Growth, Recruitment, and Mortality of the Queen Conch *Strombus gigas* in a Natural Protected Area of the Mexican Caribbean

Crecimiento, Reclutamiento y Mortalidad del Caracol Rosa *Strombus gigas* en un Área Natural Protegida del Caribe Mexicano

Croissance, Recrutement et Mortalité du Lambi *Strombus gigas*, dans une Zone Naturelle Protégée du Caraïbe Mexicaine

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ABSTRACT

The queen conch *Strombus gigas* represents one of the most important fishery resources of the Caribbean but heavy fishing pressure has led to the depletion of stocks throughout the region. The inlet of Xel-Ha has been used since 1995 as a park for ecotourism and fishing is strictly prohibited. The Park is considered a sanctuary for the conservation of the queen conch, hosting an important number of juveniles and adults. Sustainable management requires biological knowledge and protection of reproductive stages is crucial. Population size of *S. gigas* aggregations is mainly determined by recruitment processes, but recruitment may be temporally and spatially variable. Growth is paramount for estimating maturation and natural mortality. In the present study we evaluated growth, recruitment and mortality using mark-recapture methods, over a period of 3 years and compared the results of direct assessment to length frequency analysis. Growth of *S. gigas* was high within the inlet. Conch with an initial size of 110 – 129 mm grew 0.32 mm/day. An L∞ of 278.73 mm was estimated and the growth constant k was 0.71/year. Recruitment peaked twice per year (March-May and July-September) but was highly variable between years. Natural Mortality (z), estimated by mark-recapture methods, reflected natural conditions with values between 1.06 and 3.87, but a length converted catch curve showed that it was exceptionally high in conch bigger than 200 mm with z = 4.71. Since fishing is banned, this was attributed to mobility and emigration of adults. The results may be of importance to fishery management and rehabilitation.

KEY WORDS: Queen conch, *Strombus gigas,* growth, recruitment, mortality

INTRODUCTION

The queen conch *Strombus gigas* represents one of the most important fishery resources of the Caribbean but heavy fishing pressure has led to the depletion of stocks throughout the region (Brownell and Steveley 1981, Chakalall and Cochrane 1996).

The Xel-Ha Inlet has been used since 1995 as a park for ecotourism and is considered a sanctuary for the queen conch (Baqueiro-Cárdenas and Aldana Aranda, 2010).

Protecting reproductive stages is crucial for the conservation of this species, but recruitment may be temporally and spatially variable (Alcolado 1976, Appeldoorn 1987a). Growth is paramount for estimating maturation and natural mortality (Eberhardt and Valle-Esquivel 2008). The objective of this study was to estimate and compare shell growth, recruitment, and mortality of the queen conch, obtained by direct and indirect methods.

MATERIALS AND METHODS

Xel-Ha is located on the east coast of the Yucatan Peninsula (20°19'15"-20°18'50"N and 87°21'41"-87°21'15"W). The area is characterized by input of fresh water through underground rivers due to karstic conditions in the area. Xel-Ha is a highly stratified coastal lagoon that consists of a mix of fresh groundwater with seawater. The Inlet is connected to the Caribbean Sea by a 100 m wide channel and has a total surface of 14 ha, with a center area and three appendices: Bocana, North Arm and South Arm. Its depth ranges from 0.5 – 4.0 m.

Between April 2009 and September 2011, thirteen surveys were conducted, sampling a total area of 42,000 m². The number of surveys carried out varied among years: three in 2009, five in 2010 and five 2011. All organisms were collected in free-dive by three divers. We used mark-recapture method, marking all individuals with a plastic Dymo® tag, bearing a consecutive number, which was fixed to the spire of the conch with a plastic cable binder. A total of 6,627 conches could be tagged. In order to evaluate the growth rate, shell length (SL) and was determined for each individual, using a precision caliper, accurate to ±1 mm. All animals were released at the same location they were found.

Growth was determined by direct methods (mm/day) and by estimation of Von Bertalanffy Growth Parameters (k; L∞), using indirect Appeldoorn method, included in FISAT II. Recruitment was determined per year by direct methods (Histograms) and by indirect methods per month, using FISAT II. Mortality was estimated using length converted catch curves, included in FISAT II, and Jolly-Seber method.

RESULTS

Conches grow fast until they reach 220 mm SL at 2.2 years estimated age, subsequent growth is slow or null (Figure 1). The indirect method (Figure 2) predicted a similar growth pattern, reaching 220 mm at an age 2.5 years. Recruitment varied greatly among years and was highest in 2009 (Figure 3).

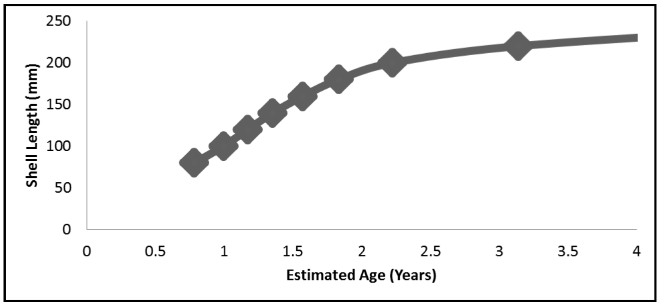

Figure 1. Shell length increment (mm) of the queen conch *S. gigas* in the Inlet of Xel-Ha estimated by direct methods.

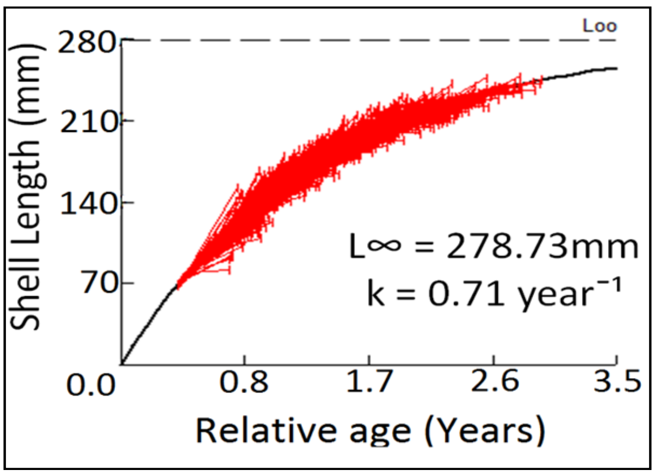

Figure 2. Shell length increment (mm) of the queen conch *S. gigas* in the Inlet of Xel-Ha estimated by Appeldoorn's Method.

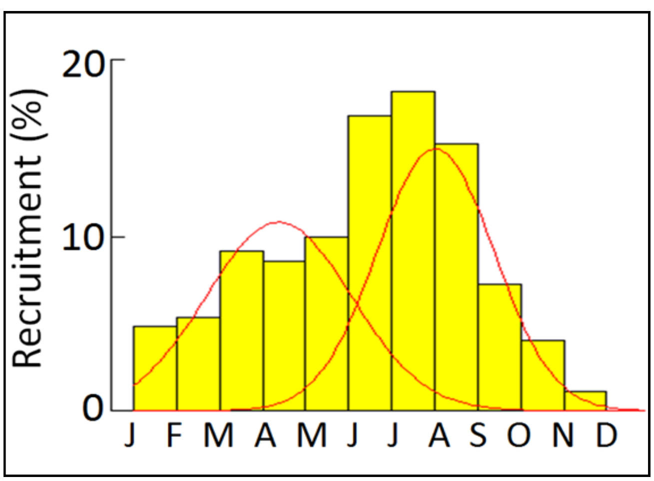

Figure 4. Monthly juvenile recruitment (%) of the queen conch *S. gigas* in the Inlet of Xel-Ha.

Recruitment was continuous throughout the year, being lowest in December. We observed two peaks, the first one between March and April and a second peak of greater magnitude between July and September (Figure 4).

Average mortality was z = 2.3 ± 0.85 after one year (Figure 5). Mortality increased in conch between 1.7 and 3.5 years and was z = 4.71 ± 0.48 (Figure 6).

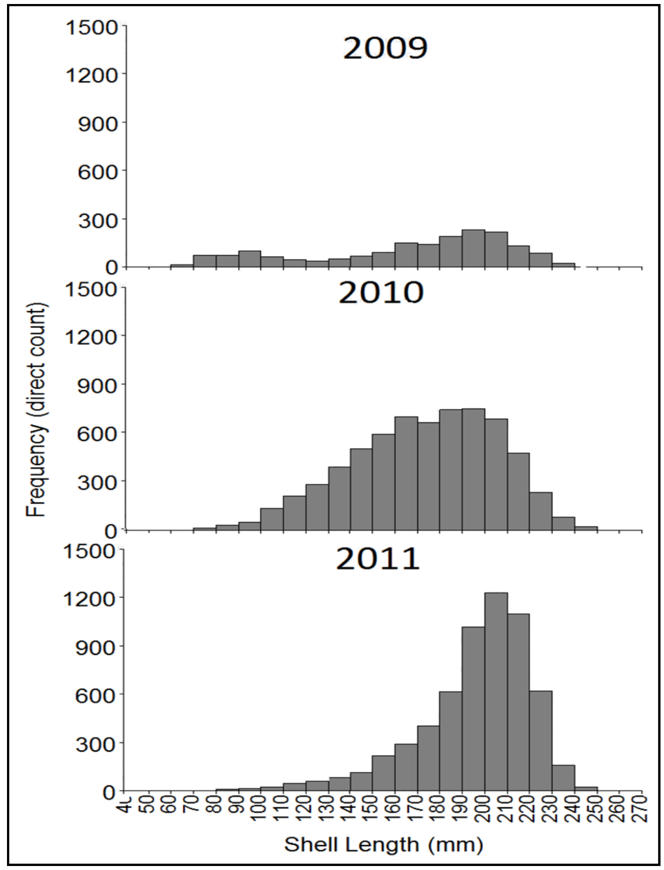

Figure 3. Juvenile recruitment of the queen conch *S. gigas* per year in the Inlet of Xel-Ha.

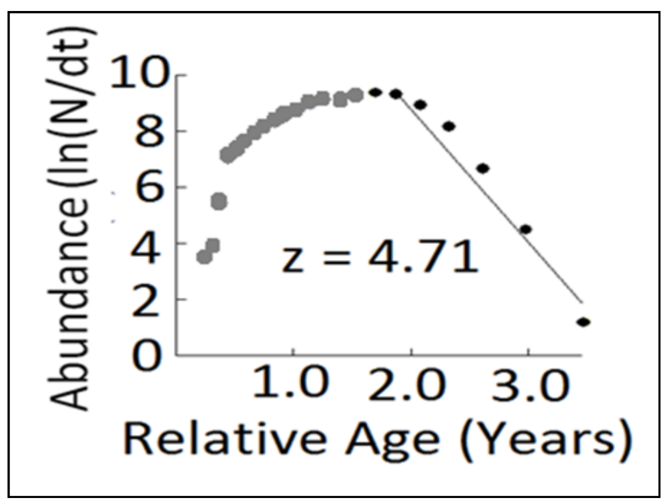

Figure 6. Mortality (z) of the queen conch *S.gigas* in the Inlet of Xel-Ha, estimated by length converted catch curve.

DISCUSSION

Growth rates obtained in this study were high. Growth rates obtained by direct methods were comparable with other studies conducted under mark-recapture conditions (Gibson et al. 1983, De Jesús-Navarrete and Oliva-Rivera 1997, Phillips et al. 2011), but still lower than growth observed by Weil and Laughlin (1984).

Growth rates have been determined for the Xel-Ha population before using indirect methods.

Growth rates obtained in this work were comparable with those obtained by Valle-Esquivel (1998) and Aldana Aranda et al. (2005), but were much higher in comparison with studies carried out by Aldana Aranda et al. (2003) and Baqueiro-Cárdenas and Aldana Aranda (2010).

In comparison with other sites of the Caribbean, growth rates, obtained by indirect methods were high within the Xel-Ha Inlet. They were only comparable with shell growth determined by García (1991) in Providencia and San Andrés, Columbia.

We observed great differences in the magnitude of recruitment between years. Similar observations have been made by Alcolado (1976) on Cuba and Appeldoorn (1987a) on Puerto Rico. In conch populations of the Bahamas it has been determined that juvenile abundance and population size are mainly regulated by supply of competent larvae to the nurseries (Stoner 2003).

We observed continuous recruitment throughout the year with two peaks. This result coincides with earlier observations made by Aldana Aranda et al. (2005), who documented reproductive activity in the Inlet in March, April, May and August. In Mexico (Pérez-Pérez and Aldana Aranda 2002, Pérez-Pérez and Aldana Aranda 2003) and on the Virgin Islands (Randall 1964), recruitment has been observed from January to October.

De Jesús-Navarrete et al. (1994) determined recruitment of juveniles with two peaks, being highest from March to August and from August to November, employing the same method as used in this work.

Mortality rates (z) obtained in this study lie within the reported range for the queen conch throughout the Caribbean area (Alcolado 1976, Iversen et al. 1987, Appeldoorn 1987b). Nevertheless, the converted catch curve showed that mortality was very high in organisms larger than 200 mm, in comparison with other studies (Appeldoorn 1988, De Jesús-Navarrete et al. 2000, Baqueiro-Cárdenas and Aldana Aranda 2010). In the case of *S. gigas*, generally mortality tends to decrease as conch age (Appeldoorn 1988). Since few empty shells could be found and fishing is banned, we believe that conches emigrate from the Inlet as they grow older and that high adult mortality rates can be attributed to the emigration effect. This has been suggested previously by Baqueiro-Cárdenas and Aldana Aranda (2010).

CONCLUSIONS

Growth was high compared to other sites, but consistent with previous studies.

Recruitment peaked twice per year, but was highly variable between years.

Mortality (z) estimated by Jolly-Seber method reflected natural conditions but the length converted catch curve showed that it was highest in conch older than two years.

The use and comparison of both, direct and indirect methods, has resulted very useful and insightful, revealing different aspects of the population dynamics.

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