Queen Conch Culture and Future Prospects in Puerto Rico

DAVID L. BALLANTINE AND RICHARD S. APPELDOORN
Department of Marine Sciences
University of Puerto Rico
Mayaguez, Puerto Rico 00708

ABSTRACT

A program for large scale *Strombus gigas* culture in Puerto Rico was initiated in 1981. Principal objectives concern determining feasibility of 1) large scale laboratory culture of *S. gigas* and 2) seeding cultured animals into depleted areas to rehabilitate local conch populations. Although efforts have chiefly concentrated on *S. gigas*, larvae and juveniles of *S. costatus* have also been cultured.

Conchs are reared from eggs collected in the field. Following hatching, larvae are cultured in 950-ℓ fiberglass tanks utilizing techniques adapted from bivalve culture. Veligers are fed predominately a diet of cultured phytoplankton species: *Isochrysis* (Tahitian), *Tetraselmis chui* and *Thalssiosira fluviatilis*. Larval growth averages 50 to 55 μm/day. Larval period varies from 12 to 22 days ($\bar{x}$ = 16.3) from hatching, and length at metamorphosis has ranged from 1.1 to 1.8 mm with a mode of between 1.4 and 1.5 mm. As larvae become competent for metamorphosis, they are exposed to macroalgae in shallow plastic wading pools. On attaining a minimum size of 2 to 3 mm, juveniles are transferred to troughs with running seawater and are supported off the bottom on screens. Supplied with abundant macroalgae, conchs grow rapidly. Initial postmetamorphosis growth is 0.2 mm/day and increases to 0.4 mm/day through the first 200 days.

Scaling up of the U.P.R. conch culture facility is discussed.

The queen conch, *Strombus gigas*, is a commercially important species in the Caribbean (Randall, 1964; Iversen, 1968; Berg, 1976; Brownell, 1977). In many areas the only fishery exceeding that for *S. gigas* is that of the spiny lobster (Brownell and Stevely, 1981). The decline in populations of *S. gigas* throughout its range due to over-fishing (Adams, 1970; Baird, 1973; Berg, 1976; Brownell et al., 1977; Blakesly, 1977; Hesse and Hesse, 1977) is well documented. Current status of the conch fishing industry in the Caribbean is reviewed by Brownell and Stevely (1981).

A landmark study in *Strombus gigas* culture conducted at Los Roques, Venezuela was reported by Berg (1976) and Brownell et al. (1977). They suggested that laboratory culture of queen conch could provide a means to produce large numbers of seed which could subsequently be used to increase reduced numbers of naturally occurring conch. Wide spread recognition of the importance of the *Strombus gigas* fishery in the wake of the successful Los Roques study has led to the establishment of a number of conch culture programs in the Caribbean. The results obtained from a conch rearing program in Puerto Rico are described here.

In January 1981, the Department of Marine Sciences of the University of Puerto Rico initiated a program to assess the feasibility of 1) large scale laboratory culture of *Strombus gigas* and 2) seeding laboratory reared animals into depleted natural habitats as a means to re-establish local conch populations. This has been a cooperative program with joint support provided by the National Marine Fisheries Service, the Puerto Rico Research Laboratory of CODREMAR, and the University of Puerto Rico Sea Grant program.

Queen Conch Fishery In Puerto Rico

Puerto Rico traditionally has had a large fishery for conchs, known locally as "carrucho." Fishing is artisanal in nature with daily catches distributed by fishermen themselves to local markets. Few conch are collected along the northern coastal

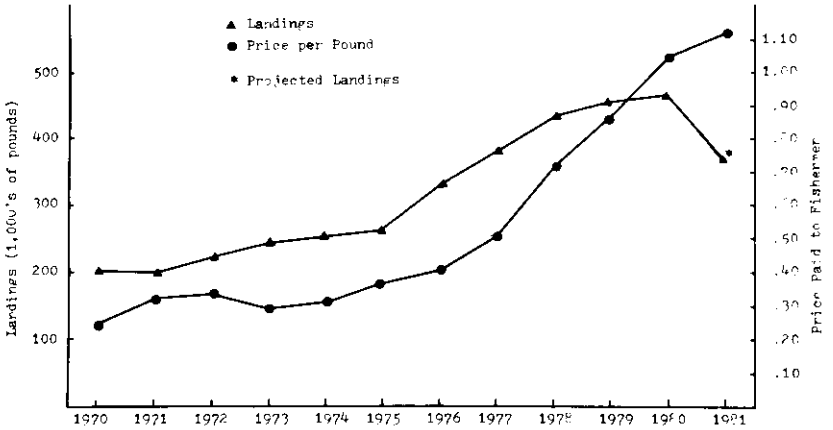

Figure 1. Landings and wholesale price per pound for queen conchs in Puerto Rico (1970 to 1981).

areas, primarily due to lack of suitable benthic substrate. There are, however, extensive algal and seagrass beds on the southern and western coastal areas that have supported local fisheries. Over the past 10 years conch populations have been severely depleted all around Puerto Rico. In shallow water easily accessible sites, where once abundant, conchs are now very scarce. Many fishermen have given up traditional means of collecting in shallow water and have begun to use SCUBA for collecting conch in water depths up to 20 m.

Figure 1 shows conch landings plus price per pound (wholesale) in Puerto Rico since 1970. As conchs have essentially been depleted from inshore seagrass beds in recent years, the fact that landings did not decrease until 1981 probably reflects a transition in fishing from shallow to deeper water habitats. Deeper water animals probably comprise the last sizable populations in Puerto Rico, and their decline in numbers is a trend which can be expected to continue. Catch per effort data is not available and has likely increased in recent years.

Table 1. Time to metamorphosis and approximate number of metamorphosed juveniles surviving 15 Strombus gigas and Strombus costatus hatches

Date of Hatch	Species	Days to Metamorphosis	Approximate No. of Metamorphosed Juveniles Surviving
5-18-81	S. costatus	16	90
6-25-81	S. gigas	14	36
7-20-81	S. gigas	12	150
8-16-81	S. gigas	16	2,000
8-27-81	S. gigas	-	1,000
10-4-81	S. costatus	18	100
10-18-81	S. costatus	-	20
11-16-81	S. gigas	19	Not Determined
11-30-81	S. costatus	14	Not Determined
2-9-82	S. costatus	16	1,700
3-16-82	S. costatus	-	60
5-5-82	S. costatus	15	3,000
5-23-82	S. gigas	17	4,000
6-14-82	S. gigas	22	1,300
8-7-82	S. gigas	17	2,000

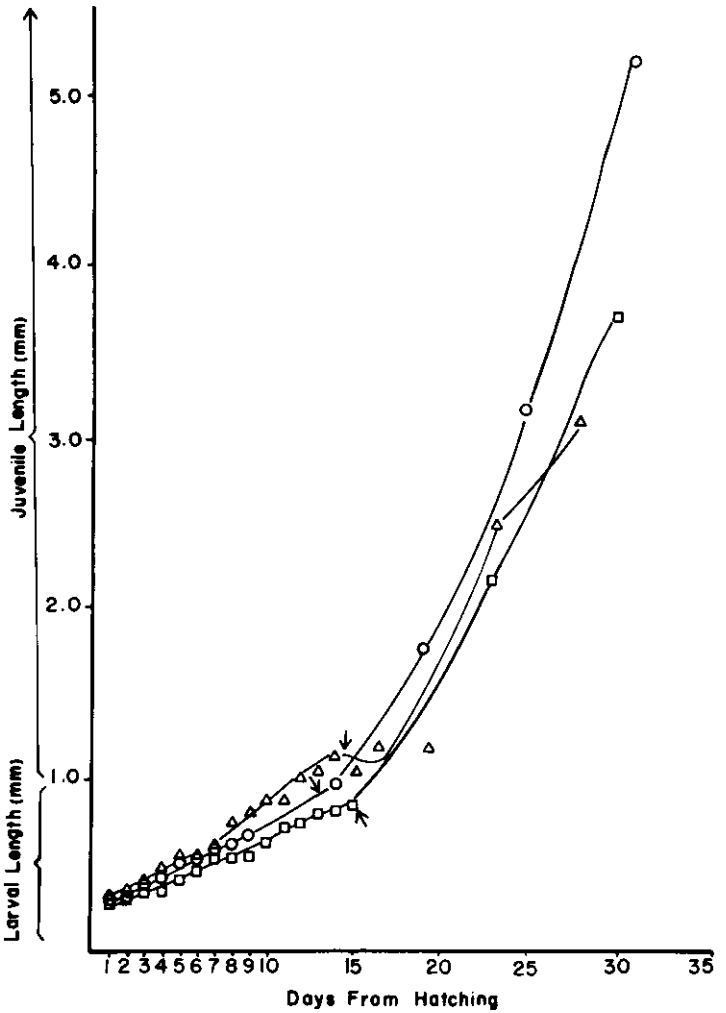

Figure 2. Larval and early juvenile growth in culture of three 1981 *Strombus gigas* cultures.

Price per pound has increased steadily and at 1980 prices the value of the Puerto Rico conch fishery was greater than $480,000. This figure is probably an underestimate due to incomplete reporting and not accounting for personal consumption of captured conchs.

CULTURE TECHNIQUES

The culture approach utilized is briefly outlined; techniques will be described in greater detail elsewhere by Chanley et al. (in preparation). A breeding population of both *Strombus gigas* and *S. costatus* has been identified in an area approximately 5 km offshore from La Parguera on the southwest coast of Puerto Rico. It is situated in 17 m of water. Eggs are collected from beneath the flared lip of laying females by SCUBA diving and returned to the laboratory. As availability of *S. gigas* eggs was unpredictable, eggs of the closely related milk conch, *S. costatus*, were collected when *S. gigas* eggs were not available. It was assumed that both species had similar

developmental characteristics and would behave similarly in culture. The scarcity of *S. gigas* eggs is a further reflection of the severity of the local population decline.

Egg masses hatch after a period of about 5 days. At that time, larvae are cultured at a concentration of 100/ℓ in two 950-ℓ fiberglass-domed bottom-tanks. Larval handling techniques are an adaption of established bivalve larval culture methods. Culture tanks are drained daily, then cleaned and refilled with fresh 30 μm filtered sea-

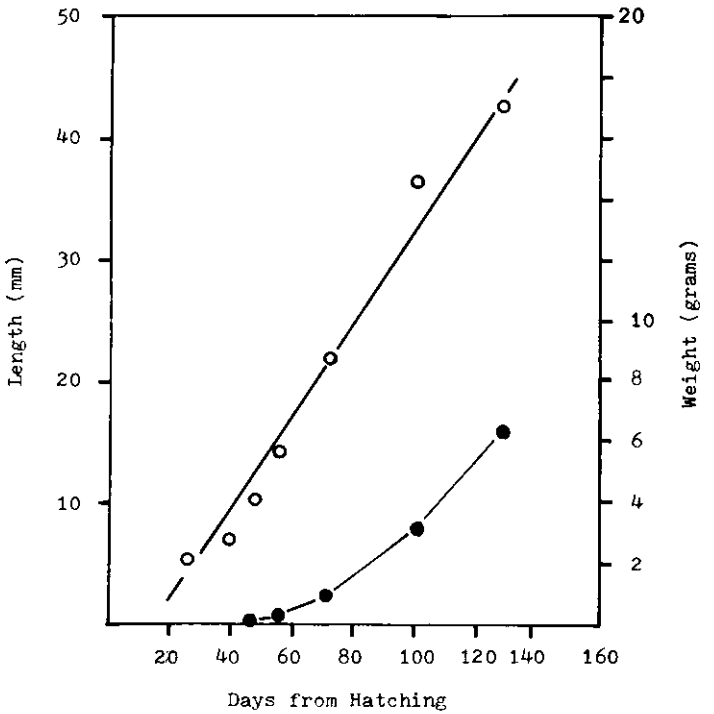

Figure 3. Length and weight growth of cultured *Strombus gigas* juveniles.

water. At this time a daily food allotment of 17 ℓ of laboratory cultured phytoplankton is added to each culture tank.

During the course of larval development, generally three algal species are fed: *Isochrysis* (Tahitian), *Tetraselmis chui*, and *Thalassiosira fluviatilis*. Microalgae are grown in Ott (1966) media in 30-ml starter cultures and subsequently scaled up through 300-ml, 2-ℓ, 17-ℓ, and 75-ℓ volumes in batch culture. The 75-ℓ cultures are utilized for actual feeding.

At time of metamorphosis, juveniles are transferred to shallow plastic pools in which macroscopic algae have been placed. Macroalgae may aid in inducement of metamorphosis and serve as substrate for settlement. When juveniles attain a size of 2- to 3-mm in length, they are transferred to cement troughs with continuously running seawater. Conchs and their macroalgal food are suspended off the trough bottom with fine mesh plastic window screen.

LARVAL AND JUVENILE GROWTH

Larvae grow rapidly in culture. Larval and early juvenile growth plotted for three *S. gigas* hatches is shown in Figure 2. Growth averaged 53 μm/day which was virtually identical to the 51 μm/day growth for *S. costatus*. Larval period has been varia-

ble with initiation of metamorphosis occurring from 12 to 22 days ($\bar{x}$ = 16.3) after hatching. See Table 1. Minimum size of fully metamorphosed individuals (without velar lobes) was 1.1 mm while most measured 1.4 to 1.5 mm at metamorphosis. Metamorphosis represents a transition in life habit and is a crucial period in development. A number of variables which affect the success of this transition are not known and the need for further research in handling techniques during this period is recognized.

Following metamorphosis, growth rate for both *S. gigas* and *S. costatus* increases to 0.2 mm/day, a rate which is maintained for 2 weeks (Fig. 2). Growth subsequently increases to a rate of 0.3 to 0.4 mm/day for the first 200 days. Growth in length and weight for juvenile *S. gigas* is shown in Figure 3 and for *S. costatus* in Figure 4.

To date conchs have been successfully reared through metamorphosis on 15 occasions at the University of Puerto Rico Laboratory and approximately 17,000 juvenile conchs have been produced (Table 1). A maximum of 4,000 animals successfully completed metamorphosis from a single hatch on one occasion. It is concluded that large scale hatchery production of juvenile conchs is feasible.

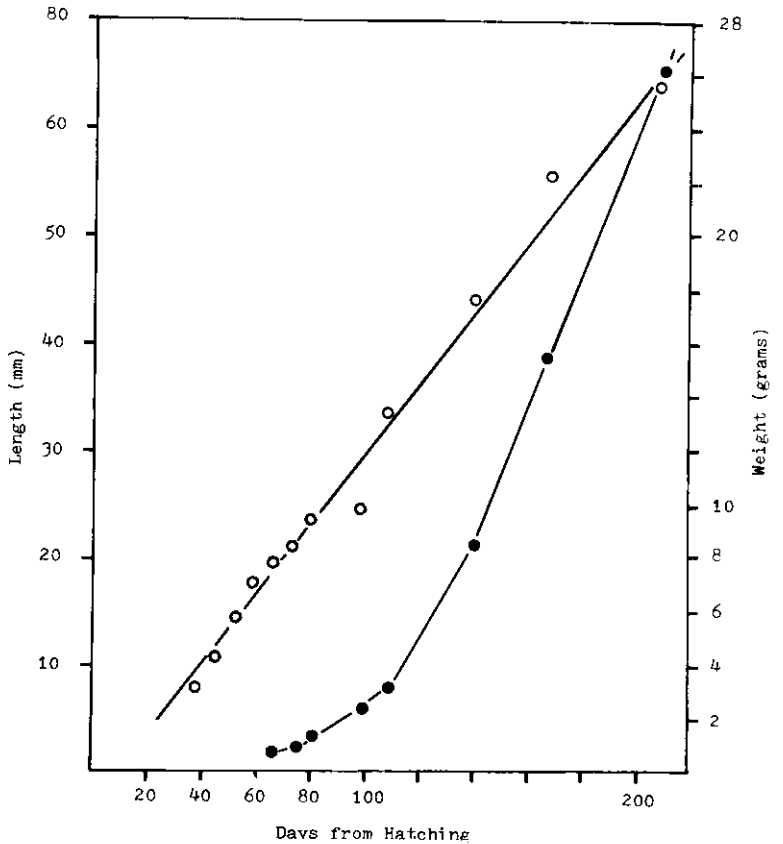

Figure 4. Length and weight growth of cultured *Strombus costatus* juveniles.

PRELIMINARY RELEASES

Five preliminary releases have been conducted involving 650 *Strombus gigas* and *S. costatus* juveniles. Conchs were released on two bottom types, a shallow (2 m) seagrass bed and a deep (17 m) offshore algal plain. Behavior, growth, mortality and movement of released laboratory reared conchs were observed and are reported by Appeldoorn et al. (1983).

SCALE UP AND FUTURE CONSIDERATIONS

In order to meet our second objective above, to determine feasibility of using laboratory reared animals to repopulate depleted habitats, we are presently expanding the U.P.R. culture facilities. This expansion will increase research capabilities and allow production of considerably larger numbers of conchs for release. Additional larval culture tanks and large volume algal culture tanks will be placed in line to augment present facilities. It is conceivable that under optimal conditions, such an expanded hatchery could produce in excess of 100,000 viable juveniles per breeding season.

A juvenile grow-out laboratory is presently under construction which on completion will have 12 concrete pools, 5 to 16 feet in diameter. These grow-out pools will require different methods of juvenile handling. A prototype floating mesh enclosure is presently being developed and will accommodate approximately 1,000 conchs, dependent on size.

For success in rehabilitating local conch populations, a management component is clearly required. Restocking can only be successful if seeded animals survive to reproduce sufficiently to insure continued population production. Brownell and Stevely (1981) state that *S. gigas* reaches marketable size before the age of first reproduction. At high fishing pressure, such as is evidenced throughout the Caribbean, spawning stocks will be clearly reduced, thereby threatening the success of future recruitment. In addition to release experiments, it is therefore important that future research be aimed at determining current stock status, the age structure of local populations and existing fishing pressure. This information is necessary as a basis for formulation of intelligent management guidelines. Without effective management, it is doubtful that reseeding alone will provide for stock rehabilitation.

ACKNOWLEDGMENTS

Mr. Paul Chanley's role in development of larval and juvenile conch culture techniques and Ms. Ana Bardales' assistance in all aspects of this research are gratefully acknowledged. In addition to their financial support, the Puerto Rico Fisheries Research Laboratory of CODREMAR made available the fisheries statistics from which Figure 1 was derived.

LITERATURE CITED

Adams, J.E.

1970. Conch fishing industry of Union Island, Grenadines, West Indies. Trop. Sci. 12: 279-287.

Appeldoorn, R.S., and D.L. Ballantine

1983. Field release of cultured queen conchs in Puerto Rico: Implications for stock restoration. Gulf Caribb. Fish. Inst. 35:89-98.

Baird, R.H.

1973. Report to the government of British Honduras on fisheries management and potential. Rep. FAO/UNDP (TA) 3203. 49 pp.

Berg, C.J. Jr.

1976. Growth of the queen conch, *Strombus gigas*, with a discussion of the practicality of its mariculture. Mar. Biol. 34: 191-199.

Blakesley, H.L.
1977. A contribution to the fisheries and biology of the queen conch, *Strombus gigas* L., in Belize. Paper read at Amer. Fish. Soc., 107 Ann. Meeting, Vancouver, B.C. Sept. 15-17, 1977.

Brownell, W.N.
1977. Reproduction, laboratory culture, and growth of *Strombus gigas, S. costatus* and *S. pugilis* in Los Roques, Venezuela Bull. Mar. Sci. 27: 668-680.

_____ Berg, C.G., Jr. and K.C. Haines.
1977. Fisheries and aquaculture of the conch, *Strombus gigas*, in the Caribbean. Paper read at CICAR II Symposium, Progress in Marine Research in the Caribbean and Adjacent Regions, Caracas, Venezuela, July 12-16, 1976. FAO Fisheries Report No. 200: 59-69.

_____ and J.M. Stevely
1981. The biology, fisheries, and management of the queen conch, *Strombus gigas*. Mar. Fish. Rev. 437: 1-12.

Hesse, C.O. and K. Hesse.
1977. Conch industry in the Turks and Caicos Islands. Underwater Naturalist 10: 4-9.

Iversen, E.S.
1968. Farming the edge of the sea. Fishing News (Books), Ltd., Surrey, Eng. 436 pp.

Ott, F.D.
1966. A selected listing of xenic algal cultures. Contr. 72, Systematics and Ecology Program, Marine Biology Laboratory, Woods Hole, Mass. 42 pp.

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