QUEEN CONCH STOCK RESTORATION

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INTRODUCTION

Queen conch are found in predominantly south Florida from the Florida Keys to Key Biscayne. They once constituted significant commercial and recreational fisheries in Florida. In 1975, the commercial fishery was closed due to overfishing. This ban was extended to the recreational fishery in 1985 in state waters (Florida Administrative Code, Chapter 68b-16.003) and 1986 in contiguous federal waters for those aboard vessels registered in Florida (Florida Administrative Code, Chapter 68b-16.005). In 1986, the State of Florida began a research program designed to monitor the recovery of the conch stock and to determine how best to rehabilitate the depleted population. The queen conch program has taken a 'community-based' approach; most of the laboratory and field studies were conducted under partnerships involving the State, the U.S. Fish and Wildlife Service, The Nature Conservancy, and an extensive base of community volunteers.

RESEARCH RESULTS

Stock Assessment/Monitoring

In 1986, the State began a program to monitor the recovery of the conch stock after the closure. From 1987 through 1993, we conducted surveys using towed-divers. These surveys showed that the population was not recovering on its own (Glazer and Berg, 1994; Berg and Glazer, 1995).

In 1992, we began to shift our focus towards the conch spawning stock and stock restoration. The spawning stock surveys were conducted using belt-transects at all spawning aggregations located on the reef tract. These surveys examined up to 27 aggregations from Key Largo to Key West on a yearly basis. The surveys determined densities (conch per m^2) within the

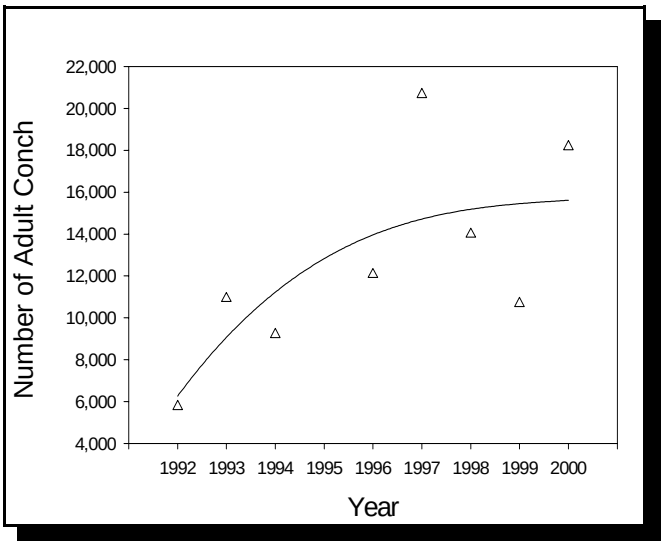

Figure 1. Estimates of adult spawning stock of queen conch in offshore aggregations from surveys conducted from 1992 through 2000.

aggregations and the area encompassed by each aggregation. The number of conch in each aggregation was estimated by multiplying these two parameters.

Through 1997, we observed an overall increase in the number of adult conch within the aggregations (Figure 1). The minimum number of adult conch we observed was approximately 5,750 in 1992 and the maximum was 20,650 in 1997. In 2000, we estimated that there were approximately 18,200 adult conch within spawning aggregations in south Florida. We also observed an increase in the area encompassed by the aggregations.

Larval Surveys

Conch recovery in south Florida has been slower than we anticipated after the closure of the fishery. Since recovery is dependant on the supply of larvae, we initiated a series of studies designed to determine the origin of conch larvae supplying south Florida's conch population. In 1990, we conducted experiments that demonstrated that the conch population in south Florida was not isolated from other populations in the Caribbean and that there was a component of the Florida conch population that originated elsewhere (Campton et al., 1992). The next step was to determine the extent of the contribution to the south Florida conch population from upstream sources in the Caribbean region (e.g., Mexico, Cuba, Belize). In 1996, we began a study to examine the extent of the contribution from to larvae recruiting to south Florida. (Hawtoff et al., 1998). The results from this study showed that few larvae were entering the Florida Keys and that the contribution from Caribbean sources was minimal. Thus, we determined that increasing the local spawning stock should result in increased larval availability.

Two additional studies supported this conclusion. In 1992, we conducted a study in conjunction with a NOAA partner, the Caribbean Marine Research Center, to determine the larval supply to Looe Key in the Florida Keys and to compare it with a population in the Bahamas where conch are abundant. This study demonstrated that larval conch abundance in Florida was an order of magnitude lower than in the Bahamas (Stoner et al. 1996). In 1997, we repeated our surveys at Looe Key. In this study, we demonstrated that the larvae were an order of magnitude more abundant than in the previous survey (Hawtoff et al., in press). The increase in larval abundance occurred simultaneously to the increase in the spawning stock (Figure 1). This led further support to our conclusions which suggested that the local spawning population is a critical source of larvae supplying south Florida.

Thus, based on our surveys of the spawning stock and on our larval surveys, we believe that the slow rate of recovery of the Florida conch population is due mainly to limited larval availability. We also believe that the recovery of the local conch stock will not occur rapidly until the local spawning stock increases substantially beyond the current levels and that further enhancement of the spawning stock is critical to rehabilitating the south Florida conch population.

Stock Restoration

We conducted a series of field and laboratory experiments with the goal of evaluating the efficacy of using hatchery-reared juvenile conch to supplement the wild spawning stock. Specifically, we examined the variables that limit post-release survival and examined how to maximize that survival. All animals used in the experiments were produced at our research-scale conch hatchery on Long Key in the Florida Keys. Table 1 presents the variables that were examined and the results from those experiments. Based on the results of the experiments, we determined that we should release 10-cm (approximately 4 inches) conch in the fall on upcoming full moons. Additionally we determined that the release site should be distant from areas of high predator density. We determined that exposing a hatchery-reared conch to a caged predator prior to release resulted in development of optimal behavioral and morphological characteristics that will result in significantly greater survival than those conch that are not exposed. After these experiments were complete, we coupled the cost of seed production with post-release survival to determine the cost per 15-cm (approximately 6 inches) survivor. We determined that a 10-cm conch released in the fall on upcoming full moons and surviving to 15-cm costs approximately $9.00 per individual.

Table 1. Variables examined and the results of experiments in the queen conch stock restoration assessment. References cited are (1) Glazer and Jones, 1997; (2) Glazer and Delgado, 1999; (3) Delgado et al., 2000; and (4) Delgado et al., in prep.

Variable	Result	Reference
Season	Fall was optimal	1
Lunar Phase	Full Moon was optimal	1
Size	9-cm was optimal	2
Predator Density	Better survival distant from optimal predator habitat	1
Behavioral Deficits	Conch can be 'trained' to bury	3,4
Morphological Deficits	Exposure to predator results in greater shell weight	3,4
Predator Exposure	Exposure to predator results in greater survival	4
Cost to Seed	a 10-cm conch released in fall and surviving to 15-cm costs approximately $9.00	2

ISSUES

Issue 1. Reproductive Failure in Nearshore Conch

Conch in the Florida Keys are distributed within two disparate zones (Figure 2). In the offshore zone, conch are found in discrete aggregations in coral rubble and sand environments in the back reef. In the nearshore zone, conch are located in the hardbottom community adjacent to the shoreline. Conch distribution within the nearshore zone is, for the most part, widespread. Juvenile and adult conch do not migrate between the two zones because the silt which characterizes the bottom of Hawk Channel is poor habitat for conch and effectively serves as a barrier (Berg and Glazer, 1995). Therefore, conch that are transported as larvae from the offshore zone and settle in the nearshore zone remain there.

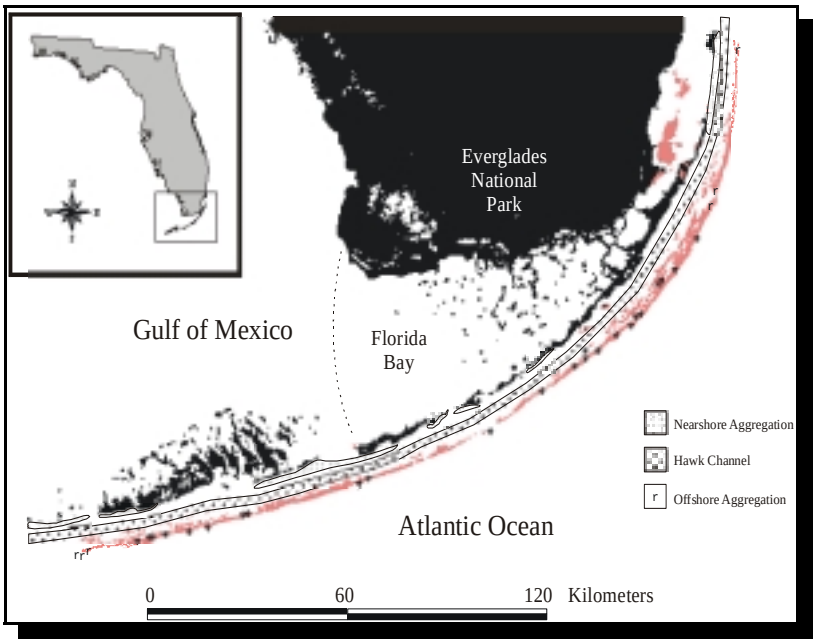

Figure 2. Distribution of conch in south Florida. Conch are located in 2 zones - nearshore and offshore. Spawning only occurs in aggregations in the offshore zone.

Despite extensive surveys, we never observed conch reproducing or spawning in nearshore aggregations; all spawning was observed offshore (Glazer and Quintero, 1998). However, we have received several anecdotal reports indicating that conch once reproduced nearshore. In 1998, we conducted a study to compare conch reproductive behavior and gonadal development between the two zones (McCarthy et al., 2000). Our studies showed that conch in the offshore zone developed normal gonads whereas those located nearshore had distinct gonadal

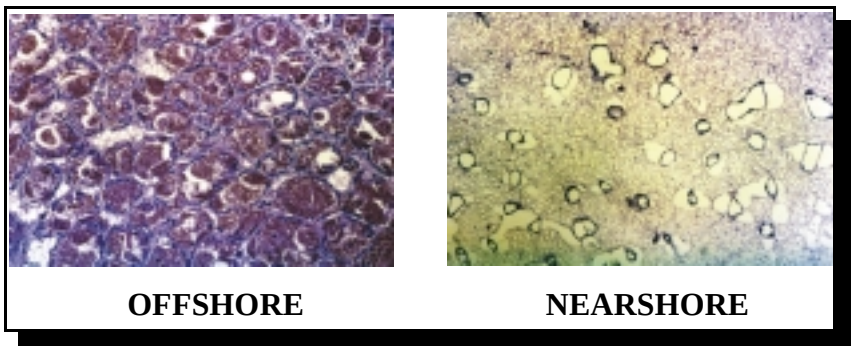

Figure 3. Female gonadal tissue from conch collected in offshore and nearshore zones. The offshore conch were ripe with over 75% gonadal material; the nearshore conch had no reproductive tissue.

deficits and were unable to reproduce (Figure 3). Our study also examined the reproductive development of conch transplanted between the two zones. The results indicated that conch transplanted from the nearshore zone to the offshore zone developed fully functional gonads. Conversely, those conch transplanted from offshore to nearshore showed rapid loss of gonadal tissue.

Issue 2. Chronic Effects of Poor Water Quality on Larval Fitness

The queen conch hatchery on Long Key was designed and constructed in 1991. When hatchery production was initiated, we quickly realized that the maximum larval density we could achieve was one larva per 2 liters of seawater. Additionally, the time to metamorphosis in our cultures was approximately 45 days. This contrasted with conditions at a commercial conch hatchery in the Turks and Caicos where they reported densities of 20 conch per liter and time to metamorphosis of approximately 20 days. After careful analysis, we implemented an ozone system for the treatment of incoming water. Ozone, when applied to seawater, removes dissolved organic materials. By adding ozone, we effectively made the nearshore waters more closely resemble the water associated with 'reef' conditions. When the ozone system became functional, we were able to culture conch larvae at densities approaching 10 larvae per liter and the time to metamorphosis dropped from approximately 45 days to approximately 20 days. Since dissolved organic materials may result from eutrophication, the results from this study suggest that declining water quality associated with nutrification may reduce the overall fitness of larval conch. This observation has widespread implications for the effects of nearshore coastal development on Florida's conch stock.

FUTURE DIRECTION

Monitoring and Larval Surveys

We will continue to monitor the spawning stock in order to assess the recovery of the population. We will also expand the monitoring program to include nearshore populations. We intend to continue limited larval surveys to facilitate the evaluation of the impacts of our restoration efforts.

Restoration Research

Beginning in the spring of 2001, we began implementing a restoration program based on a two-part approach:

1) *We began transplanting conch as a method to increase the spawning stock.* Juvenile and adult conch are transplanted from nearshore, non-spawning areas to offshore spawning aggregations. We are receiving assistance in this effort from The Nature Conservancy and our large base of community volunteers.

   We prefer this strategy to ramping-up hatchery production because it is *far* less costly (Glazer and Delgado, 1999). Additionally, the conch that are used to enhance the population are wild and, therefore, have genetic, morphological, and behavioral advantages over hatchery conch

(Stoner and Glazer, 1998). Additionally, a transplantation program fosters community involvement in the management of this resource. Since this project began in May 2001, we have transplanted 920 adult and late-stage juvenile conch. This is equivalent to releasing at least 10,000 hatchery-raised juveniles based on the expected mortality after release.

2) *Hatchery conch will be produced for release by our private partners.* We have developed strong public-private partnerships with two not-for-profit organizations (Keys Marine Conservancy and the Conch Research and Education Foundation) who have specific charters to produce conch for a queen conch restoration program. We have and will continue to provide technical assistance for the culture of hatchery-reared conch and will define the protocols for release. Conch produced by these organizations will be released only under the guidance and supervision of the FMRI at no cost to the State. These releases will augment our transplantation efforts.

The effectiveness of these programs will be evaluated by monitoring spawning aggregations for density, area encompassed by the aggregations, and abundance of conch. We also intend to continue monitoring larval supply as a mechanism for evaluating the success of these initiatives. We will examine differences in resource utilization and reproductive behavior between native conch and their transplanted and hatchery-reared counterparts. Additionally, we will examine the effects transplanting has on the habitat from which and into which they are transplanted.

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