Distribution, Density and Abundance of the Queen Conch, *Strombus gigas*, in the Los Roques Archipelago National Park, Venezuela

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ABSTRACT

In Venezuela, the populations of the queen conch , *Strombus gigas*, were submitted to very high levels of exploitation which resulted in the national closure of the fishery in 1991. The present study determined the distribution, density, and abundance of the queen conch in the Los Roques Archipelago. A visual assessment, conducted by SCUBA divers swimming transects, was carried out between July and September 1999. It involved a first random sampling, comprising the entire insular platform and a second stratified, random sampling, in the two blocks (northeast and south-southwest) where, according to the first field sampling, there was a greater abundance of queen conch. A total of 45.46 hectares were covered during the samplings, at a mean area per transect of 2,859 m^2. Individuals were found in 42 and 44 of the 78 and 56 localities visited in each phase of the sampling, respectively. A total of 641 conchs were observed, comprised primarily of adults (60%).

The overall density was estimated as 18.78 conch/ha (S.D.= 44.48), with an approximate abundance of 1,374,640 conchs (C.L. = 640,474 - 2,023,897) for the

205,684). On the northeast block, the overall density estimated was 34.74 conch/ha (S.D.=77.46) and on the south-southwest block 52.34 conch/ha (S.D.= 92.15), with an abundance of 428,970 conchs (C.L. = 206,706 - 795,952) and 332,097 conchs (C.L. = 138,892 - 555,314) in the northeast and south-southwest areas, respectively. The confidence limits of the abundance estimates were calculated using a Bootstrap technique. The northeast block showed the highest density of young conchs, 7.54 conchs/ha (S.D.= 12.88), representing a zone with potential breeding areas. The highest densities of juvenile (18.31 conchs/ha) were found on seagrass beds, at no more than 10 m depth. Significant populations of adults and older individuals, actively mating, were found on sand plains at depths greater than 16 m.

KEY WORDS: Population density, *Strombus gigas*, Los Roques, Venezuela

INTRODUCTION

The queen conch, *Strombus gigas* Linnaeus, 1758, is a large marine gastropod mollusk in the family Strombidae, which is broadly distributed in the

Caribbean Sea (Randall 1964). In its entire distribution range, this specie has been highly valued as a fishing resource, especially due to the delicious taste and nutritional value of its meat, which has acquired very high prices on the market. Due to exploitation of queen conch populations throughout its range, the Convention on the International Trade of Endangered Species (CITES) decided to include it in the appendix II of its protocol as a strategy to manage the fishery.

In Venezuela, the commercial fishery of the queen conch has been carried out almost exclusively in the insular region, constituting the archipelagos of Las Aves, Los Roques and Los Testigos, the areas accounting for the most important populations of this gastropod. The increasing demand for this resource resulted in intense fishing activity and the consequent decrease of its population (Posada y Alvarez 1988, Rodríguez y Posada 1994).

Evidence of overexploitation, detected in the Los Roques Archipelago, by Weil and Laughlin (1984), Rodríguez and Posada (1994) and Bastidas and Rada (1998), resulted in a national closure of the queen conch fishery. This regulation began in 1991 and has been extended until the present year 2000, when the Fishing and Aquaculture Resources Autonomous Service published the regulations for the reopening of the queen conch fishery, although lacking current scientific evidence on the population levels of the resource.

Therefore, the aim of the present study was to provide actualized information on the distribution, density and abundance of the queen conch in the Los Roques Archipelago National Park, which can be used to evaluate the effectiveness of the closure imposed. Also, the study includes areas of the archipelago that had not been previously sampled and the use of a practical methodology specifically designed for the assessment of gregarious populations.

MATERIALS AND METHODS

Study Area

The Los Roques Archipelago National Park is an insular reef platform located 160 km North off the central coast of Venezuela (11° 48 - 11° 58′ N and 66° 32′ - 66° 57′ W) (Figure 1), comprising an area of 1250 Km^2 and a maximum depth of 50 meters. It is conformed by 42 islands and 200 sand banks, distributed in an irregular oval, surrounding an inner lagoon with an average depth of 5 m (Amend 1992).

Field Work

Two field surveys were conducted between July and August, 1999. During the first survey (general sampling), a random stratified sampling was carried out, comprising the platform, over 40 meters depth, of the archipelago. In the second field survey, a random stratified sampling was done according to the areas where a higher density of individuals was found in the first survey. The sampling areas were located inside two blocks designated as northeast block and south-southwest block (Figure 1). At each station two SCUBA divers carried out the visual censuses, swimming over a transect of fixed width. The transects were of variable length, but a fixed time of 20 minutes.

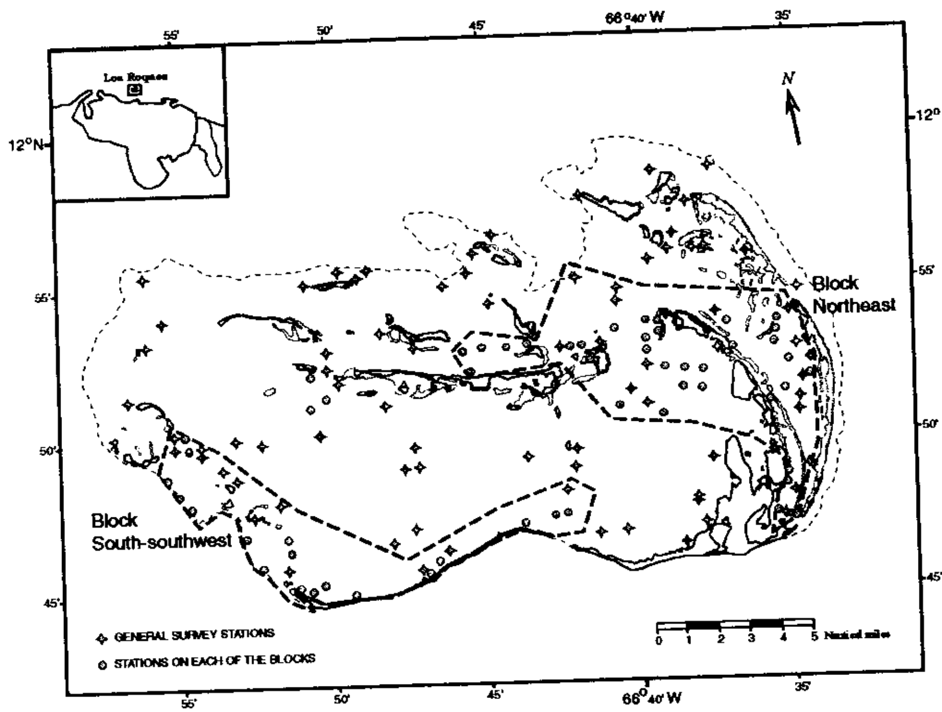

Figure 1. Location of different sampling stations visited on each of the surveys conducted in the Los Roques Archipelago National Park

During the transect swims, data on the total length and the lip width of all conch encountered was registered. They were classified into one of the following size/age categories: juvenile, subadults, adults and old, according to descriptions made by Appeldoorn (1995). At the same time, information including bottom type, depth and time at which an individual was found, was collected. The bottom types were classified in one of the following categories: fine mud, sand, algae plain, soft corals, hard bottom and seagrass (*Thalassia testudinum* and *Syringodium filiforme*) meadows. Combinations of the previous categories were used to define mixed habitats (e.g. mixed sand, mixed meadows). The depths were registered into the intervals: 0 - 5 m, 6 - 10 m, 11 - 15 m, 16 - 25 m, over 26 m.

Two estimates of abundance were carried out. First, the overall density obtained in the general sampling and the total area occupied by the archipelago platform (over 40 m depth) were used. The second estimate was made for the area occupied by the blocks (northeast and south-southwest); this was made in order to reduce the confidence limits in the estimates due to the aggregated distribution of the queen conch. Because the density estimates were not normally distributed, the confidence limits of trust were determined using a Bootstrap method (Sokal and Rohlf, 1995). The density obtained for each size/age category was compared, through the analysis of contingency tables and preference indexes (applied by Appeldoorn and Rolke 1996), between bottom types and depth ranges. In the preference index a positive result indicates preference. On the opposite, if the result is negative it indicates that there is rejection.

RESULTS

During the general sampling, a total of 78 stations were completed, covering an area of 22.2 hectares. A total of 250 conchs were counted within 42 of the transects. The population was composed mainly of adults (55.6%), followed by the old class (22.9%) (Figure 2).

In the northeast block, a total of 52 transects were carried out, comprising an area of 15.7 hectares. While in the south-southwest block., 29 transects were completed over an area of 7.6 hectares. Individuals were found in 40 and 23 of the localities visited on the northeast and south-southwest blocks, respectively. A total of 287 conchs and 222 conchs were counted in each block, most of them belonging to the adult age class (Figure 2). The mean area of a transect was 2859 m^2.

The correlation between the observations carried out by each pair of divers was high $r = 0.89$), indicating that they lacked independence. Therefore, the data collected by each diver were analyzed together to estimate the values of density and abundance.

From the overall density for the general sampling of 18.78 conch/ha (S.D.= 44.48) total abundance of 1,374,640 conch over the 73,197 ha of the insular platform was estimated (Table 1). The density estimated for each size/age category showed that the adult and old classes present the highest densities with 17.02 conchs/ha (S.D.= 44.05). On the other hand, the densities of the juvenile and subadults categories were significantly lower with 1.76 conchs/ha (S.D. = 4.85) ($p < 0.0001$) (Table 1).

In the blocks, which correspond to the areas where more conch aggregations were found, the overall queen conch densities and abundance were 34.74 conchs/ha (S.D. = 77.46) and 428,970 individuals in the northeast, and 52.34 conchs/ha (S.D. = 92.15) and 332,097 individuals in the south-southwest. As showed in table 1, in both blocks the adult and old categories presented the highest density and abundance. Nevertheless, in the northeast block the densities for the juvenile and subadults were significantly higher than in the south-southwest block, with 7.54 conchs/ha (S.D.= 12.88) and an abundance of 93,104 individuals versus 3.73 conchs/ha (S.D.= 7.60) and 23,667 individuals ($p < 0.05$) (Table 1). The confident limits in the blocks decreased by 63% compared with that in the general survey.

Most of the localities visited in both the general sampling area and in the blocks, were located at depths greater than 16 meters, as these depth strata contained the highest densities of individuals observed (Table 2). The individuals belonging to the adult and old categories showed a significant preference for the deep strata ($p < 0.005$) (Table 3). In almost all the deep stations it was usual to find solitary eggs masses, or individuals copulating or laying eggs.

A significant preference of the individuals belonging to the juvenile and subadult size/age categories for shallow depth ranges (between 0 and 10 m) was found in all surveys (Table 3). The presence of these size/age categories diminishes rapidly as depth increases.

At the general sampling site and on the blocks, a significant relationship between the densities of conchs of each size/age category and the bottom type ($p < 0.005$) (Table 4). The juvenile class showed a strong preference for the areas partially or completely covered by seagrass meadows. On the other hand, the adult and old size/age categories preferred the deep, sandy substrate (Table 5).

Table 1. Abundance of queen conch, grouped by size/age category, estimated on each of the surveys conducted in the Los Roques Archipelago National Park. The confidence limits (CL) came from a bootstrap analysis (J = Juvenile, SA = Subadult, A = Adult and O = Old).

	Age class	Density Range	Density (conch / ha)	Area (m^2)	Abundance (No. Ind)	CL (95%) Lower	CL (95%) Higher
General	J+SA	0-23.74	1.76 (±4.85)		128827	49042	205684
	A+O	0-	17.02 (±44.05)	7319	1245813	639742	2143208
	Total	0-	18.78 (±44.48)		1374640	640474	2023897
Northeast	J+S	0-65.99	7.54 (±12.88)	1234	93104	50874	147806
	A+O	0-	27.20 (±76.98)		335866	148176	652221
	Total	0-	34.74 (±77.46)		428970	206706	795952
South - southwest	J+S	0-32.78	3.73 (±7.60)		23667	6218	43527
	A+O	0-	48.60 (±90.15)	6345	308367	119350	547954
	Total	0-	52.34 (±92.15)		332097	138892	555314

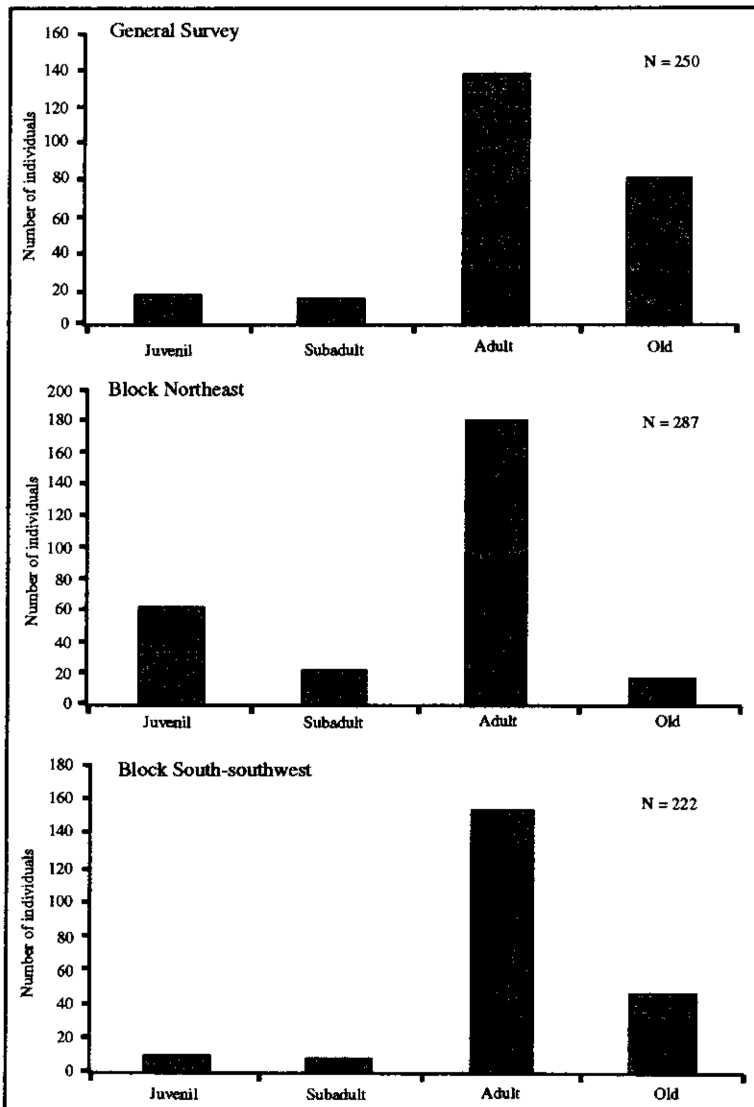

Figure 2. Age class distribution of the queen conch population on each of the surveys conducted in the Los Roques Archipelago National Park.

Table 2. Distribution and density of queen conch by depth strata and size/age classes, observed on each of the surveys conducted in the Los Roques Archipelago National Park (J = Juvenile, SA = Subadult, A = Adult, O = Old).

Depth (m)	Area (ha)	Percentage area	Number of conch J	SA	A	O	Density (conch/ha) J	SA	A	O
General Survey										
0-5	8.50	38.28	10	8	16	1	1.18	0.94	1.90	0.12
6-10	4.02	18.10	4	5	22	2	1.00	1.24	5.47	0.50
11-15	3.24	14.58	2	2	25	4	0.62	0.62	7.72	1.24
16-25	5.34	24.06	0	0	61	66	0	0	11.42	12.35
> 26	1.11	5.00	0	0	15	7	0	0	13.54	6.32
Total	22.2	100	16	15	139	80	0.72	0.68	5.59	3.28
Northeast										
0-5	8.21	52.31	52	14	40	2	6.33	1.71	4.87	0.24
6-10	1.73	11.01	5	9	28	0	2.89	5.21	16.20	0.00
11-15	2.62	16.69	6	1	30	3	2.29	0.38	11.45	1.15
16-25	2.77	17.63	1	0	69	13	0.36	0.00	24.93	4.70
> 26	0.37	2.36	0	0	14	0	0.00	0.00	37.80	0.00
Total	15.7	100.00	64	24	181	18	4.08	1.53	11.53	1.15
South-southwest										
0-5	4.25	56.17	7	3	47	3	1.65	0.71	11.07	0.71
6-10	1.59	21.05	4	4	4	16	2.51	2.51	25.77	10.06
11-15	0.78	10.37	0	2	39	7	0.00	2.55	49.72	8.92
16-25	0.93	12.28	0	0	27	22	0.00	0.00	29.08	23.69
> 26	0.01	0.04	0	0	0	0	0.00	0.00	0.00	0.00
Total	7.56	99.91	11	9	154	48	1.45	1.19	20.37	6.35

DISCUSSION

The methodology of visual data collection by SCUBA divers over transects of variable length applied in the present study was a very practical tool to assess heterogeneously distributed benthic organisms, such as the queen conch, *Strombus gigas*. The use of GPS to estimate the length of the transect, despite the small error in the calculation of positions, eliminates the complications and time consuming measurements involved using metric tapes (Tewfik et al. 1998). GPS also allows to make longer transects in less time, thus covering greater areas over a diversity of bottom types and depths.

Nevertheless, the gregarious behavior of the queen conch, together with the proximity of the divers during the visual censuses, created high correlations among their observations (no independent data), reducing the effectiveness of the method by not being able to duplicate the samples (Mateo 1997).

Table 3. Preference Index, by depth strata and queen conch size/age classes, observed on each of the surveys conducted in the Los Roques Archipelago National Park. The Preference Index is calculated as: % area - % of individuals (J = Juvenile, SA = Subadult, A = Adult and O = Old).

Depth (meters)	Area (ha)	Number of conch J	SA	A	O	Total	Area (ha)	Percentage J	SA	A	S	Total	Preference Index J	SA	A	S
General Survey																
0-5	8.50	10	8	16	1	35	38.28	62.50	53.33	11.51	1.25	14	24.22	15.06	-26.77	-37.03
6-10	4.02	4	5	22	2	33	18.10	25.00	33.33	15.83	2.50	13.2	6.90	15.24	-2.27	-15.60
11-15	3.24	2	2	25	4	33	14.58	12.50	13.33	17.99	5.00	13.2	-2.08	-1.24	3.41	-9.58
16-25	5.34	0	0	61	66	127	24.06	0	0	43.88	82.50	50.8	-24.06	-24.06	19.83	58.44
> 26	1.11	0	0	15	7	22	4.99	0	0	10.79	8.75	8.80	-4.99	-4.99	5.80	3.76
Total	22.21	16	15	139	80	250	100	100	100	100	100	100				
Northeast																
0-5	8.21	52	14	40	2	108	52.31	81.25	58.33	22.10	11.11	37.63	28.94	6.03	-30.21	-41.19
6-10	1.73	5	9	28	0	42	11.01	7.81	37.50	15.47	0	14.63	-3.20	26.49	4.46	-11.01
11-15	2.62	6	1	30	3	40	16.69	9.38	4.17	16.57	16.67	13.94	-7.31	-12.52	-0.11	-0.02
16-25	2.77	1	0	69	13	83	17.63	1.56	0	38.12	72.22	28.92	-16.07	-17.63	20.49	54.59
> 26	0.37	0	0	14	0	14	2.36	0	0	7.73	0	4.88	-2.36	-2.36	5.37	-2.36
Total	15.70	64	24	181	18	287	100	100	100	100	100	100				
South-southwest																
0-5	4.25	7	3	47	3	60	56.17	63.64	33.33	30.52	6.25	27.03	7.47	-22.83	-25.65	-49.92
6-10	1.59	4	4	41	16	65	21.05	36.36	44.44	26.62	33.33	29.28	15.32	23.40	5.58	12.29
11-15	0.78	0	2	39	7	48	10.37	0	22.22	25.32	14.58	21.62	-10.37	11.85	14.95	4.21
16-25	0.93	0	0	27	22	49	12.28	0	0	17.53	45.83	22.07	-12.28	-12.28	5.25	33.55
> 26	0.01	0	0	0	0	0	0.13	0	0	0	0	0	-0.13	-0.13	-0.13	-0.13
Total	7.56	11	9	154	48	222	100	100	100	100	100	100				

Table 4. Distribution and density of queen conch by bottom type and size/age category, observed on each of the surveys conducted in the Los Roques Archipelago National Park.

Location/		Area	Juveniles		Subadults		Adults		Olds	
Depth	Habitat	(ha)	No	Ind/ha	No.	Ind/ha	No.	Ind/ha	No.	Ind/ha
General	Fine Mud	0.06	0	0	0	0	0	0	0	0
Shallow	Sand	4.14	7	1.69	8	1.93	28	6.76	2	0.48
	Algae	2.98	0	0	1	0.34	6	2.01	1	0.34
	Soft corals	0.67	0	0	0	0	0	0	0	0
	Hard	0.13	0	0	0	0	1	7.55	0	0
	Thalassia	2.61	4	1.53	2	0.77	1	0.38	0	0
	Mixed sand	1.19	4	3.37	2	1.68	3	2.53	0	0
	Mixed	0.78	0	0	0	0	0	0	0	0
Deep	Fine mud	1.10	0	0	0	0	2	1.82	0	0
	Sand	2.97	1	0.34	1	0.34	63	21.23	47	15.84
	Algae	2.09	0	0	1	0.48	13	6.23	12	5.75
	Soft corals	1.60	0	0	0	0	4	2.50	10	6.25
	Hard	0.94	0	0	0	0	9	9.62	7	7.48
	Mixed sand	0.96	0	0	0	0	9	9.36	1	1.04
Totals		22.2	16	0.72	15	0.68	139	6.26	80	3.60N
North	Fine Mud	0.03	0	0	0	0	0	0	0	0
East	Sand	5.36	19	19	8	1.49	36	6.72	1	0.19
Shallow	Algae	0.87	2	2	4	4.61	11	12.68	0	0
	Soft corals	0.12	0	0	0	0	0	0	0	0
	Hard	0.60	0	0	2	3.35	5	8.37	1	1.67
	Thalassia	1.04	19	19	4	3.86	4	3.86	0	0
	Mixed sand	1.59	15	15	4	2.52	11	6.93	0	0
	Mixed	0.33	2	2	1	3.03	1	3.03	0	0
Deep	Fine mud	0.66	0	0	0	0	13	19.68	1	1.51
	Sand	3.19	5	5	0	0	85	26.64	13	4.08
	Algae	0.48	1	1	1	2.09	9	18.80	2	4.18
	Soft corals	0.80	1	1	0	0	3	3.75	0	0
	Hard	0.09	0	0	0	0	1	11.03	0	0
	Mixed sand	0.55	0	0	0	0	2	3.65	0	0
Totals		15.7	64	64	24	1.53	181	11.53	18	1.15
South	Fine Mud	0.02	0	0	1	59.64	0	0	2	119.29
S E	Sand	1.83	1	0.55	1	0.55	25	13.69	1	0.55
Shallow	Algae	1.54	0	0	2	1.30	18	11.72	5	3.26
	Soft corals	0.21	0	0	0	0	0	0	0	0
	Hard	0.01	0	0	0	0	0	0	0	0
	Thalassia	0.65	1	1.55	2	3.09	6	9.28	0	0
	Mixed sand	0.63	4	6.32	0	0	24	37.89	10	15.79
	Mixed	0.95	5	5.26	1	1.05	15	15.79	1	1.05
Deep	Fine mud	0.30	0	0	0	0	0	0	0	0
	Sand	0.76	0	0	1	1.32	63	83.31	29	38.35
	Algae	0.50	0	0	1	2.02	2	4.04	0	0
	Soft corals	0.10	0	0	0	0	0	0	0	0
	Hard	0.07	0	0	0	0	1	14.82	0	0
	Mixed sand	0.07	0	0	0	0	1	14.82	0	0
Totals		7.63	11	1.44	9	1.18	155	20.32	48	6.29

Table 5. Preference Index, by bottom type and queen conch size/age classes, observed on each of the surveys conducted in the Los Roques Archipelago National Park. The Preference Index is calculated as: % area - % of individuals (J = Juvenile, SA = Subadult, A = Adult, O = Old).

HABITAT	Area	Number of conchs					Area	Percentage					Preference Index			
	(ha)	J	SA	A	O	Total	(ha)	J	SA	A	O	Total	J	SA	A	O
General Survey																
Fine mud	1.16	0	0	2	0	2	5.22	0.00	0.00	1.44	0.00	0.80	-5.22	-5.22	-3.78	-5.22
Sand	7.11	8	9	92	49	158	32.00	50.00	60.00	66.19	61.25	63.20	18.00	28.00	34.19	29.25
Algae	5.07	0	2	19	13	34	22.82	0.00	13.33	13.67	16.25	13.60	-22.82	-9.48	-9.15	-6.57
Soft corals	2.27	0	0	3	10	13	10.22	0.00	0.00	2.16	12.50	5.20	-10.22	-10.22	-8.06	2.28
Hard bottom	1.07	0	0	10	7	17	4.82	0.00	0.00	7.19	8.75	6.80	-4.82	-4.82	2.38	3.93
Thalassia	2.61	4	2	1	0	7	11.75	25.00	13.33	0.72	0.00	2.80	13.25	1.59	-11.03	-11.75
Mixed sand	2.15	4	2	12	1	19	9.68	25.00	13.33	8.63	1.25	7.60	15.32	3.66	-1.04	-8.43
Mixed seagrass	0.78	0	0	0	0	0	3.51	0.00	0.00	0.00	0.00	0.00	-3.51	-3.51	-3.51	-3.51
Totals	22.22	16	15	139	80	250	100	100	100	100	100	100				
Northeast																
Fine mud	0.69	0	0	13	1	14	4.39	0.00	0.00	7.18	5.56	4.88	-4.39	-4.39	2.79	1.16
Sand	8.55	23	8	121	14	166	54.46	35.94	33.33	66.85	77.78	57.84	-18.52	-21.13	12.39	23.32
Algae	1.35	3	5	20	2	30	8.60	4.69	20.83	11.05	11.11	10.45	-3.91	12.23	2.45	2.51
Soft corals	0.92	2	0	2	0	4	5.86	3.13	0.00	1.10	0.00	1.39	-2.73	-5.86	-4.75	-5.86
Hard bottom	0.69	0	2	6	1	9	4.39	0.00	8.33	3.31	5.56	3.14	-4.39	3.94	-1.08	1.16
Thalassia	1.04	19	4	4	0	27	6.62	29.69	16.67	2.21	0.00	9.41	23.06	10.04	-4.41	-6.62
Mixed sand	2.14	15	4	14	0	33	13.63	23.44	16.67	7.73	0.00	11.50	9.81	3.04	-5.90	-13.63
Mixed seagrass	0.33	2	1	1	0	4	2.10	3.13	4.17	0.55	0.00	1.39	1.02	2.07	-1.55	-2.10
Totals	15.70	64	24	181	18	287	100	100	100	100	100	100				
South-southwest																
Fine mud	0.32	0	1	0	2	3	4.23	0.00	11.11	0.00	4.17	1.35	-4.23	6.88	-4.23	-0.07
Sand	2.59	1	2	88	30	121	34.26	9.09	22.22	57.14	62.50	54.50	-25.17	-12.04	22.89	28.24
Algae	2.04	0	3	20	5	28	26.98	0.00	33.33	12.99	10.42	12.61	-26.98	6.35	-14.00	-16.57
Soft corals	0.31	0	0	0	0	0	4.10	0.00	0.00	0.00	0.00	0.00	-4.10	-4.10	-4.10	-4.10
Hard bottom	0.01	0	0	0	0	0	0.19	0.00	0.00	0.00	0.00	0.00	-0.19	-0.19	-0.19	-0.19
Thalassia	0.65	1	2	6	0	9	8.60	9.09	22.22	3.90	0.00	4.05	0.49	13.62	-4.70	-8.60
Mixed sand	0.70	4	0	25	10	39	9.26	36.36	0.00	16.23	20.83	17.57	27.10	-9.26	6.97	11.57
Mixed seagrass	0.95	5	1	15	1	22	12.56	45.45	11.11	9.74	2.08	9.91	32.89	-1.45	-2.82	-10.48
Totals	7.56	11	9	154	48	222	100	100	100	100	100	100				

A revision of the average queen conch densities obtained in previous studies made in the archipelago and in other Caribbean regions suggests that the use of different methodologies in population assessments hinders comparative analysis (Table 6). However, when comparing those studies in which a data collection method over transects of variable length has been applied, it can be observed that the average density found in the Los Roques Archipelago (18.78 conch/ha) is closer to the values registered in overfished areas of Belize (14.6 conch/ha) and St. Thomas/St John (12.25 conch/ha), but below the density estimates of protected areas of Bahamas (53.60 and 96.00 conch/ha) (Table 6).

The presence in the general sampling of numerous localities (36 stations of 78) with zero individuals and some where the densities were very high (up to 247.01 conch/ha), is a consequence of the clumped behavior of queen conch populations. This behavior generates high variances in the density estimates and thus, wide confidence limits associated with the calculation of population abundance (Stoner and Ray 1996, Friedlander et al. 1994, Mateo 1997). For this reason, the current total abundance of 1,374,640 conch (C.L.= 640,474 – 2,023,897) found for the archipelago, should be taken with caution, since it assumes that the queen conch is distributed homogeneously in the 73,197 hectares of its platform.

Nevertheless, the general sampling allowed us to stratify the area appropriately to carry out a second field sampling in those areas where greater aggregations were found. This resulted in higher density values, even when the estimates of abundance were lower, since a smaller area was considered. The stratification in blocks reduced by 63% the confidence limits in the estimation of abundance.

According to the density estimates obtained in the blocks, it seemed that there is a recovery of queen conch populations in certain areas of the park. The presence of important populations of adults and older individuals in deep waters (> 16m) suggests that the protection strategy has allowed the migration of individuals from shallow waters toward deep waters, a natural process in the life cycle of this specie (Stoner and Sandt 1992). These aggregations represent an important larvae source for the archipelago, since reproductive activity was common between them. Similar observations have been documented in other areas of the Caribbean (Stoner et al. 1996, Stoner and Ray 1996, Stoner and Schwarte 1994, Stoner and Sandt 1992).

However, the low overall density of juvenile and sub-adults found in the present study is worrying. The same observation found in previous evaluations, made in the Los Roques Archipelago (Weil and Laughlin, 1984) and in other regions of the Caribbean (Stoner and Schwarte 1994, Stoner and Ray 1996, Mateo 1997) has been associated with a diverse of factors, among this the juveniles burring behavior, the lack of significant recruitment events (Tewfik et al. 1998) and the high mortality rate among the individuals of the juvenile age class (Appeldoorn 1988).

Table 6. Average densities of queen conch estimated in various locations in the Caribbean region.

Locality	Density (conch/ha)	Methodology	Status of the Fishery	Reference
Puerto Rico			Overfished	
West coast	8.49	Variable length transects	Recruitment of	Mateo, 1997
East coast	7.49	Variable length transects	juveniles observed	Mateo, 1997
Jamaica (Pedro's Bank)				
Artisanal zone (0-10m)	89.09	Quadrates over transects	Not sustainable	Appeldoorn, 1995
Commercial zonel (10-20)	144.46	Quadrates over transects	fishing levels	Appeldoorn, 1995
External zone (20-30m)	276.97	Quadrates over transects		Appeldoorn, 1995
Belize	14.6	Variable length transects	Overfished	Appeldoorn and Rolke,
Honduras (Cayos Cochinos)	14.6	Variable length transects	Overfished	Tewfik et al., 1998
Florida			Overfished	
High density period	4.08	Towed diver	Fishery closed	Glazer and Berg, 1994
Low density period	0.44	Towed diver	in 1985	Glazer and Berg, 1994
US Virgin Islands				
St. Thomas/St. John	9.7	Towedd diver	Overfished	Wood y Olsen, 1983
St. Thomas/St. John	12.25	Scooter diver		Friedlander et al., 1994
Venezuela (Los Roques)				
Protected zone	2130	Quadrates		Weil and Laughlin, 1984
Fished zone	900	Quadrates	Overfished	Weil and Laughlin, 1984
General	1210	Fixed length transects (3x60m)	Total closure	Bastidas and Rada, 1998
General	18.78	Variable length transects		Present study
Northeast block	34.74	Variable length transects		Present study
South-southwest block	52.34	Variable length transects		Present study
Bahamas (Exuma Cays)			Overfished	
Protected bank	53.6	Variable length transects	in specific areas	Stoner and Ray, 1996
Protected shelf	96	Towed diver		Stoner and Ray, 1996

The limited distribution of juvenile individuals in depths beyond 10 meters can be explained by the limited distribution of seagrass meadows in these depth strata. According to studies carried out by Stoner et al. (1994), the juvenile aggregations are closely related to seagrass communities with a high biomass of macroalgae, which constitutes the main source of carbon for this age class (Stoner et al. 1994).

The clear preference of adult and old individuals for sand plains observed during the present evaluation, is similar to that found by Stoner and Sandt (1992), coinciding both studies with the peaks of reproductive activity. Those authors point out that, during the reproductive season spawning individuals migrate from the feeding areas over seagrass and algae meadows to sand beds, which provides a favorable substrate for producing egg masses

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