Juvenile Queen Conch Survival in Similar Seagrass Habitats

L. S. MARSHALL JR. and R. N. LIPCIUS
Caribbean Marine Research Center
Lee Stocking Island
Exuma Cays, Bahamas
Department of Fisheries Science
Virginia Institute of Marine Science
The College of William and Mary
Gloucester Point, Virginia 23062 USA

ABSTRACT

Predation-induced mortality in juvenile queen conch, *Strombus gigas*, was quantified and the importance of select habitat and conch characteristics affecting predation intensity was assessed. Experiments were conducted in summer and early fall from 1987 through 1991 in shallow-water seagrass beds near Lee Stocking Island, Exuma Cays, Bahamas. Specific factors examined in field experiments included: (1) conch size (80-140 mm total shell length), (2) conch density (0.21-3.0 conch/m^2), (3) habitat type (seagrass beds with and without resident conch), and (4) stock type (hatchery-reared and wild juveniles). Of these factors, the impact of habitat type was most important - conch mortality was consistently and significantly lower in seagrass beds with resident conch than in beds without residents. These findings indicate that habitat type plays a critical role in mediating predator-induced mortality upon juvenile queen conch. Our discussion emphasizes the ecological and fishery implications of these findings.

INTRODUCTION

The queen conch, *Strombus gigas*, is a prosobranch gastropod widely distributed throughout shallow waters of Bermuda, the Bahamas, southern Florida, and the Caribbean (Randall, 1964). Its population biology has been studied in various locations including the Berry Islands, Bahamas (Iversen *et al.*, 1986), Cuba (Alcolado, 1976), the Virgin Islands (Randall, 1964), Venezuela (Weil and Laughlin, 1984) and Caicos Islands (Hesse, 1979). Throughout its geographic range, the queen conch is an important commercial species, but has recently experienced dramatic declines in many areas largely due to over-exploitation (Adams, 1970; Brownell *et al.*, 1977; Brownell and Stevely, 1981). Recent attempts to manage and enhance existing populations have been hindered by a lack of knowledge regarding key ecological factors affecting queen conch survival in natural habitats. In addition, previous studies on survival of juvenile queen conch in natural habitats have failed to incorporate the interactive features of predators, prey and habitat. In a series of field experiments predation-induced mortality upon juvenile queen conch, *Strombus gigas*, was examined and the importance of select habitat and conch characteristics affecting predation-intensity was assessed. Initial experiments examined the survival of juvenile conch as a function of conch size, conch density, and habitat type. These experiments were followed by an investigation of the hypothesis that juvenile conch survival in seagrass beds is due to variations in predation-induced mortality. This latter hypothesis also examined conch survival as a function of the proximity to habitats containing resident conch. Based on findings from initial experiments, the survival, growth and burial activity of wild and hatchery-reared juvenile conch in natural seagrass habitats were subsequently compared. Lastly, the use of tethering as a tool for estimating juvenile conch survival in natural habitats was examined.

METHODS AND MATERIALS

Study sites

All experiments were conducted in shallow-water seagrass beds and adjacent sand flats near Lee Stocking Island, Exuma Cays, Bahamas. Lee Stocking Island (LSI) is located at the southeastern edge of the Great Bahama Bank (23° 45' N, 76° 05' W), adjacent to Exuma Sound. To the west and southwest of LSI, large portions (2-40 hectares) of uniform seagrass beds serve as nursery grounds for 0^+ - 3^+ year-class juvenile queen conch. These juveniles have consistently been observed at moderate to high densities in at least two locations in seagrass beds near LSI (Wicklund *et al.*, 1988, pers. obs.). The nursery grounds are generally characterized by shallow water depths of three to four m; year-round surface water temperatures between 22°-32 °C; underwater visibility between 15-25 m; poorly sorted, medium to coarse grained calcareous sediments; and dense to sparse cover of *Thalassia testudinum, Syringodium filiforme, Penicillus capitatus* and other calcareous algae. Stoner *et al.* (1988), Wicklund *et al.* (1988), and Herrnkind and Lipcius (1989) provide additional detailed habitat and environmental descriptions of the area.

Experimental Procedures

In the field experiments tethering, which measures relative predator-induced mortality rates between experimental treatments (Heck and Thoman, 1981; Herrnkind and Butler, 1986; Wilson *et al.*, 1987; Eggleston *et al.*, 1990) was exmployed. The technique is not intended to measure absolute rates of predation.

Tethering techniques used in this study were similar to those described by Marshall *et al.* (in press). Briefly, one end of a monofilament line approximately 60 cm long was tied to a cable tie; the cable tie was then locked around the spire of the experimental conch. The other end of the line was attached to a stainless steel rod (approximately 25 cm in length), thus completing the tethering process. Tethered conch were then placed in experimental plots (area: 20-30 m^2). The number and size of conch used in these experiments depended on the specific size and density ranges being tested. Below we provide a brief description of the factors and variables examined in four separate experiments:

Experiment I. The survival of tethered queen conch was measured as a function of conch size (80-100 mm and 120-140 mm total shell lengths), and conch density (experimental: 0.21 conch/m^2 and 0.81 conch/m^2; ambient: 0.21-3.0 conch/m^2). Experimental plots were established in two seagrass beds of similar environmental features (*i.e.*, grass densities, sediment characteristics, detrital material, and water depth). A key difference between the two sites was in the abundance of resident benthic organisms: initial survey of site 1 indicated varying densities of juvenile conch and associated epibenthic predators, while site 2 was devoid of resident conch but contained a small number of epibenthic predators (less than two predators per 20 m^2).

Experiment II. Based on the observed patchy distribution of juvenile conch in apparently similar seagrass beds, it was hypothesized that such a pattern results in part from variations in the distribution of prey and predators. This hypothesis was examined by tethering juvenile conch (80-100 mm TSL) within three replicated treatments: two seagrass beds with resident conch, and two seagrass sites each at 50 and 350 m outside the area containing resident conch.

Experiment III. Comparisons were made of the survival of hatchery-reared and wild juvenile queen conch by examining two key features - stock type (wild and hatchery-reared), and habitat (seagrass beds with and without resident conch). Conch utilized in these experiments ranged between 60-82 mm total shell length with nominal plot densities of 0.41 conch/m^2. In each of the two experimental seagrass beds, plots containing hatchery-reared conch were systematically interspersed with plots containing wild conch.

Experiment IV. This experiment compared the predation-induced mortalities on tethered and non-tethered 80-100 mm TSL conch in the presence and absence of resident conch (60-180 mm TSL). The experimental approach used in this study involved the use of large (4 m diameter), wire mesh enclosures constructed in a uniform, moderate density seagrass bed.

RESULTS AND DISCUSSION

Experiment I. The survival of tethered queen conch measured as a function of conch size, conch density and habitat type (seagrass with and without resident conch), indicated no effect of conch size on predation-induced mortality rates in experimental sites. Mortality rates did not differ significantly between vegetated sites, however the impact of nominal conch densities on mortality rates differed within the two vegetated sites. In the seagrass bed with resident conch, conch mortality was inversely density-dependent, with highest proportional mortalities in nominal low densities and lowest mortalities at high nominal densities. A similar pattern was observed when proportional mortalities were analyzed as a function of ambient conch densities. There were no significant density effects in the seagrass site without resident conch. The mortality pattern observed in the seagrass containing resident conch in part explains the continued persistence of juvenile conch within the experimental area.

Experiment II. This examination of the hypothesis that the patchy distribution of juvenile conch in large seagrass meadows near Lee Stocking Island result in part from variations in predation-induced mortalities, cumulative mortalities varied significantly as a function of site and distance: mortalities were characteristically low in experimental sites containing resident conch (0 m sites), and highest in experimental sites furthest away (350 m) from sites with resident conch. Mortalities in experimental sites bordering areas containing resident conch were variable; being significantly higher at the CBC 50 m site than the TB 50 m site. Furthermore, epibenthic predators were not concentrated in areas containing resident conch. Hence, seagrass beds with resident conch appear to enhance conch survival. The observed pattern of juvenile conch predation-induced mortalities is only partially explained by seagrass biomass densities and epibenthic predator occurrences, both of which varied significantly between and across experimental sites. Juvenile conch survival in the experimental seagrass sites is site-specific: the presence of resident conch has a positive impact on the survival of juvenile queen conch. Observed patterns of juvenile conch survival may therefore reflect interactions between predator, prey, and several habitat variables.

Experiment III. Comparisons of survival rates between hatchery-reared and wild juvenile conch indicated that mortality was dependent upon the habitat into which conch were outplanted. Furthermore, the habitat effect swamped the effect of stock type upon mortality. Both hatchery-reared and wild conch exhibited significantly lower mortality in a seagrass bed with resident conch than in a seagrass bed without resident conch; a portion of the mortality observed in hatchery-reared conch was probably due to factors other than predation (*e.g.*, handling stress). The habitat effect was apparently due either to the presence of resident conch, or to some factor associated with the seagrass bed harboring resident conch. Although there were some differences in survival between hatchery-reared and wild conch, these findings indicate that habitat features are more important in the control of conch survival, and therefore that the use of hatchery-reared juvenile conch can be a viable strategy in the replenishment, augmentation, and management of wild queen conch stocks, if habitats are selected wisely.

Experiment IV. Mortality rates of tethered conch were not significantly different from non-tethered animals, while treatments containing free ranging resident conch experienced significantly lower mortalities than treatments without residents. In treatments containing both experimental and resident conch (*i.e.*, tethered plus resident conch; and tagged, non-tethered conch plus residents), mortality rates were significantly lower for residents than experimental conch. Since resident conch spanned a range of sizes and were generally larger that experimental conch, their increased survival may be a function of larger size. The presence of strong, non-significant interaction effects in statistical analysis indicate that only minimal if any artifacts were introduced by the tethering technique during the study. These results, combined with findings from previous similar tethering experiments indicate that tethering provide consistent and reliable estimates of relative rates of predation on juvenile queen conch in different seagrass habitats.

We conclude that various factors act interactively to produce habitat specific mortality rates in queen conch due to predation. These include: (1) habitat type, whereby seagrass beds offer some protection; (2) local population dynamics, such that populated seagrass beds exert a positive influence on conch survival; (3) in some seagrass beds, mortality is positively or inversely density-dependent as a function of population and local densities; (4) conch size, depending on specific type of habitat; and (5) predation intensity and predator guilds, which likely differ across habitats, producing habitat-specific mortality rates.

LITERATURE CITED

Adams, J. E. (1970). Conch fishing industry of the Union Island, Grenadines, West Indies. *J. Trop. Sci.* **12**: 279-288.

Alcolado, P. J. (1976). Growth, morphological variations of the shell and some biological data of the conch *Strombus gigas* L. (Mollusca: Mesogastropoda). *Acad. Cien. Cuba Ser. Oceanol.* **34**: 1-26 (English Translation).

Brownell, W. N., C. J. Berg and K. C. Haines (1977). Fisheries and aquaculture of the conch, *Strombus gigas*, in the Caribbean. *FAO Fisheries Rept.* **200**: 59-69.

Brownell, W. N. and J. M. Stevely (1981). The biology, fisheries, and management of the queen conch, *Strombus gigas*. *Mar. Fish. Rev.* **43** (7):1-12.

Eggleston, D. B., R. N. Lipcius and D. L. Miller, Coba-Cetina, L. (1990). Shelter scaling regulates survival of juvenile Caribbean spiny lobster *Panulirus argus*. *Mar. Ecol. Prog. Ser.* **62**: 79-88.

Heck, K. L., Jr. and T. A. Thoman (1981). Experiments on predator-prey interactions in vegetated aquatic environments. *J. Exp. Mar. Biol. Ecol.* **53**: 125-134.

Herrnkind, W. F. and M. J. Butler (1986). Factors regulating postlarval settlement and juvenile microhabitat use by spiny lobsters *Panulirus argus*. *Mar. Ecol. Prog. Ser.* **34**: 23-30.

Herrnkind, W. F. and R. N. Lipcius (1989). Habitat use and population biology of Bahamian spiny lobster. *Proc. Gulf Carib. Fish. Inst.* **39**: 265-278.

Hesse, K. O. (1979). Movement and migration of the queen conch, *Strombus gigas*, in the Turks and Caicos Islands. *Bull. Mar. Sci.* **29**: 303-311.

Iversen, E. S., D. E. Jory and S. P. Bannerot (1986). Predation on queen conchs, *Strombus gigas* in the Bahamas. *Bull. Mar. Sci.* **39**: 61-75.

Marshall, L. M., Jr., C. Cox and R. N. Lipcius (in press). Survival of wild and hatchery-reared juvenile queen conch, *Strombus gigas* (Linne) in natural habitats. *Fish. Bull.*, U.S.

Randall, J. E. (1964). Contributions to the biology of the queen conch, *Strombus gigas. Bull. Mar. Sci.* **14**: 246-295.

Stoner, A. W., R. N. Lipcius L. S. Marshall, Jr. and A. T. Bardales (1988). Synchronous emergence and mass migration in juvenile queen conch. *Mar. Ecol. Prog. Ser.* **49**: 51-55.

Weil, M. E. and R. A. Laughlin (1984). Biology, population dynamics and reproduction of the queen conch, *Strombus gigas* Linne in the Archipelago de Los Roques National Park. *J. Shell. Res.* **4**: 45-62.

Wicklund, R. I., L. J. Hepp and G. A. Wenz (1988). Preliminary studies on the early life history of the queen conch, *Strombus gigas* in the Exuma Cays, Bahamas. *NOAA Symp. Ser. Undersea Res.* **6**: (in press).

Wilson, K. A., K. L. Heck, Jr. and K. W. Able (1987). Juvenile blue crab, *Callinectes sapidus*, survival: An evaluation of eelgrass, *Zostera marina*, as refuge. *Fish. Bull.* **85**: 53-58.