The Harvest of Juvenile Queen Conch (*Strombus gigas*) off Cape Eleuthera, Bahamas: Implications for the Effectiveness of a Marine Reserve

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ABSTRACT

Queen conch is an important marine resource in the Bahamas, however stocks around some of the islands are being threatened. In south Eleuthera, a downturn in the local economy during recent decades has caused fishing pressure to increase, and local stocks are showing signs of stress. In response, a fully-protected marine reserve is proposed for the waters near Cape Eleuthera in an attempt to rebuild local conch populations and other commercially valuable fish stocks. Analysis of shell midden data from Cape Eleuthera revealed that over 30% of the conch were juveniles. Additionally, visual shoreline surveys of conch shells and anecdotal observations of fishing patterns suggest that juvenile conch are actively being harvested from nursery grounds. Nevertheless, preliminary results from visual surveys conducted in and around a frequently fished nursery ground indicate that the density of juveniles is relatively high (~970 conch/ha). This suggests that larval supply to the area is currently sufficient to maintain densities of small juveniles, although current fishing practices likely curtail the dispersal of juveniles to adult habitat, affecting the breeding stock. Further visual surveys of conch in this area will increase understanding of local population dynamics and improve the ability to assess the effectiveness of the proposed reserve.

KEY WORDS: Bahamas, Eleuthera, MPA, queen conch, *Strombus gigas*

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El reina caracol es un importante recurso marino en las Bahamas. No obtante algunas de las reservas alrededor de las islas han sido amenazadas. En el sur de Eleuthera, un decrecimiento de la economia local durante las ultimas decadas ha ejercido presion para incrementar la pesca, y las reservas locales han mostrado signos de desgaste. Analisis de la data de las conchas deshechadas proveniente del Cabo Eleuthera revelaron que la proporcion de los deshechos de las conchas de los caracoles jovenes es significativamente mas alta en los nuevos deshechos que en los viejos. Adicionalmente, mediciones visuales de las conchas de caracol en la costa y en observaciones historicas basadas en los patrones de pesca insinuan que las conchas de caraco-

les jovenes han sido cosechadas activamente en los viveros. Sin embargo, resultados preliminares provenientes de mediciones visuales realizados en un vivero y sus alrededores indican que la densidad de caracoles jovenes pequenos (es menor que 150mm) es relativamente alto (~ 700 conchas/ha). Esto sugiere que los suministros de larvas en el area es actualmente suficiente para mantener la densidad (poblacion) de los pequenos caracoles. Si bien la pesca actual probablemente disminuye la dispersion desde el habitat juvenil al habitat adulto, tambien afecta la reserva de crianza. El planteamiento de una reserva marina protegida para las aguas cercanas del Cabo Eleuthera en un intento de regenerar la poblacion del caracol reina. Mas mediciones visuales del caracol en esta area incrementara el entendimiento de la dinamica de la poblacion local y mejorara la aptitud para evaluar la efectividad de la reserva marina protegida.

PALABRAS CLAVES: Reina caracol, poblacion local, , *Strombus gigas*, Eleuthera, Bahamas

INTRODUCTION

Queen conch (*Strombus gigas*) has long been an important marine resource in the Caribbean (Appeldoorn 1994). In the Bahamas, this mollusk carries both cultural and economic significance. On the island of Eleuthera, a near total collapse of the tourist trade approximately 25 years ago has lead to a greater economic dependency on queen conch. Currently in south Eleuthera, there exists a small scale commercial and a subsistence fishery for queen conch.

Management of queen conch in the Bahamas has consisted primarily of fisheries regulations such as prohibiting the use of SCUBA and the harvest of juveniles (Bahamas Department of Fisheries 1986). However, due to increased pressure on queen conch and other marine species, the Bahamian government put forth a pledge in 2000 to instate a network of five fully-protected marine reserves. One site slated to be included in this network is an area off Cape Eleuthera at the southern end of Eleuthera (Figure 1). This site was chosen based on a number of socio-economic and ecological criteria including evidence of historically productive queen conch fishing grounds (Dahlgren 2002).

The goals of the proposed protected area off Cape Eleuthera are to protect habitat and facilitate an increase in biomass to the extent that larval export and the emigration of adults to fished areas occurs (Roberts and Polunin 1993). In the oldest protected area in the Bahamas, the Exuma Cays Land and Sea Park, Stoner and Ray (1996) found that the density of conch in was significantly higher than in fished areas surrounding the reserve. Critical habitat for queen conch includes that of nursery ground, which are often areas of seagrass (i.e. *Thalassia testudinum*), macroalgae covered sand, or coral rubble substrates (Danylchuk et al. 2003, Stoner 2003). The inclusion of one or more nursery grounds of queen conch in the fully-protected marine reserve off Cape

Eleuthera is important to the success of an increase in biomass, as is the inclusion of other habitats preferential to queen conch.

In order to better understand the potential effectiveness (with respect to queen conch) of the proposed fully-protected marine reserve off Cape Eleuthera, a shell midden and an area of the shoreline adjacent to a suspected nursery ground were visually surveyed to assess the age of conch being harvested. Visual surveys of live queen conch near Cape Eleuthera were also conducted to determine the extent of a suspected nursery ground.

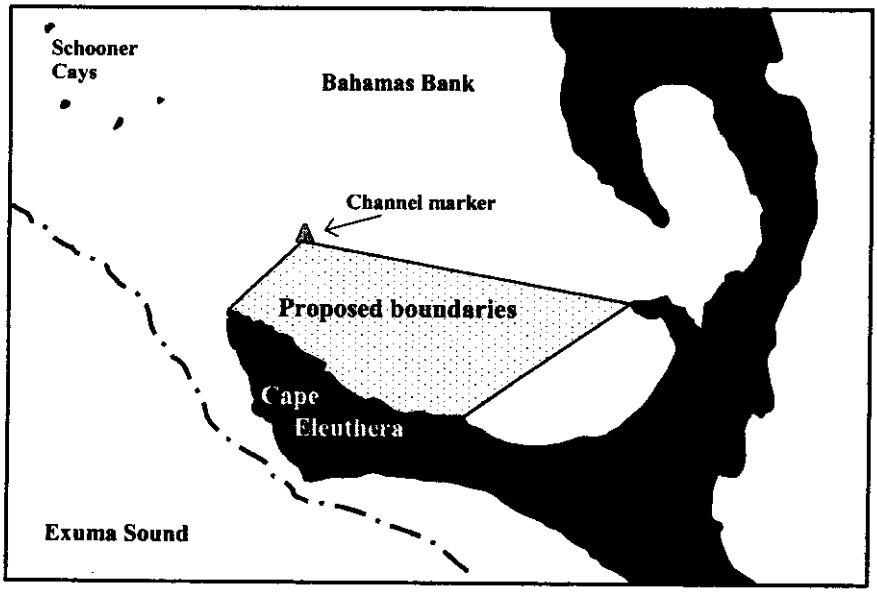

Figure 1. Proposed marine reserve boundaries for south Eleuthera, Bahamas.

MATERIALS AND METHODS

Shell Survey

A queen conch shell midden < 5 years old and located approximately 1 km from a suspected nursery ground was surveyed during October 2003. Although other conch middens are present on Cape Eleuthera, this particular midden was selected because its precise age is known and shells are actively be added to it. Queen conch shells within the midden were enumerated and categorized as either juvenile or adult based on the presence of flared shell lip. Queen conch shells from the midden were also measured (siphonal length, SL, to the nearest 0.5 cm) using bow calipers.

Visual surveys were conducted along the shoreline adjacent to a suspected nursery ground beginning in October 2003. Shoreline surveys will be conducted quarterly to examine the accumulation of discarded queen conch shells.

At three sites, three adjacent plots spanning 20m of shoreline and 10m above mean high tide line were permanently established. All queen conch shells within the plots with obvious signs of "knocking" (a hole created by fishers to remove the animal from it's shell) were enumerated and assigned to one of six size/age categories (Table 1). Small juveniles were measured (SL, to the nearest mm) using vernier calipers.

Table 1. Size/age categories of queen conch used during visual surveys off Cape Eleuthera, Bahamas (from Tewfik and Béné 2000)

Category	Code	Description
Small Juvenile	SJ	<150 mm siphonal length, no shell lip
Medium Juvenile	MJ	150-200 mm siphonal length, no shell lip
Large Juvenile	LJ	>200 mm siphonal length, no lip
Sub-Adult	SA	<4mm shell lip, prominent spines
Young Adult	YA	>4mm shell lip, prominent spines
Old Adult	OA	>4mm shell lip, worn spines/bioerosion

Population Survey

Visual surveys of queen conch were conducted in a suspected nursery ground off Cape Eleuthera between March and May 2003. Eighteen sites each measuring 200 x 200 m were established in a rectangular pattern (3 sites x 6 sites) encompassing a suspected nursery ground. In each site, three, 3 x 30 m belt transects were run. Live queen conch within each transect were enumerated and assigned to one of six size/age categories (Table 1). Small juveniles were measured (SL, to the nearest mm) using vernier calipers. Water depth and general characteristics of habitat type were also recorded for each site.

RESULTS

Shell Survey

Over 2100 queen conch shells were surveyed from the midden, ranging in size from 100 to 290 mm SL. A total of 1371 shells were adult, with a mean size of 175 mm (± 19.7 SD) (Figure 2), while 769 of the conch were juveniles, with an mean size of 167mm (± 16.3 SD) (Figure 3).

Initial survey of permanent shoreline plots yielded a total of 426 queen conch shells distributed throughout the 9 plots. Juvenile shells accounted for 62.5% of the total, while adult shells constituted 37.5 % of the total number of shells measured (Figure 4).

Population Survey

A total of 489 queen conch were surveyed in 4,860 m^2. Density of queen conch ranged from 0 to 3255 individuals/ha with a mean density of 993 conch/ha (Figure 5). Water depth ranged from 0.8 to 2.1 m with a mean of 1.7 m. All sites contained a habitat type consisting primarily of macroalgae

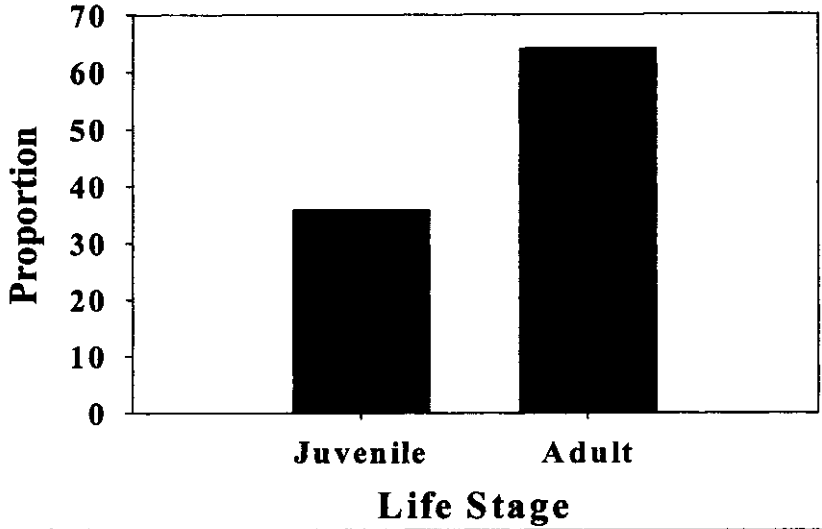

Figure 2. Proportion of juvenile and adult queen conch shells surveyed in October 2003 in a shell midden in Cape Eleuthera, Bahamas

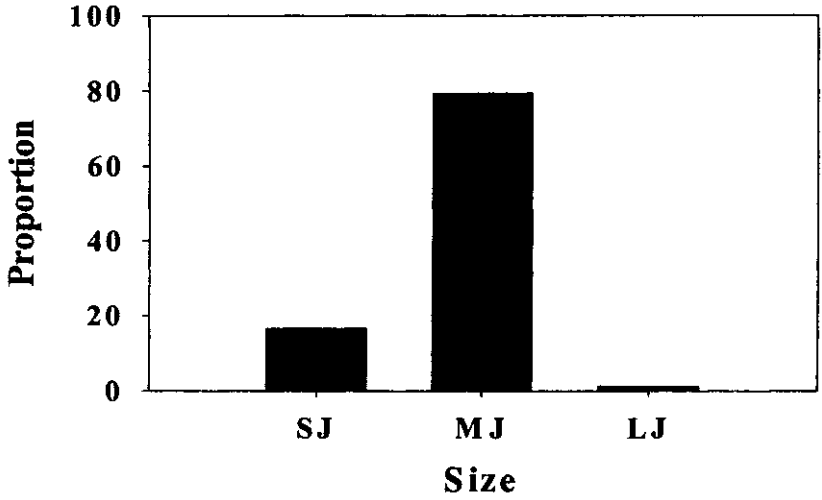

Figure 3. Proportion of small (SJ), medium (MJ), and large (LJ) juvenile queen conch shells surveyed in October 2003 in a shell midden in Cape Eleuthera, Bahamas

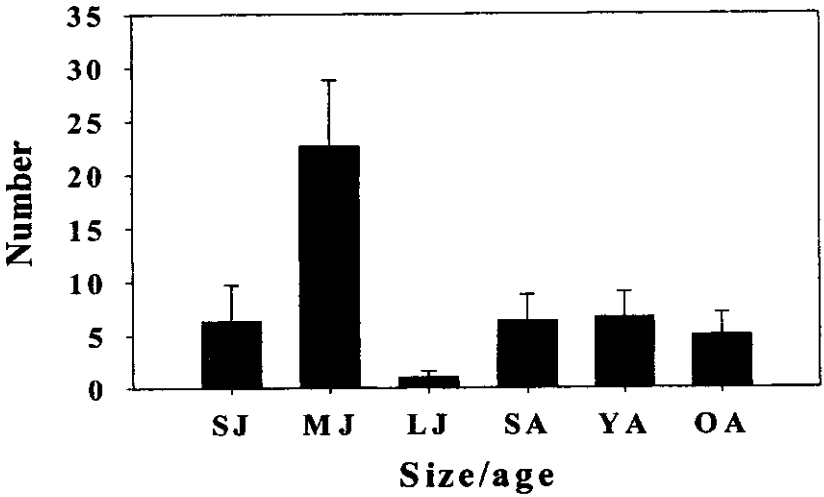

Figure 4. Mean number (± 1 SE) of small juvenile (SJ), medium juvenile (MJ), large juvenile (LJ), sub adult (SA), young adult (YA), and old adult (OA) queen conch shells enumerated during shoreline surveys on Cape Eleuthera, Bahamas, in October 2003

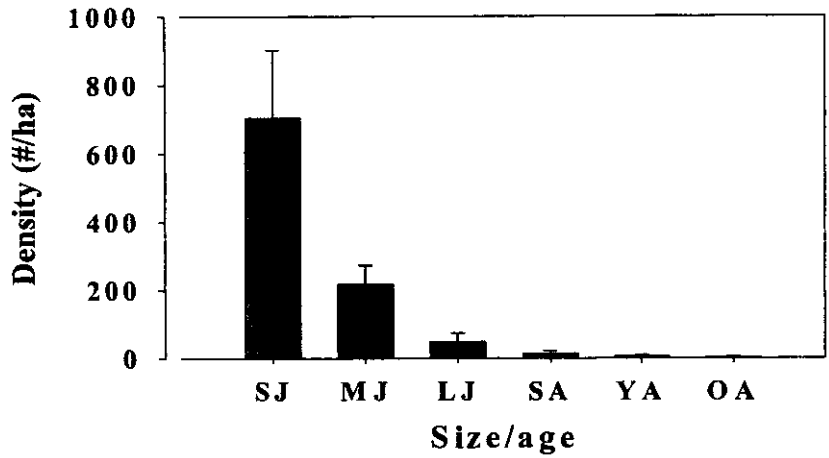

Figure 5. Mean density (± 1 SE) of small juvenile (SJ), medium juvenile (MJ), large juvenile (LJ), sub adult (SA), young adult (YA), and old adult (OA) queen conch surveyed between March and May 2003 in a suspected nursery ground off Cape Eleuthera, Bahamas

(*Laurencia spp., Penicilus spp., and Sargassum spp.*), sparse seagrass, and soft, sandy substrate.

DISCUSSION

Midden and shoreline shell surveys indicate that a high proportion of queen conch currently being harvested from the area around Cape Eleuthera are juveniles. There appears to exist two modes of harvest for queen conch near Cape Eleuthera, which are defined by fishing methodology. The deposition of queen conch shells in middens appears to be the result of a small-scale commercial fishery where fishing occurs from small (<7m) boats. The casual deposition of shells along the shoreline, however, appears to represent a "walk-in" subsistence fishery where fishers wade in shallow water close to shore to search for conch. In both cases, the high proportion of juveniles harvested suggests that either adult conch are becoming more difficult to find, or that juveniles are simply more accessible and that fisheries regulations are not sufficient encouragement for fishers to find adult queen conch.

High densities of small and medium juveniles observed during population surveys indicate that an area to the north-east of Cape Eleuthera is a nursery ground. The mean density of juvenile queen conch in our visual surveys was similar to that found in nursery grounds in the Exuma Cays, Bahamas (Stoner and Waite 1991) but lower than densities observed for a nursery ground in a marine reserve in the Turks and Caicos Islands by Danylchuk et al. (2003). Fishing mortality may limit the density of juvenile queen conch in the nursery grounds near Cape Eleuthera, ultimately affecting the overall population density. In addition, although other characteristics of the sites, such as depth, habitat type, and presence of strong tidal currents, are similar to those of known nursery grounds (Stoner and Waite 1990, Stoner and Sandt 1991, Stoner 1997, Danylchuk et al. 2003), site-specific differences in these characteristics could also affect the juvenile density. A more detailed analysis of habitat and fine-scale visual surveys are needed to better understand the importance of this nursery ground to stocks around Cape Eleuthera.

Protecting the nursery ground off Cape Eleuthera could potentially increase the abundance of queen conch both inside and outside the reserve boundaries by ensuring that a greater proportion of settled larvae reach maturity. Stoner et al. (1998) described the importance of settlement and post-settlement processes as determinants of population size, and stressed habitat (i.e. nursery grounds) as especially important. As such, the protection of juvenile queen conch in the nursery ground off Cape Eleuthera could increase abundances of adult queen conch inside the reserve. Increases in spawning stock would lead, in turn, to an increase in larval export and the spillover effect, thus generating fishery benefits. Although these are only theoretical benefits of a fully protected marine reserve, protected areas have been shown to contain greater abundances of queen conch than adjacent fished areas (Stoner and Ray 1996, Tewfik and Béné 2000).

While ecologically it appears that the inclusion of nursery grounds in the proposed fully-protected marine reserve off Cape Eleuthera could lead to fishery benefits, this study did not address the socioeconomic aspects of imple-

a closure of this area will create conflicts. Appeldoorn (1994) stressed the importance of addressing socioeconomic needs in effective queen conch management. Further research and consideration of the socioeconomic issues is ultimately needed for the success of the proposed fully-protected marine reserve.

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