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Occurrence, Abundance, and Length Frequency Distribution of Queen Conch, *Strombus gigas* (Gastropoda) in 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 of 2 to 4 m, and seagrass beds with intermediate biomass. Knowledge of the location of nursery grounds is important to guarantee their protection for fisheries management or stock enhancement programs. 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. To provide precise information on juvenile queen conch distribution in the shallow waters of the Jaragua National Park, 34 sites (stations) were visited during the months of March and June-July, 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 (114.2 conchs/ha) and abundance (658,707 conchs), while Bucan de Tui had the lowest density (4.0 conchs/ha) and Cabo Rojo had the lowest abundance (14,343 conchs). The overall estimates of juvenile density and abundance was 53.0 conchs/ha and 1,076,169 conchs, respectively. Juveniles ranged from 5 to 26 cm in length (mean: 14 cm). 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 is a suitable nursery ground and should be protected.

RESUMEN.—La distribución de juveniles del caracol reina se ha asociado con ciertas características ecológicas particulares, tales como patrones de corrientes de marea fuertes, profundidades entre 2 y 4 m, y praderas de hierbas marinas de biomasa intermedia. El conocer la localización de tales viveros es importante para garantizar la protección de los mismos mediante un manejo pesquero o programas de repoblación de las existencias. El Parque Nacional Jaragua está localizado en la porción suroccidental de la República Dominicana y sostiene una importante actividad pesquera artesanal, especialmente de langostas, caracoles y peces. Se visitaron 34 localidades (estaciones) entre los meses de marzo y junio-julio de 1997, para obtener información precisa sobre la distribución del caracol reina en las aguas someras del Parque Nacional Jaragua. Se colectó información sobre su abundancia, longitud, edad, tipo de hábitat y profundidad (hasta un máximo de 20 m). Para estimar su densidad y abundancia, el área fue dividida en cinco regiones (Canal de Beata, Bucan de Tui, El Cuevón, Bahía de Las Águilas, Cabo Rojo). La mayoría de los caracoles observados fueron juveniles (88.9%). El Canal de Beata presentó la mayor densidad (114.2 caracoles/hec) y abundancia (658,707 caracoles) de juveniles, mientras que Bucan de Tui presentó la menor densidad (4.0 caracoles/hec) y Cabo Rojo la menor abundancia (14,343 caracoles). El estimado general de densidad y abundancia de juveniles fue de 53.0 caracoles/hec y 1,076,169 caracoles, respectivamente. La talla de los juveniles osciló entre 5 y 26 cm (media: 14 cm). La densidad de los juveniles fue mayor sobre praderas mixtas de hierbas marinas (73.9 caracoles/hec) y a profundidades por debajo de los 7 m (73.7 caracoles/hec). La densidad de los adultos a esas profundidades fue de 4.6 caracoles/hec. El Canal de Beata es un importante vivero de juveniles y debe ser protejido.

INTRODUCTION

The queen conch, *Strombus gigas*, is an important commercial 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, 1994a). 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, 1994a). As a consequence of overfishing, there has been an increase in research on the biology and ecology of queen 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) seagrass meadows (Stoner, 1997). However, despite the presence of extensive seagrass meadows in certain productive areas such as Florida, Puerto Rico, Belize, and Bahamas, only a few sectors of the meadows have actually shown potential as nurseries areas.

The uniqueness of queen conch nursery habitats has important implications for both fisheries management and stock enhancement of this seriously overfished resource (Stoner, 1997). Studies in the Bahamas (Stoner et al., 1996; Jones, 1996) have attempted to describe the major biotic and abiotic characteristics for potential nursery grounds: intermediate density of seagrass (usually 30-80g 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 among 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 fisheries management and stock enhancement. These critical habitats must be identified and protected if production is to be maintained.

Jaragua National Park is the largest marine park in the Dominican Republic (792 km^2). It is located in the Southwest portion of the Dominican Republic (Fig. 1) and has a vast diversity of marine ecosystems, such as mangroves, seagrass beds, coral reefs, a 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 the Dominican Republic come from this area (Tejeda, 1995).

The purpose of this study was to estimate conch abundance and distribution around the shallow waters of Jaragua National Park to identify potential conch nursery sites. This study is part of a multidisciplinary project to characterize the status of the Jaragua National Park, organized by Grupo Jaragua Inc., Santo Domingo, Dominican Republic.

MATERIALS AND METHODS

A preliminary survey was conducted during November 24 to 29, 1996 to obtain a general overview of the distribution of queen conch in the shallow waters of the park (Fig. 1). The survey was conducted by a towed diver (J. Posada) who tried to cover representative portions of the shallow waters of the park. Results were complemented with information obtained from fishers and from a previous study in the area (Appeldoorn, 1993).

As a result of the preliminary survey, the formal study area was limited to the 20m depth contour (188 Km^2, extended from Cabo Beata to Cabo Rojo) and arbitrarily divided into five zones (Fig. 2). The total area and the area of each zone was calculated with a planimeter. Stations were randomly chosen within each of these five zones by placing a grid drawn at a scale of 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 around 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 (two transects per station, oriented according to the dominant water current). Transect width was four meters, while transect length was variable according to depth (due to diving safety procedures). Buoys were dropped at the starting and ending points of the pair of transects and the coordinates of these points were obtained using a Global Positioning System (GPS). Transect length was estimated by calculating the distance between these points.

While surveying a station, divers followed a fixed compass reading for a set

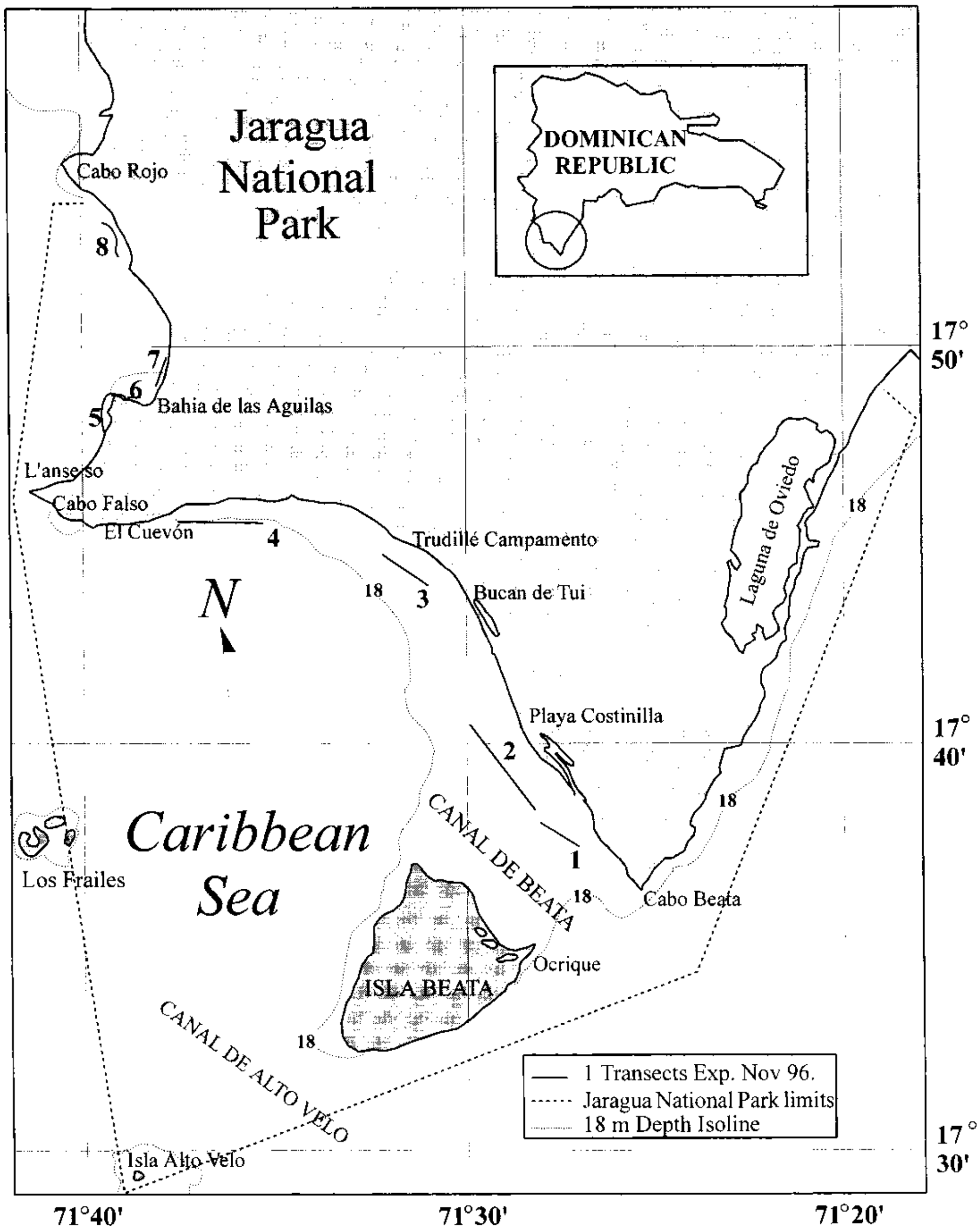

FIG. 1. Map of Jaragua National Park showing the limits of the park and the areas covered in the preliminary survey.

period of time (variable according to depth) and kept approximately one meter above bottom. All living and dead conchs were counted. The length of all living individuals (siphonal length; Appeldoorn, 1994b) was estimated to the nearest 1 cm, and if an adult was found, its age was estimated as one of four relative age classes based on the

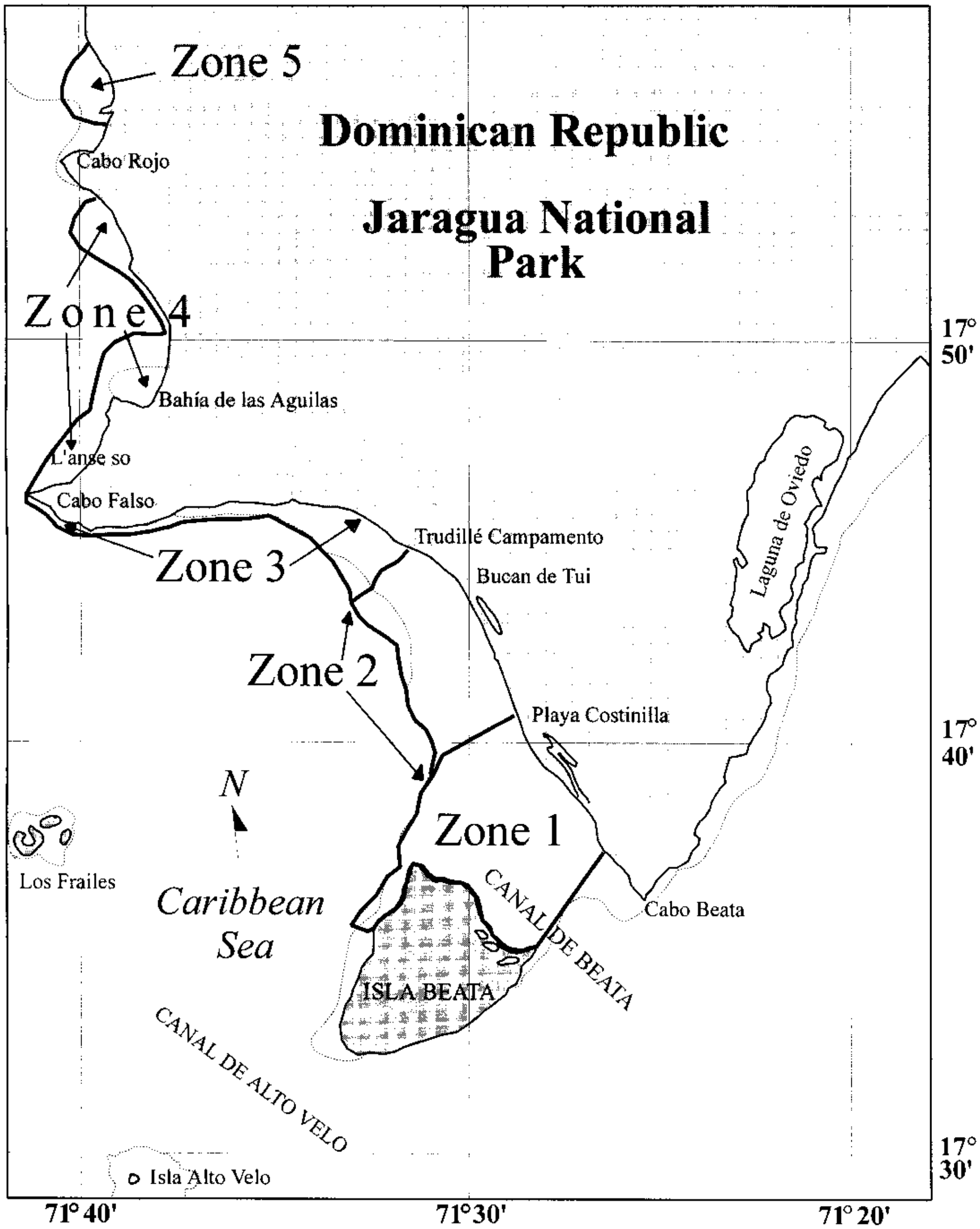

FIG. 2. Map showing the zones into which the shallow waters of the park were arbitrarily divided.

degree of shell erosion: newly mature, adult, old, and very old (Table 1).

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*, *Syringodium*, *Halimeda*, *Halophila*, mud,

TABLE 1. Definitions of adult queen conch age classes (Appeldoorn, 1995).

Age Classes	Definition
Newly Mature	Flared lip starting to grow or very thin (lip generally <5 mm thick). Periostrocum tan and clean. Often the lip is thin enough to allow the periostrocum to give color to the underside of the lip.
Adult	Flared lip is fully formed, with minimal to moderate erosion. Periostrocum tan but may be sand covered or with some algal growth. Lip underside generally white with pink interior.
Old Adult	Outer lip starting to erode (as viewed from bottom). Top of shell still well formed, but periostrocum is lost and spines have rounded with moderate erosion and fouling on the outside shell. Lip underside may have platinum color, with darker pink interior.
Very Old Adult	Lip is very thick and flared portion may be completely eroded away. Outer shell is highly fouled and eroded, often resulting in a short total length. Viewed from the underside, the lip is squared off, the white portion is often completely eroded and the interior is a dark pink.

coral, and hard bottom. Analyses were made by zones and habitat type.

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 by multiplying the average conch density in the zone by the total area of the zone. Ninety-five percent 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 and dividing that by the area of depth range. Length (juvenile and adult) and age (adult) frequency distributions were determined. Kruskal-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 Kruskal-Wallis rank sum tests performed on the density data, to determine which habitats and zones had significantly different abundance of conchs.

RESULTS

Locations and sampling dates for each station are given on Table 2. Information from the first survey (November 1996) was used to obtain preliminary data on the distribution of queen conch in the shallow waters of Jaragua National Park, but was not quantitatively analyzed.

The results obtained from March and June-July, 1997 are presented on Table 3. Conch were found at 29 of 34 stations. A total of 165,043m^2 were surveyed and 948 conchs were observed. Since stations 30 and 31 (Alto Velo Is.) are out of the zonification (Fig. 2), these results were not included in other analyses. Although surveys at these two stations reflected zero conch, fishers with queen conch in their boats were observed on Alto Velo Is.

Total conch number and total conch density, within individual transects with conch, ranged from 1 (station 18, replicate 2) to 114 individuals (station 34, replicate 2) and 6.9 (station 6, replicate 1) to 509.0 conchs/ha (station 34, replicate 2), respectively (Table 3). Most of the conch observed were juveniles (88.9%). Adults were equitably distributed among newly mature and mature. Neither old or very old conch were found.

Estimates of area, density, and abundance, for the five zones, are presented on Table 4. The total area (within the 20m depth contour) was estimated as 188 km^2. 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 and abundance [95% confidence interval (CI): 383,442 to 933,973], while zone 2 had the lowest density and zone 5 had the lowest abundance (95% CI: 5,587 to 23,098). Zone 3 had the highest

TABLE 2. Locations and survey dates for each examined station. All latitudes at 17° North and all longitudes at 71° West.

Date	Station	Zone	Initial Point		Final Point	
Mar. 2, 97	1	1	37′ 852″ N	27′ 713″ W	38′ 247″ N	27′ 857″ W
Mar. 2, 97	2	1	39′ 170″ N	29′ 165″ W	38′ 732″ N	28′ 447″ W
Mar. 3, 97	3	2	43′ 471″ N	32′ 711″ W	43′ 328″ N	32′ 170″ W
Mar. 3, 97	4	2	42′ 025″ N	31′ 045″ W	42′ 202″ N	31′ 634″ W
Mar. 4, 97	5	3	45′ 538″ N	36′ 719″ W	45′ 551″ N	37′ 140″ W
Mar. 4, 97	6	4	46′ 707″ N	40′ 662″ W	46′ 551″ N	40′ 283″ W
Mar. 4, 97	7	4	52′ 100″ N	38′ 947″ W	52′ 328″ N	39′ 115″ W
Mar. 4, 97	8	4	52′ 200″ N	39′ 090″ W	52′ 568″ N	39′ 225″ W
Mar. 5, 97	9	4	49′ 262″ N	38′ 125″ W	49′ 598″ N	37′ 755″ W
Mar. 5, 97	10	5	55′ 870″ N	39′ 556″ W	56′ 681″ N	39′ 948″ W
Mar. 5, 97	11	5	56′ 095″ N	39′ 556″ W	56′ 681″ N	39′ 948″ W
Mar. 6, 97	12	1	37′ 960″ N	27′ 760″ W	38′ 173″ N	28′ 037″ W
Mar. 6, 97	13	1	35′ 584″ N	29′ 080″ W	35′ 853″ N	29′ 486″ W
Mar. 7, 97	14	1	35′ 943″ N	32′ 107″ W	35′ 908″ N	32′ 505″ W
Mar. 7, 97	15	1	37′ 250″ N	30′ 863″ W	37′ 568″ N	30′ 760″ W
Jun. 29, 97	16	1	37′ 948″ N	28′ 388″ W	38′ 043″ N	28′ 706″ W
Jun. 29, 97	17	1	37′ 427″ N	28′ 910″ W	37′ 354″ N	29′ 066″ W
Jun. 29, 97	18	2	43′ 077″ N	30′ 428″ W	43′ 108″ N	30′ 594″ W
Jun. 29, 97	19	2	43′ 163″ N	31′ 242″ W	43′ 266″ N	31′ 360″ W
Jun. 29, 97	20	3	44′ 856″ N	33′ 662″ W	44′ 927″ N	33′ 843″ W
Jul. 1, 97	21	3	44′ 937″ N	32′ 961″ W	44′ 947″ N	33′ 296″ W
Jul. 1, 97	22	3	44′ 770″ N	34′ 111″ W	44′ 847″ N	34′ 119″ W
Jul. 1, 97	23	3	44′ 829″ N	34′ 107″ W	45′ 079″ N	34′ 397″ W
Jul. 1, 97	24	4	44′ 779″ N	39′ 180″ W	48′ 954″ N	38′ 997″ W
Jul. 1, 97	25	4	48′ 894″ N	38′ 137″ W	49′ 098″ N	38′ 113″ W
Jul. 2, 97	26	4	52′ 146″ N	39′ 028″ W	52′ 416″ N	39′ 163″ W
Jul. 2, 97	27	4	52′ 542″ N	39′ 201″ W	52′ 685″ N	39′ 322″ W
Jul. 2, 97	28	5	55′ 799″ N	39′ 674″ W	55′ 863″ N	39′ 603″ W
Jul. 2, 97	29	5	56′ 244″ N	39′ 796″ W	56′ 304″ N	40′ 045″ W
Jul. 3, 97	30	Alto Velo	29′ 115″ N	38′ 529″ W	29′ 195″ N	38′ 518″ W
Jul. 3, 97	31	Alto Velo	29′ 413″ N	38′ 638″ W	29′ 582″ N	38′ 526″ W
Jul. 4, 97	32	1	38′ 732″ N	30′ 277″ W	39′ 106″ N	30′ 789″ W
Jul. 4, 97	33	1	35′ 501″ N	28′ 847″ W	35′ 639″ N	29′ 182″ W
Jul. 4, 97	34	1	37′ 101″ N	30′ 728″ W	37′ 204″ N	30′ 728″ W

adult density, while zone 1 had the highest adult abundance. Dunn's pair-wise multiple comparisons isolated zone 1 and zone 3 as having significantly different densities of juveniles ($p < 0.05$), but no other comparisons yielded significant differences. Average juvenile density over all stations was 53.0 conchs/ha, while adult average density over all stations was 4.3 conchs/ha (both estimated from the entire data set).

Number and density estimates of dead juvenile and adult conch are presented on Table 5. Stations with the highest densities of dead juvenile and adult conch were in zone 1 and zone 5.

Mixed *Thalassia-Syringodium* was the most abundant habitat type encountered, constituting 39% of the total, followed by *Thalassia,* and algal plain. There were no significant differences in density among habitats for juveniles (Kruskal-Wallis, H = 8.44, DF 6, $p = 0.2075$) and adults (Kruskal-Wallis, H = 8.04, DF 6, $p = 0.2351$). Mixed *Thalassia-Syringodium* had the highest juvenile number and density with 476 conch and 73.9 conchs/ha, respectively. Adult conch percentage was highest in *Thalassia* (43.2%), while adult conch density was highest in *Syringodium* (8.3 conchs/ha), followed by *Thalassia* (7.6 conch/ha).

Depths sampled ranged from 1.84 to 18 meters (mean: 7 m) (Table 3). The highest juvenile number and density occurred in water shallower than 7 meters (531 conch

TABLE 3. Depth range, area covered, and number and density of individuals per transect at each of the survey stations. Juveniles (J), newly mature (NM), mature (M). Old or very old conch were not found.

Station	Depth range (m)	Transect replicate	Area (m^2)	Number of individuals				Density of individuals (conch/ha)			
				J	NM	M	Total	J	NM	M	Total
1	5.2-6.1	1	3,097.7	21	0	4	25	67.8	0.0	12.9	80.7
1	5.2-6.1	2	3,097.7	36	1	0	37	116.2	3.2	0.0	119.4
2	4.3-6.1	1	6,018.2	8	4	1	13	13.3	6.7	1.7	21.6
2	4.3-6.1	2	6,018.2	9	4	3	16	15.0	6.7	5.0	26.6
3	14.0-15.2	1	3,961.8	3	0	4	7	7.6	0.0	10.1	17.7
3	14.0-15.2	2	3,961.8	1	2	1	4	2.5	5.1	2.5	10.1
4	10.1-12.5	1	4,358.6	2	0	2	4	4.6	0.0	4.6	9.2
4	10.1-12.5	2	4,358.6	4	0	1	5	9.2	0.0	2.3	11.5
5	14.0-15.8	1	2,970.3	4	0	2	6	13.5	0.0	6.7	20.2
5	14.0-15.8	2	2,970.3	4	0	4	8	13.5	0.0	13.5	26.9
6	2.1-14.6	1	2,912.7	2	0	0	2	6.9	0.0	0.0	6.9
6	2.1-14.6	2	2,912.7	4	0	0	4	13.7	0.0	0.0	13.7
7	6.1-9.1	1	2,063.0	7	3	0	10	33.9	14.5	0.0	48.5
7	6.1-9.1	2	2,063.0	6	0	0	6	29.1	0.0	0.0	29.1
8	10.0-10.7	1	2,887.5	5	0	0	5	17.3	0.0	0.0	17.3
8	10.0-10.7	2	2,887.5	7	1	1	9	24.2	3.5	3.5	31.2
9	2.4-9.8	1	3,606.2	11	0	0	11	30.5	0.0	0.0	30.5
9	2.4-9.8	2	3,606.2	8	0	0	8	22.2	0.0	0.0	22.2
10	8.2-9.1	1	1,157.0	3	0	0	3	25.9	0.0	0.0	25.9
10	8.2-9.1	2	1,157.0	3	1	0	4	25.9	8.6	0.0	34.6
11	2.1-3.7	1	5,145.7	8	0	0	8	15.6	0.0	0.0	15.5
11	2.1-3.7	2	5,145.7	0	0	0	0	0.0	0.0	0.0	0.0
12	5.8-7.0	1	2,512.8	44	3	0	47	175.1	11.9	0.0	187.0
12	5.8-7.0	2	2,512.8	40	1	0	41	159.2	4.0	0.0	163.2
13	2.4-3.7	1	3,491.5	7	0	0	7	20.1	0.0	0.0	20.1
13	2.4-3.7	2	3,491.5	19	1	0	20	54.4	2.9	0.0	57.3
14	8.2-17.9	1	2,822.3	2	0	1	3	7.1	0.0	3.5	10.6
14	8.2-17.9	2	2,822.3	4	0	1	5	14.2	0.0	3.5	17.7
15	3.7-4.3	1	2,465.4	61	0	0	61	247.4	0.0	0.0	247.4
15	3.7-4.3	2	2,465.4	57	0	0	57	231.2	0.0	0.0	231.2
16	6.1-6.7	1	2,352.8	8	0	0	8	34.0	0.0	0.0	34.0
16	6.1-6.7	2	2,352.8	19	1	1	21	80.8	4.3	4.3	89.3
17	5.8-6.4	1	1,227.0	3	0	1	4	24.5	0.0	8.2	32.6
17	5.8-6.4	2	1,227.0	7	0	2	9	57.1	0.0	16.3	73.4
18	5.2-5.5	1	1,193.7	0	0	0	0	0.0	0.0	0.0	0.0
18	5.2-5.5	2	1,193.7	1	0	0	1	8.4	0.0	0.0	8.4
19	9.0-14.0	1	1,129.4	0	0	0	0	0.0	0.0	0.0	0.0
19	9.0-14.0	2	1,129.4	0	0	0	0	0.0	0.0	0.0	0.0
20	15.2-16.1	1	1,381.1	17	2	0	19	123.1	14.5	0.0	137.6
20	15.2-16.1	2	1,381.1	14	1	0	15	101.4	7.2	0.0	108.6
21	10.4-10.7	1	2,364.7	2	0	1	3	8.5	4.2	0.0	12.7
21	10.4-10.7	2	2,364.7	2	0	0	2	8.5	0.0	0.0	8.5
22	9.1-11.2	1	573.2	2	0	0	2	34.9	0.0	0.0	34.9
22	9.1-11.2	2	573.2	6	1	0	7	104.7	17.5	0.0	122.1
23	14.6-15.2	1	2,759.8	23	0	0	23	83.3	0.0	0.0	83.3
23	14.6-15.2	2	2,759.8	26	0	2	28	94.2	0.0	7.3	101.5
24	15.5-17.0	1	1,829.3	3	0	1	4	16.4	0.0	5.5	21.9
24	15.5-17.0	2	1,829.3	5	0	0	5	27.3	0.0	0.0	27.3
25	3.6-4.6	1	1,520.7	0	0	0	0	0.0	0.0	0.0	0.0
25	3.6-4.6	2	1,520.7	0	0	0	0	0.0	0.0	0.0	0.0
26	5.5-10.0	1	2,215.1	7	0	0	7	31.6	0.0	0.0	31.6
26	5.5-10.0	2	2,215.1	4	1	0	5	18.1	4.5	0.0	22.6

TABLE 3. (Continued) Depth range, area covered, and number and density of individuals per transect at each of the survey stations. Juveniles (J), newly mature (NM), mature (M). Old or very old conch were not found.

Station	Depth range (m)	Transect replicate	Area (m^2)	Number of individuals				Density of individuals (conch/ha)			
				J	NM	M	Total	J	NM	M	Total
27	8.2-11.6	1	1,360.1	5	0	0	5	36.8	0.0	0.0	36.8
27	8.2-11.6	2	1,360.1	5	0	1	6	36.8	0.0	7.4	44.1
28	6.4-9.1	1	689.4	0	0	0	0	0.0	0.0	0.0	0.0
28	6.4-9.1	2	689.4	0	0	0	0	0.0	0.0	0.0	0.0
29	6.4-7.3	1	1,810.4	6	0	0	6	33.1	0.0	0.0	33.1
29	6.4-7.3	2	1,810.4	5	0	0	5	27.6	0.0	0.0	27.6
30	7.62	1	597.7	0	0	0	0	0.0	0.0	0.0	0.0
30	7.62	2	597.7	0	0	0	0	0.0	0.0	0.0	0.0
31	12.8	1	1,481.1	0	0	0	0	0.0	0.0	0.0	0.0
31	12.8	2	1,481.1	0	0	0	0	0.0	0.0	0.0	0.0
32	4.3-7.6	1	4,554.1	70	1	1	81	173.5	2.0	2.0	177.9
32	4.3-7.6	2	4,554.1	110	4	0	114	242.5	9.0	0.0	250.3
33	1.8-3.4	1	2,577.1	15	0	0	15	58.2	0.0	0.0	58.2
33	1.8-3.4	2	2,577.1	17	0	1	18	66.0	0.0	4.0	69.9
34	3.7-4.0	1	1,434.2	24	0	2	26	167.3	0.0	13.9	181.3
34	3.7-4.0	2	1,434.2	70	3	0	73	488.1	21.0	0.0	509.0

and 73.7 conch/ha). The percentage of juveniles decreased with depth (Table 6). Adult density (2.9 conchs/ha) was lower within the 7 to 12 meters stratum and higher (8.4 conchs/ha) within the deeper than 12 meters stratum (Table 6).

Length of juveniles ranged from 7 to 23 cm in March (mean 14.4 cm; Fig. 3), while in July it ranged from 5 to 26 cm (mean 14.9 cm; Fig. 4). Length of adults ranged from 16 to 27 cm in March (mean: 22.4 cm; Fig. 3), while in July it ranged from 16 to 29 cm (mean: 21.4 cm; Fig. 4). The length frequency distribution of juveniles in March shows a dominant year class (1+ years) centered at 14 cm (Fig. 3), while three year classes appeared to be differentiated in July: a strong l+ year class centered at 14.6 cm, an older year class (2+ years) centered at 17.8 cm, and the remains of a third (3+ years) now maturing into adults (Fig. 4).

DISCUSSION

The surveys covered representative shallow water areas of the Jaragua National Park. As expected, most of the observed queen conch were juveniles and neither old or very old conch were observed. Similar results have been obtained 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 shallow waters (Weil and Laughlin, 1984; Appeldoorn, 1993; Stoner and Schwarte, 1994; Stoner, 1997).

In terms of fishing activities, most of the conch observed were below the minimum legal size (25 cm SL; Tejeda, in press). The lowest total density of juvenile conch was observed at zone 2. This region, also including the deeper waters, was the area reported by Colom et al. (1991) and Infante and Silva (1992) as the most important landing district in Jaragua National Park. Its nearest town, Trudille, supports an 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 shallow water stocks, especially for free divers, have been diminished.

Juveniles and adults were predominantly found in seagrasses, although there were no significant differences in mean densities among habitats. Although sand was the habitat with the second highest juvenile density, this may be an artifact influenced

TABLE 4. Estimates of density and abundance among zones.

	Conchs/ha	Abundance	95% confidence limits Lower	Upper
Zone 1				
Juveniles	114.2	658,707	383,442	933,973
Adults	6.7	385,030		
Total	120.8	697,210	419,868	974,553
Area (km²)	57.7			
Zone 2				
Juveniles	4.0	24,453	8,919	71,156
Adults	3.1	18,622	3,033	55,990
Total	7.1	43,075	17,475	124,390
Area (km²)	60.7			
Zone 3				
Juveniles	58.5	221,293	111,823	39,987
Adults	7.1	26,799	11,923	34,223
Total	65.6	248,084	131,193	68,689
Area (km²)	37.8			
Zone 4				
Juveniles	21.0	46,001	111,823	330,763
Adults	2.4	5,307	11,923	41,634
Total	23.5	51,308	131,193	364,951
Area (km²)	21.9			
Zone 5				
Juveniles	16.0	14,343	5,587	330,763
Adults	1.1	966		41,634
Total	17.1	15,309	6,553	364,951
Area (km²)	9.0			
Total density and abundance				
	Density	Abundance		
Juveniles	53.0	996,076		
Adults	4.3	80,092		
Total	57.2	1,076,169		
Area (km2)	188.0			

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 zones 1 and 3. This coincides with the preliminary observations made by Appeldoorn (1993) and indicates that there are areas at the Jaragua National Park where juvenile queen conch have a higher yearly abundance. Stoner et al. (1996) and Jones (1996) described some of the features needed for potential nursery grounds: intermediate density of seagrass, depth of 2-4m, strong tidal current, and clear oceanic water flushing. It appears that some areas of zone 1 (especially) and zone 3 combine all or some of the appropriate biotic and abiotic factors needed for a habitat to become a nursery ground.

Continued research is needed, specifically 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). Such models may aid in locating the existence of nursery grounds, determine critical habitats, and establish reserve areas. A continued effort in collecting size-frequency data could provide valuable information on recruitment variability, growth, and total mortality.

TABLE 5. Number and density of dead juvenile (J) and adult (A) conchs.

		Number of individuals			Density of individuals (conch/ha)		
Station	Zone	J	A	Total	J	A	Total
1	1	37	9	46	119.4	29.1	148.5
2	1	1	5	6	1.7	8.3	10.0
3	2	6	7	13	15.1	17.7	32.8
4	2	2	2	4	4.6	4.6	9.2
5	3	2	12	14			
6	4	15	0	15	51.5	0.0	51.5
7	4	3	0	3	14.5	0.0	14.5
8	4	5	1	6	17.3	3.5	30.8
9	4	21	3	24	58.2	8.3	66.6
10	5	12	6	18	103.7	51.9	155.6
11	5	13	0	13	25.3	0.0	25.3
12	1	26	6	32	103.5	23.9	127.4
13	1	18	5	23	51.6	14.3	65.9
14	1	8	8	16	28.4	28.4	56.7
15	1	30	12	42	121.7	48.7	170.4
16	1	14	1	15	59.5	4.3	63.8
17	1	7	1	8	57.1	8.2	65.2
20	3	2	2	0	14.5	14.5	0.0
21	3	0	4	4	0.0	16.9	16.9
23	3	2	0	2	7.3	0.0	7.3
24	4	1	2	3	5.5	10.9	16.4
26	4	2	1	3	9.0	4.5	13.5
27	4	8	0	8	58.8	0.0	58.8
28	5	4	0	4	58.0	0.0	58.0
29	5	16	0	16	88.4	0.0	88.4
32	1	6	0	6	13.2	0.0	13.2
33	1	3	0	3	11.6	0.0	11.6
34	1	17	2	19	118.5	13.9	132.5

Although juvenile conch densities are rarely reported and sampling methods vary among studies, conch juvenile density (53 conch/ha) in Jaragua National Park is higher than in areas such as Belize, Jamaica (Pedro Bank), the Florida Keys, Puerto Rico, and the US Virgin Islands (Table 7). Jaragua National Park is not environmentally threatened, although some coastal development has been proposed for Bahia de las Aguilas.

A preliminary conservation initiative is to establish an area of special protection within the National Park (e.g., establish zone 1 as a queen conch harvest refuge). In accordance with previous reports by Colom el al. (1991), Infante and Silva (1992), Appeldoorn (1993) and Tejeda (in press), juveniles and adult queen conch are very abundant in Alto Velo. If protected, this area could function as a marine sanctuary

TABLE 6. Distribution of juvenile (J) and adult (A) conchs by depth.

Depth Range (m)	Area (m^2)	% Area	Number of conch			% of conch		Density (conch/ha)		
			J	A	Total	%J	%A	J	A	Total
<7	71,903	43.6	531	33	564	94.2	5.9	73.7	4.6	78.4
7-12	65,672	39.8	241	19	260	92.7	7.3	36.7	2.9	39.6
>12	27,466	16.6	101	23	124	81.5	18.5	36.8	8.4	45.2
Total	165,042		873	75	948					

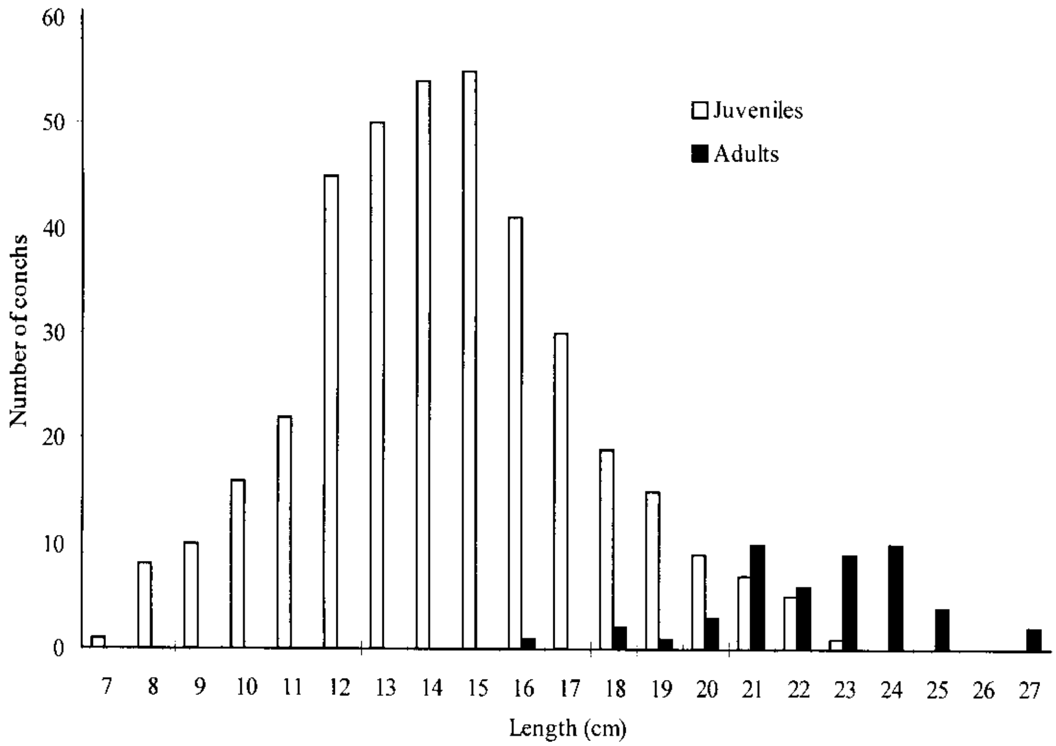

FIG. 3. Length-frequency distribution of queen conch (juveniles and adults) in March at Jaragua National Park, Dominican Republic.

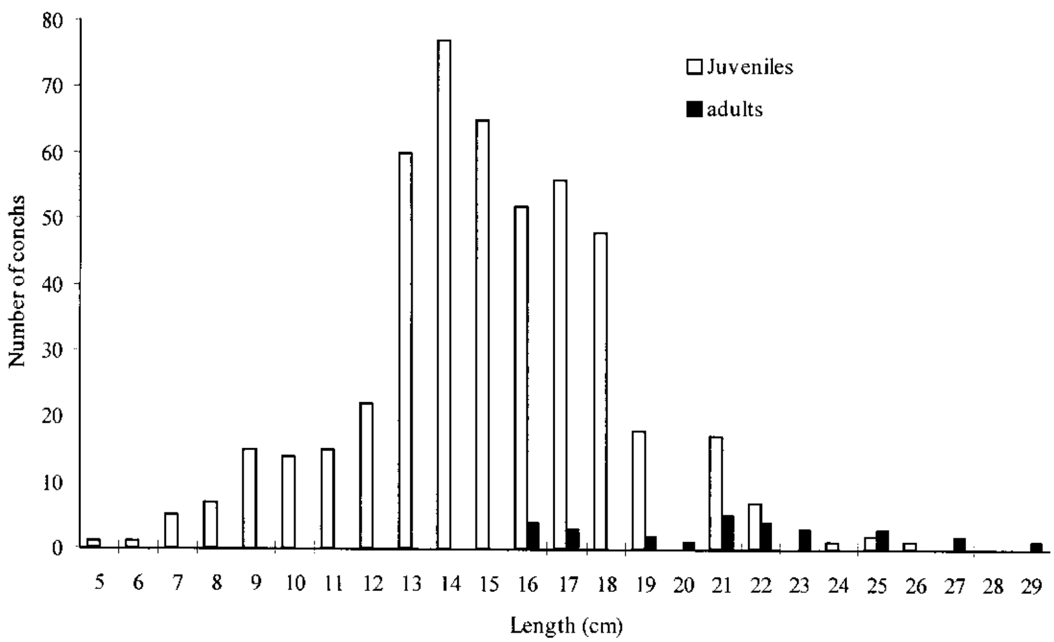

FIG. 4. Length-frequency distribution of queen conch (juveniles and adults) in July at Jaragua National Park, Dominican Republic.

TABLE 7. Average juvenile density of *Strombus gigas* determined by abundance surveys.

Location	Density (conch/ha)	Reference
Pedro Bank, Jamaica		
Artisanal Zone (0-10 m)	7.9	Appeldoorn, 1995
Industrial Zone (10-20 m)	30.3	Appeldoorn, 1995
20-30 m	57.9	Appeldoorn, 1995
U.S. Virgin Islands		
St. Thomas/St. John	16.5	Friedlander, 1996
Bahamas		
Protected Bank	<5	Stoner and Ray, 1996
Protected Shelf	<6	Stoner and Ray, 1996
Florida Keys		
1987-1988	1.9	Berg and Glazer, 1995
1990	0.7	Berg and Glazer, 1995
Belize	14.0	Appeldoorn and Rolke, 1996
Puerto Rico	5.5	Torres Rosado, 1987
Puerto Rico West coast	6.2	Mateo, 1997
Puerto Rico East coast	4.1	Mateo, 1997
Dominican Republic		
Jaragua National Park	53.0	This study

to guarantee a reserve for spawning adults, thus ensuring future potential for recruitment. The fishing community can be part of these actions if a regular exchange is established to convey conservation issues and the need for regulations.

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