Histories of Success for the Conservation of Populations of Queen Conch *(Strombus gigas)*

ERICK BAQUEIRO CÁRDENAS and DALILA ALDANA ARANDA*
*CINVESTAV, IPN, Unidad Merida, antigua caretera a Progreso, Merida, Yucatán ,Mexico. * Corresponding author*

ABSTRACT

The Queen conch, *Strombus gigas,* from Xel-Há Park was studied to determine the role of the natural protected area on the species' structure and basic population parameters, estimated from catch recapture data. Conchs were sampled from November 2001 to August 2005 to evaluate the Von Bertalanffy equation parameters for total shell length and weight, with and without flared lip. Lip thickness was used only for conchs with flared lips. The population number varies through the year, with a minimum of 49 in April, 2003 and maximum of 9 800 during June, 2005. Growth parameters estimated from weight gave a good adjustment for both segments of the population. A maximum age of 19 years was estimated for the population. Mortality estimates was 0.55 a year for conchs without flared lip and 0.72 a year for those with a flared lip. The presence of older and larger individuals (19 years age), as well as the presence of larger number of juveniles, is an indication of the effectiveness of the Xel-Há Park as a marine protected area (MPA) and supports the thesis that MPA's are an effective safe ground for juveniles and reproductive stocks of *S. gigas.*

KEY WORDS: Queen conch, *Strombus gigas*, population, Caribbean

Historia de Éxito para la Conservación de Poblaciones del Caracol Rosa (*Strombus gigas*) en el Caribe de México

El caracol rosa, *Strombus gigas*, del parquet de Xel-Há park se estudio para determiner el papel que juega esta area natural protegida tomando como referencia la estructura y parametros poblacionales, estimados por métodos de captura-recaptura. Los caracoles fueron muestreados de 2001 a 2009 para evaluar los parámetros de la ecuación de von bertalanffy para la longitud de la concha y el peso. El numero de la población varia a través del año, con un máximo de 9 800 caracoles. Los parámetros de crecimiento estimados tuvieron un buen ajuste para el peso. La edad maxima estimada fue de 19 años. La mortalidad fue estimada en 0.55 al año para caracoles sin labio y de 0.72 al año para caracoles con labio. El reclutamiento mostró dos pulsos máximos durante primavera–verano y un segundo durante el otoño. tanto la presencia de caracoles viejos (19 años) como la de un gran numero de caracoles juveniles durante estos casi 10 años de muestreo muestran la efectividad del parque de xel-há para la protección de esta especie amenazada, cuando no hay extracción ilegal, demostrando que al menos para los requerimientos de *S. gigas* que ecoturismo y conservación son factibles.

PALABRAS CLAVES: Caracol rosa, *Strombus gigas*, conservación, caribe, parque Xel Há

Cas de Reussite pour la Conservation des Populations de Lambis (*Strombus gigas*) de la Zone Caraïbe du Mexique

Les lambis (*Strombus gigas*), du parc Xel-Há ont été étudiés pour déterminer le rôle de la protection normale sur la structure des espèces et les paramètres de base des populations, sur la base de données de prises et recaptures. Les lambis ont été prélevés de 2001 à 2009 pour évaluer les paramètres d'équation de Von Bertalanffy pour la longueur totale de coquille, et le poids avec et sans la lèvre évasée. Le nombre d'individus dans une population change au cours de l'année, avec un maximum de 9 800 lambis. Les paramètres de croissance estimés à partir du poids ont donné un bon ajustement pour les deux segments de la population. Un âge maximum de 19 ans a été estimé pour la population. Les évaluations de mortalité étaient de 0,55 par année pour des lambis sans lèvre évasée et 0,72 par an pour ceux avec une lèvre évasée. Les modèles de recrutement ont montré deux impulsions, maximum pendant l'été et secondaire pendant en automne. La présence des individus plus anciens et plus grands (19 ans d'âge) comme la présence d'un plus grand nombre de juvéniles pendant dix ans est une indication de l'efficacité du parc de Xel-Há comme secteur marin protégé (MPA) et soutient la thèse que les réserves sont une protection efficace pour des juvéniles et les stocks de reproducteurs. La surveillance sur presque 10 ans a permis d'observer qu'on pouvait allier écotourisme et conservation d'une espèce menacée comme le *S. gigas*.

MOTS CLÉS: Lambi, *Strombus gigas*, protection, Caraïbe, parc de Xel Ha

INTRODUCTION

The queen conch *Strombus gigas* Linné, 1758 is a gastropod of commercial importance in the Caribbean. With a distribution ranging from Venezuela to Florida and the Bahamas, including the Lesser and Greater Antilles, it is known with several common names of local usage. Due to the high fishing pressure that is exerted upon most of its populations, several stocks have been reduced to levels where the population can no longer recover and commercial fishing is no longer feasible (Appeldoorn 1994a). As a result of the high demand, vulnerability, and the overexploitation of local stocks, since 1992 the species has been included in the Convention on International Trade in Endangered Species of Wild Fauna and Flora, and in 1994 it was added to the International Union for the Conservation of Nature's Red List. Along the Caribbean region, different management strategies are being applied to limit exploitation. The strategies that focus on the resource, to limit fishing effort and to protect the population in the marine protected areas.

Growth parameters are routinely assessed from length frequency analysis, which is acceptable for the queen conch only for the first four years of life, or until animals reach sexual maturity when length growth ceases and the characteristic flared lip of the species is formed. Once sexual maturity is reached, growth in length stops and growth can only be checked from lip thickness and weight (Alcolado 1976, Appeldoorn 1994b). This paper presents the analysis of growth parameters from shell length and lip thickness frequency analysis, for organisms sampled in a multiple catch recapture study, in an attempt to estimate the population structure of animals once they have attained sexual maturity, and the effect on the population structure of enforcement to prevent pouching in a natural protected area.

MATERIAL AND METHODS

Sampling Area

Xel-Há is a coastal lagoon located on the east coast of the Yucatan Peninsula located 20° 15' 54" N and 87° 24' 08" W. Communication to the Caribbean Sea is through a 90 meters wide mouth, extending 0.7 km inland with a total area of 0.3 km^2. The weather in the region is classified as hot, sub-humid, with dominant rains during summer and only 5% of annual rainfall during winter. Average rain fall is of 2,500 mm a year with a total evaporation of 2,300 mm. Mean annual temperature is 24.9ºC, with the coldest month in December, average 23.1ºC, and the hottest in June with 26.2ºC as an average.

A massive catch, mark, and release program for queen conch was started on November 2001 at Xel-Há lagoon natural marine reserve, and continued monthly until August 2005. A total of 2,590 conchs were marked during the four years of study. Measurements of shell length and lip thickness for every animal were taken, and they were tagged with a piece of nylon ribbon on the spire to which a plastic identification tag was affixed. The number of organisms within the lagoon was estimated by the Jolly's method for multiple recapture (Poole 1974). The von Bertalanffy growth equation parameters were estimated from length frequency analysis for shell length, weight, and lip thickness using Appeldoorn's method of the FISAT II (Gayalino and Pauly 1997). With seasonality introduced to evaluate the effect of environment on growth through the year. Recruitment and mortality were calculated for the estimated parameter with the FISAT II subroutines, using the length converted catch curve subroutine for mortality. The number of organisms used for the analysis of length frequency varied monthly (Table 1).

Table 1. Number of organisms (Initial number) used for the estimation of population parameters by length frequency analysis and abundances from catch - recapture data using Joly's method (Estimated number) at Xel-Há Park (Pool1974). Ns, no sample.

		Initial number	Estimated number
2002	FEB	91	157
	MAR	35	1741
	APR	362	667
	MAY	211	919
	JUN	248	1122
	JUL	146	4652
	AUG	Ns	Ns
	SEP	212	384
	OCT	291	873
	NOV	187	67
	DEC	180	49
2003	JAN	305	558
	FEB	Ns	Ns
	MAR	94	83
	APR	Ns	Ns
	MAY	373	80
	JUN	149	70
	JUL	9	50
	AUG	11	85
	SEP	18	98
	OCT	2	105
	NOV	14	130
	DEC	72	433
2004	JAN	90	1167
	FEB	58	641
	MAR	27	1143
	APR	30	597
	MAY	27	202
	JUN	63	1880
	JUL	19	109
	AUG	45	364
	SEP	57	403
	OCT	76	599
	NOV	108	767
2005	DEC	88	738
	JAN	69	252
	FEB	151	9848
	MAR	110	1578
	Mean	150.	616
	Median	88	433
	Std	103	1771

RESULTS

Population Size Estimate

The Jolly´s analysis of abundance presented in Table 1 shows that the population of queen conch fluctuates through the year. The lowest values were found during November and December, 2002 and from March to September, 2003. Higher abundance was detected during March and July 2002; January to June, 2004, and February and March, 2005, when the highest numbers were found.

Population Structure

Size structure for shell length for the fractions with and without flared lip are presented in Figures 1a and 1b, respectively. Figure 2 presents the population structure for lip thickness of conchs with flared lip. Shell length distribution of the flared lip fraction is unimodal with a mean of 220 mm and a dominant class of 222.5 mm. While conchs without flared lips present a polymodal distribution with a mean of 179 mm, the mean length for the population is 209 mm.

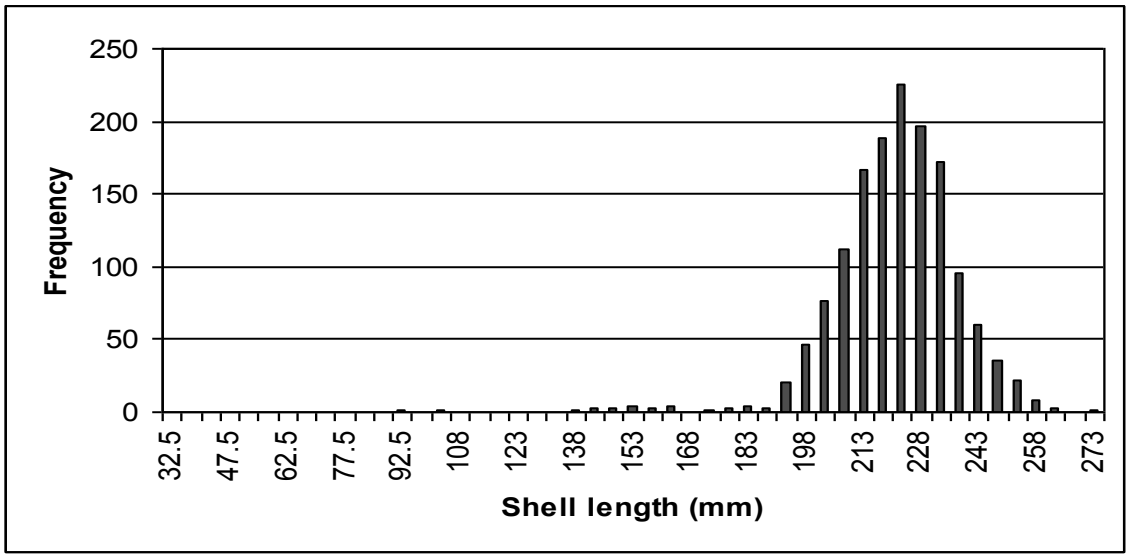

Figure 1. Size structure for shell length for the fractions of conchs, *Strombus gigas* with flared lip.

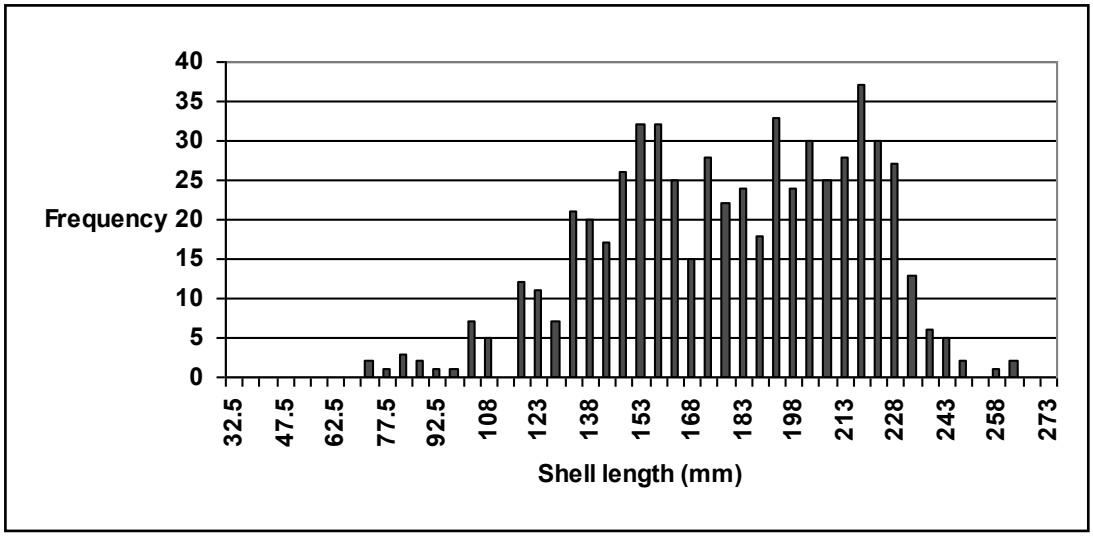

Figure 2. Size structure for shell length for the conchs, *Strombus gigas* without flared lip.

The population structure presented by lip thickness shows an overlapping of several age classes with a maximum of 41 mm and a mean of 16.25 mm. A very low correlation was found for lip thickness *versus* weight (r^2 = 0.2641) (Figure 3).

Growth Equations and Age Estimates

The von Bertalanfy growth parameters estimated from shell length, weight and lip thickness are given in Table 2. For shell length two different equations have been estimated; one for conchs without flared lip and another for the flared lip fraction. Adjusting the growth parameters for the fraction of conchs without flared lip to the mean of 179 mm of shell length to give an age of 4 years, and using this same size as starting point to estimate age of the fraction with flared lip, which gave an age of 15 years, giving a total age for the population of 19 years.

Recruitment Pattern

Recruitment can be inferred on the size frequency distribution from the presence of the smallest classes which appear from January to June with the 52 mm class for total shell length, with an age of six months (T_0= 0.8). Recruitment patterns estimated with the FISAT program, show very different trends (Figure 4).

Mortality

Mortality was estimated from total shell length for conchs without flared lip was 0.55 a year and 0.72 a year for flared lip conchs. and for the flared lip fraction, estimated from lip thickness, mortality was only 0.55 a year (Table 2).

DISCUSSION

Given the minimum size registered of 69 mm and recapture frequencies, with a maximum residence of one year, and exceptionally remain in the sampling area during the whole sampling period, it is assumed that conchs enter the lagoon and either move to the inner lagoon or crawl out within a year. The habit of burrowing (Hesse 1979, Stoner and Sandt 1992) during storms may be an explanation for the low numbers registered during some periods. The population structure presented by length size distribution shows that organisms without flared lip grow as large as those that have a flared lip, therefore maximum shell length is attained before sexual maturity. The best fit of the von Bertalanffy equation for the whole population was attained from weight data. The growth parameters estimated from lip thickness give the best fit for the flared lip conchs. Lip thickness is a measure of growth once shell length ceases, and it is a measurement that can be registered in animals once they have attained sexual maturity (Appeldorn 1994b).

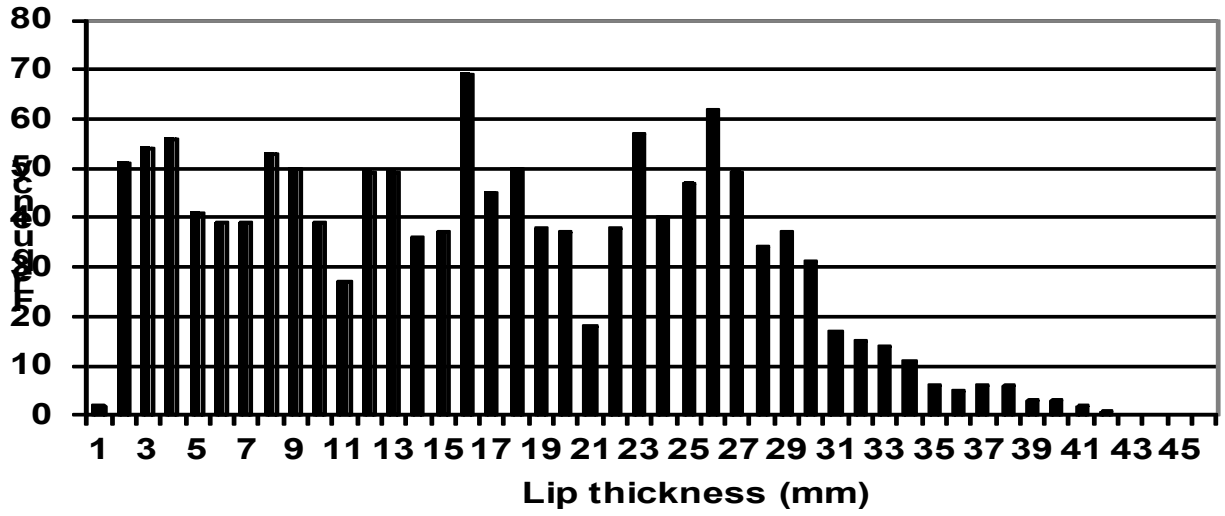

Figure 3. Lip thickness - weight correlation for the population of *Strombus gigas* from Xel-Ha park, Quintana Roo. Mexico.

Table 2. Von Bertalanffy growth parameters for S. gigas without flare lip and S. gigas with flare lip from Xel Ha Park. L1, shell length for conchs without flared lip; L2, shell length for flared lip conchs; W, weight for the whole population; Lt, lip thickness.

	L1 mm	L2 mm	W g	Lt
Loo	251	330	3850	47.78
K	0.3	0.07	0.36	0.17
Wp	0.3	0.5	0.3	0.5
C	0.8	0.5	0.8	0.3
Z	0.55	0.72	1.05	0.55
T0	-0.4	-0.8	-0.8	-0.48

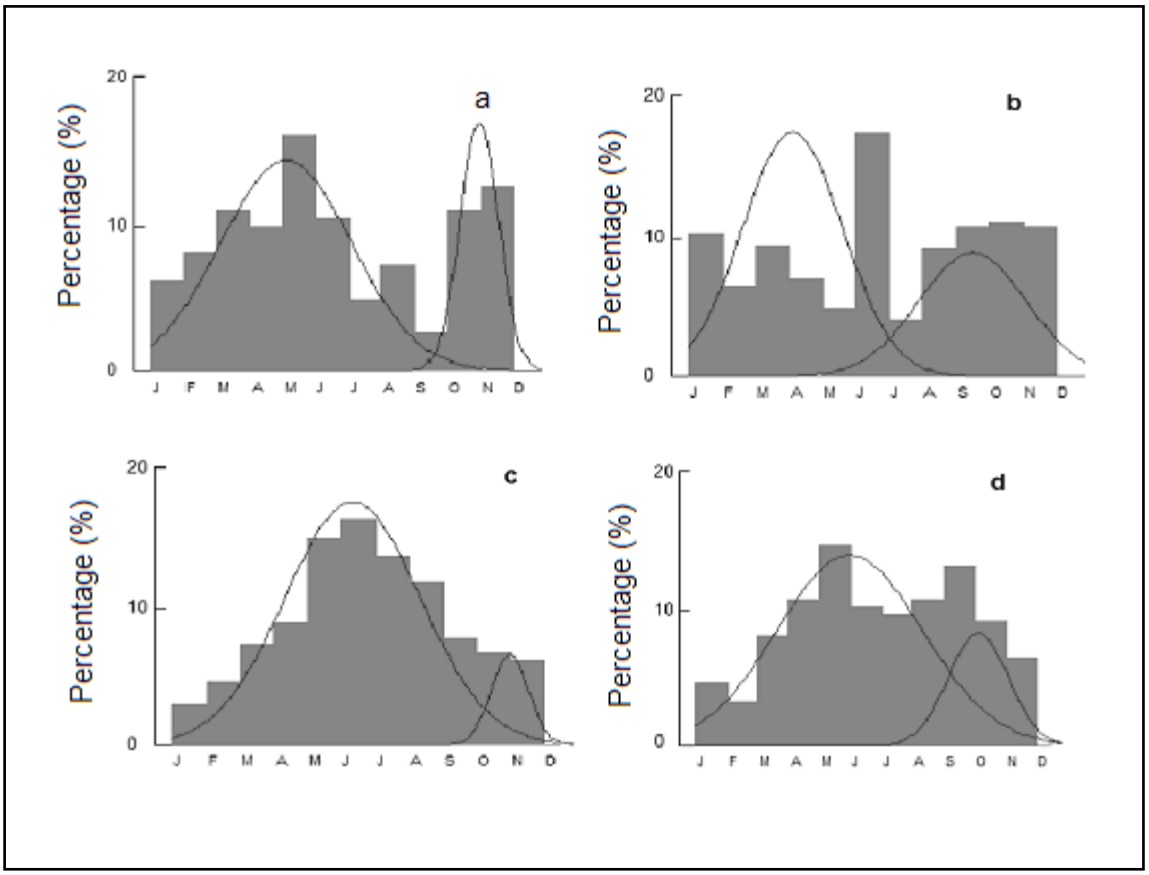

Figure 4. Recruitment patterns for *S. gigas* Xel-Há population, estimated for the different equations: a) for length increments for conchs without flared lip; b) for length increments for conchs with flared lip; c) for lip thickness for conchs with flared lip. Bars represent percentage of recruitment. Lines are an estimate of normal distribution for two components.

Stoner and Glazer (1998) give mortality rates for 100 mm conchs without flared lip of 0.5 to 12 and for conchs of 200 mm from 2 to 12. These authors associate high mortality rates to deficit in behavior and shell form associated with hatchery rearing. Lara Peréz-Soto (1992) reports for conch without flared lip mortality rates of 0.23 to 0.54 and of 0.55 to 0.75 for flared lip conch. This coincides with mortality rates estimated in this work for both conchs with and without flared lip.

The maximum age of conchs is adjusted to the time Xel-Há park has been actively promoting the protection of *Strombus gigas*, as compared to what has been reported for populations under fishing pressure. Growth parameters given for different localities on the coast of Quintana Roo, Mexico given in Table 3 present a larger maximum shell length (L∞), and much higher growth rates (K), except for the locality of Mahahual, where Diaz (1991) reported from a juvenile population 227 mm for L∞, and a similar growth rate (K) to the one found in this study. The presence of older individuals (19 years age) as well as the presence of a larger number of juveniles is an indication of the effectiveness of the Xel-Há Park as a marine protected area (MPA) and supports the thesis that MPA's are an effective safe ground for juveniles and reproductive stocks, allowing for a longer life span as compared to fished populations. This should hold true as long as enforcement is effective to prevent pouching and the essence of conservation of MPA's is applied.

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Table 3. Growth parameters of the von Bertalanffy equation for *S. gigas* estimated for different localities of Quintana Roo, Mexico. L, shell length for the whole population; L1, for conchs without flared lip; L2, shell length for flared lip conchs; W, weight for the whole population; Lt, lip thickness.

Locality	L∞ mm	K	T_0 Years	Maximum Age	Authority
Banco Chinchorro L	283.5	0.4	-0.74	9	Castro de Anda, 1994
Punta Chen L	293.8	0.27	-0.53	11	De Jesús *et al*., 1999
Banco Chinchorro L	297.8	0.3	0.002	8	Cruz *et a*l., 1994
Mahahual L	227	0.036	-	>20	Dìaz, 1991
Xel-Ha L1	251	0.3	-0.4	22	This work
Xel-Ha L2	330	0.07	-0.8	19	This work
Xel-Ha W	3850	0.36	-0.8	11	This work
Xel-Ha Lt	47.78	0.17	-0.48	18	This work

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