (Pedro Bank), the Florida Keys, Puerto Rico and the US Virgin Islands (Table 5). The Jaragua National Park does not seem to be environmentally threatened, although some coastal development has been proposed for Bahia de las Aguilas, with the opposition of environmental groups (Grupo Jaragua).

A preliminary initiative that may be taken is to establish, at least for Zone 1, an area of special protection within the National Park (i.e., queen conch harvest refuge). In accordance with previous reports by Colom et al. (1991), Infante and Silva (1992), Appeldoorn (1993) and Tejeda (in press), a large abundance of juveniles and adult queen conch are reported from Alto Velo. If protected, this area could function as a marine sanctuary, in order to guarantee a reserve for spawning adults, thus ensuring a future potential for recruitment. The fishing community may be part of these actions if a regular exchange is established to convey conservation issues and the reason for regulations.

Table 3. Habitat distribution of juvenile (J) and adult (A) conchs on the Jaragua National Park, Dominican Republic.

Habitat Type	Area (m^2)	% Area	J	% J	J /ha	A	% Adult	A /ha
Thalassia-Syringodium	64,359.70	39.24	476	54.52	73.96	25	33.78	3.88
Thalassia	41,905.43	25.55	226	25.89	53.93	32	43.24	7.64
Algal Plain	18,907.03	11.53	103	11.80	54.48	5	6.76	2.64
Hard bottom with gorgonians	14,322.68	8.73	10	1.15	6.98	2	2.70	1.40
Syringodium	12,100.23	7.38	23	2.63	19.01	10	13.51	8.26
Hard bottom with corals	9,468.02	5.77	8	0.92	8.45	0	0	0
Sand	3,979.85	2.43	27	3.09	67.84	1	1.35	2.51
Total	16,5042.94		873			75		

Table 4. Distribution of juvenile (J) and adult (A) conchs by depth on the Jaragua NationalPark, Dominican Republic. Density in number of conchs/ha.

Depth range (m)	Area (m^2)	Area (%)	No. Juv.	No. Adults	To-tal No.	Juv. density	Adult density	Total den-sity	% J	% A	% J (T-otal)	% A (Total)	Total %
<6	71,903	43.6	531	33	564	73.7	4.6	78.4	94.1	5.8	60.8	44.0	59.49
7-12	65,672	39.8	241	19	260	36.7	2.9	39.6	92.7	7.3	27.6	25.3	27.43
13-18	27,466	16.6	101	23	124	36.8	8.4	45.2	81.4	18.6	11.6	30.7	13.08
Total	165042		873	75	948								

Table 5. Average juvenile density of *Strombus gigas* determined by abundance surveys.

Location	Density (Conch/ha)	Reference
Pedro Bank		
Industrial Zone (10 -	30.31	Appeldoorn, 1995
20 - 30 m	57.88	Appeldoorn, 1995
U.S.Virgin		
St. Thomas/St. John	16.52	Friedlander, 1996
Bahamas		
Protected Bank	< 5	Stoner and Ray,
Protected Shelf	< 6	Stoner and Ray,
Florida Keys		
1987 - 1988	1.93	Berg and Glazer,
1990	0.72	Berg and Glazer,
Belize	14	Appeldoorn and
Puerto Rico	5.47	Torres Rosado, 1987
Puerto Rico West	6.24	Mateo 1997
Puerto Rico East	4.06	Mateo 1997
Jaragua National Park, D.R.	52.98	This study

ACKNOWLEDGMENTS

This survey was supported by the Jaragua group and the Project JEF. Very special thanks are due to Barbara Reveles and the Captain and the crew of the R/V Mago del Mar. We would also like to thank Dr. R. Appeldoorn for his valuable criticism and comments on this paper.

LITERATURE CITED

Appeldoorn, R.S. 1993. Report on the Lambi fishery and resource in the area of Punta Beata, Dominican Republic. Propescar-Sur. Unpubl. Ms. 5 pp.

Appeldoorn, R.S. 1994. Queen conch management and research: Status, needs and priorities. Pages 301-319 in: R.S. Appeldoorn and B. Rodríguez (eds.) *Queen conch biology, fisheries and mariculture.* Fund. Cientif. Los Roques, Caracas, Venezuela. 356 pp.

Appeldoorn, R.S. 1995. Stock abundance and potential yield of queen conch of

Pedro Bank. Fisheries Division, Ministry of Agriculture, Kingston, Jamaica. Unpubl. Ms. 31 pp.

Appeldoorn, R.S., and W. Rolke. 1996. Stock abundance and potential yield of queen conch resource in Belize. CARICOM Fisheries Research Assessment and Management Program (CFRAMP) and Belize Fisheries Department, Belize City, Belize. Unpubl Ms. 7 pp.

Berg, C.J., and Glazer, R.A. 1995. Stock assessment of a large marine gastropod (*Strombus gigas*) using randomized and stratified towed - diver censusing. *ICES Mar. Sci. Symp.* **199**:247-258.

Brownell, W.N., and J.M. Stevely. 1981. The biology, fisheries and management of the queen conch, *Strombus gigas*. *Mar. Fish. Rev.* **43**(7):1-12.

Colom, R. Z. Reyes and Y. Gil. 1991. Censo comprensivo de la pesca artesanal en la Republica Dominicana. *Sea-Propescar-Sur* No 3. 37p p.

Friedlander, A. 1996. Status of queen conch populations around the northern U.S. Virgin Islands with management recommendations for Virgin Islands National Park. National Biological Service Virgin Islands NP Field Station St. John, USVI. Unpubl Ms. 34 pp.

Infante, J., and M. Silva. 1992. Produccion pesquera en las provincias de Barahona y Pedernales. Sea-*Propescar-Sur* No 11. 16 pp.

Jones, R.L. 1996. Spatial analysis of biological and physical features associated with the distribution of queen conch, *Strombus gigas*, nursery habitats. MS Thesis, Florida State Univ. 98 pp.

Mateo, I. 1997. Spatial variations in stock abundance of Queen Conch *Strombus gigas* in the west and east coasts of Puerto Rico. MS Thesis. Univ. Puerto Rico, Mayagüez Campus. 72 pp.

Sokal, R.R., and F.J. Rohlf. 1981. *Biometry.* W.H. Freeman and Company, New York. 959 pp.

Stoner, A.W. 1997. Status of queen conch research in the Caribbean. Pages 22-39 in: J.M. Posada and G. Garcia-Moliner (eds.) *International Queen Conch Conference*. Caribbean Fishery Management Council, San Juan, Puerto Rico. 151 pp.

Stoner, A..W., P.A. Pitts, and R.A. Armstrong. 1996. The interaction of physical and biological factors in the large-scale distribution of queen conch populations in seagrass meadows. *Bull. Mar. Sci.* **58**:217-233.

Stoner, A.W., and M. Ray. 1996. Queen conch, *Strombus gigas*, in fished and unfished locations of the Bahamas: Effects of a marine fishery reserveon adults, juveniles, and larval production. *Fish. Bull.* **94**:551-565.

Stoner, A.W., and K.C. Schwarte. 1994. Queen conch, *Strombus gigas*, reproductive stocks in the central Bahamas: distribution and probable

Tejeda, J.C. Resultados preliminales de los niveles de captura y distribución de frecuencia de tallas de lambi, ***Strombus gigas*** (L), en el Parque Nacional Jaragua, Barahona, Republica Dominicana. *Proc. Gulf and Carib. Fish. Inst.* In Press.

Torres-Rosado, Z.A. 1987. Distribution of two mesogastropods, ***Strombus gigas*** (Linnaeus), and the Milk conch, ***Strombus costatus*** Gmelin, in La Parguera, Lajas, Puerto Rico. MS Thesis, UPR, Mayagüez Campus. 37 pp.

Weil, E., and R.A. Laughlin. 1984. Biology, population dynamics and reproduction of the queen conch, ***Strombus gigas*** (L), in the Archepielago de Los Roques National Park. *J. Shell. Res.* **4**(1):45-62.