Repeated Surveys of Queen Conch (*Lobatus gigas*) in The Bahamas Show Population Declines and a Morphometric Shift Towards Smaller Sizes

Estudios Repetidas de Caracol (*Lobatus gigas*) en las Bahamas Muestran Disminución de la Población y un Cambio de Morfométrico hacia Tamaños más Pequeños

Des Recensements Répétés de Lambi (*Lobatus gigas*) dans les Bahamas Montre un Déclin de la Population et un Changement Morphologique en Faveur de plus Petites Tailles

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EXTENDED ABSTRACT

Introduction

The queen conch is a valuable and easy to harvest denizen of Caribbean benthic marine ecosystems, leading to population declines in many locations. In response, fishery regulations have been instituted in some nations, often designed to temper harvest by ensuring that only mature adults are harvested. Conch aggregate in shallow water sites during the reproductive season and shell lip thickness is a relative indicator of age (Appeldoorn 1988, Stoner et al. 2012a). Predictable shell growth and aggregation patterns facilitate the assessment of population density, size, and age structure in tandem over large areas.

Methods

We analyze data collected during 2016 from surveys repeated at intervals between 5 and 7 years. Previous surveys were carried out by the non-profit organization Community Conch. Surveys consisted of towed underwater observer surveys and *in situ* shell measurements of conch from *ca.* 400 km^2 of fished and protected bank habitat in The Bahamas. The fished locations included the banks southwest of the Berry Islands, and near the Grassy Cays south of Andros. Our protected population was in the Exuma Cays Land and Sea Park (ECLSP) adjacent to Warderick Wells. The habitat in our study areas was typically sandy bottom covered with seagrasses or macroalgae, although patch reefs and rubble environments were occasionally encountered (Stoner et al. 1998). In the 2016 surveys, we focused on areas that contained the highest densities of conch in the earlier surveys and were thus presumed to be the breeding and population cores.

Towed observer surveys were used to estimate conch abundance at depths of less than 10 m. An observer was towed behind a skiff at about 4 km / hr and tabulated queen conch in each of three classes that fell within a 6 m band beneath the observer following previous protocol (Stoner and Ray 1996). In the survey we defined juveniles as conch < 15 cm in length, subadults as greater than 15 cm in length but lacking a flared lip, and adults as individuals with flared lips. Survey areas were stratified into 1´ × 1´ grids of latitude and longitude that served as the units for each survey. Approximately 1 km of towed effort was allocated within each grid to provide counts that were transformed into densities per hectare using realized tow distances and the survey band width. The past survey in the ECLSP was designed based on Stoner and Ray (1996) but densities were transformed to conform with the 1´ × 1´ gridsize.

Morphometrics were taken to describe adult age within encountered aggregations. Measurements were taken of at least 50 individuals from large aggregations (greater than 100 adult conch). Shell length was measured from the tip of the spire to the siphonal canal. Shell lip thickness was measured following Appeldoorn (1988): within the mid-lateral region between 3 and 4 cm from the lip edge to avoid misreadings from damaged and eroded shells.

Differences between mean abundances of adults and subadults in each survey grid were assessed separately using one-way ANOVA with the factor year for each location. Density data was zero-inflated and skewed so a log (x + 1) transformation was applied prior to statistical analysis. Differences between the shell length and shell lip-thickness of measured conch was also assessed using one-way ANOVA with the factor year for each location.

RESULTS AND DISCUSSION

Our results show that the population density of adult conch is decreasing significantly in both fished locations (Table 1; Figure 1). However, the subadult population is not yet decreasing significantly within the two fished areas although it is trending downwards (Table 1). These results suggest that the recruitment into the fishery areas has not disappeared, yet heavy fishing pressure is continuing to deplete the adult population. Considering that conch have density dependent breeding (Stoner and Ray 2000, Stoner et al. 2012b), the continued extraction from the breeding cores of the fished populations will lead to a collapse if densities regress to a level prohibitive to mating (< 100 adults / hectare). This appears to be happening in the Berry Islands, where we have documented a 73% decline in abundance in just 7 years.

Table 1. Changes in queen conch population density and size during repeated surveys. The statistic for a one-way ANOVA testing for a difference between survey means is presented in each case and bold where significant ($p < 0.05$). Abundances were log (x+1) transformed for analysis to account for zero inflated data.

		Adults / hectare				Subadults / hectare			
Location (year of earlier survey)	Number of grids	Community Conch Survey	2016 Survey	F	p	Community Conch Survey	2016 Survey	F	p
Grassy Cays (2010)	26	237 ± 177	180 ± 184	4.9	**0.032**	72 ± 70	57 ± 72	0.01	0.914
Berry Islands (2009)	59	108 ± 222	28 ± 85	12.6	**0.0006**	64 ± 134	39 ± 57	0.64	0.426
Exuma Cays Land and Sea Park (2011)	14	32 ± 83	10 ± 18	0.13	0.7186	11 ± 19	14 ± 26	0.002	0.9693
		Lip thickness (mm)				Shell Length (mm)			
Location (year of earlier survey)	Number conch measured, Community Conch & 2016	Community Conch Survey	2016 Survey	F	p	Community Conch Survey	2016 Survey	F	p
Grassy Cays (2010)	30 & 341	14.8 ± 7.0	16.3 ± 7.0	1.2	0.274	176.8 ± 27.5	164.3 ± 16.0	14.62	**0.0002**
Berry Islands (2009)	46 & 484	14.5 ± 6.0	14.8 ± 5.0	0.13	0.7202	157.2 ± 21.6	156.4 ± 14.9	0.12	0.724
Exuma Cays Land and Sea Park (2011)	192 & 625	25.8 ± 7.9	28.6 ± 7.3	19.9	**< 0.0001**	202.0 ± 20.7	186.5 ± 19.3	92.26	**< 0.0001**

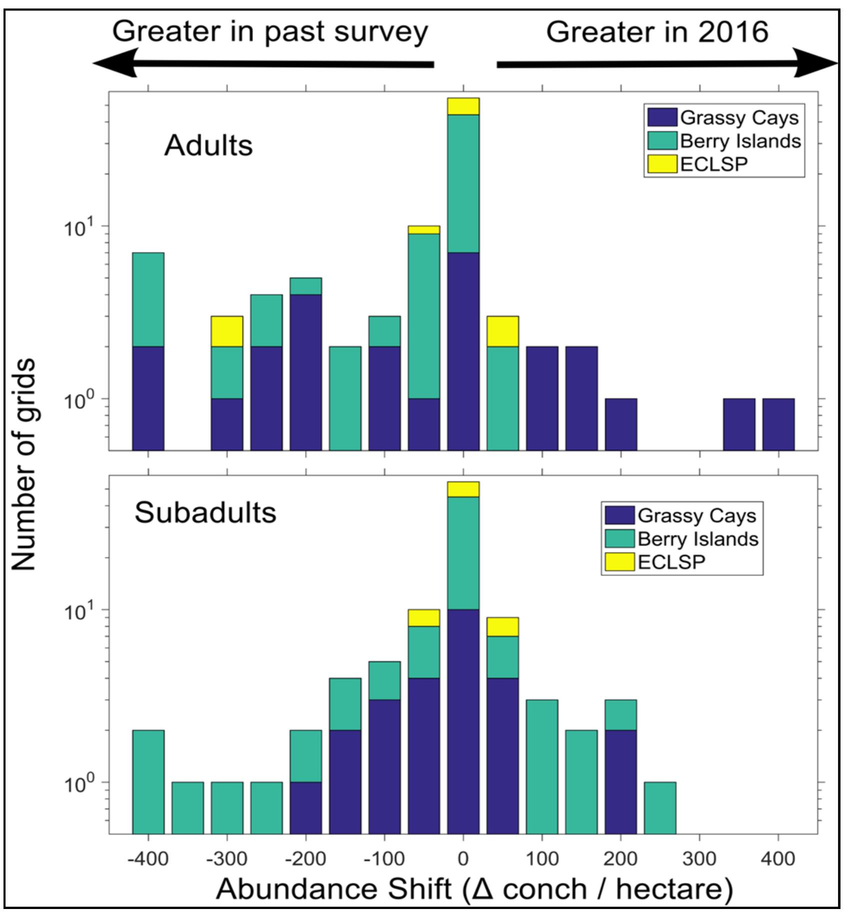

Figure 1. Shift in adult and subadult abundance during repeated surveys. The difference in conch abundance within each grid of a repeated towed observer survey was calculated in the population cores of the Grassy Cays, the Berry Islands and from a previously measured population in the ECLSP. Adult populations are declining in each location.

Further, we observe a decrease in the average shell length of live conch with flared lips in the fished area near the Grassy Cays, while the ECLSP population significantly increased in age (thicker shells) and also decreased in shell length. We greatly increased the number of conch measured during the 2016 surveys in an attempt to decrease variance in size and age estimates. We increased our sample size by more exhaustively measuring conch within aggregations that we encountered and still measured conch from a similar number of aggregations (Berrys 2009 N = 3, 2016 N = 5 locations; Grassy Cays 2010 N = 8, 2016 N = 5; ECLSP 2011 N = 6, 2016 N = 7). The trends are clear: all three populations are being comprised of smaller individuals over a relatively short timespan (5 to 7 years).

The decrease in adult density and decrease in shell length are both indications of heavy fishing pressure. Substantiating this hypothesis was evidence obtained by opportunistically sampling harvested conch, which demonstrated that fishermen are selecting the largest individuals. We suggest that fishing is shaping the abundance and morphology of Bahamian conch, which indicates that current regulations are inadequate for a sustainable future. The decline of adults in the ECLSP, while substantial, was not significant; however, the increase in shell lip-thickness suggests that the park population is slowly dying of old age despite a well-enforced fishing ban in the park.

KEYWORDS: Queen Conch (*Lobatus gigas*), benthic survey, size and age

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