Population Trends and Management Effectiveness of Queen Conch, *Strombus gigas*, in Western Puerto Rico

Tendencias de la Población y Eficacia de la Gestión del Carrucho, *Strombus gigas*, en el Oeste de Puerto Rico

Les Tendances Démographiques et L'efficacité de la Gestion du Strombe Rose, *Strombus gigas*, dans L'ouest de Puerto Rico

NICOLE BAKER[1*], RICHARD APPELDOORN[1], and PEDRO A. TORRES-SAAVEDRA[2]
[1]*Department of Marine Science and Statistics Consulting Lab[2], University of Puerto Rico, P O Box 9000, Mayaguez, Puerto Rico 00681 USA. *nbaker493@gmail.com.*

KEY WORDS: Queen conch, management, Puerto Rico, fisheries, GLMM

EXTENDED ABSTRACT

Introduction

The queen conch, *Strombus gigas*, resource continues to support a commercial fishery (valued at around $543,000 USD) in Puerto Rico, despite a history of overfishing and low densities. In the mid 1980s, one boat trip could average 73-kg of meat, while the same trip in the early 2000s could only average 33-kg (Valle-Esquival 2002). Catch was based on juveniles (Appeldoorn 1991), and fishing mortality was greater than natural mortality (Appeldoorn 1987). A general trend of decreasing catch has been observed since the early 1980's (SEDAR 2007) and total density has not exceeded 22/ha (Figure 1). In order to reassess the population status, the goals of this study were to generate updated density estimates for queen conch and to assess trends and evaluate hypotheses of management interest using generalized linear mixed models. Density data were supplemented by size/age data.

Methods

Visual Surveys — Survey areas were chosen based on interviews with fisherman, and then 46 random sites were selected within those areas identified as conch fishing grounds. A 27 m maximum depth limit was chosen for diver safety, and direction of the transect from the random start point was a pre-selected random compass heading. Along the surveys, which used underwater scooters to maximize area covered, data were collected on habitat, depth, estimated conch length and age class. Transects were 4-m wide and of variable length, with two per site. A buoy signaled the end of the transect, and the location was recorded by the support vessel.

Data Analysis — Comparisons of both adult and juvenile densities between years (1997, 2001, 2006 and 2013) were made using a model that included year, depth and habitat, and for sites where more than one habitat was dominant, counts of queen conch were attributed to both habitat types. The data analysis was generated using SAS® software, Version 9.3 (SAS Institute, Cary NC). Analyses were conducted using the PROC GLIMMIX of SAS, based on a negative binomial distribution for the counts. A separate model included a location and year*location term to compare the mean density of adults and juveniles in local waters versus the US Exclusive Economic Zone (EEZ). The analysis was restricted to densities less than 200/ha because sample means were highly influenced by a site with density around 200/ha and goodness of fit of the model improved with removal of this outlier. Density plots showing the distribution of length (for juveniles and adults) were constructed using shell length for 1997 and then 2006 pooled with 2013. Age class distributions were constructed for 1997 and 2013 showing the percentage of total conch observed in each of the five age classes (J, NMA, A, OA, VOA). A Kolmogorov-Smirnov test was done to compare the length distributions between 1997 and 2006/2013 pooled. A Pearson's chi-squared test was done to compare the proportions of conch in each age class between 1997 and 2013.

Results

Total area surveyed was 37.45 ha at 46 sites. Total number of conch seen was 380: 194 juveniles and 186 adults. Total mean density was 14.05/ha (adults = 7.32/ha; juveniles = 6.63/ha). Year and habitat were significant factors influencing adult and juvenile density. Transects with reef present had significantly lower densities of juvenile queen conch ($p = 0.05$), while transects with sand were also inversely related to juvenile density but at a lower significance level ($p = 0.10$). Lower mean densities of adults were found on transects with mud present ($p = 0.05$). Lower densities of both juvenile and adult queen conch were observed in 1997 and 2001 respectively compared to 2013. The location effect compared sites within the EEZ which is closed to fishing versus local waters which are open to fishing. The location term was significant for adults, with less conch inshore, but this was true regardless of year. This was not the case for juveniles, where the location and year*location terms were significant. An increase of 2.3 to 10.01/ha from 1997 to 2013 was observed in the EEZ (excluding sites where density > 200/ha). Length-frequency diagrams showed an increase in the proportion of conch less than 20 cm in

2006 - 2013 pooled relative to 1997 (D = 0.2854, $p < 0.001$). Juveniles comprised 50% of the population in 2013, compared to 70% in 1997, and adults were found in the oldest age class during the 2013 survey.

Discussion

Management regulations such as closed seasons and areas, size limits and daily bag limits that have been put in place to help the population recover from overfishing, and results show that density has increased since 1997 and 2001. However, the lack of any improvements in density since 2006 is troubling. Some positive results include evidence from the length frequency analysis that suggests an effect of the 22.86 cm minimum size limit implemented in 2004, and age class analysis suggests an overall decrease in fishing mortality. Additionally, a recent study showed conch are at least occurring in high enough density to maintain reproductive output (Appeldoorn et al. 2011). In order to more accurately determine the effects of specific management regulations, changes in survey methodology are recommended. These include but are not limited to, increasing the number of sites but shortening each transect, utilizing a two stage design, not utilizing scooters, standardizing area surveyed, stratifying by depth and habitat, and allocating effort to specifically address management questions (e.g., selecting equal number of sites inside and outside EEZ).

LITERATURE CITED

Appeldoorn, R.S. 1987. Assessment of mortality in an offshore population of queen conch, *Strombus gigas* Linnaeus, in southwest Puerto Rico. *Fishery Bulletin* **85**:797-804.

Appeldoorn, R.S. 1991. History and recent status of the Puerto Rican conch fishery. *Proceedings of the Gulf and Caribbean Fisheries Institute* **40**:267-282.

Appeldoorn, R.S., J.A. Rivera, and A. Maldonado. 2011. A re-examination of the peak spawning season for queen conch in Puerto Rico. Caribbean Fisheries Management Council, San Juan, Puerto Rico.

SEDAR (Southeast Data, Assessment and Review). 2007. Stock assessment report of Caribbean queen conch. SEDAR 14, Stock Assessment Report 3. North Charleston, South Carolina, USA.

Valle-Esquivel, M. 2002. Standardized catch rates and preliminary assessment scenarios for queen conch (*Strombus gigas*) in the United States Caribbean. NOAA National Marine Fisheries Service. Contribution SFD-02/03-184. Miami, Florida.

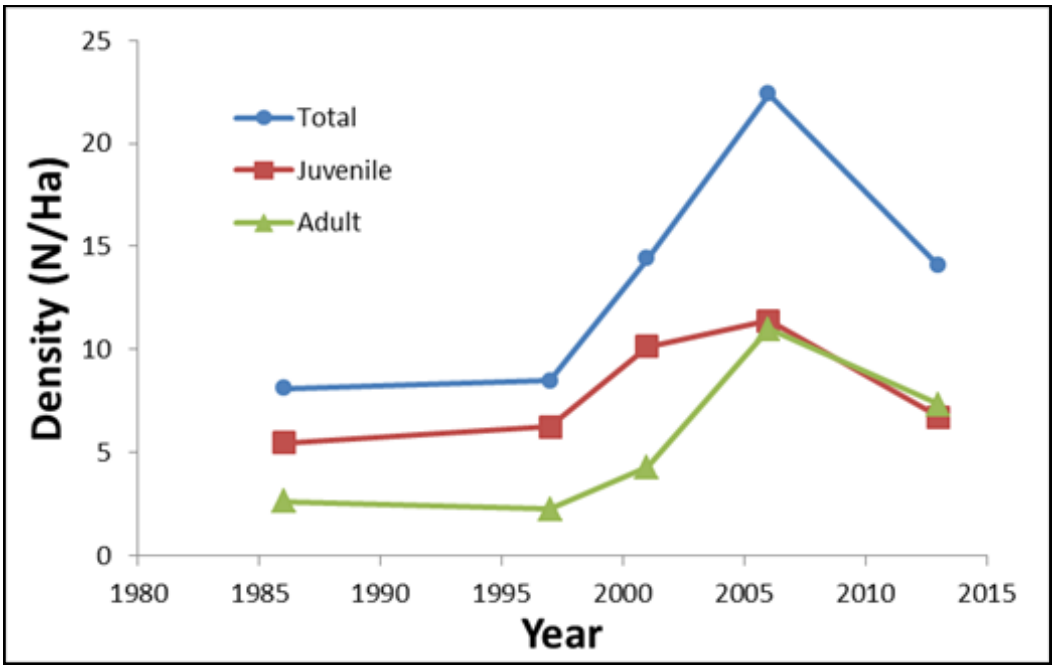

Figure 1. Density (N/ha) trends over time from queen conch surveys in western Puerto Rico. Top line (blue circles) is total (adults+juveniles), middle line (red squares) is juveniles and bottom line (green triangles) is adults. Surveys were done in 1986, 1997, 2001, 2006 and 2013.