Feasibility of Increasing Bahamian Conch Production by Mariculture

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ABSTRACT

The major objective of field studies of the queen conch (*Strombus gigas*) was to obtain basic biological information on the species in the Bahamas to assess the ability of hatchery produced conchs to grow and survive in captivity and when planted in natural habitats. A second objective was to make information on conch biology available to assist managers of conch stocks. In this report emphasis is on the evaluation of these data for possible applications to intensive and extensive mariculture. Conchs collected in the wild from the Berry Islands were reared in pens and cages of different sizes and at various stocking densities, to obtain data on growth and survival. Similar data were collected on wild populations. Growth as related to time of year, density of conchs and food availability is discussed. Using various rates of survival and rearing costs, analyses suggest that governmental authorities should plant first generation hatchery-reared conchs and protect them from fishing until they spawn. The analyses further show that offspring of these spawners surviving to market size provide economic benefit to the program.

The present over-exploited state of many of the queen conch, *Strombus gigas*, fisheries in the Bahamas and the Caribbean and the lack of adequate biological data on the species dictate an urgent need to obtain adequate background information on conch biology, fisheries and the feasibility of conch mariculture to determine appropriate management plans for the many countries that exploit the conch. This field

operations. Collections and observations were made at several adjacent cays (Whale Cay, Vigilant Cay, Little Cockroach Cay, Bird Cay, Cat Cay). Twenty-three field trips were made to the Berry Islands in connection with this aspect of the work from February 1980 through February 1983.

The objectives of these field studies were: (1) To obtain reliable data on conch biology directed at management. In the past there has been considerable speculation about conch biology based on data limited in geographic area and sample size. (2) To determine if intensive (enclosed) culture of queen conch is feasible. Because of the habits of this species there have been numerous suggestions in the literature that queen conch are a suitable candidate species for intensive mariculture. (Berg, 1976; Brownell, 1977; Brownell et al., 1977; Brownell and Stevely, 1981). (3) To determine if extensive (planted in nature) supplementation of natural stocks is feasible. Here again, this concept has been proposed by many of the authors listed above as a means to supplement the dwindling stocks of conch.

Only aspects of the biology of queen conch that affect mariculture are summarized briefly in this report to try to answer the question of the feasibility of conch mariculture (intensive and/or extensive) in the Bahamas. Details on the results of the biological studies plus information not relevant to mariculture will be published elsewhere.

METHODS AND MATERIALS

After trying several different tags for conchs, we found that a thin plastic tag measuring $^3/_8 \times ^7/_{16}$ in from the Floy Tag Co. (Seattle, Washington) worked very well. The tag was easily seen and yet was not too large even for the small conch (ca 2-3 cm) we tagged. A spot on the spire of conchs to be tagged was cleaned, dried and the tag was affixed using underwater epoxy. Conchs held over night after being tagged showed no adverse effects resulting from the tagging operation. These tags remained on conchs for about 2 years with indications of only a few being shed. Over 2,500 conch were tagged in this manner.

Growth of penned and unpenned conchs was measured by the tagging technique. Conch were tagged, measured on the long axis on a measuring board, released, periodically recaptured and remeasured. Length measurements were also made on untagged conchs and plotted as length frequencies to determine growth; that is, definite modal groups were located and followed in the periodic samples.

The rate of survival of tagged conchs was calculated by the use of the Jackson (1939) formula. Since there is no known practical way to age conch, monthly time intervals were used instead of annual intervals.

Six pens, 5 m on a side, were constructed of monofilament webbing about 30 cm high and held up by buoys. The pens were held in close contact with the bottom by heavy chains and stakes driven into the bottom. The pens were stocked with 1 or 2 conch (about 10-15 cm long)/m^2. Tagged conchs of approximately the same size were released in the vicinity of the pens as controls. Two larger pens of about 100 m^2 area each were also constructed and planted with 1 conch/m^2 using conch within the same size range. The duration of the pen experiments extended from 5 to 15 months and covered all seasons of the year.

Two floating cages covered with fine mesh screening, one measuring 1 × 1m × 6 cm and another 61 cm on each side were stocked with 50 and 10 conchs respectively. Observations on growth and survival were made over a 1-year period on these small ($<$9 cm) caged conchs.

RESULTS

Growth

Average monthly growth of wild and penned conchs is shown in Table 1. For wild conchs in the size range of about 10 to 15 cm at an average density of about 1 conch/m^2 the average monthly growth varied between 0.25 and 0.48 cm. These rates are related to the density of conch at the various sampling locations and temperature as was noted by Alcolada (1976) who studied queen conch growth in Cuba. Growth is significantly faster in summer (April to October) than for the rest of the year. Based on the Von Bertalanffy growth curve and the analyses of size frequency histograms (published elsewhere), it appears that growth of conchs in the Berry Islands is slightly slower than has been reported in the Virgin Islands (Randall, 1964; Berg, 1976) and Cuba (Alcolada, 1976).

Penned conchs of about the same size and density/m^2 showed that the growth is substantially slower, varying from no growth to 0.17 cm/month. There was no obvious difference in growth between densities of 1 and 2 penned conchs/m^2. Tagged conchs released in the immediate vicinity of the pens showed monthly growth averaging 0.40 cm (Little Whale Cay growth). In one experiment, eight tagged conchs that had shown zero growth each month for 4 months during the summer were released from their pen. One month later (September) they had grown an average of 0.30 cm. We cannot explain the lack of growth in pens. However, the relatively extensive movements of queen conch (Hesse, 1979) suggest that they graze over wide areas and may need to do so to obtain adequate food to realize good growth.

Based on data covering more than 1 year for each of the two cages, the average monthly growth rate (0.25-0.35 cm) of these small conchs (<9.6 cm) was similar to that of wild, although larger, conchs.

Table 1. Comparison of average monthly growth (length in cm.) between penned and wild conchs

			Wild*			
Cat Cay			Little Whale Cay		Little Cockroach Cay	
0.25			0.40		0.48	
			Penned +			
No. 5	No.6	No.7	No.2	No.9	No.3	No. 1
0.00	0.00	0.00	0.08	0.11	0.15	0.17

* Size range 9.6-15.3 and average density 0.8 conchs/m^2
\+ Size range 9.6-15 and average density 1&2 conchs/m^2

TAG RECOVERIES

Our recoveries of juvenile tagged conchs on an annual basis was surprisingly low, 2-9%, and is affected by several factors all of which tend to decrease the number of tagged conchs recovered and hence the apparent survival rate: (1) Migration of tagged conchs from the search area, (2) Buried tagged conchs were overlooked, (3) Tagged conchs not spotted due to algae and encrusting organisms on their shells, (4) Shedding of tags and (5) Some fishing mortality on the larger tagged conchs.

Because of the factors that reduce the number of tag recoveries, apparent survival is much too low and results in annual mortality values of Z=2.41 to 3.91. Alcolada (1976) found annual survival values of about 15-35% or mortality figures of Z=1.06 to 1.90 for queen conch in Cuba, which is high compared to our data. Annual survival of penned conchs varied between 28 and 73%; however, in two pens all conchs died.

Survival in floating cages was high. Losses encountered were due mainly to poor cage design which allowed small conchs to escape around the cage door, and through tears in the screening made by floating debris.

FEASIBILITY OF CONCH MARICULTURE

Intensive mariculture of conch in pens does not seem to hold much promise for success due to the slow growth of penned conch. Based on our results with pens, we believe that only in certain protected locations with good water exchange where pen construction is inexpensive and can be monitored regularly is there hope for success. Also, if the growth rate of penned queen conchs is reduced due to lack of food, then if an inexpensive food can be constituted for them perhaps pens would be promising.

The growth and survival of small conchs (<3 cm) in floating cages suggests that this technique can play an important role in over-wintering young hatchery-reared conchs. Clearly, growth is rapid in cages and the method is reasonably inexpensive, as the conchs graze on the algae that grows on the screening.

To evaluate the feasibility of extensive mariculture, I have made some estimates using "worst case" values, "mid-values" and "best case" values for mortality and cost figures. In this model (Table 2) it is proposed to grow out hatchery-reared conchs that have over-wintered in cages and are to be released in suitable habitats at about 3 cm to allow them to grow to adult sizes. Using mid values with a 10% annual survival for each of 2 years, gives a rate of survival of 0.01; hence to obtain 1,000 surviving adults from such a planting, 100,000 releases are required. At a mid cost of 7.5 cents (U.S.) per young hatchery-reared conch, the cost is $7,500, or $7.50 per conch that reaches adult size. Using the same steps for the worst, and best cases gives values of from $40.00 to $1.25 for each adult. These estimates assume that all adults of market size will be caught, but do not include the cost of fishing.

Table 2. Feasibility of increasing conch production by extensive mariculture hatchery plantings

	Estimates Worst	 Mid Values	 Best
% Survival in nature 3 cm adults	5/year	10/year	20/year
Survival for 2 years	.0025	.01	.04
No. conchs planted to get 1,000 adults	400,000	100,000	25,000
Cost of hatchery Reared conchs	@ 10¢ each $40,000	@ 7.5¢ each $7,500	@ 5¢ each $1,250
Cost/adult conch all survivors caught	$40.00	$7.50	$1.25

Most projections that are made for success of hatchery-reared animals that have been planted in the wild, stop at the first generation and view the hatchery rearing as unprofitable, or highly unprofitable, depending on the estimates used to arrive at the cost/benefit ratio. Consider the results, however, if we protect and allow 1,000 surviving adults that have high survival in nature due to their large size and heavy shell to spawn. Using the same estimates as before, we can better evaluate the desirability of supplementing natural stocks with hatchery-reared conchs. In Table 3, I have listed the number of spawnings per season per female from 1 to 6 based on studies by D'Asaro (1965), Randall (1964) and Robertson (1959). However, all estimates given below involve only a single spawning per season to provide a conservative estimate. Following the mid values for a single spawning of 400,000 eggs, and the survival

Table 3. Feasibility of increasing conch production by extensive mariculture (second generation)

	Estimates		
	Worst	Mid Values	Best
Times/season 500 protected females will spawn	1	3	6
Range of number of eggs/egg mass (spawning)	300,000	400,000	450,000
% Survival-hatching through metamorphosis	1	5	15
Survivors through metamorphosis	3,000	20,000	67,000
% Survival of natural spawn metamorphosis-market size	0.25	1	4
No. of conch survivors to market size/female	7.5	200	2,700
Multiply by 500 females	3,750	100,000	1.35×10^6
Value 40¢ each	1,500	40,000	540,000
Deducting cost of seed	-$38,500	$32,500	$538,750

through metamorphosis of 5%, and survival of 1% from metamorphosis to market size, gives 200 conchs per female that would survive. Randall (1964) found a sex ratio of 50:50. Therefore, of the 1,000 planted, 500 would be females. Hence, these 500 females should provide 100,000 conchs of market size (each female produces 400,000 eggs once a year × 0.05 survival through metamorphosis = 20,000 × 1% survivors to market size/female = 200/female × 500 females = 100,000). Using a value of 40 cents each as adults and deducting the cost of seed, shows a net gain to the fishery of $32,000. With worst case estimates, there is a loss of about the same amount, and with the best case there should be a substantial profit (over $500,000) for the 6-year period.

These analyses show that for relatively small differences in survival during the early life of the queen conch, the end result can be greatly different. Based on our research and this conservative analysis, I feel that the most likely result would lie somewhere between the mid-value and the best case and indeed would produce a profit to the fishery. An important factor in this analysis is that this large, heavy-shelled snail as an adult is well protected from predators which suggests that this method of augmenting natural stocks from hatchery plantings by government agencies has merit in stocking self contained, or unit, stocks.

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