Size-Dependent Habitat Use of Juvenile Queen Conch (*Strombus gigas*) in East Harbour Lobster and Conch Reserve, Turks and Caicos Islands, BWI

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ABSTRACT

To better understand the habitat requirements of juvenile queen conch, we conducted visual surveys in a variety of habitats within East Harbour Lobster and Conch Reserve (EHLCR) from July 2000 to August 2001. Visual surveys were carried out using integrated line and belt transects at randomly selected sites within the reserve every three to four months. All juvenile conch encountered were enumerated and categorized as small (< 150 mm), medium (150 – 200 mm), or large (> 200 mm), and the habitat type recorded to determine whether ontogenetic shifts in habitat use were evident. The siphonal length of small juveniles was also measured to determine whether habitat use was size-dependent within this category. In addition, because small juveniles often remain in the substrate during the day, we conducted paired diurnal-nocturnal visual surveys in different habitats within the reserve to monitor their emergence. Our results indicate that small, medium, and large juveniles were most abundant in a unique, densely vegetated coral rubble habitat. Algal plain habitat also contained a relatively high number of small juveniles, with the highest densities occurring within a small area (< 5 ha) believed to be a nursery ground. The majority of smaller juveniles (55-90 mm) observed during our surveys were found in this area, primarily at night. From these results we conclude that juvenile queen conch occupy a variety of habitats in EHLCR and that use of these different habitats is size-dependent. Our results also suggest that algal plain habitat may be important for small, post-settlement juveniles, although the generality of this finding remains to be tested.

KEY WORDS: Habitat use, juvenile queen conch, Turks and Caicos Islands

INTRODUCTION

The queen conch (*Strombus gigas*) is an important marine resource that has a long history of supporting subsistence and commercial fisheries throughout its' range (Mulliken 1996). Recently though, queen conch stocks have been overexploited in many areas (reviewed by Appeldoorn 1994), and a variety of measures have been taken to reduce fishing pressure and conserve stocks. One such measure is the establishment of no-take fishing reserves designed to protect critical habitats and enhance queen conch stocks (e.g., Posada et al. 2000, Tewfik and Béné 2000). However, for these reserves to be effective and their benefits sustained, they need to include the critical habitats of all life stages of queen conch, from post-settlement juveniles to spawning adults (Stoner 1997).

Although the habitat use of adult queen conch is well studied, less in known about the habitat requirements of juveniles, particularly small (< 150 mm) individuals. Because queen conch are primarily infaunal during their first year emerging from the substrate only at night to feed (Iverson et al. 1986, 1989), areas inhabited by small juveniles are often overlooked. Even so, it is reasonable to hypothesize that the survival of small, post-settlement juveniles (age 0 to age 1) is higher in areas where food is abundant and the substrate is conducive to burial. It is also likely that as juveniles grow their habitat requirements change, since, for example, their need to bury to avoid predators decreases with size and shell strength (Appeldoorn 1984).

To better understand the habitat requirements of juvenile queen conch, we conducted visual surveys within East Harbour Lobster and Conch Reserve (EHLCR), a no-take fishing reserve off of South Caicos, Turks and Caicos Islands (TCI). During these surveys we examined the distribution and abundance of juvenile queen conch to assess whether habitat use is size-dependent, and to investigate the presence of a suspected nursery ground within EHLCR.

MATERIALS AND METHODS

The TCI are located at the southern end of the Bahamian archipelago, about 180 km north of Hispaniola. South Caicos is situated on the eastern side of the Caicos Bank with EHLCR abutting the island and covering an area of shallow bank approximately 13 km^2 in size (Figure 1).

Manta-tow surveys conducted in April 2000 revealed that most of the queen conch within EHLCR inhabit the eastern quarter of the reserve. As such, our sampling sites were randomly selected from this area using a remote sensing image (the Landsat 7 Thematic Mapper image, September, 1999) and Idrisi 32 (Clark Labs, Worcester, MA, USA). To ensure that the trend we observed during the manta-tow surveys was consistent throughout the year, sites were also periodically surveyed throughout the entire reserve. Surveys were conducted approximately every three to four months, with more than 170 sites surveyed between July 2000 and August 2001.

Three integrated line intercept and belt transects were run at each site. Line intercept transects were 30 m long and were used to determine habitat type. Habitats intercepted by the transect line were assigned to one of six categories based on substrate composition (Table 1). If a transect line intercepted more than one habitat, the distance at which the transition occurred was measured, and the proportion of each habitat type determined accordingly.

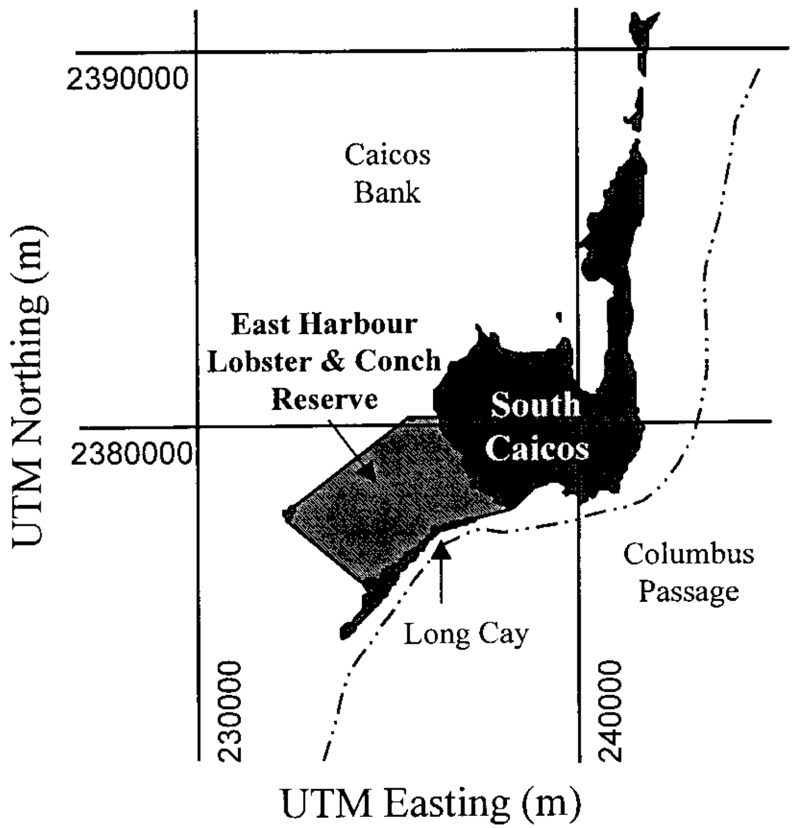

Figure 1. East Harbour Lobster and Conch Reserve, South Caicos, BWI. Coordinates are for the Universal Transverse Mercator (UTM) metric grid system in Zone 19N.

Each intercept transect was bounded by a 3-m wide belt, for a total survey area of 90 m^2 per transect and 270 m^2 per site (3 x 90 m^2). Queen conch found within the belt transect were enumerated and categorized by size/age based on siphonal length (SL), and the development of the shell lip (Table 2). All queen conch categorized as small juveniles (< 150 mm SL) were measured to the nearest mm with vernier calipers.

The abundance of juveniles within the small (< 150 mm), medium (150 - 200 mm), and large (< 200 mm) categories was determined for each transect, and the mean abundance of each size category calculated for all sites. To examine whether habitat use is size-dependent within the reserve, mean abundances were converted to densities (#/ ha) for each site and then compared among habitat types.

Table 1. Habitat categories used during visual surveys of juvenile queen conch in EHLCR (modified from Tewfik and Béné 2000).

Category	Code	Description
Algal plain	AP	Coarse or fine sand with benthic macroalgae (*Laurencia spp.*, *Penicillus spp.*, *Dictyota spp.*, *Batophora spp.)*
Seagrass	SG	Coarse sand bottom dominated by *Thalassia sp.* and/or *Syringodium sp.*
Sand plain	SP	Coarse sand or fine coral rubble with little or no algae or seagrass
Coral rubble	CR	Coarse coral rubble with benthic algae and/or seagrass cover
Gorgonian/sponge	GS	Hard bottom dominated by gorgonians (*Gorgonia spp.*, *Plexaura spp.*, *Pterogorgia spp.*, *Pseudoterogorgia spp.*) and sponges
Coral heads	CH	Small coral heads surrounded by other habitat types; living coral

Table 2. Size/age categories of juvenile queen conch used during visual surveys in EHLCR (from Tewfik and Béné 2000).

Category	Code	Description
Small Juvenile	SM	<150 mm siphonal length, no shell lip
Medium Juvenile	ME	150-200 mm siphonal length, no shell lip
Large Juvenile	LG	>200 mm siphonal length, no lip

To test for differences in the size of small juveniles among habitat types, the mean SL of small juveniles was calculated for each transect and a mean generated for each site surveyed. One site in each of four different habitats where small juveniles were found during the day, was also selected for paired diurnal-nocturnal surveys during each sampling period. The data from all sampling periods were then pooled and day-night length-frequency distributions generated to determine whether small juveniles were more abundant at night within certain habitats.

Data were tested for normality and homogeneity of variance with Shapiro-Wilk and Bartlett tests, respectively (Sokal and Rohlf 1995). When necessary, the data were transformed ($\log_{10}$ or $\log x+1$) to meet the assumptions of parametric statistics (t-test, ANOVA and Tukey's LSD test), and when these assumptions could not be satisfied, non-parametric statistics (Kruskal-Wallis, Mann-Whitney U) were employed. Length-frequency distributions were compared using Kolmogorov-Smirnov two sample tests (Sokal and Rohlf 1995). For all statistical tests, differences among variables were considered marginally significant if $0.1 \geq P > 0.05$ and significant if $P \leq 0.05$. All statistical analyses were performed using Statistica '99 for the PC (StatSoft Inc., Tulsa, Oklahoma USA).

RESULTS

Over the course of our study we encountered more than 5400 juvenile queen conch in six different habitat types, and surveyed over 46,000 m^2 (4.6 ha) of EHLCR. Within the reserve, the density of small (log x+1), medium, and large juveniles was significantly different among habitat types (small, ANOVA $P < 0.01$; medium and large, Kruskal-Wallis, $P < 0.01$), with the densities of all three size categories higher in coral rubble (CR) than in any other habitat type (small, Tukey's LSD, $P < 0.05$; medium and large, Mann-Whitney U, $P < 0.01$; Figure 2). The density of small juveniles was also higher in algal plain (AP) than in seagrass (SG), gorgonian/sponge (GS) or sand plain (SP) (Tukey's LSD, $P < 0.05$), whereas the density of medium juveniles was not significantly different in AP and SG ($P > 0.1$), but was higher in these two habitats than in GS and SP (Tukey's LSD, $P < 0.05$). The density of large juveniles was also higher in SG than in SP (Mann-Whitney U, $P < 0.05$), but not significantly different than in AP, CH, or GS ($P > 0.1$).

Differences in the siphonal length of small juveniles among habitat types were marginally significant (Kruskal-Wallis, $P < 0.1$), with a trend towards larger individuals in CR and coral head (CH) habitats (Figure 3). Day-night comparisons in AP, SG, CR, and SP revealed that more, smaller individuals were present at night in AP, SG, and SP (Figure 4), yet these differences were only statistically significant in AP (Kolmogorov-Smirnov, $P < 0.05$).

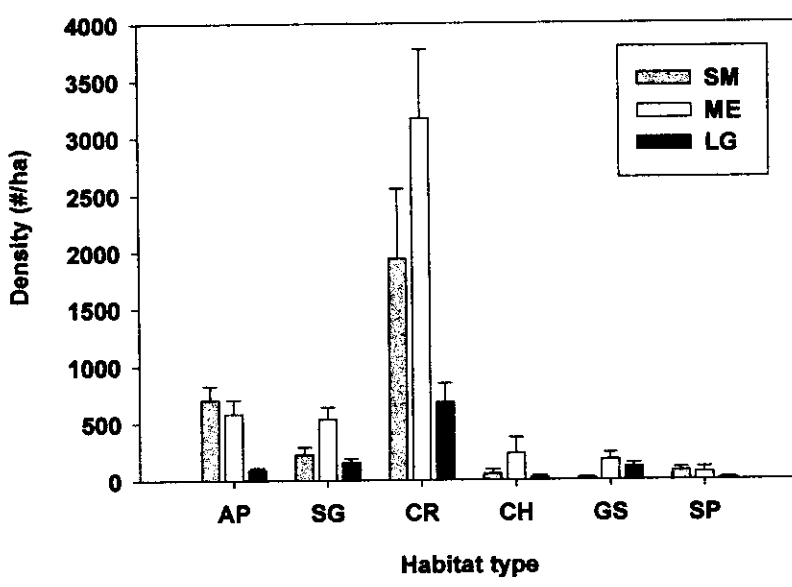

Figure 2. Mean density (± 1 SE) of small (SM), medium (ME), and large (LG) juvenile queen conch observed in different habitats in EHLCR from July 2000 to August 2001. Note: AP = algal plain, SG = seagrass, CR = coral rubble, CH = coral heads, GS = gorgonian/sponge, and SP = sand plain.

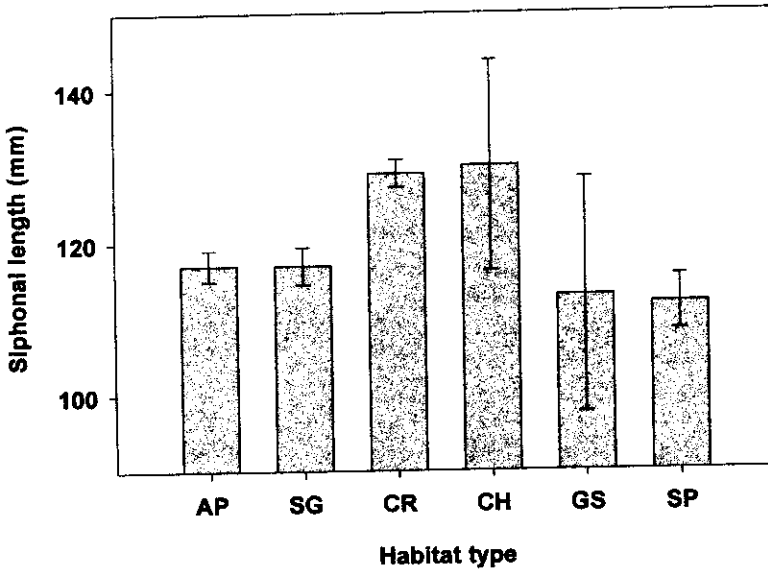

Figure 3. Mean siphonal length (± 1 SE) of small juvenile queen conch found in different habitats in EHLCR from July 2000 to August 2001. Note: AP = algal plain, SG = seagrass, CR = coral rubble, CH = coral heads, GS = gorgonian/sponge, and SP = sand plain.

DISCUSSION

Our results indicate that within EHLCR juvenile queen conch are most abundant in a unique CR habitat overgrown with macroalgae and interspersed with seagrass. Although many small juveniles (< 150 mm) were found within this habitat, the highest number of juveniles between 55 and 90 mm were found within AP, primarily at night. This suggests that within EHLCR larval settlement and juvenile survival may be highest in AP, possibly because the macroalgae within this habitat induce settlement (Boettcher and Target 1996, Davis and Stoner 1994) and provide a suitable food source (Stoner and Waite 1990), while the sandy substrate allows juveniles to bury to avoid predation. On the other hand, no juveniles smaller than 95 mm were found in CR suggesting that the survival of post-settlement juveniles (age 0 to age 1) is low, possibly because the very coarse substrate is not conducive to burial. This notion is supported by our diurnal-nocturnal survey data, which show significant differences in the day-night length frequency distribution in AP but not in CR.

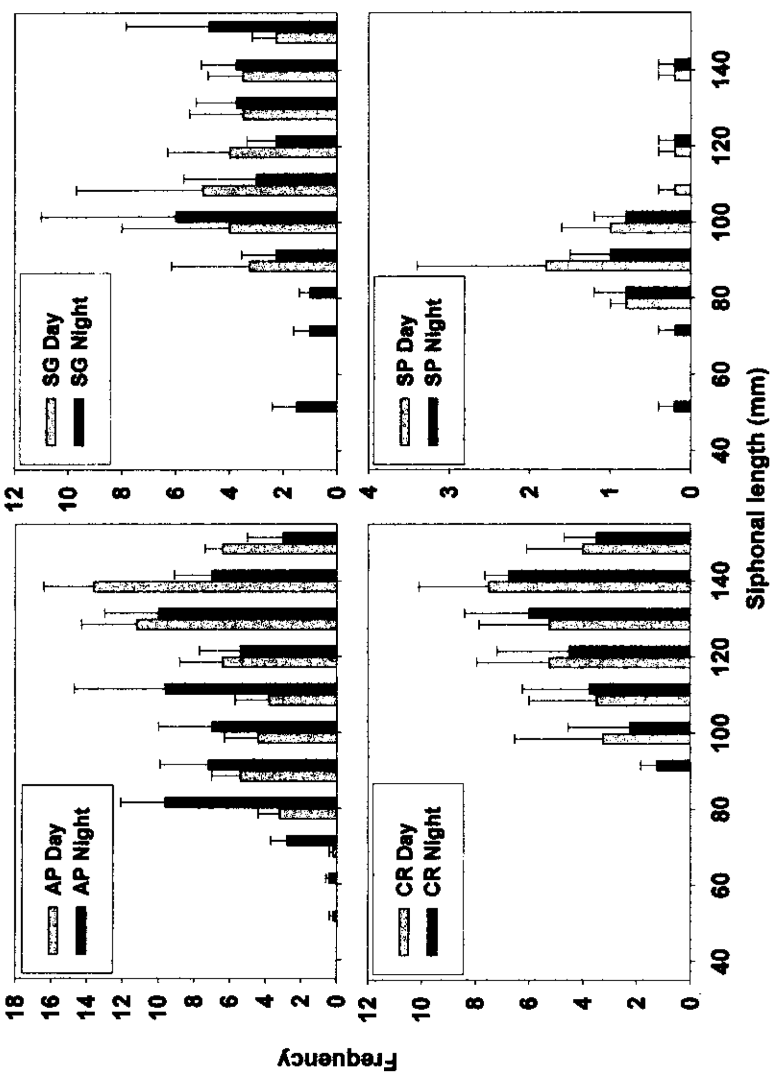

Figure 4. Mean length-frequency distribution (± 1 SE) of small juvenile queen conch observed during paired diurnal-nocturnal surveys in four habitats in EHLCR from July 2000 to August 2001. Note: AP = algal plain, SG = seagrass, CR = coral rubble, and SP = sand plain.

While several studies have identified seagrass as favorable habitat for juvenile queen conch (e.g., Stoner and Waite 1990, Stoner and Sandt. 1991), it is now widely recognized that site-specific factors such as hydrography and predator abundance, likely play a significant role in the establishment and maintenance of nursery grounds rather than habitat type alone (reviewed by Stoner 1997). Although small, post-settlement juveniles did make use of SG and to a lesser extent SP within EHLCR, densities were highest in AP, particularly within a relatively small area (< 5 ha) in the southeast end of the reserve that we believe to be a nursery ground. Additional studies are needed to determine whether the importance of AP habitat in EHLCR is dependent on site-specific factors, or if they are important nursery areas throughout the region.

Preliminary spatial analysis and tagging studies in EHLCR suggest that post-settlement juveniles are moving from the suspected nursery area into adjacent CR habitat (Danylchuk and Rudd, unpublished data). Small juveniles may be moving from the nursery ground where they initially settle into CR when they are larger and no longer need to bury to avoid predation, or are better able to negotiate the coarse CR terrain. Moreover, as they grow juveniles require more food (Ray and Stoner 1995), which might explain why they are moving into the densely vegetated CR habitat and why we found high densities of medium and large juveniles in CR. Regardless of why small juveniles are moving from AP into CR, it is clear that the recruitment of these individuals into suitable areas as they grow is enhanced by the contiguity of critical juvenile habitats. Fortunately in the case of EHLCR, these critical habitats are within the reserve boundaries and therefore protected, however, our study underscores the importance of understanding the habitat use of all life stages of queen conch in designing no-take reserves.

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