New Large-Scale Culturing Techniques for *Strombus gigas* Post Larvae in the Turks and Caicos Islands

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Caicos Conch Farm has operated a large-scale mariculture facility producing queen conch, *Strombus gigas*, since July, 1984. Established routines for egg mass collection, hatchery rearing, and metamorphosis were used during the 1987 season.

The hatchery produces an abundance of veligers for metamorphosis on a weekly basis. One week after metamorphosis 16,000 conch (1.8 mm) are transferred to the new post-larvae culturing facility.

The post-larvae (PL) conch are maintained in a 120 m^2 greenhouse building capable of holding 200,000 post larvae conch, 1.8 - 50.0 mm in length. Presently (Oct. 87), 20,000 small juvenile conch 25-35 mm and 150,000 post larvae 2-12 mm are housed in the 72 tank system. Each fiberglass tank is 1.2 m x 2.4 m and holds eight screened bottom trays. The trays are 5 cm deep and have a 2 cm layer of graded sand; this substrate allows a mixed diet to be downwelled onto the surface. The dietary components: cultured diatoms, fractionated macro algae, and microencapsulated food are combined in proportions specific to PL age. Density in each tray is 2000 at 1.8 mm, 150 at 25 mm, and 20 at 50 mm. Growth rates in the production facility range between 0.1 - 0.3 mm/day, 0.5 mm/day was achieved under research conditions. Survival is 95% per week over the first month and then increases to approximately 98% per week.

The Caicos Conch Farm has recently developed a market for cultured 5 cm conch: the restauranteurs on Providenciales now offer cultured conch escargot. Conch have been grown for this market in 9 months, and with improved feeding they will reach 5 cm in 6 months. The new post-larvae culturing techniques discussed in this paper are applicable to any venture wanting to grow conch for market, grow-out, or restocking in the Caribbean.

INTRODUCTION

In 1975 research began on culturing the queen conch, *Strombus gigas*, in laboratories throughout the Caribbean and Florida. The research developed techniques for egg collection, hatchery, metamorphosis, post-larvae, and grow-out procedures. Most of these mariculture methods are documented in the Proceedings of the Queen Conch Fisheries and Mariculture Meeting (1981), Journal of Shellfish Research (1984), and Proceedings of the Gulf and

Caribbean Fisheries Institute (1982, 1985). The purpose of these efforts has been primarily to grow conch for reseeding over-fished areas, and secondarily for farming conch as a business. There has been little success in either, mainly because of inadequate recapture of reseeded conch—due to lack of biological information and engineering difficulties—but also partially because large numbers of appropriately sized conch have not been available for the necessary large scale studies. This paper describes a system developed at the Caicos Conch Farm to grow hundreds of thousands of post larvae (PL) conch to 5 cm length.

POST LARVAE CULTURE

System Design

In 1987 the Caicos Conch Farm used routine egg mass collection from an egg farm (Davis *et al.*, 1984), and metamorphosis procedures (Davis *et al.*, 1985; Ray and Davis, 1986) to produce an excess of newly-metamorphosed conch. Groups of animals move through the various systems (egg to larvae to post larvae) on a deliberate schedule; at each stage it was possible to select the healthiest animals for further culturing. To keep a steady number available for a post larvae system ten egg masses were collected twice a week. Four of these were hatched each week producing about 100,000 competent veligers for metamorphosis. A week after metamorphosis 16,000 PL conch were transferred to the post larvae facility; the remaining were released to sea.

Post larvae culture methods tried at the Conch Farm using silt covered astroturf or algae coated screens held vertically in 1 meter deep tanks proved too labor intensive and inefficient in supplying food to the conch (Ray and Davis, 1986). A new post larval system was developed in early 1987 that incorporated advances in nutrition with use of a natural substrate in manageable culture trays. The criteria used to develop the system were: culture space, substrate, water circulation, food application, maintenance of culturing environment, and cost. The PL system was designed to take conch from post-metamorphosis to 5.0 cm in 6 - 9 months. At 4.0 - 5.0 cm the juvenile conch can be used for reseeding (Berg, 1976), stocking grow-out pastures or for special markets.

An inexpensive greenhouse building (8 x 15 meters) was built and plumbed to contain estimated 200,000 post larvae conch. The PL conch are arranged according to size within the facility, allowing for efficient daily management. To maximize use of space twelve wooden racks 2.4 meters high are arranged in six rows. Each rack contains six tanks with 0.4 meters vertical work space between each tank. The fiber glass tanks are 1.2 x 2.4 x 0.05 meters, with a 250 liters of water capacity. The tanks are white gel-coated inside with a pyramid sloped bottom and 2" pvc drain in the center for ease of cleaning. Each of the 72 tanks has a exterior standpipe that controls the water level and drainage.

In each tank eight polyethylene trays (60 x 60 cm) fit tightly in two rows and are supported by the tank edge and a central wooden brace. The trays have rounded corners to induce circular water movement. The open bottom of the tray is fitted with mosquito screen that supports a 2 cm layer of disinfected graded sand. Specific sand and screen sizes (Table 1) are used to simplify application of food and separation of the conch from the sand during exchanges.

Sea water is pumped through a sandfilter into two 12,000 liter head tanks and is gravity fed to the PL building. Each tank has a control valve to regulate flow to the input wand. This water wand is made of 1/2" pvc and is supported on the central wooden brace. Each wand has four (3/16") holes spaced evenly apart on both sides; one hole per tray. The flow (1 liter/minute/tray) creates a vortex around the tray, gradually downwelling through the tray. The depth of the water in the trays is about 2 cm and is regulated by adjusting the exterior standpipe. A removable pvc spillway is used to stop the inflow water from excavating the sand.

System Maintenance

The sand in the culture trays is flushed with high pressure water every three days to remove conch waste and residual food. The tank and trays are completely drained and a high pressure water wand is passed over the sand. The 60 cm wand has 1/16" holes spaced 5 mm apart. The jet of water pushes the feces and excess food through the sand and screen, and exits down the central drain. During the flushing, the sand and animals are left intact and the conch usually lie dormant throughout the procedure. After every other flush the trays are temporarily removed and the bottom of the tank is sponged clean; the standpipe is reset and the tank is filled with water. Twenty-four tanks are flushed daily, each tank takes two technicians 20 minutes.

Every 3-4 weeks the tanks are exchanged and thoroughly cleaned with chlorine bleach. The primary reason for the exchange is to reduce density of animals per tank (Table 1). During an exchange a tray is removed from the tank and taken to a sorting screen. The sorting screen (2.2 or 3.0 mm mesh depending on the size of the conch) is agitated so that the sand falls through onto a PL tray below leaving the conch on the sorting screen. The conch are washed off the sorting screen, counted, reduced in density and put onto a clean tray with sand. This procedure continues for all eight trays in the tank. Tanks and equipment are cleaned with 1% chlorine bleach solution. The PL tray that caught the sand during the sorting is removed, flushed of wastes, and stacked in a deep tank with 1% chlorine bleach for 24 hours. After removal the trays are rinsed well and put into a clean tank ready to have conch put back on. The exchange and sorting process takes two technicians one hour.

Table 1. Age, Length, Density, and Feeding Guide.

AGE (Pl weeks)	LENGTH (mm)	DENSITY (conch/tray)	SAND+SCREEN Size(mm)	Feeding Proportions Daily Ration per Tray: Benthic diatom culture (liters)	Macro-algae (liters)	microencapsulated food (grams)
0-3	1.8-6.0	2000	1.5-2.0mm sand on 0.875mm screen			
3-6	6-10	1000		20	0.2	0.5
6-9	10-15	400				
9-12	15-20	200	2.0-3.0mm sand on 1.5mm screen			
12-18	20-30	100		12	0.3	1.0
18-24	30-40	50				
24-30	40-50	25				

Food and Feeding Techniques

Three types of food are fed to post larvae conch: cultured benthic diatoms, collected macro-algae, and a commercial microencapsulated shrimp diet. Food is the most important factor affecting growth, survival and health. Nutritional requirements are not well known, but encouraging work is underway on shelf stable diets specifically formulated for PL conch (Creswell, pers. comm.).

Benthic diatoms (BD) have been found to be the most valuable ingredient in the diet of cultured post larvae conch at all sizes (Dalton, unpubl. ms.). The present BD system used (Ray and Davis, 1986) needs modifications to produce higher yields. The innoculum for the BD is collected on 1.0 x 1.5 meter sheets of poultry grade astroturf. The collectors are attached to anchors in rows and are suspended 30 cm below the waters surface. After two weeks at sea the collectors are covered with silt and an assemblage of up to 20 species of diatoms. A majority of the species are *Navicula* and *Nitzschia* (Ray and Davis, 1986).

Fourteen silt collectors are brought ashore daily, the BD innoculum is washed off the astroturf with high pressure water. The innoculum is diluted so that approximately 6000 liters of BD culture is started per day. The innoculum is pumped from the dock into transparent fiberglass tubes (150-2000 liters) in a second 120 meter square greenhouse. The cultures are nutrified with a modified version of Guillard's F/2 media (Guillard, 1975). The silt in the cultures tends to settle on the bottom, and although each culture is aerated with a air ring additional manual stirring is necessary twice daily. The BD culture is fed to the conch after 5 days of growth.

Various species of macro-algae are fed to the PL conch because not enough BD can be cultured presently at the Conch Farm. However, experiments have shown that appropriate supplemental feeding of macro-algae allows twice as many PL's to be held in inventory. The algae is collected from the reef and shallow banks. The dominant reef algae collected is *Dictyota*, other reef algae include species of: *Amphiroa, Padina, Sargassum, Stypopodium, and Turbinaria.* They are found attached, floating, or in mats on the bottom. The dominant bank algae collected is *Laurencia; Bataphora and Dictyosphaeria* are collected incidentally and are also used. The bank algae are found attached to the substrate or in windrows, and are collected most often because they are found in abundance. The reef algae is a valuable food source, however it is seasonal and not as convenient to collect as the bank algae.

Every three days, 600 liters of bulk macro-algae is collected and delivered to the food production facility. The algae is sorted to remove shells, coral rocks, and sponges, then blended with sea water in an industrial blender. Two liters of bulk macro-algae makes three liters of blended slurry. The blended algae is fractionated through two screens; a 1.2 mm screen is used for the 1.8-20 mm conch and a 1.8 mm screen is used for the 20-50 mm conch. Two sizes of

fractionated macro-algae are used because small conch (less than 20 mm) do not eat the larger sized particles.

The microencapsulated formulated feed used at the Conch Farm was developed for penaeid shrimp mariculture. Microencapsulated food (250 microns) is being experimentally fed to PL conch 1.8-10.0 mm. This food has a one year shelf life, and if kept refrigerated, is usable for up to one month after opening. Microencapsulated food must be fed in small quantities, because it has been found to be toxic when added to a PL tray with insufficient water flow.

Experiments have shown that a combination of cultured benthic diatoms, fractionated macro-algae and microencapsulated food produces the best growth and survival (Table 2).

The three ingredients are combined in two 500 liter vats in the algae green house and is gravity fed to the PL greenhouse. One vat contains a mix for small conch and the other for the large conch (Table 1). Food is poured into the trays by hand using one liter pitchers.

Every morning each tray is observed; the amount of food left and the behavior of the PL conch is noted to determine whether the correct amount of food was added the afternoon before. It is critical to feed to demand but not to overfeed. Overfeeding is defined as more than 10% left over. For instance, if the conch climb up the sides of the tray they were underfed. Whereas, if the conch are buried with no activity, enough food was added.

PL survival is also influenced by the quantity and quality of food. Dead conch are removed from the trays during the morning observations. It is difficult, and appears unnecessary, to remove dead conch when the group is less than 6 mm average length. Survival in the production facility is presently about 95% per week up to 10 mm and 98% per week from 10.0-50.0 mm (Figure 1).

Length measurements are taken weekly, the overall growth rate in the PL system being a reflection of the quantity and quality of food fed that week. Density in the PL trays also affects feeding behavior and growth (Table 2).

SUMMARY

The PL system described can be duplicated anywhere in the Caribbean to produce a sufficient number of 5 cm conch for large-scale reseeding or grow-out studies. Being a commercial venture, the Conch Farm has also chosen to pursue alternative markets for 5 cm juvenile conch. There are several potential markets for sub-adult conch, and following other successful mariculture businesses (*e.g.*, Abalone, Atlantic Salmon) there is no reason to limit the product to full-grown adult animals.

The marine aquarium market for 2.5 - 4.0 cm conch is relatively small, and may include other species of *Strombus* that can be cultured using similar techniques as the queen conch. A distribution center for aquarium business is conveniently located in Miami.

Table 2. Growth and survival from various feeding studies (Dalton, unpubl. ms.).

DATE (1987)	EXPERIMENTAL TREATMENT: Diet	Density (PLs/tray):	(PLs/ meter sq.)	AGE (PL Days)	LENGTH (mm)	GROWTH (mm/day)	SURVIVAL %
20.May-	1)BD culture	67	230	174-217	35.7-41.3	0.132	100.0
1.July	2)BD + Macro algae	67	230	174-217	36.9-42.8	0.137	100.0
	3)Macro algae	67	230	174-217	36.0-37.7	0.039	100.0
1.July-	1)BD culture	20	68	217-248	41.3-49.9	0.277	100.0
30.July	2)BD + Macro algae	20	68	217-248	42.8-50.3	0.242	100.0
	3)BD culture	20	68	217-248	37.7-44.8	0.229	100.0
18.May-	1)BD culture	750	2402	20-35	3.6-7.4	0.256	87.6
1.June	2)BD culture	1500	4804	20-35	3.5-7.2	0.248	90.7
1.June-	1)BD culture	200	641	35-49	7.4-14.2	0.486	99.5
16.June	2)BD culture	600	1921	35-49	7.2-13.9	0.478	99.3
16.June-	1)BD culture	1000	3204	7-20	1.9-5.5	0.276	92.1
28.June	2)BD culture	4000	12812	7-20	1.9-4.7	0.221	94.0
28.June-	1)BD culture	500	1602	20-31	5.5-10.7	0.454	99.2
8.July	2)BD culture	2000	6408	20-31	4.7-9.2	0.385	98.7
20.July-	1)Microcapsules	1000	3204	33-46	4.5-7.0	0.178	96.7
3.August	2)BD + Microcapsules	1000	3204	33-46	4.4-9.7	0.378	98.7
	3)BD culture	1000	3204	33-46	4.6-9.1	0.323	97.8
15.October-	1)BD + Macro algae	60	192	119-135	25.9-29.3	0.213	100.0
31.October	2)BD + Macro algae + microcapsules	60	192	119-135	25.9-31.1	0.325	100.0

Table 2 (continued).

DATE (1987)	EXPERIMENTAL TREATMENT: Diet	Density (PLs/tray):	(PLs/ meter sq.)	AGE (PL Days)	LENGTH (mm)	GROWTH (mm/day)	SURVIVAL %
	3) BD culture	60	192	119-135	25.9-29.4	.218	100.0
	4)BD + Macro algae	750	2402	48-64	7.9-12.5	.286	97.7
	5)BD + Macro algae + microcapsules	750	2402	48-64	7.9-13.5	.347	87.7
	6)BD culture	750	2402	48-64	7.9-12.9	.312	97.2

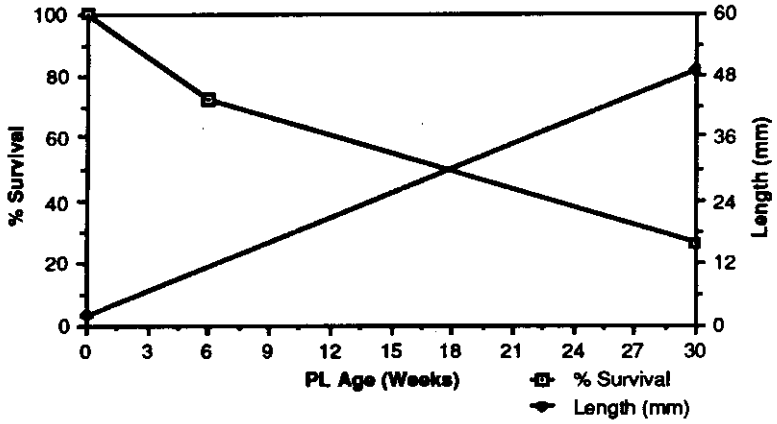

Figure 1. Projected growth and survival for PL to 5 cm, based on 1987 production and research data.

A potentially more substantial market exists in conch escargot. Five centimeter conch are cooked and served whole in the shell with a traditional garlic butter sauce. The reception on Providenciales has been excellent, and there is interest in other countries in the Caribbean and in the U.S.

Creating fishing pressure on wild juveniles is not a likely problem. In fact, the scientific community has failed to find substantial numbers of small juveniles (less than 7 cm), and knowledge of such finds would provide important ecological information helpful in reseeding and grow-out work. Only through mariculture efforts can substantial numbers of small juveniles be produced.

Grow-out at the sea is the obvious next step being developed at the Conch Farm. Preliminary results in the Turks and Caicos Islands and throughout the Caribbean indicate that although growth rates are acceptable for released conch, predation is generally high for juveniles less than about 10 cm in length (Rathier, pers. comm.). Not coincidentally this is the smallest size of wild conch encountered in significant numbers. Grow-out studies are encouraged to continue throughout the Caribbean region.

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