Research on First Year Queen Conch, *Strombus gigas*, Relevant to Fisheries Management

EDWIN S. IVERSEN[1], DARRYL E. JORY[1] and DANIEL J. DIRESTA[2]
[1]*University of Miami*
Rosenstiel School of Marine and Atmospheric Science
Division of Marine Biology and Fisheries
4600 Rickenbacker Causeway
Miami, Florida 33149-1908.
[2]*University of Miami*
Department of Biology
Coral Gables, Florida 33124

ABSTRACT

There is a pressing need for biological information on the queen conch, *Strombus gigas*, because of the decimated condition of stocks in the Caribbean and throughout the Florida Keys. Considerable progress has been made during the past decade in our understanding of various aspects of conch biology and population dynamics. However, most of this new knowledge pertains to large juveniles (> 5 cm shell length, SL) and adults; our knowledge of the first year (FY) queen conch is still relatively inadequate for stock management purposes.

In this paper we summarize known features of the early life history of queen conch from literature and recent field studies including distribution of planktonic stages, settlement, population sizes and factors affecting these. We also discuss management alternatives available for augmenting natural populations through selective planting of hatchery-reared seed, and transplantations of young to habitats more favorable for their growth and survival.

INTRODUCTION

The early life history of queen conch, *Strombus gigas*, is one of dramatic habitat changes. The egg masses are usually deposited in deep water on sandy bottoms with strong currents. Upon hatching they leave this brief sedentary-benthic life and drift in the water column. On metamorphosis, they settle upon the water-substrate interface. Soon thereafter they apparently bury in the substrate for a considerable time, perhaps as long as a year. They emerge when they reach about 5 cm shell length (SL) and spend more time grazing at the substrate surface on detritus and microalgae, and less time buried. Despite the considerable commercial and recreational value of queen conch, little is known of their first year of life (FY) in nature.

The purpose of this paper is to review what is known about the FY conch, survival strategies and distribution, and to question the future role of the hatchery in sustaining viable fisheries. The apparent extended period of burying raises special questions about how these tiny creatures survive in what must be a hostile environment, where obtaining adequate dissolved oxygen and food are critical as is the means of waste removal. Developing reliable methods of assessing the population size of buried FY conch is an especially challenging problem facing researchers.

Surveys have shown that there are large areas which seem to be suitable for conch to grow to market/maturity sizes, yet few or no conch are found in these areas. Is transplantation a viable option for improving queen conch production?

METHODS AND MATERIALS

In our field studies in the southern Berry Islands (Bahamas), individual conch were identified with thin plastic tags attached with underwater epoxy (Iversen *et al.*., 1987) on several experiments. Counts of tagged conch in the shallow intertidal waters were made while wading, and in the deeper off shore water investigators used snorkel gear on 23 samples approximately 5 weeks apart covering the period May 1980 to February 1983. In the nursery areas, small conch (5 cm SL) were marked with yarn to indicate their location and depth buried.

We used a suction dredge to sample various substrates for FY conch. The dredge employs the Venturi principle. A Tee centrifugal pump with a 5-cm inlet and discharge, powered by a 5 hp Briggs and Stratton gasoline engine, provided the suction. The pump delivered over 37,850 liters of sea water per hour with a head of less than 3 m. A small mesh (5 mm) dive bag was placed over the Venturi outlet to retain and sieve the samples.

RESULTS AND GENERAL DISCUSSION

In summarizing known features of the early life history of queen conch from literature, we have drawn on available information from several authors such as Robertson (1959), Randall (1964), Brownell *et al.* (1977) and others.

Spawning

Conchs are mature at an age of about three and a half years and have a well developed flared lip. Breeding takes place during the warm months. During mating the male inserts an organ called a "verge" into the female and fertilizes her eggs. When the eggs are released, usually in deep water, sand grains stick to the gelatinous egg strands. The sand is believed to camouflage the egg mass and anchor it to the bottom. Estimates of eggs released at a single spawning vary from about a quarter of a million to three-quarters of a million. A single female may spawn 6 times during the warm months. Percent hatching is high, judging from hatchery results.

Planktonic Stage

The length of time queen conch spend in the planktonic stages is based on several different data sets from different hatcheries and research laboratories, each using somewhat different culture parameters. Generally, it ranges between 13-35 days from hatching with an average time of about 3 weeks in the plankton before settlement. Soon after hatching, two rounded ciliated lobes appear, then four and finally six. The larvae retain metamorphic competence to settle for a period of about three to four days. If settlement is not accomplished within this time, the larvae die (Mianmanus, 1988).

The role of ocean currents in distributing mollusks with planktonic larvae over long distances has been suggested by the presence of larvae in both near shore and oceanic waters (Berg, 1975 and 1976; Laursen, 1981; Scheltema, 1986a, 1986b). Whether oceanic larvae survive long distance transport and contribute to downstream populations is questionable. Recently, the application of biochemical genetic techniques to determine the extent of gene flow in conch populations has provided some evidence that transport of larvae by ocean currents plays an important role in larval distribution throughout the Caribbean. Based on analysis of allelic frequencies at several polymorphic loci among different Caribbean populations, Mitton *et al.* (1989) have concluded that extensive gene flow occurs due to downstream populations experiencing high recruitment from upstream populations. Both recruitment of adults from planktonic larval pools and the spread of larvae over long distances from parents contribute to the apparent lack of geographic structure among the populations. Specific discontinuities in allelic frequencies between local populations in close proximity may be due to complex currents which restrict gene flow.

In addition to sharing with electrophoretic protein surveys the possibilities for assaying genetic diversity among and within natural populations, restriction assays of mitochondrial DNA provides additional information. Since both male and female progeny inherit maternal mtDNA but only females subsequently transmit mtDNA to future generations, mtDNA variation can be used to examine the evolutionary history of female movement and survival in conch populations. This is of particular interest for populations which appear to be self-sustaining, such as in Bermuda and Barbados, where retention of offspring in local circulation patterns is the major source of recruits Mitton *et al.* (1989). Studies of mitochondrial DNA restriction patterns to identify variation among mitochondrial genotypes of selected populations are currently in progress in our laboratory.

Behavior at Settlement

When larval conch discard their ciliated velar lobes settlement follows immediately. Settlement has been achieved in about three hours in the laboratory (Mianmanus, 1988). A shell growth period follows; next shell growth stops and organ system differentiation is apparent.

Nine species of red algae were tested by Mianmanus (1988) to determine the degree of substrate specificity of metamorphosing queen conch larvae. The experimental larvae metamorphosed on all nine algal species suggesting that queen conch larvae are not highly specific to algal species.

Conch Distribution

The distribution of juvenile queen conch in the southern Berry Islands and Exuma, Bahamas varies greatly from cay to cay. We visited 14 cays on the Great Bahamas Bank and saw large cays with what appears to be suitable conch substrate, but only a few or no, conch were found.

The distribution of juveniles around some cays and not others raises the question of what factors control distribution. Based on the positions of cays with and without juvenile conch populations and the inferred prevailing water currents, it is our contention that particular tidal transport and positions of cays is very important in carrying the planktonic stages of conch to a suitable place for settlement. It would also seem that an extended period of slack water is necessary for the conch to be able to settle out of the water column and "hold on" to the bottom so as not to be swept back out to sea on the ebbing tide. This requirement means that the settlement area should have a rather large tidal range and a gentle slope off the beach.

Emery (1972) found that littoral animals with long pelagic larval stages were more abundant in areas influenced by eddies than in exposed areas. He postulates that eddies in island wakes may provide the retaining potential in an oceanic situation. The "island mass effect", which refers to enhancement of primary production by increased nutrient availability around oceanic islands (Jones, 1962; Sander, 1981), may also play a role in settlement of FY conch and subsequent survival.

Selectivity of Substrate

In searching for buried small wild conch we found significantly greater numbers in depressions than in flat areas. Using red yarn, 100 hatchery-reared conch (approximately 3 cm SL) were marked and released at random in an area of Bird Cay-Cat Cay Channel known to contain FY wild conch. After 14 days, 51 of the 67 live conch found (79 %) were recovered in depressions.

Samples of particle sizes in the substrate were sieved from location in the Cat/Bird Channel on May 23, 1987 and again July 1988 in a location where most FY conch were found. The pattern of particle size in depressions in Cat/Bird Channel varies greatly but suggests that the preference of FY conch may be based in part on areas with a high percentage of large particles.

Depth and Time of Burial

In the two areas we surveyed for FY conch the most productive one was the Cat Cay/Bird Cay Channel on the south Berry Islands. FY conch were found on the substrate surface and just beneath the surface in broken shell-coral rubble.

The deepest conch found was at about 21 cm. Judging from the number of conch just above FY sizes present there, we believe that large numbers of FY conch should be buried close by. However, we were unable to find any large, high density concentrations. The majority of FY conch appear to bury for about one year.

Better results were obtained at Norman's Cay, Exuma, where 33 conch under 5 cm SL were collected from samples taken at mean depths of 45 cm.

Transplantation

The management concept and technique of transplanting individuals of a species of both land and sea animals from an area of high density to one of low density to increase production is not new. For example, some oyster farmers routinely "relay" oysters. The objective is to reduce interspecific competition for the necessities of life and thereby produce higher survival and larger, better shaped oysters. This procedure consists of harvesting young oysters from areas with a heavy natural spat fall, breaking up large clusters of oysters and returning them to the oyster bar.

Emmett and Jamieson (1988) concluded that it is feasible to transplant 50-100 mm northern abalone (*Haliotis kamtschatkana*) in British Columbia in order to enhance their growth.

There are numerous reports of density-dependent growth rates in queen conch (Alcolado, 1976; Iversen *et al.* 1986; Weil and Laughlin, 1984; Appeldoorn and Saunders, 1984). Iversen *et al.* (1987) found that juvenile queen conch confined in pens grew extremely slowly, or not at all. It seems likely that for herbivorous gastropods like queen conch, reduced growth from high density may be more directly related to competition for food than it might be in filter feeding mollusks such as clams and oysters. Reports of very large concentrations of queen conch have been made by Stoner *et al.* (1988) in the Exuma Cays (570,000 juveniles), and by Hesse (1979) in Turks and Caicos. It is likely that many large aggregations have occurred that have not been reported in the scientific literature. Such large aggregations could be expected to occur occasionally in highly fecund species such as the queen conch when environmental conditions are optimum for settlement, growth and survival. In our surveys of conch distribution in the Berry Islands we found many areas that would seem to be ideal for conch to live, but they had only a few or no conch. These small populations may be due to the lack of suitable currents to carry the planktonic stages of the conch to the area, or to extremely high predation on young juvenile conch in that area, or possibly a combination of these factors.

We suggest that transplanting conch of the proper size to avoid the majority of predators into habitats that would encourage rapid growth has merit to increase production of this valuable species.

Augmenting Natural Populations with Hatchery Seed

Over 15 years ago seeding of suitable areas with hatchery-reared conch juveniles was proposed as a means to augment or re-introduce conch populations (Brownell *et al.* 1977). During the 1980s various researchers suggested that this could be accomplished by releasing 1-2 cm conch.

However, it seems doubtful that releasing small hatchery-reared juvenile conch (< 5 cm SL) will be very successful in augmenting wild stocks due to the extremely high natural mortality after release. Conch are preyed upon by a large variety of predators, including several species of other mollusks, crustaceans, fishes and marine turtles. Predation pressure is particularly intense on the smaller animals, and diminishes as the animals grow (Coulston *et al.*, 1987; Iversen *et al.*, 1986; 1987; Jory and Iversen, 1983). Our experiments have shown that the shell strength of young conch increases considerably after 60 mm SL, and we recommend this as the minimum release size for conch planting projects (Jory and Iversen, 1988) To raise juvenile conchs to a much larger size so that they can escape heavy predation is costly, so that a compromise between desired size at release and cost must be reached.

Stoner (in press) suggests using "simple transplant experiments" to determine the suitability of "outplanting" of hatchery-reared stocks. We recommend field trials that consider different season and time of the day for release, factors which are known to affect predation on young conch (Jory and Iversen, 1983).

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